

Grounding urban energy tools in the lived experiences of the urban poor - a case for incorporating participatory methods in urban building energy models.

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Abstract

Urban building energy models (UBEMs) are an example of a data-driven method for predicting energy consumption and assessing the impacts of policies aimed at reducing carbon emissions in cities. Such tools are gaining increasing ground as cities and governments seek to understand and manage energy demand. Originally developed for developed cities in the global North, there is now considerable interest in their application in the rapidly urbanising cities of the global South. This development history means that to date, UBEMs have not incorporated slums. With almost 30% of the global urban population living in slums and the vast majority of those in the global South, this paper considers the challenges of energy access for the urban poor in the global South and how people have been represented in UBEMs thus far. The implications of this failure to incorporate a large section of the urban population are considered. Participatory research methods are proposed as a method for collecting, processing and developing the data which is necessary to ground UBEMs and similar tools in the lived experiences of the urban poor.

Introduction

Energy plays a crucial role for the productive and reproductive aspects in people's lives. Access to affordable and reliable modern forms of energy services is essential to reduce poverty and promote economic growth, especially for developing countries (Fuso Nerini et al., 2018; The World Bank, The International Energy Agency, The International Renewable Energy Agency, The United Nations Statistics Division, & The World Health Organisation, 2019). In the face of rapid urbanisation, urban energy planning and urbanisation management is pivotal for creating the right framework conditions for sustainable energy futures. Such a framework must address equity and justice as the experience of urban dwellers in the face of increased stresses on resources, such as land, housing, infrastructure and services, is not homogeneous across a city. Rather, it manifests in an uneven landscape with a clear intersection between poverty and inequality.

Urban building energy models (UBEMs) are expert-led and data-driven tools for predicting energy consumption and informing policies to reduce carbon emissions in cities. The richness of geospatial data incorporated within these models means there is increasing interest in expanding their application beyond energy consumption and into other aspects of urban planning. However, the predominant focus of such models on the global North, resulting in a range of aspects of life in the rapidly-developing cities of the global South which are not adequately addressed (Fennell, Ruysevelt, Rawal, & Poola, 2019; Janda, Fennell, Johnson, Tomei, & Lemaire, 2019) including:

- Rapidly evolving building stock
- Increased sun exposure at lower latitudes
- Higher surface temperatures mean increased importance of longwave radiative heat transfer between surfaces (Evins, Dorer, & Carmeliet, 2014)

- Lack of data availability (Shnapp & Laustsen, 2013)
- Very different practices of energy consumption, partly due to financial constraints on energy demand (Roy, 2000)

Perhaps the most significant gap is the absence of informal settlements, in response, this paper begins by defining slums and informal settlements and the energy challenges faced by the urban poor. The role of planning tools such as Urban Scale Building Energy Models (UBEMs) is discussed together with existing representations of slums in such models. The need for better understanding of energy practices is highlighted to address the lack of representation of slums in such models and participatory research methods are proposed as a means of both addressing the representation gap and empowering marginalised communities in the process.

Slums and informal settlements

Slums have many names, including informal settlements, townships, barrios, favelas, colonias, ghettos, shacklands, or shantytowns. Slums are officially defined by UN-HABITAT (Mwelu, 2015) as housing in an urban area where the inhabitants lack one or more of the following:

1. Durable housing of a permanent nature that protects against extreme climate conditions.
2. Sufficient living space which means not more than three people sharing the same room.
3. Easy access to safe water in sufficient amounts at an affordable price.
4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people.
5. Security of tenure that prevents forced evictions.

Globally, one in eight people live in slums, and informal settlements are a significant feature of cities in the global south. 30% of the populations of these cities live in slums, and while the proportion of slum dwellers is decreasing, their total population is increasing (UN-Habitat, 2016). One of the greatest challenges for urban development is

“how to build resilience for the billion urban dwellers who are estimated to live in what are termed informal settlements. These settlements have been built outside the ‘formal’ system of laws and regulations that are meant to ensure safe, resilient structures, settlements and systems” (Mwelu, 2015).

UN HABITAT’s New Urban Agenda highlights the need to address informal settlements to achieve a number of SDGs including improved health, poverty eradication, economic development, gender equality, social cohesion and energy access. The New Urban Agenda also recognises the difficulty in addressing the growth of slums and improving living conditions within them. Factors include inability to build enough adequate housing at the speed necessary to accommodate immigration and population growth, limited municipal budgets, legal complexity and environmental consequences (UN-Habitat, 2016). Slums are therefore a significant and enduring reality for urban populations in the global south, improving slum dwelling is a core concern, and energy access is intricately related.

Academic research on slum dwelling and energy use indicate further complexity beyond the economic and technical aspects of providing energy services. Parikh et al. (2012) demonstrate how energy access is linked to livelihoods and aspirations. They show that when slum dwellers’ basic services needs are met, they are able to then aspire for better healthcare, housing and education; service provision is therefore a bedrock for development.

Energy challenges for the urban poor

Although sustainable access to energy underpins the achievement of most of the sustainable development goals (Fuso Nerini et al., 2018), it remains a multifaceted challenge for the urban poor with a wide range of factors including tenure status, access to decision making processes, access to key appliances and the built environment having a large impact (Broto et al., 2017). For the urban poor, achieving sustainable energy access is a much broader problem

than simply ensuring sufficient generation capacity or fuel supply. These complex and intricately interconnected challenges are evidenced by studies in a wide range of contexts:

- **Tenure status** - Lipu et al. (2013) highlight the primacy of having a legal settlement as a prerequisite for legal access to energy services in Bangladesh. The relationship between tenure and energy access is a complex political one: Gupta (2015) discusses electricity connections in Indian informal settlements, explaining that electricity connections
“...can be leveraged to prove residence and thereby to convert unauthorized hutments into legal occupancy. Therefore, power companies refuse to give official connections to residents of slums. However, they recognize that people need electricity to live in an urban environment. Thus, they unofficially allow slum residents to tap into power lines. Politicians, police, and bureaucrats are all complicit in this lawbreaking, going so far as to collect rent from residents for unauthorized access to electricity. For their part, residents do not pay for the electricity they use, even if they pay an equivalent amount in bribes”.
Where legal connection is possible despite insecure tenure, high costs of connection are a major barrier for marginalised communities under constant threat of eviction; for the urban poor of Dhaka city, the connection fee represents 5 or 6 months’ income (Lipu et al., 2013), Butera et al. (2016) report unaffordable costs of connection in Latin America.
- **Access to decision-making processes** - lacking a voice in decision-making processes leaves the urban poor vulnerable to exploitation by those with political influence, Lipu et al. (2013) cite the example of communal electricity meters for slums in Dhaka where local leaders control pricing and access, leading to extortion with households paying three times the actual metered cost.
- **Access to key appliances** - energy efficient appliances are often beyond the reach of the urban poor, Butera et al. report this as a particular concern for Latin America where the high up-front cost of more efficient appliances leaves poorer households locked into lower efficiency products and higher bills as a result.
- **Built environment** - the built environment presents a range of complex interactions with energy consumption for the urban poor in the global South. Sunikka-Blank et al.’s (2019) study of poor urban residents in Mumbai highlighted the impact which urban form had on energy usage. Lack of cross ventilation led to a need for cooling and television was used to compensate for the lack of opportunity for outside play for children in high-rise buildings. Poor quality of building fabric significantly increases the risk of exposure to heat stresses for inhabitants (Mastrucci, Byers, Pachauri, & Rao, 2019) driving an increased need for cooling.
- **Safety** - informal electricity connections, self-constructed accommodation, use of open fires for cooking and closely packed structures create a significant fire risk. In a survey of slum-dwellers located on Mumbai’s eastern waterfront, 8% had experienced the loss of their home in a fire.
- **Clean fuels for cooking** - access to clean and safe fuel sources for cooking varies considerably for the urban poor depending on geographic location and is a particular concern for the urban poor in Africa (Butera et al., 2016).

The complex interplay between these challenges make achieving SDG 7, affordable and clean energy, a particular challenge for the urban poor. Indeed, as highlighted by Mastrucci et al. (2019), when cooling requirements to avoid the risk to health and life presented by heat extremes are accounted for, the energy poverty gap is much greater than that estimated as part of SDG7.

The difficulty of achieving energy access

The interconnected nature of the challenges to achieving safe and sustainable energy access for the urban poor means that there is a significant risk of causing harm to already marginalised and vulnerable communities with well-intended but poorly planned or implemented interventions. Mahadevia et al. (2013) provide a detailed critique of poor design and implementation of accommodation in slum redevelopment programmes which led to a decrease in standards of living for residents as a result of a redevelopment programme in which they had no voice. Sunikka-Blank et al. (Sunikka-Blank et al., 2019) used focus groups and semi-structured interviews to understand how energy practices had changed as a result of slum-redevelopment and found that purpose-built accommodation to replace slums resulted in a loss of economic opportunities for residents, reduced social interaction and a four-fold increase in energy costs which drove many residents to choose to move back to the slums they had originated from.

It is clear from these examples that any interventions to try to improve living conditions for slum-dwellers require careful consideration to ensure that they do not further marginalise the most vulnerable members of society by cutting off economic opportunities and locking in carbon intensive energy practices (e.g. the use of solid fuel for cooking), (Colenbrander et al., 2017).

Urban scale building energy models as energy planning tools

Urban building energy models (UBEMs) are large-scale models which incorporate representations of large numbers of individual buildings in order to create a model of a neighbourhood or even an entire city. UBEMs are a relatively recent development (Reinhart & Cerezo Davila, 2016). They are physics-based building energy models used to calculate the energy consumption of individual buildings or premises based on calculating heat and energy flows, both within the building and to and from its surroundings. Models vary considerably in their complexity and the timesteps in which they are evaluated; however, all require:

- a representation of the thermo-physical properties of the building, for example, the area of walls and their ability to transmit heat
- details of the energy conversion systems within the building such as heating, cooling or lighting systems
- and a representation of the patterns of occupancy and equipment use.

Since the building stock of a large city can be of the order of 1 million individual buildings, UBEMs require very large quantities of data to characterise a whole building stock. Therefore, models often develop proxies, averages, and simplifying assumptions to manage the data.

As availability of processing power has increased, UBEMs have emerged as powerful opportunities in urban policy and planning, offering detailed insights into:

- Diagnosing energy consumption across a building stock, allowing energy efficiency interventions to be targeted at areas of greatest need.
- Assessing the impact of potential intervention strategies across the stock, allowing competing strategies to be ranked
- Predicting energy consumption and carbon emissions under climate change
- Exploring the impact of renewable energy strategies, such as large-scale deployment of solar PV installations, or peak demand shaving; and
- Evaluating alternative development options for new construction and redevelopment of existing stock

Fennell et. al.'s (2019) review of the literature suggests that coverage is much greater in the USA and Europe than the rest of the world, although China is reasonably well represented. Coverage is notably absent in low- and middle-income developing countries, in

South America, Africa and Southern and South Eastern Asia. No references to slums or informal settlements were found in the reviewed literature suggesting that to date they have not been included.

Excluding informal settlements from UBEMs could be justified on the grounds that the energy consumption is limited, while the academic resources needed to incorporate this consumption in the model would be high. However, as the research cited above demonstrates, access to energy is about more than energy consumption. Energy access is fundamental to sustainable urban development. By excluding informal settlements from their calculations, UBEMs risk adding to the impediments faced by slum dwellers and contributing to reproduction of their exclusion into the future.

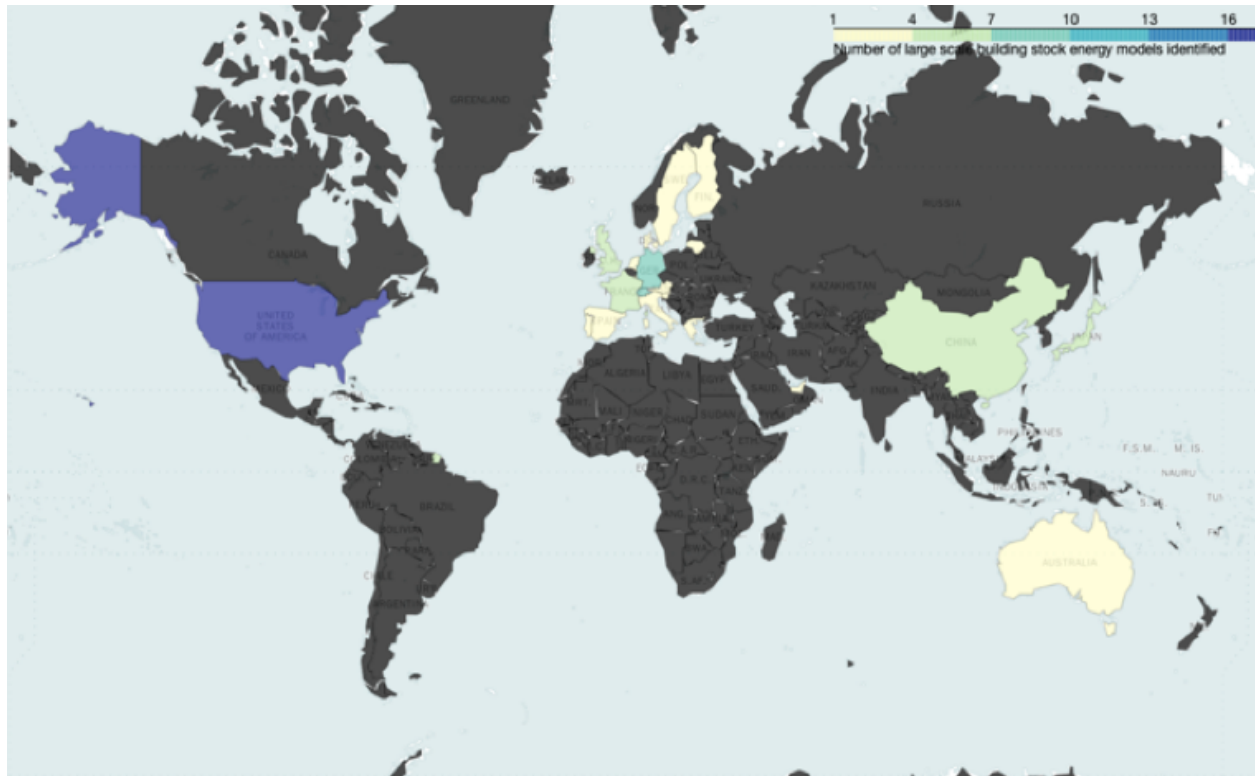


Figure 1: Geographic distribution of urban and city scale models (created using folium 0.10.10)

How are people represented in UBEMs?

Although, the fundamental driver of energy consumption in the urban environment are the inhabitants and their need for the services energy can provide, such as thermal comfort, entertainment, cooking, economic activity etc., representations of people in UBEMs are typically limited to a set of rules for interaction with buildings and systems. In Fennell et al.'s (2019) review, the majority of UBEMs used a small number of occupancy profiles to determine operating schedules for equipment, while a much smaller number use probabilistic methods to determine the likelihood of appliance ownership and usage.

Shove (2018) argues persuasively that such a mechanistic approach to understanding the relationships between people and energy use is doomed to failure partly because they “reproduce specific understandings of ‘service’ (including ideas about comfort, lighting, mobility, convenience etc.), not all of which are sustainable in the longer run”. More importantly

for UBEMs, however, she argues that the abstraction of energy from the situations in which it is used and performed makes it difficult to understand longer term societal shifts. Understanding such longer-term shifts is critical for urban energy planning in the global South.

The need for participatory processes

The dangers Shove highlights, of creating models which represent a single (and fixed) framing of energy practices are enhanced when seeking to include the behaviours of under-represented groups whose energy practices are at least partly dictated by contextual and financial constraints. As the examples from Sunikka-Blank et al. (2019) and Mahadevia et al. (2013) highlighted earlier show, the consequences of failing to understand those practices and constraints are significant. For this reason, participatory processes are necessary to create the knowledge needed to inform models and, in turn, decision making and the design and implementation of inclusive urban energy planning.

Participatory research involves knowledge exchange between experts and non-experts and the co-production of solutions. It changes the shape and nature of what expertise is and where it resides. As Bergold and Thomas (2012) describe:

“Participatory research involves a joint process of knowledge-production that leads to new insights on the part of both scientists and practitioners... Participatory research is conducted directly with the immediately affected persons; the aim is the reconstruction of their knowledge and ability in a process of understanding and empowerment. In the majority of cases, these co-researchers are marginalized groups whose views are seldom sought, and whose voices are rarely heard. Normally, these groups have little opportunity to articulate, justify, and assert their interests”.

Underpinning participatory processes is the decision to treat the study participants as research partners with equal rights. This acknowledges that people's lived experiences have to be considered expert knowledge thus challenging a solely top-down approach (Lambert & Allen, 2016).

Often, local communities are treated simply as data sources. However, the meaningful participation of communities would imply their inclusion in all stages of the research, from the design of the methodology for data collection, through to its analysis and interpretation. A participatory assessment of informal communities, their current and future energy needs and how these can be incorporated into UBEM models ultimately informs the design of just and energy solutions. Participatory research not only offers a more precise and comprehensive spatial, social and economic diagnosis but it can also be a means to raise awareness of safe and sustainable energy practices and strengthen local capacities.

Extending participation to strategically draw-in various actors that play a role in energy planning and implementation, can open up dialogue and negotiation in decision making amongst different stakeholders. The co-production of knowledge between local communities, experts and local authorities articulates different types of knowledge and the inclusion of such knowledge in UBEM energy models can, in turn, inform more inclusive energy futures.

Conclusions and policy implications

Achieving SDG7: Affordable and clean energy, is dependent on a range of complex and interconnected deprivation processes faced by the urban poor in the global South. As data-driven tools gain increasing ground in decision-making processes, there is a high risk of

repeating the mistakes of the past and designing policy solutions which further marginalise the most vulnerable communities and lock-in carbon intensive. Participatory research processes are an essential strategy for developing better models of inhabitants and their every-day energy practices which will ensure that decision-making is grounded in the lived experiences of the urban poor. Without this grounding, decision-makers risk implementing expensive policies which in the worst cases, may not only have a detrimental effect on quality of life for the people they are intended to help, but also increase energy demand.

References

- Bergold, J., & Thomas, S. (2012). Participatory Research Methods: A Methodological Approach in Motion. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, 13(1). <https://doi.org/10.17169/fqs-13.1.1801>
- Broto, V. C., Stevens, L., Ackom, E., Tomei, J., Parikh, P., Bisaga, I., ... Mulugetta, Y. (2017). A research agenda for a people-centred approach to energy access in the urbanizing global south. *Nature Energy*, 2(10), 776–779. <https://doi.org/10.1038/s41560-017-0007-x>
- Butera, F. M., Caputo, P., Adhikari, R. S., & Facchini, A. (2016). Urban Development and Energy Access in Informal Settlements. A Review for Latin America and Africa. *Procedia Engineering*, 161, 2093–2099. <https://doi.org/10.1016/j.proeng.2016.08.680>
- Colenbrander, S., Gouldson, A., Roy, J., Kerr, N., Sarkar, S., Hall, S., ... McAnulla, F. (2017). Can low-carbon urban development be pro-poor? The case of Kolkata, India. *Environment and Urbanisation*, 29(1), 139–158. <https://doi.org/10.1177/0956247816677775>
- Evins, R., Dorer, V., & Carmeliet, J. (2014). Simulating external longwave radiation exchange for buildings. *Energy and Buildings*, 75, 472–482. <https://doi.org/10.1016/j.enbuild.2014.02.030>
- Fennell, P. J., Ruyssevelt, P. A., Rawal, R., & Poola, V. (2019). Determining the most appropriate form of Urban Building Energy Simulation Model for the city of Ahmedabad. *Proceedings of the 16th IBPSA International Conference and Exhibition, Building Simulation 2019*, 8. Retrieved from <http://discovery.ucl.ac.uk/10078363/>
- Fuso Nerini, F., Tomei, J., To, L. S., Bisaga, I., Parikh, P., Black, M., ... Mulugetta, Y. (2018). Mapping synergies and trade-offs between energy and the Sustainable Development Goals. *Nature Energy*, 3(1), 10–15. <https://doi.org/10.1038/s41560-017-0036-5>
- Gupta, A. (2015). An Anthropology of Electricity from the Global South. *Cultural Anthropology*, 30(4), 555–568. <https://doi.org/10.14506/ca30.4.04>
- Janda, K. B., Fennell, P., Johnson, C., Tomei, J., & Lemaire, X. (2019). Towards inclusive urban building energy models: Incorporating slum-dwellers and informal settlements (IN-UBEMs). *ECEEE SUMMER STUDY PROCEEDINGS*, 973–981. Belambra Presqu'île de Giens, France.
- Lambert, R., & Allen, A. (2016). Participatory Mapping to Disrupt Unjust Urban Trajectories in Lima. In P. Imperatore & A. Pepe (Eds.), *Geospatial Technology—Environmental and Social Applications*. <https://doi.org/10.5772/64303>
- Lipu, M. S. H., Jamal, T., & Miah, M. A. R. (2013). *Barriers to Energy Access in the Urban Poor Areas of Dhaka, Bangladesh: Analysis of Present Situation and Recommendations*. 3(4), 17.
- Mahadevia, D., Datey, A., & Mishra, A. (2013). *Foisting Mass Housing on the Poor: Lessons from Social Audit of BSUP* (No. WP21; p. 30). Retrieved from Centre for Urban Equity, CEPT University website: https://cept.ac.in/UserFiles/File/CUE/Working%20Papers/Revised%20New/21CUEWP%2021_Foisting%20mass%20housing%20on%20the%20poor.pdf

- Mastrucci, A., Byers, E., Pachauri, S., & Rao, N. D. (2019). Improving the SDG energy poverty targets: Residential cooling needs in the Global South. *Energy and Buildings*, 186, 405–415. <https://doi.org/10.1016/j.enbuild.2019.01.015>
- Mwelu, J. (2015). *Slum Almanac 2015—2016* (p. 98). UN-Habitat.
- Parikh, P., Chaturvedi, S., & George, G. (2012). Empowering change: The effects of energy provision on individual aspirations in slum communities. *Energy Policy*, 50, 477–485. <https://doi.org/10.1016/j.enpol.2012.07.046>
- Reinhart, C. F., & Cerezo Davila, C. (2016). Urban building energy modeling – A review of a nascent field. *Building and Environment*, 97, 196–202. <https://doi.org/10.1016/j.buildenv.2015.12.001>
- Roy, J. (2000). The rebound effect: Some empirical evidence from India. *Energy Policy*, 6.
- Shnapp, S., & Laustsen, J. (2013). *MITIGATION POTENTIAL FROM INDIA'S BUILDINGS*. Global Buildings Performance Network.
- Shove, E. (2018). What is wrong with energy efficiency? *Building Research & Information*, 46(7), 779–789. <https://doi.org/10.1080/09613218.2017.1361746>
- Sunikka-Blank, M., Bardhan, R., & Haque, A. N. (2019). Gender, domestic energy and design of inclusive low-income habitats: A case of slum rehabilitation housing in Mumbai, India. *Energy Research & Social Science*, 49, 53–67. <https://doi.org/10.1016/j.erss.2018.10.020>
- The World Bank, The International Energy Agency, The International Renewable Energy Agency, The United Nations Statistics Division, & The World Health Organisation. (2019). *2019 Tracking SDG7—The Energy Progress Report* (p. 176). Retrieved from <https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019>
- UN-Habitat. (2016). *Urbanization and Development, Emerging Futures*. Nairobi, Kenya: United Nations Human Settlements Programme.