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New paper: Review and Analysis of Strategies for Reducing Life Cycle GHG Emissions of Residential Buildings in Humid Subtropical and Tropical Climates by Daniel Satola et al. 2021 - A Thread (1/9)

buildings

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Review

Life Cycle GHG Emissions of Residential Buildings in Humid Subtropical and Tropical Climates: Systematic Review and Analysis

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Abstract: Improving the environmental life cycle performance of buildings by focusing on the reduction of greenhouse gas (GHG) emissions along the building life cycle is considered a crucial step in achieving global climate targets. This paper provides a systematic review and analysis of 75 residential case studies in humid subtropical and tropical climates. The study investigates GHG emissions across the building life cycle, i.e., it analyses both embodied and operational GHG emissions. Furthermore, the influence of various parameters, such as building location, typology, construction materials and energy performance, as well as methodological aspects are investigated. Through comparative analysis, the study identifies promising design strategies for reducing life cycle-related GHG emissions of buildings operating in subtropical and tropical climate zones. The results show that life cycle GHG emissions in the analysed studies are mostly dominated by operational emissions and are the highest for energy-intensive multi-family buildings. Buildings following low or net-zero energy performance targets show potential reductions of 50–80% for total life cycle GHG emissions, compared to buildings with conventional energy performance. Implementation of on-site photovoltaic (PV) systems provides the highest reduction potential for both operational and total life cycle GHG emissions, with potential reductions of 92% to 100% and 48% to 66%, respectively. Strategies related to increased use of timber and other bio-based materials present the highest potential for reduction of embodied GHG emissions, with reductions of 9% to 73%.

Keywords: GHG emissions; life cycle assessment; residential buildings; design strategies; humid subtropical climate; tropical climate

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We reviewed more than 70 building LCA studies in climate regions common in the Global South, studying building cases from Asia, Oceania, South America and North America. We conduct detailed analyses ...
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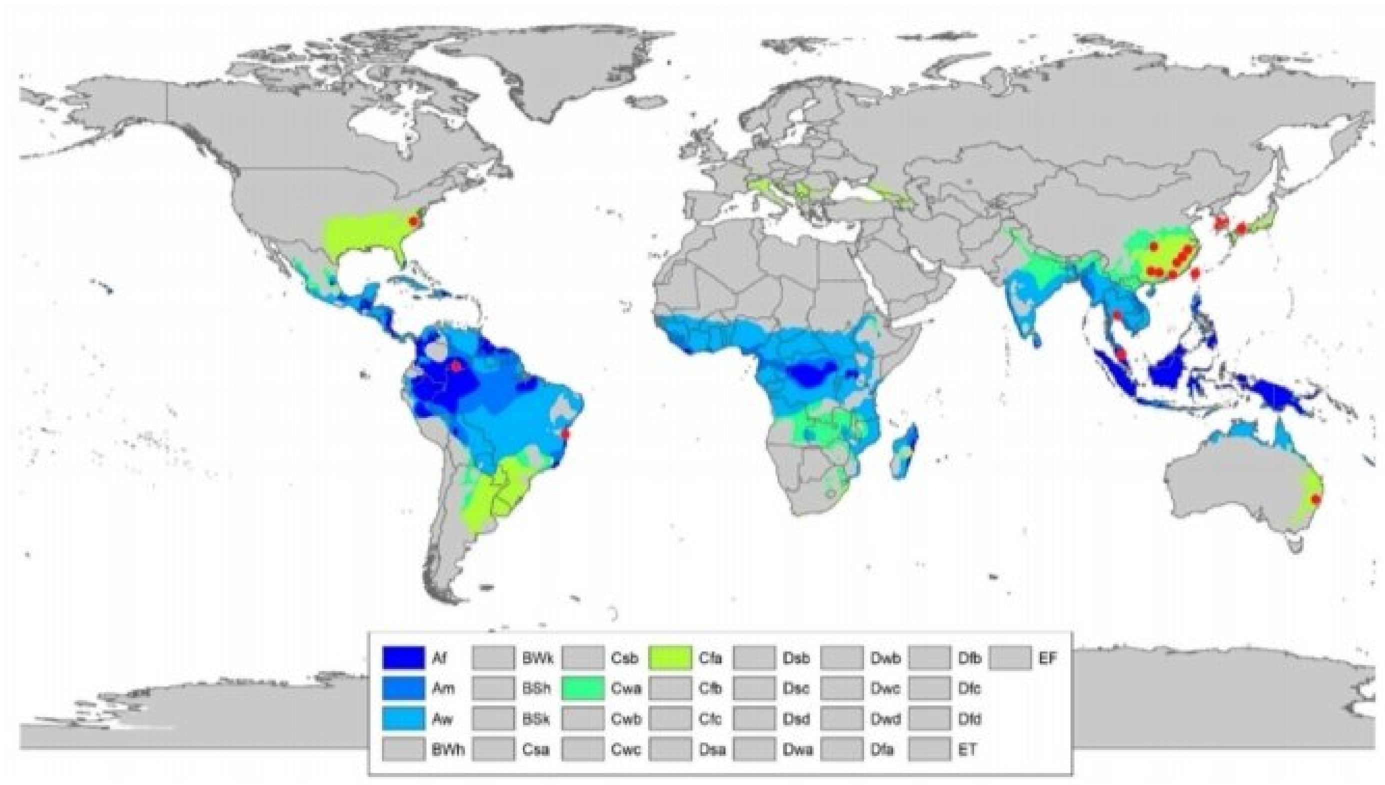

Figure 5. Locations of 36 case studies in the final sample.

...based on a final sample of 36 building cases which were fit for harmonization of results. Therein, life cycle GHG emissions show a wide range of 491 to 4811 kgCO2eq/m2. To understand more: First, how structural material choice is influencing emissions...

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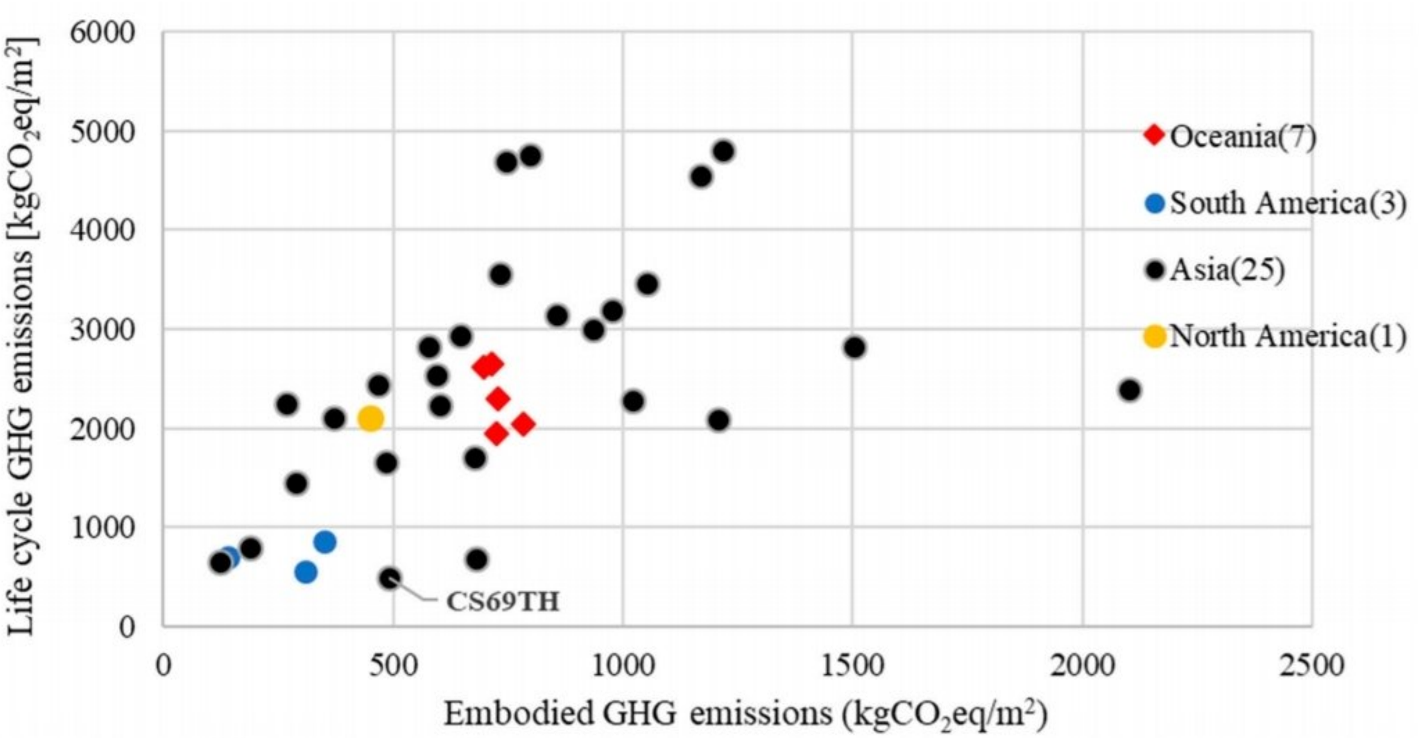

Figure 6. Harmonised embodied and life cycle GHG emissions from 36 case studies.

...we study both embodied and life cycle GHG emission in relation to primary materials used in the building structure. This shows lowest embodied emissions with wood as structural material, and potentially low emissions from use of concrete (non-reinforced). Second,... (4/9)

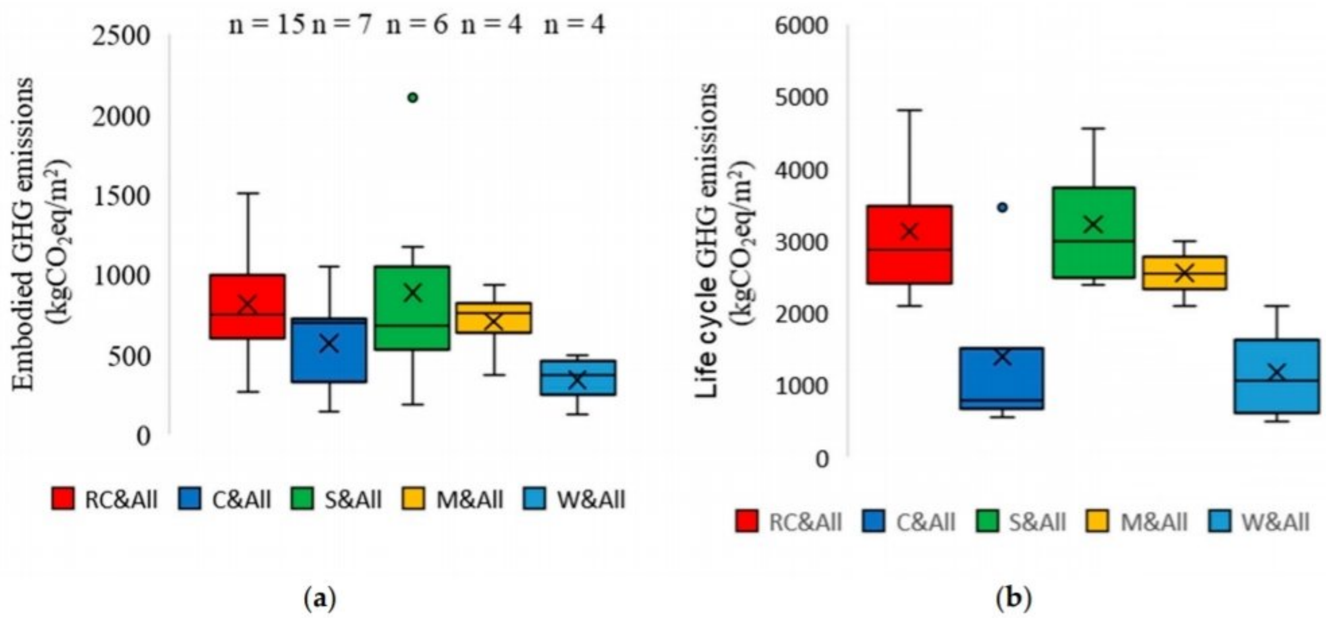

Figure 11. (**a**) Embodied and (**b**) total life cycle GHG emissions in relation to the primary structure materials. RC, reinforced concrete; C, concrete; S, steel; M, masonry brick; W, wood and All, secondary materials. n, number of case studies with a specific primary structure material.

...we investigate specific design strategies applied in the different cases to analyse their potential for reducing operational and/or embodied GHG emissions. Substantial embodied GHG emissions reduction can be achieved by use of local materials, ... (5/9)

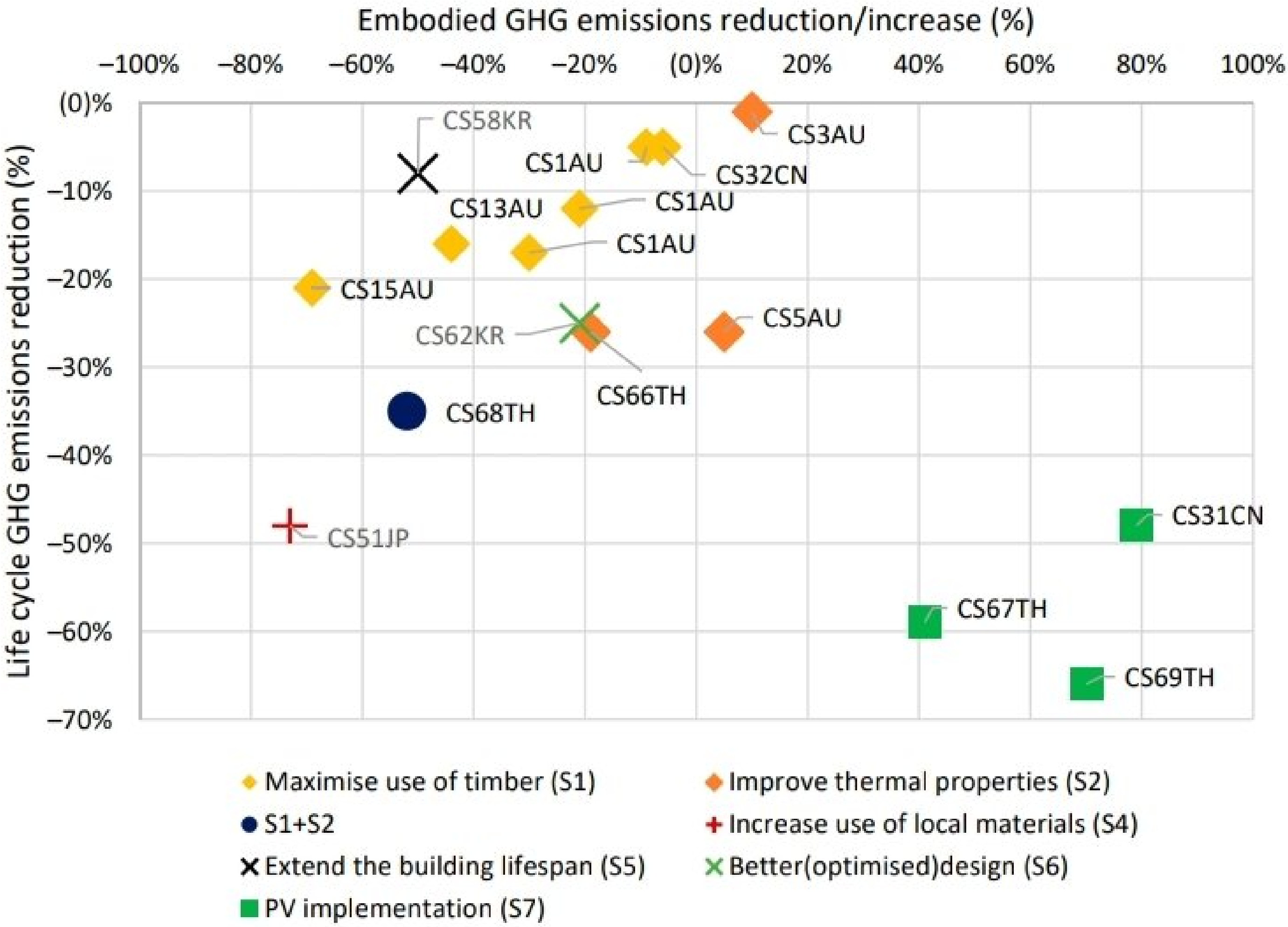

Figure 12. Embodied and life cycle GHG emission reduction potentials of the identified design strategies.

... wood-based structures and extended service life, among other strategies.

Strongest potential for reducing operational emissions is use of photovoltaics, thermal improvement of building envelope, among other strategies. PV shows trade-offs with embodied emissions. (6/9)

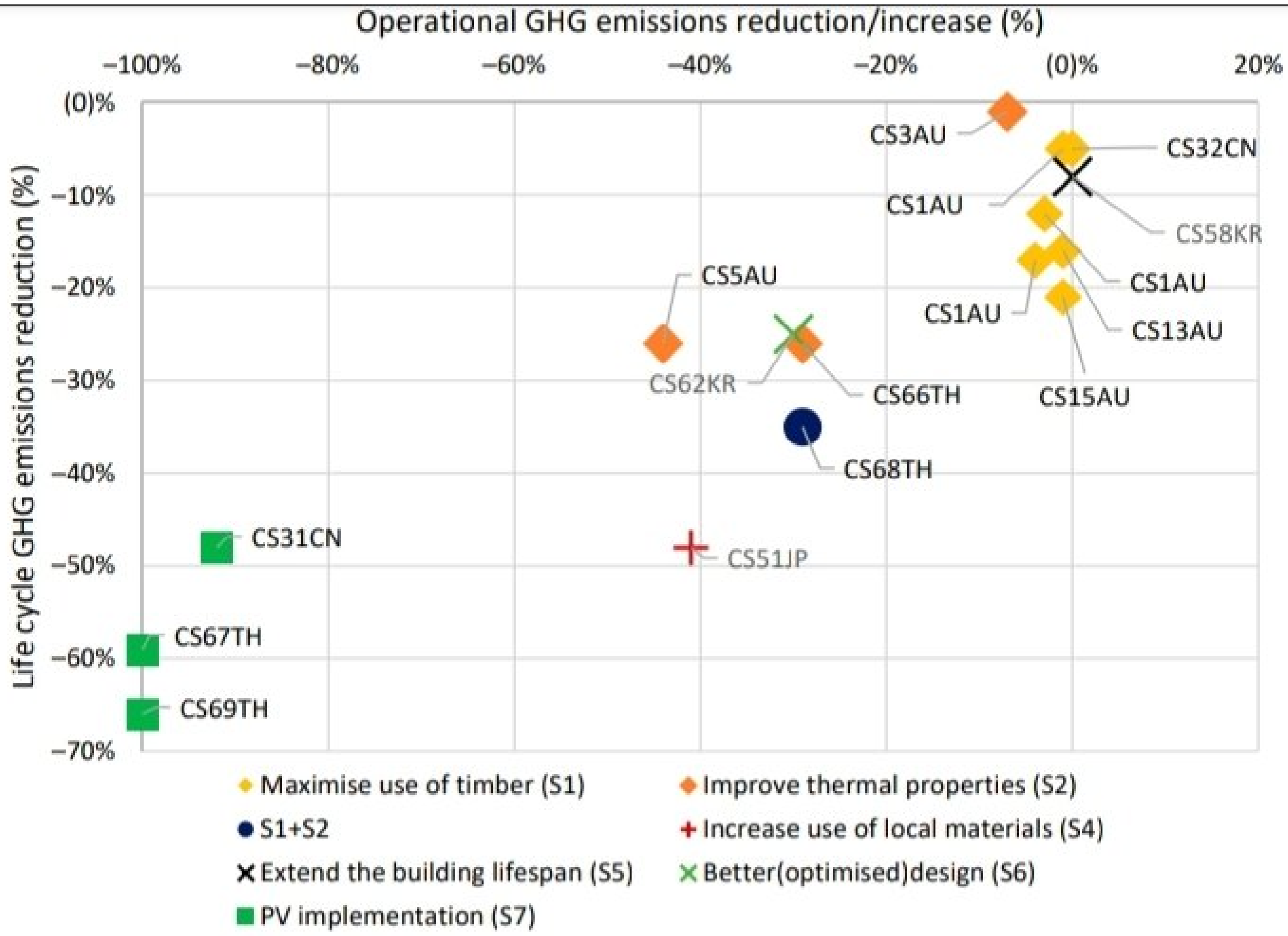

Figure 13. Operational and life cycle GHG emission reduction potentials of the identified design strategies.

Energy and grid electricity mixes have strong influence as well. Find more on energy mixes and other relevant aspects in the paper. Below the full table of building design strategies we investigated and their respective reduction potential. Thanks for your interest!
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Table 4. Overview of GHG emission reduction strategies.

Reduction Strategy	Case Study	Description	GHG Emission Reduction (−) or Increase (+) (%) Relative to Baseline Scenario		
			Embodied	Operational	Total Life Cycle
S1: Maximise use of timber	CS1 AU	Replacement of steel structure frame (base design CS2AU) with timber frame	−30%	−4%	−17%
		Replacement of concrete slab (base design CS2AU) with elevated timber floor	−21%	−3%	−12%
		Replacement of brick veneer (base design CS2AU) with weatherboard cladding	−9%	−1%	−5%
	CS13 AU	Switch concrete sub-floor, double brick wall covering and roof steel frame (base design CS12) to timber products	−44%	−1%	−16%
	CS15 AU	Switch concrete sub-floor, double brick wall covering and roof steel frame (base design CS14) to timber products	−69%	−1%	−21%
	CS32 CN	Replace aluminium panel wall (base design CS31CN) with timber wall	−6%	0%	−5%
S2: Improve thermal properties	CS4 AU	Implement reflective insulation for non-insulated carpet floor (base design CS3)	+10%	−7%	−1%
	CS5 AU	Replace non-insulated carpet floor (base design CS3) with insulated hardwood timber floor	+5%	−44%	−26%
	CS66 TH	Replace non-insulated reinforced concrete structure (base design CS65TH) with insulated steel frame	−19%	−29%	−26%
S1+S2: Maximise use of timber + improve thermal properties	CS69 TH	Replace non-insulated reinforced concrete structure (base design CS65TH) with insulated timber frame	−52%	−29%	−35%
S3: Use lower EC materials	CS58 KR	Replace standard concrete (base design CS57KR) with non-cement concrete panels and amorphous steel fibre concrete (low GHG emission)	−25%	0%	−7%
	CS61 TW	Replace reinforced concrete structure (base design CS66TW) with lightweight steel frame	−34%	−18%	−25%
S4: Increase use of local materials	CS51 JP	Replace standard timber construction with (a) locally produced timber, (b) no laminated wood, (c) natural and locally produced insulation materials	−73%	−41%	−48%
S5: Extend building lifetime	CS58 KR	Extend 50-year building lifespan (base design CS57KR) to 100 years by replacing standard 24 MPa strength concrete (base design CS57KR) with high-strength (40 MPa) concrete	−50%	0%	−8%
S6: Optimise form (material efficiency)	CS62 KR	Optimise building form and design by using T-type instead of flat-type concrete blocks (base design CS61KR)	−21%	−30%	−25%
S7: Implement PV systems (on site)	CS31 CN	Implement on-site PV system of 2.8 kW in reference to design scenario CS32CN	+79%	−92%	−48%
	CS67 TH	Implement on-site PV system of 5 kW in reference to design scenario CS66TH	+41%	−100%	−59%
	CS69 TH	Implement PV system of 5 kW in reference to design scenario CS68TH	+70%	−100%	−66%

Find the full paper here open access:
https://t.co/FsQjSR6C2f

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(8/9)

Thanks to Daniel Satola for inviting me to contribute to this paper and the analysis of cases in his review. We also added the buildings to our larger building LCA dataset and will present further analyses in the future, so stay tuned!✌ (End)