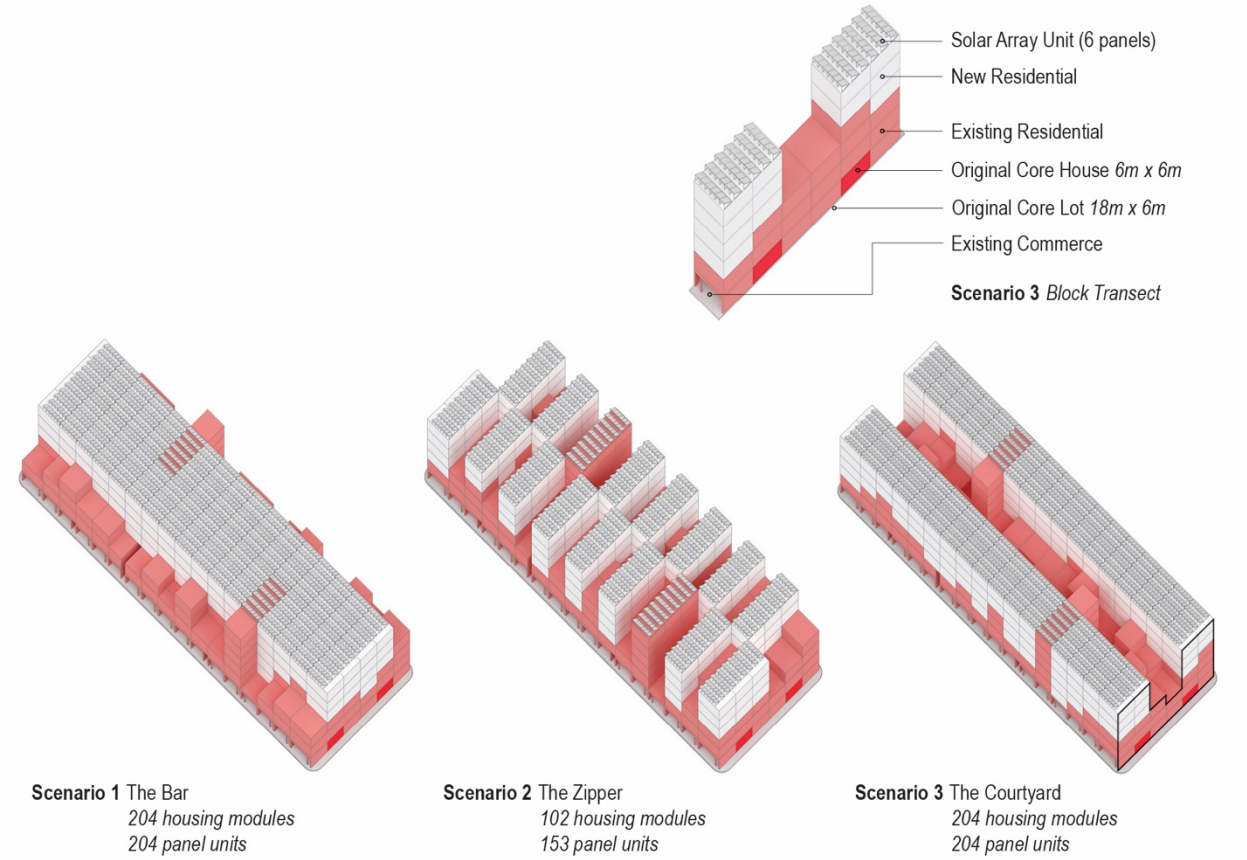
Stiphany, K. and Moore, S.A. (Forthcoming July, 2021). Retrofitting incremental housing for solar resilience in Brazilian favelas. *Buildings and Cities*. Special Issue Retrofitting at Scale: Accelerating Capabilities for Domestic Building Stocks.



Models: Jesus Ruelas

Abstract

A common concern for urban planning in rapidly growing cities of the global south is integrating informal settlements into urban transformations that improve urban resilience (Muhibuddin, Handmer, Mitchell, and Ahmed, 2014). To achieve the United Nations Sustainable Development goal 7 (SDG 7), the delivery of modern energy to the urban poor, there is a growing focus on solar energy production (Conway, et. al. 2019). In Brazil, although there have been investments in rural solar, there has been little consideration for how informal, incremental housing types might provide a social and technical substrate for solar generation in urban contexts (Moore, 2014; Stollman, 2016). In fact, such adaptations were the original idea behind "core" or "sites and services" housing, a "kit" that came with a serviced infrastructural plenum, a basic dwelling, and a lot that users could build out as their time and resources permitted. This model became popular for the 1970s, when it was widely exported by international aid agencies as an economically, socially, and technically viable way to ensure

basic sanitation and shelter across developing regions (Ward, 2012). Across the diversity of these regions, core housing types begin and end with wildly distinct outcomes that vary by country, city, and even within communities (Stiphany, forthcoming). In Brazil, the development of core housing also had ties to popular participation, and is known as the 'mutirão' or mutual housing that, in providing a stable structure and "freedom to build," also provided the material conditions for a right to the city (Turner, 1976; Bonduki, 2000). Given the potential for core housing types to adapt to different scales of change, this article asks: what sociotechnical transformations could retrofit core housing to mediate surging energy vulnerabilities in informal settlements and accelerate resilience in cities? To answer this question, we use data that was collected in the context of a civic data project in São Paulo (www.chapa.io), where the first author and community residents undertook a combined household and participatory post-occupancy analysis of 805 informal houses, 296 of which are mutirão houses. We found that informal housing growth is severely taxing existing infrastructural systems, particularly in the area of energy. To assess the suitability of mutirão housing for solar generation, we interview engineers, architects, and policy makers familiar with how the mutirão adjusted to particular contexts, and in two cases, undertake a comparative technical analysis of orientation, structural integrity, and density across four types of mutirão housing. We present typologies of energy vulnerability and opportunity, and scenarios for evaluating possible interactions between retrofit transformations and policy change. Achieving urban resilience through small scale retrofits can improve energy access, but requires the following for local buy-in: (1) expanding multi-sector renewable energy research and development to encompass informal infrastructural networks; (2) modifying redevelopment or 'slum upgrading' policies to prioritize integrated housing and energy retrofit programs; (3) developing civic data tools that owners of core housing can use to assess solar suitability, apply for financial subsidies, and manage array efficacy; (4) extending Brazil's existing progressive policy infrastructure to form civic energy councils that monitor solar generation and distribution; and (5) establishing transnational comparative research infrastructures for training professionals in the security and adaptability of solar retrofits across global core housing models.

Keywords informal settlements, incremental housing, retrofitting, solar energy, resilience, Brazil

This paper addresses the following Special Issue Questions:

1) "Mass vs individual retrofit for housing: technologies for retrofit at scale;"

2) "The development of appropriate standards and retrofit processes for the particular contexts of developing countries."

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