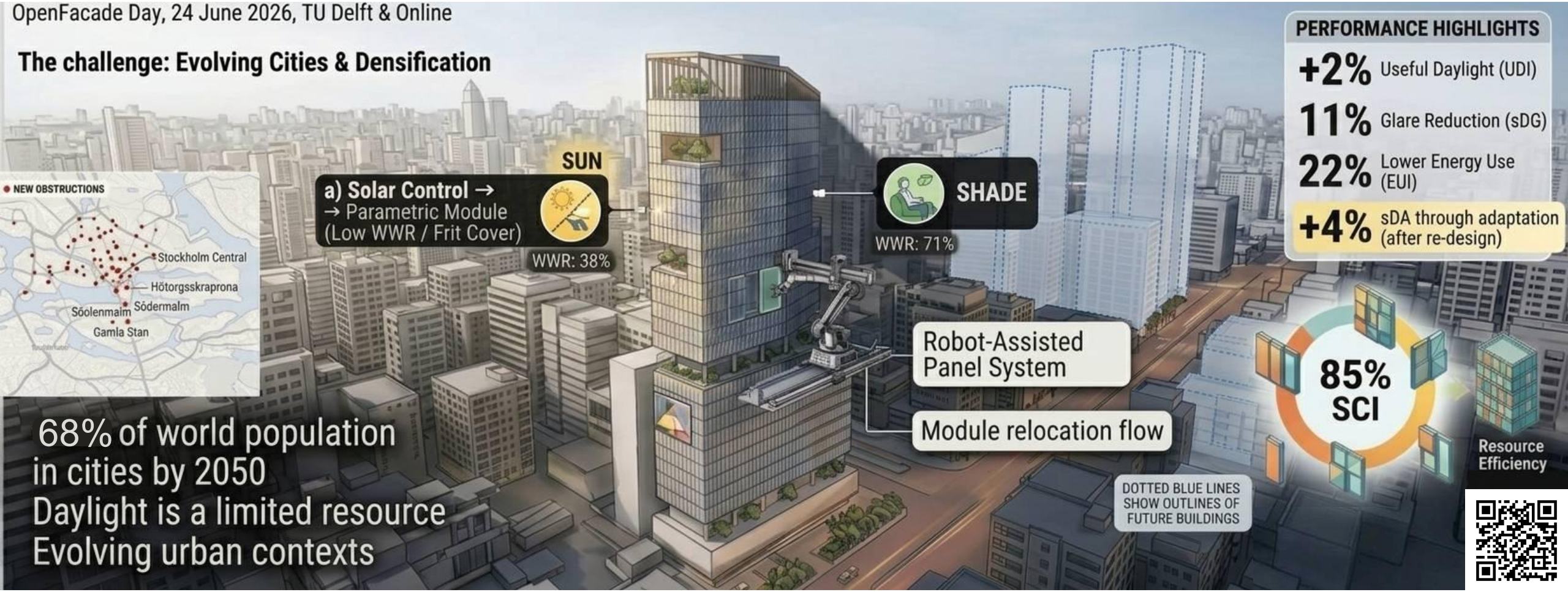
Solar, Adaptive and Circular Facades: Parametric Design Workflow for Evolving Cities



Arlind Dervishaj
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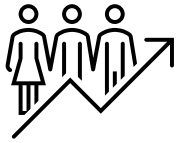
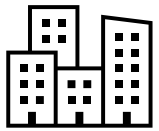
KTH Royal Institute of Technology

The challenge

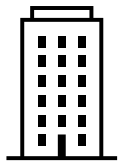


- **Urbanization** (another 2.5 billion people to cities by 2050)



- **Densification** in cities (In 2018, 55%, and by 2050, 68% of the world's population will live in cities).

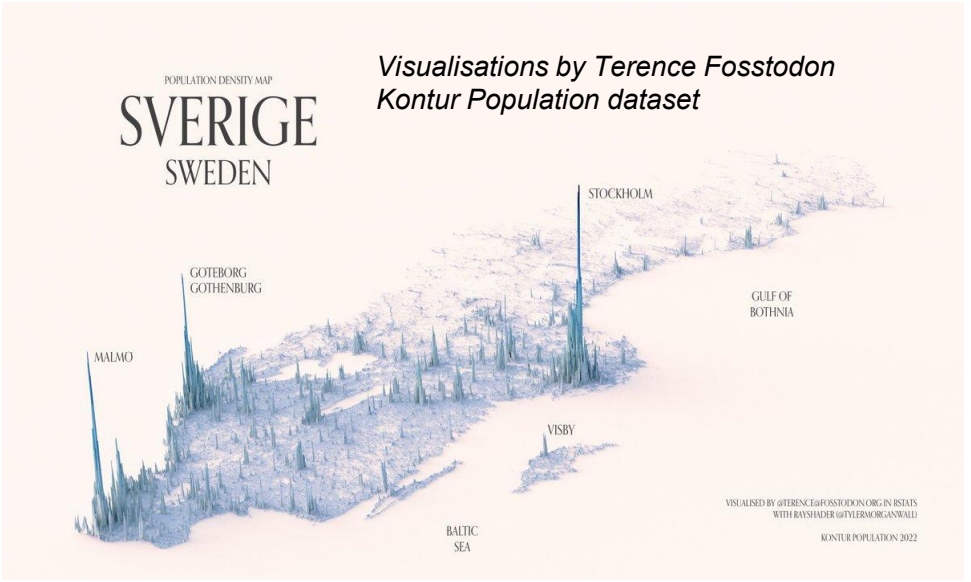
- **Megacities** with over 10 million inhabitants are expected to reach 43 by 2030, with rapid growth in Asia and Africa

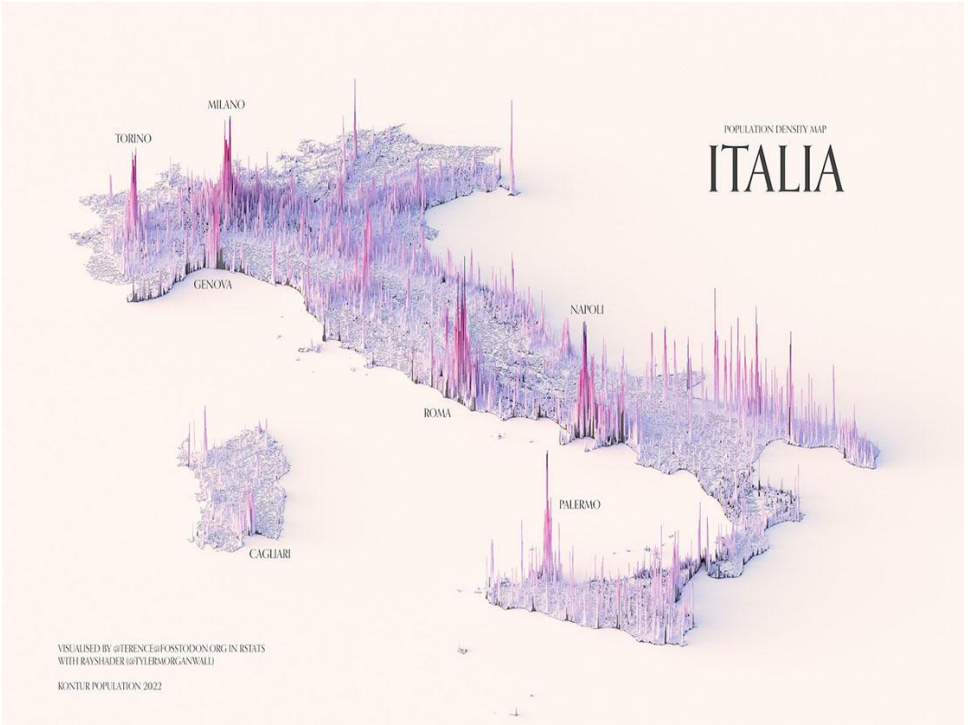


- **Daylight is a limited resource in cities**

UN's 2018 Revision of World Urbanization Prospects

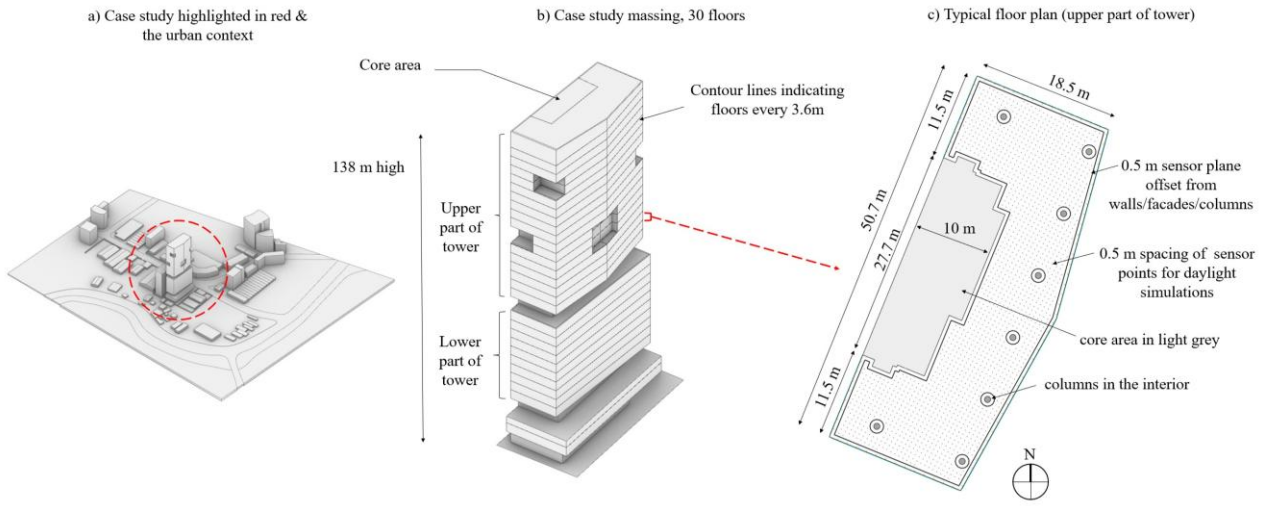
Visualisations by Terence Fosstodon
Kontur Population dataset



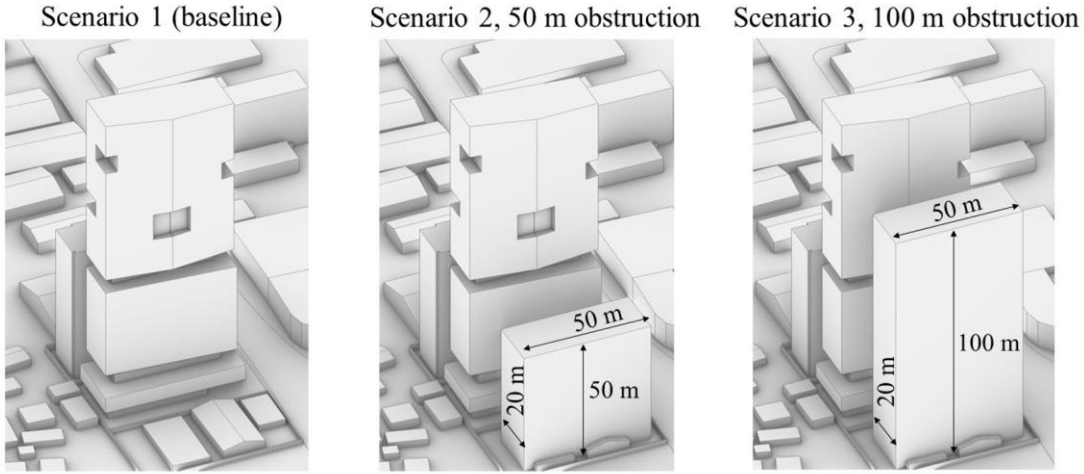


How can we design and future-proof buildings to

- address undergoing urbanization and densification globally, while maintaining
- human health and comfort, e.g., daylight and building performance
- enhance the adaptability and circularity of facades in changing urban environments



Case study (context, building, floor plan)



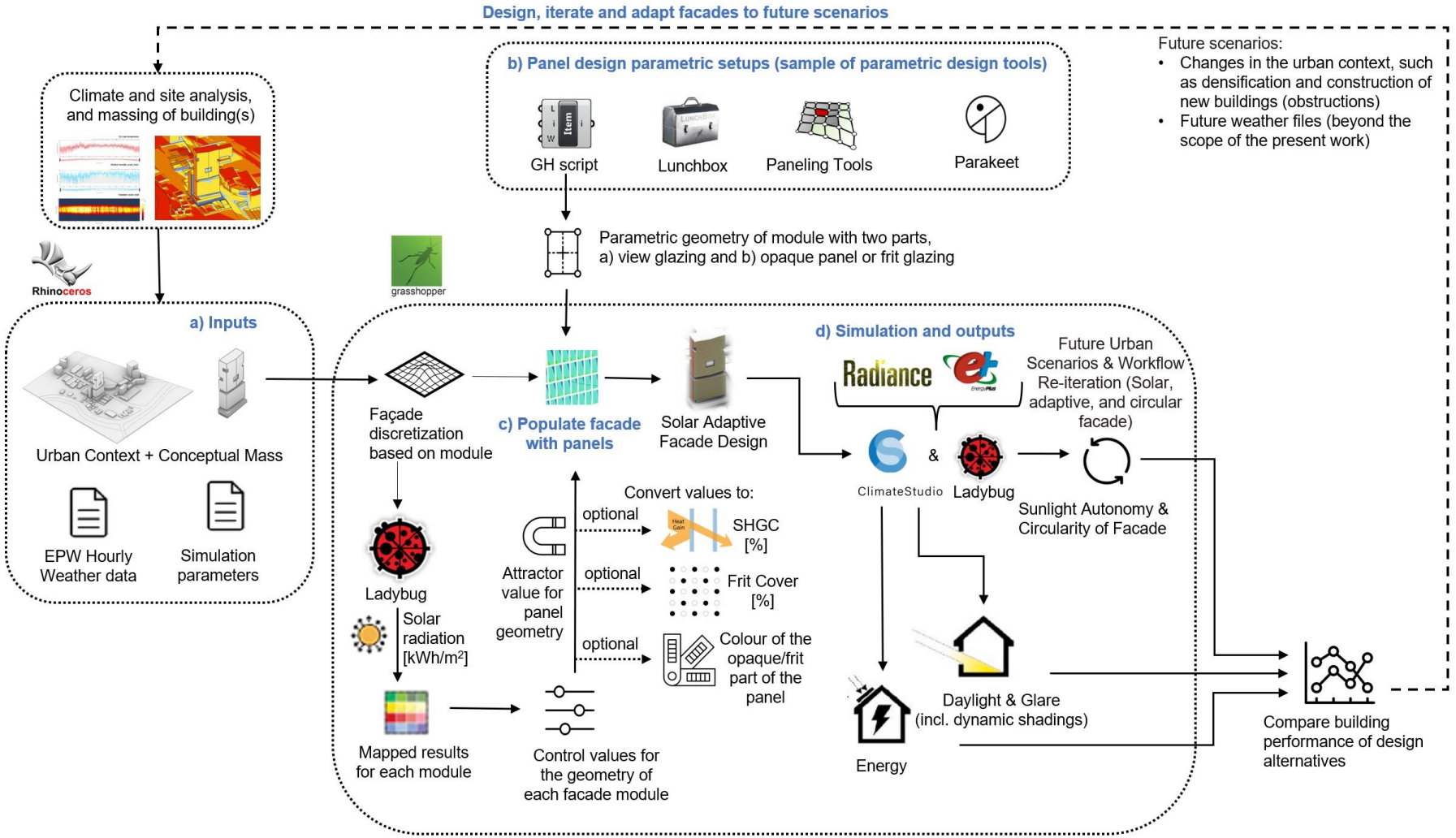
Three scenarios of urban densification

Parametric design workflow for evolving cities

Solar Mapping: Radiation analysis informs module "openness" or Window-to-Wall Ratio (WWR), frit cover, and/or the solar heat gain coefficient (SHGC) of glass.

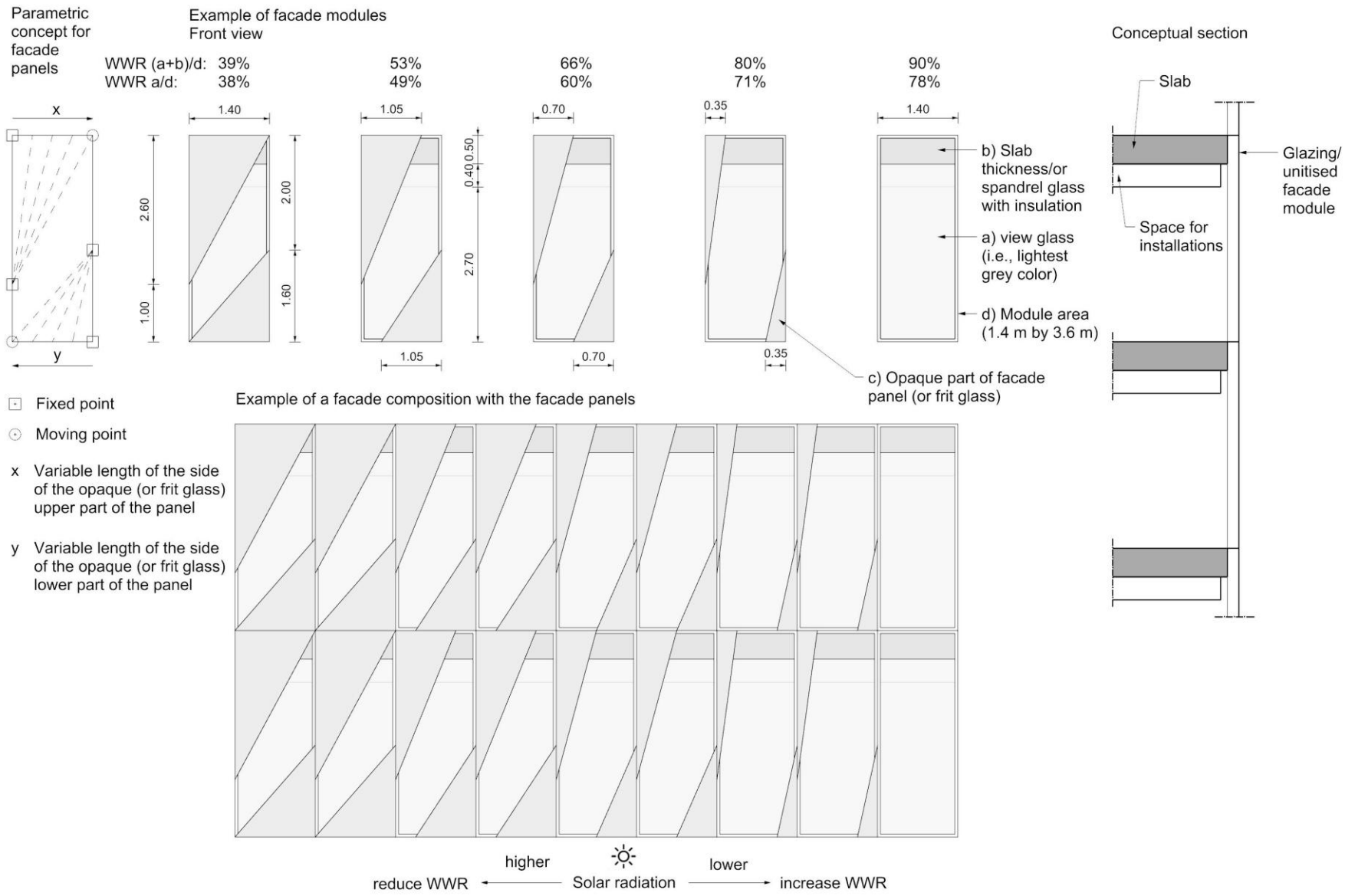
Adaptation: increase WWR in shaded areas to maximize light and decrease it in high-sun zones to control heat.

Design Continuity: Maintains original aesthetics while replacing or relocating panels as the city grows.

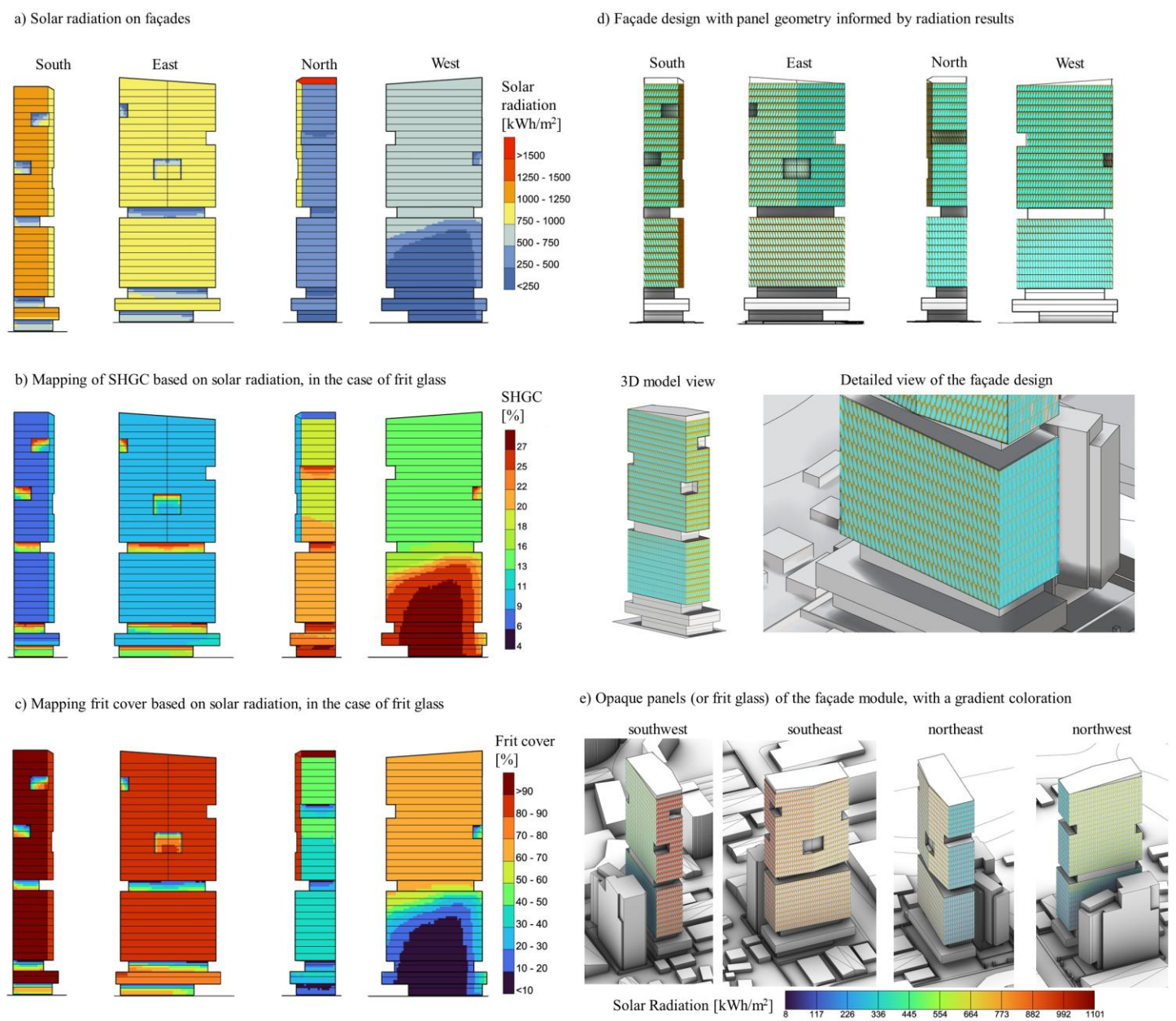


https://doi.org/10.1080/19401493.2024.2432916

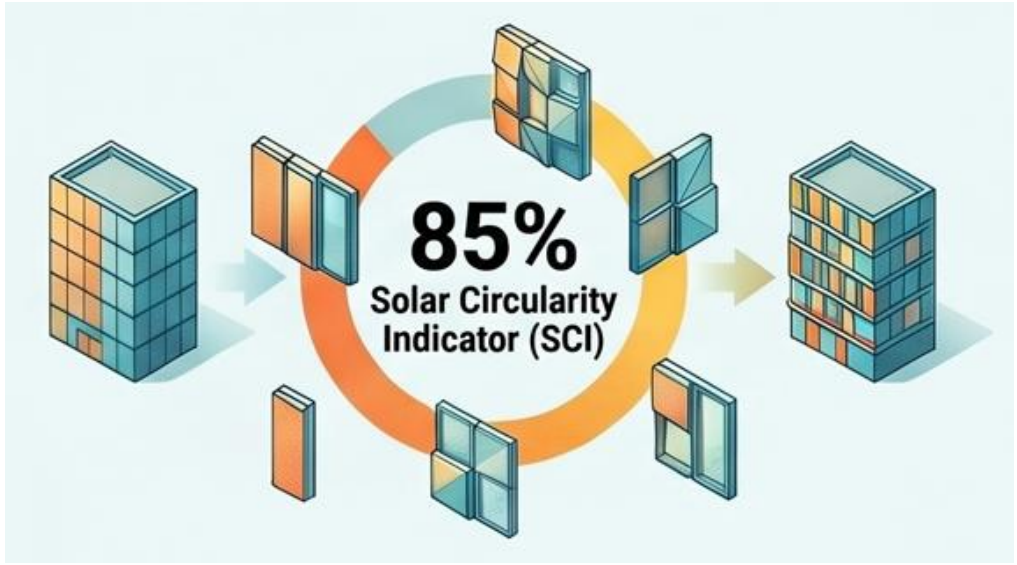
Facade concept



Simulation: solar energy & mapping of glazing properties e.g. frit cover



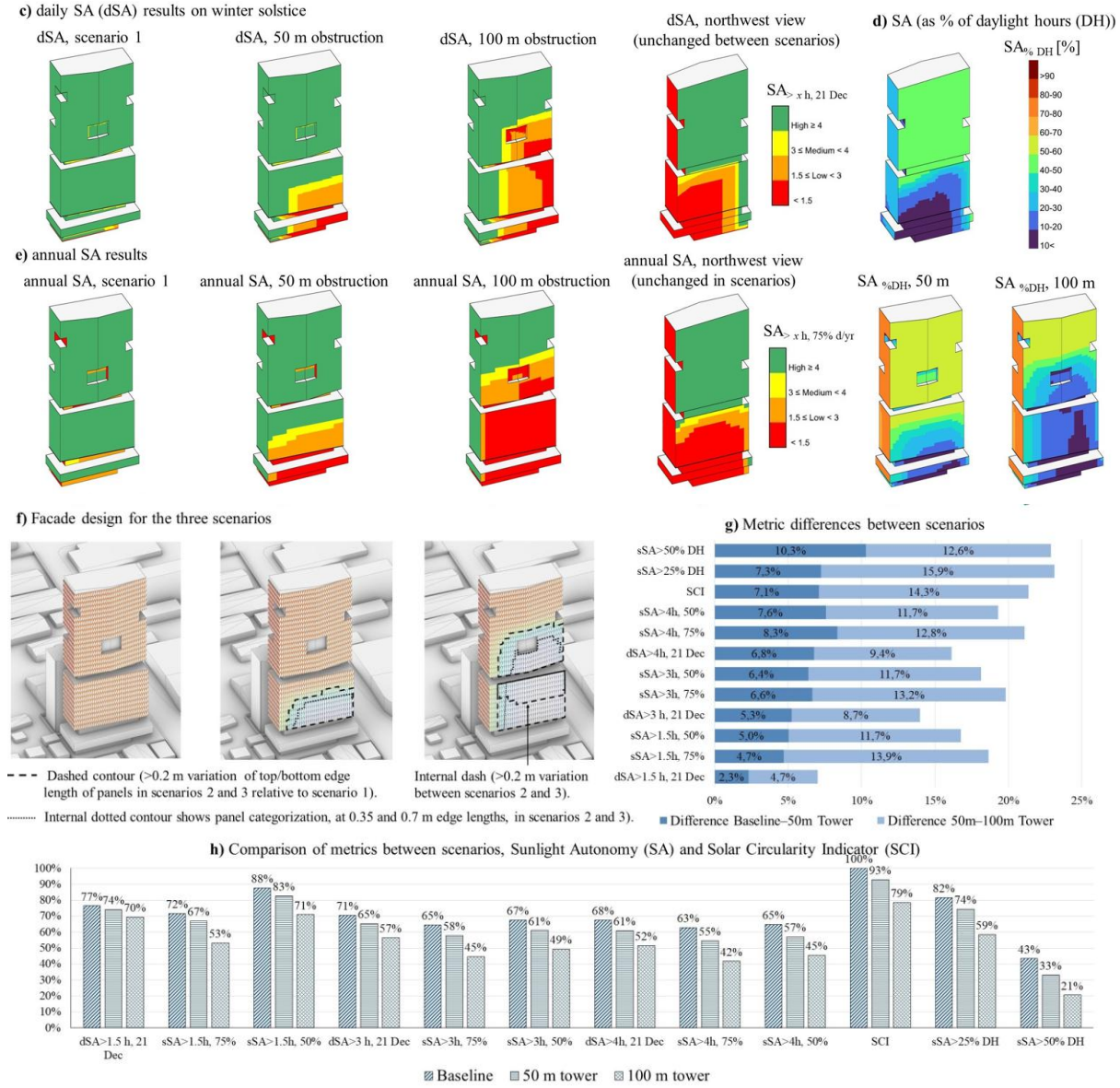
Façade design/refurbishment after e.g. 30 years and denser environment



Tracks maintenance, reuse, and relocation of facade elements.

Achieved an 85% SCI in a 100 m obstruction scenario.

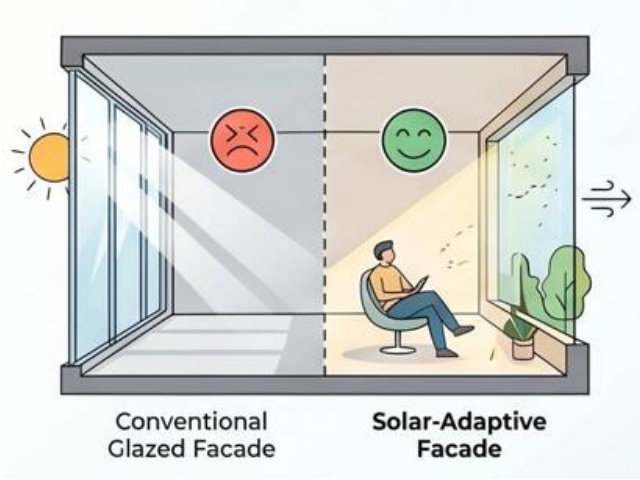
Maintained 79% of modules and reused 29% of those altered by new urban shadows.



Daylight & building performance

Enhanced Daylight Autonomy

Redesigning facades for new urban obstructions improves spatial daylight autonomy by **up to 4%**.

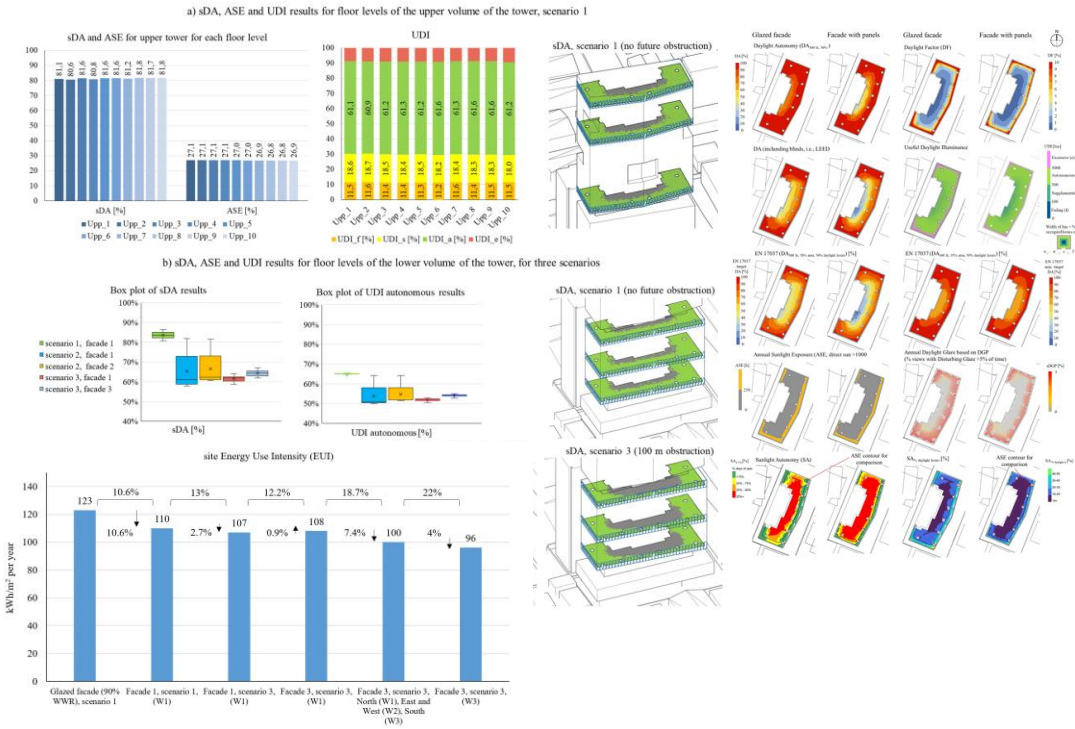


2% more Useful Daylight Illuminance (UDI 100-3000 lux)

11% reduction in spatial Daylight Glare (sDG)

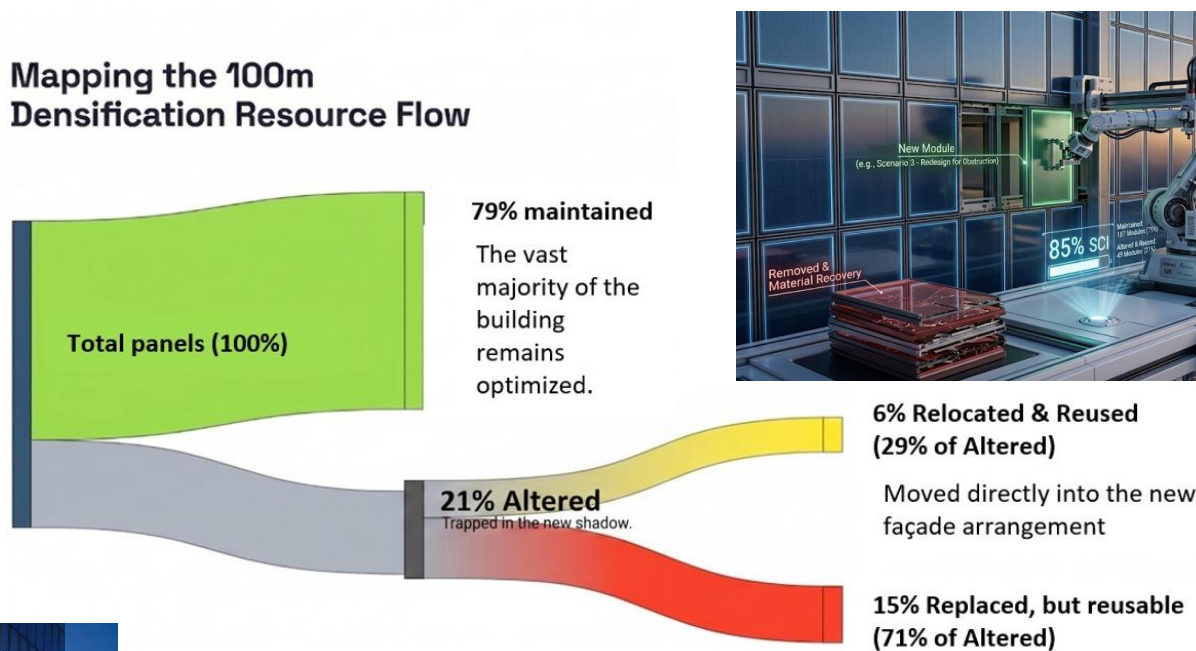
22% lower Energy Use Intensity (EUI)

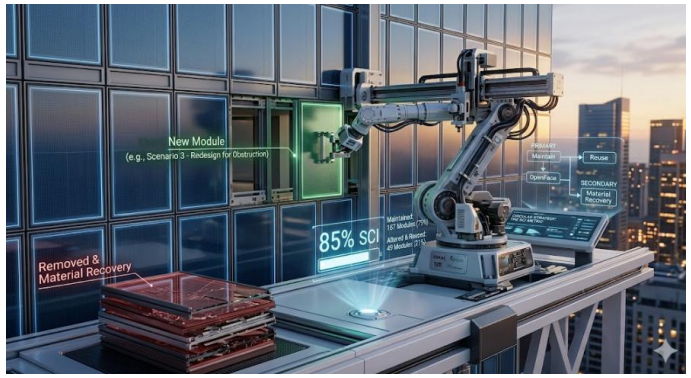
Detailed results on daylight in the paper:

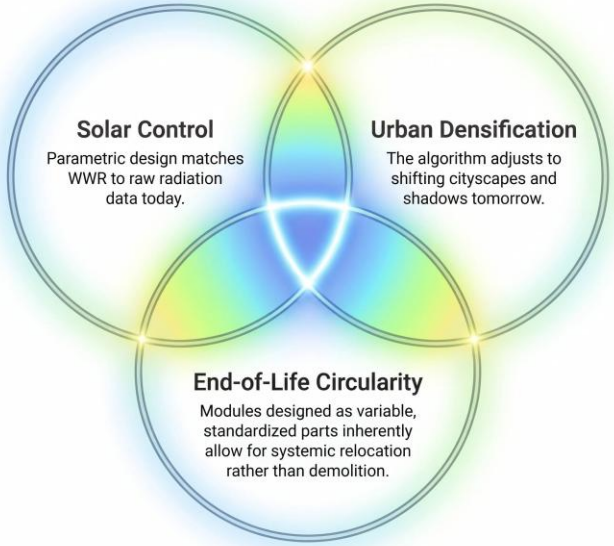


Overview

SOLAR-ADAPTIVE FAÇADE DESIGN → **CIRCULAR FACADE FLOWS** → **DIGITAL TWIN & ROBOT-ASSISTED FACADE UPGRADES** → **ADAPTABILITY IS CIRCULARITY**







REUSABLE IN OTHER BUILDINGS

Parametric design workflow for solar, context-adaptive and reusable facades in changing urban environments. Journal of Building Performance Simulation, https://doi.org/10.1080/19401493.2024.2432916