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Exploring multi-domain simulation workflows for 'Sustainable cities & communities' (UN SDG11)

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ABSTRACT
This positional paper discusses the results of a call for action put forward to the IBPSA community in 2021, in the aftermath of the COVID-19 pandemic which sparked a resurgence of interest in wider sustainability issues potentially promoting closer dialogues between scientists and policymakers. The pandemic made clear that we must re-think our cities and the way we live and that we have powerful political tools to implement dramatic change in short time frames. Simulations are key in providing evidence-based guidance in producing healthy cities, neighbourhoods, and buildings, showing how design and policy solutions can work together at different levels. This paper highlights the hidden potential of the building performance simulation community to demonstrate that buildings transcend their boundaries and perform beyond their primary functions and scale. It provokes a broader debate around the role of simulations, calling for immediate and decisive action towards achieving a sustainable future for all.

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Calling for action

The UN's 2030 Agenda for Sustainable Development (Walsh, Banerjee, and Murphy 2022) provides an ambitious and comprehensive action plan with its 17 Sustainable Development Goals (SDGs) (United Nations, n.d.-b). To advance the 2030 Agenda, the United Nations Economic Commission for Europe (UNECE) has adopted a 'nexus' approach in its work, focusing on high-impact areas where multiple SDGs converge. 'People Smart Sustainable Cities' (Golubchikov 2020) is arguably one of the highest impact nexus areas. Cities are the centrepiece of economic, social, and cultural life. They represent a complex arrangement of many interrelated systems, both social and technical so that they are best placed to address multiple sustainability goals at once. Although they are known for concentrating high levels of energy consumption (Urban Energy | UN-Habitat, n.d.), cities also offer more rapid, practice-informed and grounded responses to sustainability challenges.

Time is overdue for us to re-think our cities, neighbourhoods and the way we live our lives, to properly align with climate-related agendas and initiatives worldwide to create sustainable cities and communities for all. Buildings are the starting point for how we shape human settlements, neighbourhoods, districts, communities and cities, and their configurations impact on the way in which people inhabit spaces, live and interact. We need to go beyond the single target of designing buildings that reduce carbon emissions, focussing on creating better places, reversing the decline in biodiversity, and building-in appropriate measures to more effectively support mitigation and adaptation to climate change.

The United Nations Sustainable Development Goal 11 (UN SDG11) is at the centre of this call for action; it is a catalyst for making cities and human settlements more inclusive, safe, resilient and sustainable (United Nations, n.d.-a). From a policy perspective, governments must activate the capabilities of cities to implement sustainable solutions by promoting a culture of innovation and deliberation which systematically explores new opportunities, identifies what works and what does not, unlocks untapped potential, and generates new values by overcoming fragmentation and inefficiency. SDG11 contains 10 targets and 15 monitoring indicators to push for change (United Nations, n.d.-a). Although these targets and indicators have a social, economic and political focus, they interweave with technical actions particularly with regard to the following:

- Target 11.1: Ensure access to adequate, safe and affordable housing together with its basic services;

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- Target 11.2: Ensure access to safe, affordable, accessible and sustainable transport expanding the public network to reach the vulnerable;
- Target 11.3: Deliver integrated and sustainable settlement planning and management;
- Target 11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage;
- Target 11.5: Reduce risks associated with disaster;
- Target 11.6: Reduce the environmental impact of cities, with special attention to air quality and waste management;
- Target 11.7: Provide universal access to safe, inclusive and accessible green and public spaces;
- Target 11.b: Adopt and implement integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change and resilience to disasters – considering risks at all levels.

From a built environment perspective, the construction industry needs to work with governments and businesses globally to implement UN SDGs to provide safe, healthy places for people to live and work in, and to be able to do this quicker, cheaper and better than ever before, especially in emerging and fragile economies where progress is critical. However, to date, we have lacked the capability to undertake comprehensive, multi-domain evaluation of interconnected social, economic and political issues and we are still at infancy with coupling multi-domain evaluation of interconnected technical issues. This presents us with a significant challenge but also a precious opportunity.

The IBPSA community currently lacks a discussion forum to properly collate all these initiatives, showcase them, and push for change. In our everyday lives, we still rely on disparate simulation tools and models, working in isolation to solve specific technical problems. These models and tools are disconnected from the complex reality of designing neighbourhoods, districts and cities, which involves developing solutions that not only cater for energy transitions but also consider requirements related to accessibility, green and blue infrastructures, indoor and outdoor air pollution, mitigation of flooding, etc.

At the end of the day, our colleagues in practice must deal with a collage of Key Performance Indicators (KPIs). They have to make sense of overwhelming amounts of information and propose solutions to deal with each part of this complexity. This approach results in the creation of buildings, neighbourhoods and cities that are an assemblage of disjointed technical solutions; which are resource-intensive and expensive, contributing to accentuate inequalities and negative environmental impacts. As a community, we need to put ourselves in the shoes of those who must deliver against internationally agreed targets and grand challenges. Furthermore, we need to understand the challenges they face and how this translates to our domain: What design parameters are shared between different knowledge domains? Can we develop models and workflows which use these parameters to address multi-domain targets?

This Special Issue is a call for us to abandon our habit of working in silos and focus on the pressing need to develop tools and workflows that support practitioner colleagues to produce integrated solutions within a reasonable timescale. We are good at developing tools which produce robust evidence. It is now time to focus on integrating this knowledge for the greater good. To this end, the UN SDG11 targets can be seen as an urgent call for the IBPSA community to work together; 'an urgent call for action by all countries in global partnership … [to provide] a shared blueprint for peace and prosperity for people and the planet, now and into the future' (United Nations, n.d.-b).

A manifesto for a new IBPSA

Simulation plays an important role in identifying solutions to the problems we are now facing by testing new ideas about how buildings and places work at both microscopic and macroscopic levels. There is clear evidence of a growing interest and an upsurge of research into urban scale simulation (Corrado et al. 2019; Pan and Yan 2023) which has created an opportunity for the building performance simulation community to be at the forefront of developing and testing solutions to address UN SDG challenges on a number of levels.

When looking around the various IBPSA Affiliate Regions there is evidence of a wide range and depth of activities emerging which include the use of simulation to support policy development and decision-making for Regional and National Governments (Nägeli et al. 2020; Sandberg et al. 2021; Yamaguchi et al. 2022) with examples around building stock management and new approaches to handling big data at a municipal scale. They also include the role of simulation in accelerating the integration of Smart Technologies into Smart Grids (Flett and Tuohy 2017) from the deployment of renewables and clean energy at a city scale to the role of simulation in moving forward on e-mobility (Kelly, Flett, and Hand 2023), new generation 'battery power stations' (Li et al. 2023), to digital transformation and digital twinning at a building or city scale (Bettencourt 2014). Examples of creating urban data streams linking factors such as Geographical Information Systems (GIS), CityGML, and census data to building energy demand profiles to predict current and potential future conditions (Masoumi et al. 2023; Schrotter and Hürzeler 2020) also exist.

However, there is little evidence, for instance, of alignment with parallel leading-edge work being undertaken in schools of urban design and planning. For instance, fields such as urban morphology, which addresses the detailed analysis of physical form, street pattern, plots and urban grain using cartographic sources (Kandt and Batty 2021) provide rich layers of data telling the story of the evolution of our cities whilst also enabling us to analyse future planning scenarios. There is a missed opportunity to explore their potential to enrich research in environmental urban simulation, as the work of simulation experts could enhance the understanding of the form and structure of cities, creating a positive synergy between these disciplines. Examples of these include integrating several types of simulation tools to understand climate adaptation, assessing historical responses to climate resilience, identifying point(s) in time when we deviated from working with climate to designing without considering its impacts, up to evaluating future urban developments by assessing layers of form to better understand how physical design features affect environmental performance and human behaviours.

Motivation for this can already be seen in areas such as urban planning through (i) merging the conceptualization of spatial form in urban ecology with that in urban design for a more powerful exploration of attributes that build resilience in urban systems (Marcus and Colding 2014); (ii) exploring how urban morphology, climate science, and energy systems must integrate to address sustainability and optimize urban-environmental interactions effectively (Ratti, Raydan, and Steemers 2003) and; (iii) discussing on the value of integrating landscape ecology and urban morphology in order to provide evidence to enhance biodiversity and strengthen urban ecosystems (Marcus, Berghauser Pont, and Barthel 2019). Motivations from architectural design are also starting to emerge (humARCH2019 summer school – EPFL 2019) bringing together daylighting and wayfinding simulations as two human-centric performance areas in a continuous dialogue to enhance evidence-based architectural design. We simulationists could be capitalizing on this knowledge base, while at the same time enabling the construction industry and researchers in the field to support the delivery of SDGs and targets that mirror how our cities perform. This can be done through evidence-based data, with a view to creating 'people-smart sustainable cities' that foster sustainability and liveability in an integrated manner (Golubchikov 2020).

To this end, much is still to be done by the IBPSA community to maximize the potential and benefits of simulation towards developing cities that are smart and sustainable and which plan for the future, in readiness for whatever might happen, politically or climatologically. The end goal being building cities that are accessible, flexible, healthy, inclusive, innovative, liveable, people-centred, resilient, resourceful, robust, technologically and digitally interconnected, climate neutral, environmentally responsible, and much more.

To maximize the potential and benefits of simulations, our ultimate aims must be very clear when developing new tools, methods and workflows, removing the negative impacts of working within disciplinary silos. It is about time for the IBPSA community to address the inefficiencies and limitations of attempting to join together concepts and ideas that bear no relationship to one another in the real world; whereas in practice they cater only for a small part of the universe of parameters practitioners have to deal with when developing design solutions.

This Special Issue is a manifesto for the IBPSA community, with simulation providing the evidence to provoke a more active debate in mitigating the environmental impacts of climate change while building resilient cities and communities, in tune with the UN blueprint to achieve a sustainable future for all. It showcases examples in which simulation workflows integrating models from different domains or disciplines are used to evidence-based, solve conflicts and/or reconcile design solutions towards achieving UN SDG11. It exposes the hidden potential of the building performance simulation community to demonstrate that buildings transcend their boundaries and perform roles within neighbourhoods and communities beyond their primary functions and scale.

An initial response from the IBPSA community

Originally our proposed themes focused on the use of multi-domain simulation models to evidence-based design decisions geared towards achieving disaster preparedness and post-disaster relief, integrated public spaces, sustainable and low-carbon neighbourhoods, sustainable and integrated land use, and integrated sustainable transport. While not all themes have been covered in an equal manner in the Special Issue, this thematic spectrum has attracted a rich variety of research aimed at producing diverse types of evidence, particularly in the context of reconciling disparate knowledge domains across diverse spatial scales.

Therefore, following common urban planning perspectives and approaches, contributions can be organized according to their scale-specific focus and unit of analysis, more specifically micro-scale models, neighbourhood-scale models, and city-scale models. By examining various scales, from micro to macro, simulations can indeed provide nuanced insights into the intricate interplay between social, economic, and environmental parameters within urban environments, thereby enabling targeted interventions. Developing simulations at multiple scales also contributes to capturing the complex interactions between various components of urban systems at higher and lower levels, fostering the development of integrated urban design and planning strategies. What facilitates the identification of trade-offs and synergies between distinct types of interventions, guiding decision-makers in developing strategies that maximize overall positive outcomes. This approach shifts the focus away from single solutions and fosters the scalability and transferability of design- and policy-oriented strategies by facilitating the extraction of insights from one scale to inform interventions at others through simulations.

At the micro-scale, Zeeshan et al. (2022) delve into the intricacies of designing integrated public spaces, offering a novel approach to parameterizing urban vegetation, particularly street trees, which significantly impact on urban microclimates and community well-being. This research aims to enhance the use of outdoor spaces by improving pedestrian thermal comfort and minimizing the cooling demands of adjacent buildings through air temperature reduction. Their method focuses on parameterizing the aerodynamic effects of tree vegetation to feed Computational Fluid Dynamics (CFD) modelling – combining heat transfer, wind flow, and mass transfer while carefully controlling boundary conditions – and assess the evapotranspiration cooling effects of green infrastructure. To achieve this, they introduce two new modelling parameters: a form drag coefficient, accounting for tree canopy shape and variable leaf area density along the tree height, and a variable tree transpiration rate, quantifying the volumetric cooling power of the vegetation based on leaf temperature and leaf area density. Through a representative case study in a hot humid climate, they demonstrate the effectiveness of their approach by modelling and simulating scenarios with and without vegetation. By virtually adding trees to identified areas in need of cooling and comparing conventional and newly proposed parameters, they validate their methodology and show the outcomes of adopting their approach. The study evaluates outdoor thermal comfort improvements from tree canopies based on apparent temperatures, highlighting that these proposed parameters provide a more pronounced cooling effect than the conventional ones, despite comfort benefits being localized (i.e. limited to the immediate vicinity of the trees), reducing air flow velocities with implications for urban ventilation. Interestingly, the study also shows that trees provided daytime cooling but nighttime heating. Ultimately, their findings highlight the potential of vegetation in reducing building and ground surface temperatures and hence energy demands, despite variations in estimated energy savings attributed to differences in street tree morphology and arrangement.

Transitioning to neighbourhood-scale models, Gascón Alvarez et al. (2023), Gonzalez-Caceres et al. (2024), and Kelly, Flett, and Hand (2023) collectively explore the nuances of sustainable and low-carbon neighbourhoods, emphasizing the critical role of buildings, heat sinks, charging hubs, and digital twins in urban sustainability initiatives. Gascón Alvarez et al. (2023) propose a multi-domain parametric design framework to assess integrated passive design strategies that dissipate excess heat and mitigate urban heat island effects, supporting the development of climate-adaptive neighbourhoods with minimum environmental impact. The framework assesses the performance of low-cost passive heat dissipation systems as urban heat sinks considering how these interact with urban form, affecting building energy simulation and embodied CO_2 calculations. It focuses on the early design stages and therefore simplifies the design process to the manipulation of massing, parameterizing building structural systems as a function of floor area ratio (a proxy for urban density) and plan area density (also known as building coverage ratio). The framework couples parameterizing building massing, structural design, and foundation sizing, with urban heat sink evaluation, to assess ground dissipation of shallow geothermal foundations and sky dissipation of roof-integrated night-sky cooling systems considering urban microclimate. This integrated assessment helps identifying synergies and trade-offs between urban geometry factors and urban heat sink availability based on local weather data while considering energy exchanges between the building with its surroundings and the urban boundary layer. The workflow therefore gauges positive feedback loops in which the higher the rejection of heat from buildings to the urban heat sink, the lower the urban heat island effect and, therefore, the building cooling load. Since the effectiveness of the heat sinks are a function of local climate, floor area ratio and plan area density, the proposal opens clear avenues for decision-makers to investigate the impact of neighbourhood-scale developments. This includes understanding how their choices in relation to these parameters can contribute to mitigating urban heat island effects; what could be transferred to retrofitting neighbourhoods to withstand the challenges of climate change.

Kelly, Flett, and Hand (2023) propose and test a new simulation model and workflow which maximizes the use of electricity generation resources within sustainable neighbourhoods towards reducing their carbon footprint and strengthening local capacity. They address a key issue related to the electrification of transport – that electrified transport not only will contribute to peak and bulk power demand increases, but mainly that it will be part of, and needs to be assessed as, an extra contributor to building electricity demand. What calls for integrated simulations that consider EV charging patterns together with microgrid renewable energy generation. Their proposal comprises the development of a rules-based statistical EV charging demand model which can be coupled with building simulation tools to assess electricity consumption and/or predict electricity renewable generation demand at various scales. Using real data, they develop and test a new electricity demand simulation model based on daily charging probability, charging time and energy use. The model is then coupled to a building energy model considering additional electrical loads and local network features, plus a PV rooftop array and buffering battery, which is supposed to act as a prospective charging hub. This generates evidence on the carbon emissions associated with the hub, considering: the renewable energy contribution; battery state of charge; peak power imported or exported from the grid; and energy exchanges with the grid happening when EV charging is not restricted. The model and workflow are transferable to other places, provided there is local data to re-calibrate the EV charging model.

Gonzalez-Caceres et al. (2024) propose a decision support system, in the form of a Digital Twin (DT), to aid decision-makers to design denser but healthy neighbourhoods by maximizing indoor-outdoor relationships in urban settlements. The proposal is centred on assessing the effects of building form and its impact on the performance of urban spaces and existing neighbouring buildings, considering outdoor wind comfort and noise levels, indoor energy demand for heating and cooling, and solar radiation losses (in new and existing buildings). The proposed multi-domain workflow enables to visualize environmental parameters individually and/or in combination after normalizing results from each domain (considering the weighted area for wind and noise levels) to compare urban design alternatives and rank them using a base-case as a reference. Results are displayed in combination using percentage values within a Tornado chart, in a single indicator, and on a 3D model using an interactive visualization of multiple simulation outputs. The proposal provides a practical tool to assess the complex interactions and effects of urban form factors like buildings' shape and density with main outdoor and indoor environmental parameters by coupling different knowledge domains in a single environment, facilitating collaboration and integrated decision-making. The advantages of a single environment are twofold: it enables all stakeholders to use the same dataset whereas at the same time seeing the impact of alternative design interventions in multiple domains. This bypasses the need to combine specific knowledge and exchange information and data to run complex calculations every time a design change is proposed.

Dealing with data is paramount in the development of multi-domain simulations that bridge smaller with higher spatial scales, serving as the cornerstone for accurately capturing the intricate dynamics of urban systems and guiding evidence-based decision-making processes. In the context of climate crisis management, the work by Luo et al. (2022) exemplifies this importance, offering a valuable contribution that enhances disaster preparedness and post-disaster relief through the integration and analysis of multi-domain data. Their research supports the generation of evidence to deepen our understanding of climate-related risks in contemporary urban environments and enhances the adaptive response of built assets and infrastructure systems against extreme weather events such as heat waves and cold snaps. Employing predictive Urban Microclimate Models (UCM), rooted in physics, and Urban Building Energy Models (UBEM), they effectively account for the two-way interactions between buildings and their surroundings, facilitating the dynamic exchange of boundary conditions' information to run accurate simulations of future scenarios involving heat waves and overheating. However, integrating UCM with UBEM presents challenges, given their distinct knowledge domains and data requirements, including spatial scales and timesteps, which need to be harmonized prior to their integration in co-simulation workflows. To bridge this gap, Luo et al. (2022) propose and test a flexible (i.e. tool independent) data schema enabling seamless information exchange between UBEM and UCM, which fosters integrated analysis across various spatial scales and temporal resolutions. This data schema not only enhances the realism of the simulations but also enables the generation of robust evidence depicting the impacts of extreme heat waves on building energy consumption and production loops at the urban scale. By computing the contribution of wasted heat from buildings to their surroundings and the resulting effects on ambient temperatures, cooling loads, and associated emissions, their work provides valuable insights for informed decision-making in climate-resilient urban planning and infrastructure development.

At a larger scale, Felkner et al. (2024) and Stracqualursi (2023) develop city-scale models which delve into the complexities of sustainable and integrated land-use planning, encompassing considerations of form, microclimate, spatial navigation, and broader economic and policy frameworks.

Stracqualursi (2023) assesses the effects of urban form in two knowledge domains to understand how it affects the use of outdoor spaces in terms of wayfinding and spatial accessibility while mitigating adverse climate effects. The author proposes a workflow with common input data to simulate outdoor thermal conditions as well as the spatial logic of streets and open spaces considering how they are affected by urban compactness: a property described through the urban Shape Factor (SF) and Sky View Factor (SVF). The outdoor microclimate simulation comprehends mainly wind (speed and direction), temperatures (MRT and air) and relative humidity, whereas the configurational properties of urban spaces are expressed in terms of Normalized Angular Choice (NACH), Normalized Angular Integration (NAIN) for the road-network graph, and Connectivity and Visual Integration for two-dimensional spaces. Results are analysed individually primarily looking at how SF and SVF contributed to improve outdoor thermal conditions in ancient cities by reducing incident solar radiation and temperatures while favouring natural ventilation in alleys and courtyards. SF and SVF are then considered with regard to how they adversely affect space navigation and social connections, by repressing the creation of larger open spaces for gathering and potentially separating different ethnic groups through the creation of a microsystem of segregated routes, while at the same time creating cities with unique identities and adaptive thermal comfort conditions.

Felkner et al. (2024) perhaps present the most ambitious proposition; a bottom-up multidomain modelling framework that combines policy formulation with climate strategy implementation, coupling land-use policies and technical solutions for decarbonization scenarios, towards addressing climate change at a broader urban scale. The paper combines forward projection of top-down policies related to land-use zoning with mandates and incentives to push for individual decision-making related to consumer-driven technology adoption, to understand what can be realistically achieved in terms of reducing energy demand, climate change and decarbonization targets at a city scale. The proposed modelling framework is multi-domain and combines:

(i) Economic data comprising vectorized parcel-level datasets of existing geographies, economic potential of each property, building age, lot and building footprint size, plus household income;
(ii) Future land use/transformation scenarios considering building type and morphology data, location data (transit-oriented development areas), activity corridors, and centres for future growth;
(iii) (iii) Building and energy performance simulation data, including IPCC emission scenarios for future climates;
(iv) (iv) Bounded policy scenarios with tax incentives for technology adoption;
(v) Agent-based modelling to simulate the diffusion of different technologies at the household level based on sufficient financial resources to uptake the technology considering access to financial and information resources, location and type of dwelling, future sale prices of home energy technologies, policy context of incentives and financial burden, and exchange of information with neighbours; and
(vi) (vi) Grid decarbonization scenarios including a mix of renewables and energy fuel types with different decarbonization rates.

They test their proposal in the city of Austin (USA) considering two main scenarios for urban development: low-density urban sprawl with large single-family homes and high-density urban development with intensive pedestrian and vehicular transit and a combination of multi-storey residential and commercial buildings. Results show relative and total annual emissions for each scenario combination of high or low density, grid decarbonization rate, and technology adoption, from 2020 to 2100 in relation to climate change forecasts. The breadth of their multi-domain framework enables them to undertake comprehensive sensitivity analyses to evidence-based and gauge, individually or in combination, the role of urban development, zoning policies, urban density, market-driven solutions, decarbonization policies, etc. in achieving climate targets. Conclusions show that technology adoption is not sufficiently powerful to trigger significant change. Therefore, grid decarbonization scenarios, plus urban form and its planning (with specific reference to density) need to be coordinated for climate targets to be achieved; meaning simulations can inform not only policymaking but also contribute to implement UN SDG11 in real contexts.

Overall, the models presented offer valuable insights across different scales, from micro-scale interventions to city-wide strategies, demonstrating the importance of multi-scalar approaches to addressing the complex challenges of urbanization and climate resilience. Micro-scale models provided more in-depth insights into individual urban design projects, particularly concerning the use of vegetation in urban streets (Zeeshan et al. 2022). Neighbourhood-scale models differ in that they focused on the interaction of buildings with their immediate contexts to promote the construction of healthy districts (Gonzalez-Caceres et al. 2024) while mitigating localized problems such as the presence of urban heat islands (Gascón Alvarez et al. 2023) and imbalances in the production and consumption of electricity by buildings due to the electrification of private transport (Kelly, Flett, and Hand 2023), thereby equipping decision-makers with robust data on different types of developments. Finally, city-scale models address broader urban planning and design strategies related to sustainable urban development such as dealing with urban warming (Luo et al. 2022), manipulating urban form to design climate-resilient and culturally sustainable public open spaces (Stracqualursi 2023), and performing comprehensive assessments of future urban development scenarios (Felkner et al. 2024), particularly in areas vulnerable to the effects of climate change.

Although different design parameters and multi-domain targets are incorporated into all these models on top of standard building physics ones, socioeconomic parameters and targets are predominantly associated with the broader urban scale. Notably urban form parameters – especially those related to land use and built density – are considered across all three scales, highlighting their significant influence on the performance of buildings and cities. However, specific types of information related to urban form vary according to the scale and focus of the analysis. For instance, spatial configuration is considered only in one city-scale study, while road landscape features are considered exclusively in the micro-scale model. Looking ahead, there is significant potential to further align urban form with socioeconomic parameters and targets to increasingly promote the development and use of multi-domain modelling efforts towards meeting the UN Sustainable Development agenda, including integrating models related to sustainable transportation, public spaces' accessibility and affordable housing, among others.

What is still missing? A provocation for the future

Responses to this Special Issue call suggest, overall, the pivotal role played by simulations in addressing the different challenges faced by contemporary cities and communities, offering a new framework to tackle complexities across different spatial and temporal scales. They also show the IBPSA community has the capacity to engage with and address different targets within UN SDG11, not only by complementing and enhancing them but also by connecting multiple UN SDG11 targets to each other. Furthermore, the community can work beyond the scope of UN SDG11, connecting it with other SDGs to produce evidence that drives real change.

Gonzalez-Caceres et al. (2024), Luo et al. (2022), and Zeeshan et al. (2022) show that work needs to be done to address specific targets from UN SDG11. Zeeshan et al. (2022), engage with UN SDG11 Target 11.7, producing knowledge and providing a method to improve the quality of green public spaces: an important point to complement target requirements focused on improving access to these spaces. They produce evidence to design greener streets which improve pedestrian comfort and reduce heating demand on buildings adjacent to them. Luo et al. (2022) work within UN SDG11 Target 11.b, providing evidence useful to inform decision-making related to climate resilience by connecting buildings and neighbourhood heat exchanges to assess more accurately the potential impact of hazards caused by climate change, such as heat waves and overheating, in future scenarios. Gonzalez-Caceres et al. (2024) enrich UN SDG11 Target 11.3 by addressing both indoor and outdoor environmental performance, quantifying comfort at multiple levels together with its impact on energy use. Their work supports the integrated design of buildings and neighbourhoods, coupling multiple environmental knowledge domains within a single digital environment. These contributions show the IBPSA existing potential in terms of what it can provide externally by exploring simulation workflows which connect different knowledge domains it currently caters for at the building and urban scales. Additionally, it provides evidence to quantify at which quality some of the UN SDG11 targets are achieved.

Gascón Alvarez et al. (2023) and Stracqualursi (2023) illustrate how simulations can be used to address and connect some of the UN SDG11 Targets with each other. Gascón Alvarez et al. (2023) showcase an example in which buildings transcend their boundaries and perform within neighbourhoods and communities beyond their primary functions and scale, examining passive building features' and components' interaction with urban form reducing urban heat island effects. Exploring synergies between structural engineering, building physics and urban boundary layer models, this paper couples UN SDG11 Targets 11.3 and 11.b showing that integrated and sustainable building plus settlement planning and management can provide mitigation and adaptation to climate change. Stracqualursi (2023) on the other hand, shows how environmental simulations can be aligned with urban morphology studies to understand how these two knowledge domains can work together towards enhancing liveability. At the same time, this research shows the role of vernacular urban features in enabling the adaption of historic cities to adverse thermal conditions and climate-related stress. To this end, it connects UN SDG11 Targets 11.3 and 11.7, showing that integrated and sustainable settlement planning and management can provide universal access to safe, inclusive and accessible public spaces, adding to this Target 11.4 which focuses on protecting and safeguarding world's cultural heritage. This was the only contribution that explored urban form, street patterns, grid configuration and urban grain to understand what spatial qualities and features make cities and their open spaces not only feel comfortable but also alive. To what extent can these qualities be quantified? How can simulations cater for them (either in quantifiable and unquantifiable format) so we can build places that are environmentally, socially and culturally sustainable rather than sterile, repetitive and deprived of character and 'sense of place'? The IBPSA community could capitalize more on these discussions, reaching schools of urban design and planning and offering models and simulation workflows that generate evidence but are at the same time open to be adapted to cater for qualitative and intangible design solutions and parameters.

Felkner et al. (2024) and Kelly, Flett, and Hand (2023) go beyond UN SDG11, exploring its integration with other SDGs, among which UN SDG7 'Affordable and Clean Energy'. Kelly, Flett, and Hand (2023) address the consequences of promoting green transition for transport in neighbourhoods' electrical infrastructure, particularly looking at the impact of using electricity to charge electric vehicles in relation to rooftop PV generation. This work opens the door for IBPSA to explore more in-depth the integration between UN SDG7 'Affordable and Clean Energy' and UN SDG11, showing that transport and housing energy transition policies need to be coordinated at a deeper level when the electricity grid, including renewable energy sources, are to feed both. It also exposes a lack of work in the IBPSA community around integrated sustainable transport, calling for buildings, urban and transport simulation models to be put together for evidence-based actions related to the green transition. Multi-domain models of this type could also trigger further explorations such as simulation workflows which prioritize the traveller and connect pedestrian microsimulation models with transport, configurational, and environmental analysis models and beyond, towards better integrating the design of cities with that of transport infrastructures.

In addition, Felkner et al. (2024) show how far simulation can go in terms of integrating different knowledge domains, particularly economic models behind energy transitions, up to producing clear evidence to inform policy-making. This paper demonstrates the role of simulation in pushing for responsive political action towards addressing several targets from UN SDG7 related to clean energy, in integration with UN SDG13 'limit and adapt to climate change' Target 13.2 (integrate climate change measures into strategies, policies and planning) and UNSDG11 Targets 11.3 and 11.b. Additionally, it highlights multi-domain simulation workflows sit before software development as workflows relate primarily to decision-making. It also shows policy strategies, mandates and incentives need testing and can be informed by evidence from different types of simulations through iterative and comprehensive feedback cycles to assess their impact in society and the environment. These feedback cycles are not 'one size fits all', technocratic optimization or multicriteria approaches. They are a comprehensive outcome-driven decision-making process in which simulations contribute to develop scenario trajectories for the implementation of policy's mandates and incentives (Altafini et al. 2024), with their respective uptake by the market and end-users, aiding the evaluation of the complex interactions among different parts of society and their result in sustainability and decarbonization. Through these means, the paper shows that time for action is short and that the market alone, without the support of strong decarbonization policies, is not enough to promote solutions that mitigate climate change.

Contributions such as Felkner et al. (2024) clearly show that the IBPSA community is able to provide value to decision-makers and that a closer dialogue between scientists and policy makers is urgent. Our Special Issue calls for the IBPSA community to put this dialogue at the forefront of its agenda, if it really wants to contribute to building a better future. This is because policy makers, practitioners, urban planners, economists, city, community or infrastructure operators do not necessarily know what can be achieved with simulations, meaning it is our duty to show them pathways to test the impact of their proposals on society and the environment. As we learned in 2020 that powerful political tools can be put in place to implement dramatic change in short time frames, time is overdue for the IBPSA community to rethink its mission and adopt a more sustained, proactive approach to addressing UN SDGs. The global challenges we face demand an integrated effort to provide robust evidence and engage in policy advocacy. It is imperative that IBPSA aligns its expertise with the UN blueprint to achieve a sustainable future for all, providing useful information and clear pathways to influence and support policy-makers in taking immediate, decisive action. The moment to act is now – our collective future depends on it.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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