



A.I. and the rewiring of Madrid: Narratives of Water, Energy, and the Built World

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Abstract

This paper is structured as an instrumental case study assessing the impacts of the incorporation of AI platforms within the iterative design process of a fifth-year undergraduate architectural studio. The topic of focus for the studio was the rewiring of energy and water infrastructures within the city of Madrid, Spain. Within the contemporary city, such urban infrastructures have tended to be moulded around a strictly top-down, public-to-private gradient. This unidirectional, innately hierarchical, and centralized approach to the provision of energy and water has been accompanied by a range of issues, including cascading systemic failures, low systemic resilience, and issues of inequitable access to resources. A more hybridized approach to urban infrastructural networks continues to gain traction within the discourse, one which takes advantage of the capacities of more decentralized systems and greater private stakeholder engagement, while not shying away from some of the benefits of more centralized systems. This studio was oriented towards achieving a deep dive into such hybridized infrastructural frameworks while leveraging artificial intelligence platforms for the purposes of accelerating and amplifying portions of the iterative design process, refining project narratives, and accelerating the student research process.

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Keywords

Built environment; Urban infrastructure; Sustainability; Energy; Water; Artificial intelligence

1. Introduction

This paper presents the findings and outputs of a fifth-year undergraduate architecture studio, specifically assessing the impacts of the incorporation of AI platforms into the course structure for the purposes of accelerating and amplifying portions of the iterative design and research process. The topic of focus for the studio, Alternative Practices: Urban Infrastructures, was the rewiring of energy and water infrastructures within the city of Madrid. The course took place in the Fall term of 2023 at IE University's School of Architecture and Design (Segovia, Spain).

Within the contemporary city, urban infrastructure related to energy and water has tended to be moulded around a top-down, public-to-private gradient (Goldthau, 2014, 136; Leigh and Lee, 2019, 918; Sitzenfrei and Rauch, 2014, 1549). Large-scale infrastructural networks, shaped, controlled, and maintained by public agencies, have been tasked with operations concerning resource generation, extraction, delivery, and recovery, while the private domain, composed of an aggregation of singular individuals and companies, has been tasked with consumption.

This unidirectional, innately hierarchical, and centralized approach to the provision of energy and water has been accompanied by a range of issues. These include: Potential cascading failures and low systemic resilience (Goldthau,

2014, 136); inequitable access to resources (Alstone et al., 2015, 313); long and complex planning efforts that require large front-loaded capital investments (Sitzenfrei and Rauch, 2014, 1549-1550); and predicted difficulties in coping with the varying environmental stresses and systemic changes set in motion by the contemporary climate crisis (Nelson, 2008, 12).

Reacting to these vulnerabilities, a more hybridized approach to urban infrastructural networks continues to gain traction within the discourse—an approach that pushes for the adoption, in complement to centralized structures, of more decentralized systems relying on cross-scalar public and private stakeholder engagement. There is a fairly wide array of systemic gains that accompanies this hybridized approach—e.g., systemic redundancies that can better withstand disturbance regimes (Hines et al., 2009, 27); the capacity to construct infrastructure incrementally, requiring less large-scale capital investment upfront (ibid); reduced transmission costs and increased efficiencies of grid systems (ibid); a higher potential for bottom-up innovation due to a cross-scalar engagement of stakeholders and the establishment of cross-scalar networks of mutual learning (ibid); and greater adaptability to localized contexts, both in terms of local climate and geologic conditions, but also with regard to localized knowledge structures and building cultures (Leigh and Lee, 2019, 918).

This transition requires the private domains and micro scales of the built environment to take on much more productive, not simply consumptive, roles within urban infrastructural networks. The individual person and economic entity are called upon to adopt the role of prosumers as opposed to strictly consumers. The building scale as a consequence is called upon to play a critical constructive role within a broader portfolio-of-solutions approach to urban infrastructural functionality (Alstone et al., 2015; Child et al., 2020; Hines et al., 2009; Leigh and Lee, 2019).

Although this novel approach is underscored as an “essential element of the low carbon transition” (Goldthau, 2014, 136), there remains a range of factors holding change at bay. At the heart of the issue is the “inertia and drag” inherent to heavily centralized institutional and infrastructural structures (Hines et al., 2009, 27), and the “technological entrapment” that produces a rather counterproductively “slow adoption rate” of novel technologies and systemic approaches (Leigh and Lee, 2019, 918). Despite these challenges, varying scales of the built environment continue to be incrementally activated toward achieving heightened productive roles within urban energy and water infrastructural systems.

Within the context of Madrid, the locus of investigation for the fifth-year architecture studio framed within this text, significant and polarized issues related to water and energy have been at the forefront of urban discussions. Over the past several years, anomalously heavy flooding has overwhelmed portions of the urban fabric of the city, along with other urban nodes throughout the Iberian peninsula, causing significant infrastructural debilitation, loss of capital, and loss of life (Landauro and Latona, 2023). Within the opposite extreme, extensive droughts have also noticeably begun to take root in Spain’s regular climatic cycles, with varying predictions of longer-lasting water scarcity episodes on the horizon (Guerreiro et al., 2017). Simultaneously, the European energy crisis, accelerated by the Russian invasion of Ukraine in 2022, has propelled a radical reassessment of energy infrastructures across the European continent (Liu et al., 2023). In Spain, this has come accompanied by a rapid expansion of localized renewable energy production (Euronews, 2022), and a firm reaffirmation of the 2030 carbon footprint reduction goals (International Energy Association, 2023).

1.1. Background

Within the built environmental discourse, the potential applications of artificial intelligence tend to be discussed around a rather broad spectrum. At the two poles of the discursive range, there are competing conceptions of the nature and limits of artificial intelligence. At one pole, AI is conceptualized as a quantitative calculator operating at the behest of human-built-environmental professionals. On the other pole, AI is conceived as a fully capable synthetic competitor in emergence.

Part of this duality is shaped by whether the artificial intelligence system is ideally conceived around a black-boxed or grey-boxed framework (Chaillou, 2020). Within the former (black-boxed) structure, a human operator gives initial inputs to the synthetic operator, and the AI subsequently produces final outputs, with no interaction between human and synthetic occurring in between (ibid). Within the latter (grey-boxed) framework, the middle phase is opened up,

allowing for more iterative and potentially reciprocal input-output cycles to take place (ibid). While the quantitative-calculator model could in theory be shaped around a black-box or grey-box approach, the synthetic competitor model must, given its discretion-based operations, be anchored around a grey-boxed approach at minimum.

As the discourse meanders towards the quantitative-calculator pole, the potentials of artificial intelligence are presumed to be best leveraged around the topics of: Energy and carbon footprints (Budenny et al., 2022), environmental control systems (Park et al., 2020), structural systems (Salehi and Burgueño, 2018, 184), building codes and urban regulations (Ilal and Günaydın, 2017; Rafsanjani and Nabizadeh, 2023), urban infrastructure (Nikitas et al., 2020; Zhang et al., 2021); post-occupancy analysis (Nayeri, 2023), and participatory design (Llach, 2015; Neuhauser and Kreps, 2011). On the other end of the spectrum, as the discourse meanders towards the synthetic-competitor pole, AI is seen to have discretionary and creative capacities in addition to the quantitative areas noted above, allowing it to be leveraged within the iterative or conceptual design process itself (Barker, 2023; Reinholdt, 2023; UNStudio, 2023).

Regardless of the discursive location within which it is placed, AI is clearly understood as a new and lasting actor within the built environmental landscape. At a minimum, it is seen as having the potential for increasing efficiency and productivity within built environmental authorship. This increased capacity could on the one hand allow smaller firms to compete better with larger firms, or it may pull the momentum further towards the side of larger firms who may be able to more readily take advantage of new technological developments (Leach, 2023). At the more disruptive end, AI is presumed to be on a path that will lead to its independent entry into the market of built environmental authorship, engaging in direct competition with human actors—wherein it is oft presumed that the free market competition between synthetic and human will favour the former, and make obsolete the latter (Leach, 2023).

In contrast to the bipolar spectrum noted above, the discourse concerning the leveraging of AI at the scale of urban infrastructure leans predominantly, if not ubiquitously, towards the potential of AI as a quantitative prosthetic. To give some examples from recent pieces occupying representative niches within the contemporary discursive landscape: Lutfiani et al. (2024) focuses on AI's potential for the optimization of resources and energy use, and for the creation of more efficient infrastructural monitoring and control systems; He and Chen (2024, 835) focuses on AI's capacity for “predictive analytics, decision-making improvements, and the automation of complex geospatial tasks in urban areas;” offering a broad survey of the urban planning profession within the United States, Sanchez et al (2023) asserts that much of the profession considers the most straightforward potential of AI to lie in the realms of demographic and transportation-network analysis; Forkan et al. (2024) and Rezvani et al. (2024) note the potentials of AI as a “proactive detection” tool for transportation networks; Sepehr (2024) focuses on a comparable quantitative application of AI within traffic light systems; Jagatheesaperumal et al. (2024) tackle similar quantitative transportation network issues except via the slightly-more specific lens of smart city frameworks; and Dai et al. (2024) take this capacity for AI to monitor critical predictors to the domain of urban ecological systems.

In general, there is a marked paucity within the discourse of urban infrastructure of texts noting the more qualitative potentials of AI. It is only when the scale of concern shifts down to the actual design of urban form, landscape architecture, architecture, or interior architecture that references to AI with regard to its more creative or qualitative potentials begin to proliferate.

2. Materials and Methods

Taught within the 5th year sequence of IE University's School of Architecture and Design, Alternative Practices: Urban Infrastructures tasked students to reconceptualize the energy and water infrastructural systems of Madrid. In the context of water, the aim was the development of cross-scalar drought- and flood-oriented nature-based infrastructural systems. In the context of energy, the development of cross-scalar net-positive energy conditions across the urban fabric was the aim. The incorporation of AI into the overarching course structure was geared towards achieving a more qualitative integration of artificial intelligence platforms within the iterative design and research process, aiming to offer a counterpoint to the predominantly quantitative approach to the use of AI within the educational landscape concerning the larger scales of the built environment, as noted in the prior section.

The course was structured as a three-week accelerated studio. Group work was leveraged as a means of achieving the robust discourse analyses required to suitably anchor project development, as well as a means of propelling said development across multiple built environmental scales. Groups were required to achieve infrastructural rewiring of the city across five scales at a minimum—e.g., the scale of the dwelling unit, the alley, the building, the building cluster, the street, the boulevard, the block, the superblock, the plaza, the neighbourhood, and the city.

At the start of the course, a broad range of contemporary built environmental approaches aimed at achieving micro-to-macro scale water and energy infrastructural changes was discussed. These concepts were built upon prior case studies and strategies introduced to the student cohort in a preceding 4th-year urbanism course. Within the scope of blue-green-gray infrastructure, the topics were focused on strategies aimed at water detention, retention, as well as decentralized water treatment systems. More fine-grained topics included: green roofs, blue roofs, green facades, rainwater harvesting systems, bioswales, permeable hardscaping, retention and detention tanks, water plazas, decentralized greywater/blackwater remediation systems, riparian and wildlife corridor revitalization efforts, hinterland soil degradation, and soil-based carbon sequestration. Within the scope of energy infrastructures, the umbrella topics were focused on the mitigation of negative climatic impacts, heightened building performance, and renewable energy generation. The micro-topics covered included autochthonous landscaping, nature-based air pollution remediation, cool surfaces, natural daylighting, super-insulated buildings, passive cooling and heating strategies (including but not limited to trombe walls, solar heat chimneys, wind catchers, night-flush cooling, cross-ventilation, and seasonal thermal energy storage systems), renewable energy production, positive energy buildings and districts, district cogeneration plants, and fifteen-minute city models.

In both the case of water and energy, more fundamental discursive questions were also brought to the forefront—for instance, issues of inequity concerning access and proximity to resources and infrastructural networks; sociocultural and political impacts of infrastructural decentralization; and how sufficiency and efficiency must be pursued in tandem to critically rethink contemporary urban infrastructural deficiencies.

Two artificial intelligence platforms were introduced as technological anchors to the course—ChatGPT and Midjourney. These tools were used: (1) to accelerate the initial research process into the subjects of blue-green-gray infrastructure and positive energy buildings/districts; (2) to serve as a theoretical sounding board for the proposed projects' underpinning narratives, namely to proactively expose inherent logical discrepancies as they developed; and (3) to generate the background imagery upon which large-scale section perspectives, the dominant architectural drawing type utilized throughout the course, could be anchored.

While Midjourney was the main AI-based image generation platform introduced to students to iterate the background imagery that would serve to develop the dominant section perspectives of the course, students were freely permitted to experiment with various platforms as they pleased. Dall-E and DreamStudio were two others explored to this end. The `/blend` (Figure 1) and `/imagine` (Figure 2) commands were the two primary functions presented to students as a means of generating visual media via Midjourney.

Within the broader context of the discursive landscapes concerning, on the one hand, the incorporation of AI into university education, and on the other hand, the incorporation of AI into the domain of urban infrastructure, this design studio was attempting to assess: (1) the impacts of hallucinations—i.e., inaccurate information fabricated via AI platforms (Alier et al., 2024, 9)—upon the iterative design process; (2) how changing proportions of human-to-human versus human-to-technology interactions (Alier et al., 2024; Ayeni et al., 2024) affected the design studio culture; (3) how students' understanding of AI and the nature of authorship changed throughout this studio; and (4) the potential of AI platforms as inherently qualitative or creative tools (as opposed to purely quantitative tools, as is the presumption with much of the extant discursive landscape) within the domain of urban infrastructural investigations.

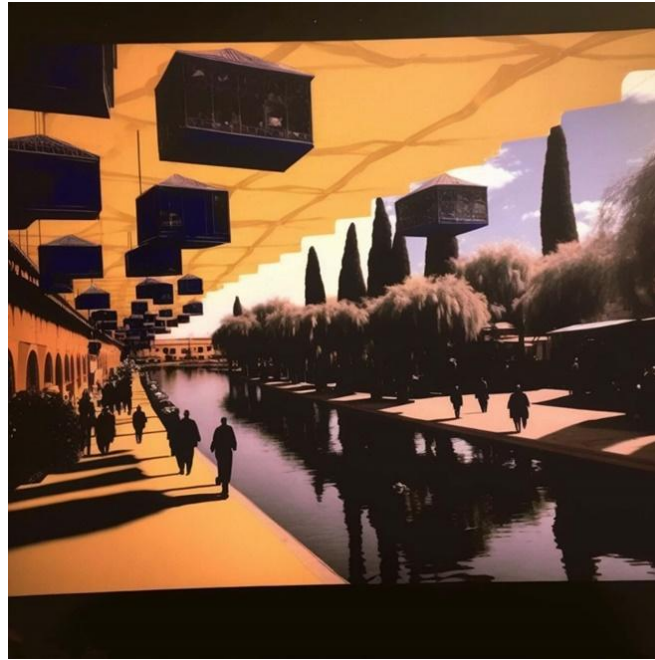


Figure 1: Image produced via Midjourney using the blend command to combine a landscape image from Granada, a streetscape image from Malaga, and imagery from the work of Yona Friedman. (By the author, October 2023).



Figure 2: Image produced via Midjourney using the imagine command to visualize blue-green infrastructural works transcribed upon the Berlin streetscape. (by the author, October 2023)

3. Results

The following results are broken down into four areas of focus: (1) the challenges and potentials of AI-generated hallucinations; (2) the impacts of growing human-synthetic interactions within the context of a university project-based studio course; (3) the changing and evolving perceptions concerning authorship observed throughout this course; and (4) the details of the range of urban infrastructure projects produced within the scope of this accelerated studio.

3.1. Hallucinations

In its current form, the most problematic aspect of ChatGPT is its fundamental inability to confess a lack of knowledge. “I don’t know” is simply not within its programmed vocabulary, leaving the platform to generate farcical information or data points, particularly when faced with limited or inadequate datasets, that can be misleading. Alier

et al. (2024, 9) refer to these as “hallucinations.” A rather egregious form of this is when ChatGPT is asked for a list of articles relevant to a subject, to which it often generates a list of non-existent articles in non-existent journals.

Within generative AI platforms that produce visual media, such hallucinations take on a slightly different tone. For instance, a simple prompt of “a group of people holding their hands in front of their faces” can produce what seems like a fairly accurate image; however upon further inspection, various physical anomalies often emerge—in this case, a number of six-fingered hands, unusually shaped thumbs, appendages which seem to emerge from and belong to multiple persons, and so forth (see Figure 3).



Figure 3: Image generated by Midjourney using the imagine command to visualize “a group of people holding their hands in front of their faces. (by the author, September 2024).

Throughout the studio, once this capacity for AI platforms to produce hallucinations became apparent to students, not as an anomalous, but rather as a consistent tendency, a range of different outcomes began to emerge.

With regard to ChatGPT, students no longer regarded the platform as a source of infinite and infallible knowledge, but rather as an *aged uncle* (as per a student’s description) that had accrued significant amounts of knowledge, but also was prone to going off on fictional tangents. As a consequence, students began to engage the platform as a supplementary, not primary, research tool. Questions to ChatGPT were limited to more strategic or conceptual approaches to blue-green-gray infrastructure and net-positive urban energy systems. The instructor of the course, along with peer-reviewed publications, functioned not only to open up deeper areas of investigation but also as a baseline fact checker for ChatGPT’s initial analyses.

In general, ChatGPT performed accurately when framing the overarching concepts, strategies, and ideas in use within each discursive domain. However, when delving into more specific and fine-grained areas, there was an increased likelihood of the platform generating fallacies. With regard to Midjourney and other image-generating AI platforms, such *hallucinations* proved to be productive in different ways.

Each group was required to produce a set of five large-scale background images, via image-generating AI platforms, focusing on different built environmental scales. The background images were initially prompted to accommodate a series of systemic interventions as framed by the students. However, the produced images often had errors or noise of various kinds—e.g., infrastructural systems that illogically overlapped with buildings and built-environmental conditions that collided in manners that betrayed the basic fundamentals of construction systems (or physics). Student discretion and knowledge were subsequently required to refine these elements back into a workable order.

Through this process, new built environmental ideas often emerged. Per the students’ own acknowledgement, the outcome was often a built world condition that was more “layered” than what they would have achieved if the AI platform had not been part of the process. This is in line with the findings of Liu (2024, 945) which notes that “errors,

while challenging, also [serve] as unintended prompts for students to consider alternative designs and solutions, fostering a space for innovative thinking.”

Of critical import here, is that AI-imagery was not unidirectionally molded around human-authored project narratives. Rather, AI platforms were invariably granted a partial co-authorship capacity and were allowed to reshape and refine the initial narrative set forth by the human actor. Whether or not students consciously recognized or acknowledged said co-authorship however, is a different subject altogether, as discussed in Section 3.3.

3.2. Human-to-Technology Interactions

ChatGPT’s utility as a sounding board was much more consistent when compared to the above-mentioned areas of use. Groups could ask, “We are doing x, y, z with this proposal, but we are also trying to do a, b, c—is there a logical discrepancy across these efforts?” To such questions, ChatGPT proved quite capable of underscoring anomalies or contradictions to the overarching project narrative and suggesting alternative pathways for consideration (see Figure 4). This is in line with AI’s theorized potential as a type of “thought processor” as discussed by prior scholars within the artificial intelligence field (Kolata 1996). What is of particular intrigue is that the utilization of ChatGPT as this manner of thought processor allowed for the emergence of a third party within the design studio culture.

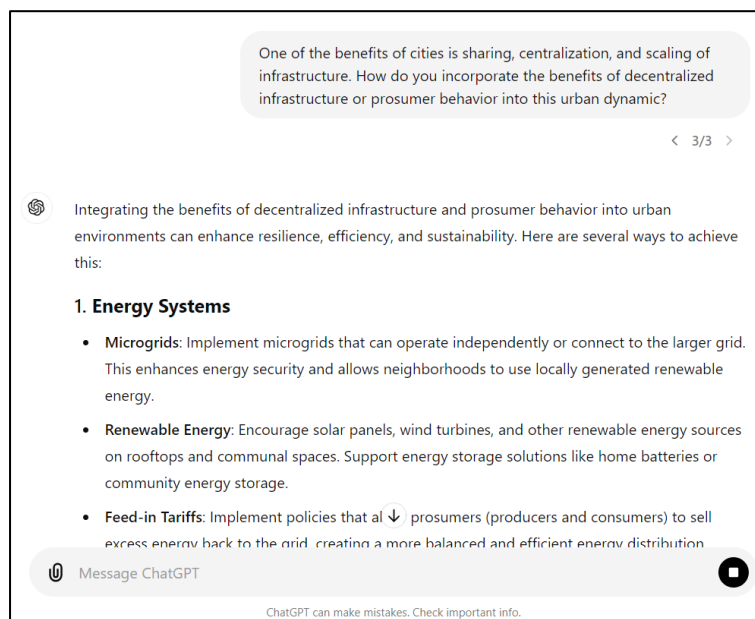


Figure 4: Screenshot showing ChatGPT giving feedback to a narrative-oriented query. (By the author, October 2023).

In this new role, ChatGPT was utilized in two manners. First, as an internal logic checker which students could deploy individually, to verify if their own narratives concerning a specific area of a project were indeed sound. Second, as a mediating or arbitrating voice in discussions.

The architecture studio is, at least in theory, a place of exchange and collaboration. However, structures of hierarchy, whether real or perceived, may inhibit this ideal, and the number of voices offering different perspectives can become limited. The worldviews, ideologies, and inclinations of the instructor may be inadvertently mirrored by some students. In some cases, these frameworks may be imposed, consciously or unconsciously, by the instructor upon the students in a hierarchical manner. Groupthink dynamics may create artificially cohesive clusters within the student cohort. There may also be a real or perceived hierarchy amidst the student body based on prior academic or creative performance.

It is quite rare for a student to be able to receive external feedback (whether from an instructor or a peer) and not have these structural hierarchies, biases, issues of internal competition, and peer pressure, inhibit the depth to which said feedback is received. ChatGPT is quite an anomaly in this regard, in that it clearly functions outside of the studio culture, and outside of its real or perceived dynamics.

Within the course, particularly when dialogues internal to a group, or between a group and the instructor, became locked in place around a bi-faceted structure, ChatGPT was brought in to help disentangle the polarized state of the discussion. Initially, the deployment of ChatGPT in this manner was coincidental. However as the studio progressed, this became a pedagogical tool that was deliberately deployed towards this end. This role as a disentangler was also aided by the perception of ChatGPT as a more neutral participant without a stake in the outcome of the overarching project.

For the instructor, ChatGPT thus served as an easily accessible second point of view which could help underscore the vulnerabilities of a position that a student was defensively holding onto. For the student, the platform served as a readily accessible second point of authority that could serve to counter or verify the instructor's argument. This was particularly useful in the context of a studio which can oftentimes fall to, or at least be perceived as falling to, a clear hierarchical structure, laced with internal structural biases.

3.3. Authorship

Both at the start and near the terminus of the course, students were queried about how they understood the nature of authorship in the context of the visual media generated via AI platforms. This was structured as an informal discussion which the instructor subsequently recorded the details of in the form of field notes.

At the beginning of the course, 10 out of the 16 enrolled students asserted that they were undecided on the matter of authorship, and had to further engage with such image-generating AI platforms to better understand the situation. Four asserted that ownership of the content produced belonged to the AI. One student asserted that the authorship belonged to the human user inputting the prompts, while another asserted that there was some manner of human-synthetic co-authorship taking place.

By the end of the course, 13 leaned towards the position that there was some form of human-synthetic co-authorship taking place, with varying degrees of collaboration. Two students asserted that the imagery produced was purely the intellectual property of the generative AI platform. One student asserted that the imagery was entirely the intellectual property of the human user.

Across the course, students also used artificial intelligence platforms to periodically mine for imagery to help move past creative blocks. Students asserted that this was similar to the process of mining across image-archiving platforms such as Pinterest (i.e., *Pinterest mining*). However, students felt much more liberated to intellectually or creatively absorb the images generated via AI platforms, since their perceived synthetic origins allowed students to avoid the fear of replicating something that had already been done by another human hand. Even students who stressed that AI-generated imagery was the intellectual property of the AI platform confirmed this inclination—the main reasoning being that said imagery was not the product of a prolonged effort by the AI platform, but rather something produced with great rapidity, as if in passing.

3.4. Projects

Excerpts from the final deliverables of three of the four group projects generated via the studio are shown here. The first (Energetic Madrid) deals with urban energy systems, and the latter two (Flood Harvest and Waterkeepers) are focused on blue-green infrastructural systems. For brevity, the fourth project generated via the studio, focused on urban energy systems, was omitted from the paper.

Energetic Madrid, by Ghofrane Benajiba, Daniela Figueroa, Nathan Robert, and Tristan Sartorius, focused on the scale of the street, building (Figure 5), block (Figure 6), plaza (Figure 7), and superblock to establish a net-positive-energy infrastructural system throughout the city. Solar heat chimneys, trombe walls, night-flush cooling, biomass-based heat generation, seasonal thermal storage systems, photovoltaic energy generation, reductions of domestic consumption footprints, heat recovery from industrial programs, and fifteen-minute city models were some of the primary elements deployed throughout the work. The end outcome was a mixed-use urban condition with: (1) reduced carbon and energy footprints, (2) heightened energy generation capabilities (achieving cross-scalar energy surpluses subsequently stored in the form of heat within seasonal thermal energy storage systems), (3) and in-built proximities to critical urban resources modelled off of fifteen-minute city ideals.

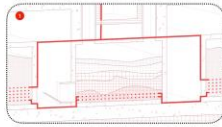
1. the building scale

On the building scale, we explore both passive and active solutions that allow the building to be efficient all through the seasons and train underlying community engagement. With heating and cooling accounting for 61% of energy consumption, our system operates year-round using a solar chimney coming through the building for natural ventilation. In summer, it keeps warm air while in winter it distributes passively heated air. The south-facing apartments benefit from a trombe wall system connected to passive energy storage, while the opposite side employs a composting system, merging energy generation and storage. Additionally, we foster communal living by creating an agricultural hub and communal kitchen on the rooftop, encouraging residents to grow and cook their own food collectively, reducing transportation, and promoting a sustainable, interconnected urban environment.

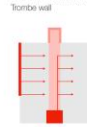
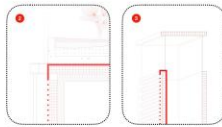


Current energy consumed
And how it is produced

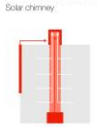
Energy produced/mitigated
And how it is stored and used for new programs



Compost dump & sand batteries



Winter Compost and trombe wall heats up interior



Summer Compost and trombe wall heats up solar chimney for ventilation

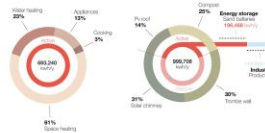


Figure 5: Section perspective (originally A0 format) from Energetic Madrid focused on the scale of the building. (Ghofrane Benajiba, Daniela Figueroa, Nathan Robert, and Tristan Sartorius, November 2023).

2. the block scale

The block scale encompasses storage, mitigation, reduction, and generation techniques, blending passive and active solutions while fostering community engagement and supporting industrial development. In order to achieve this, we re-imagine the role of the different buildings in the block as one entity, the new hub for activity both communal and industrial. In this, industry, communal gardens and kitchens will be located in the rooftops. The steam generated from industry heats reservoirs, and communal facilities like the kitchen and rooftop agriculture benefit from the shared heat source. Additionally, utilizing communal batteries for composting reduce energy expenditure by consolidating resources in one location, eliminating the need for transportation and promoting energy efficiency within the community.

Current energy consumed
Currently, energy consumption is distributed as it shows in the graph on the right, which also represents the way the proposal mitigates and produces each electricity.



Energy produced/mitigated
Active systems generate energy for some specific needs, while passive solutions reduce the energy needed for those areas, this creates a surplus of energy that is used in the industrial production while some other is stored.

+196.468 Kwh/y
60 ↑

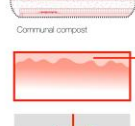
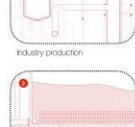
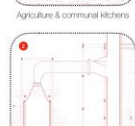


Figure 6: Section perspective (originally A0 format) from Energetic Madrid focused on the scale of the block. (By Ghofrane Benajiba, Daniela Figueroa, Nathan Robert, and Tristan Sartorius, November 2023).

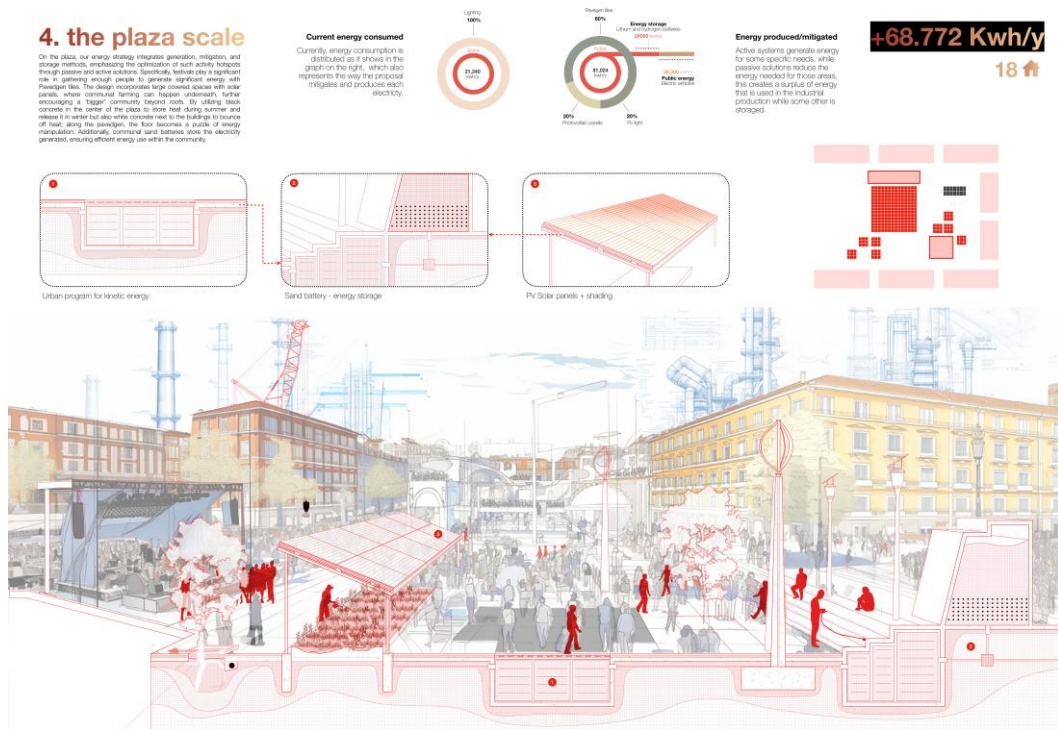
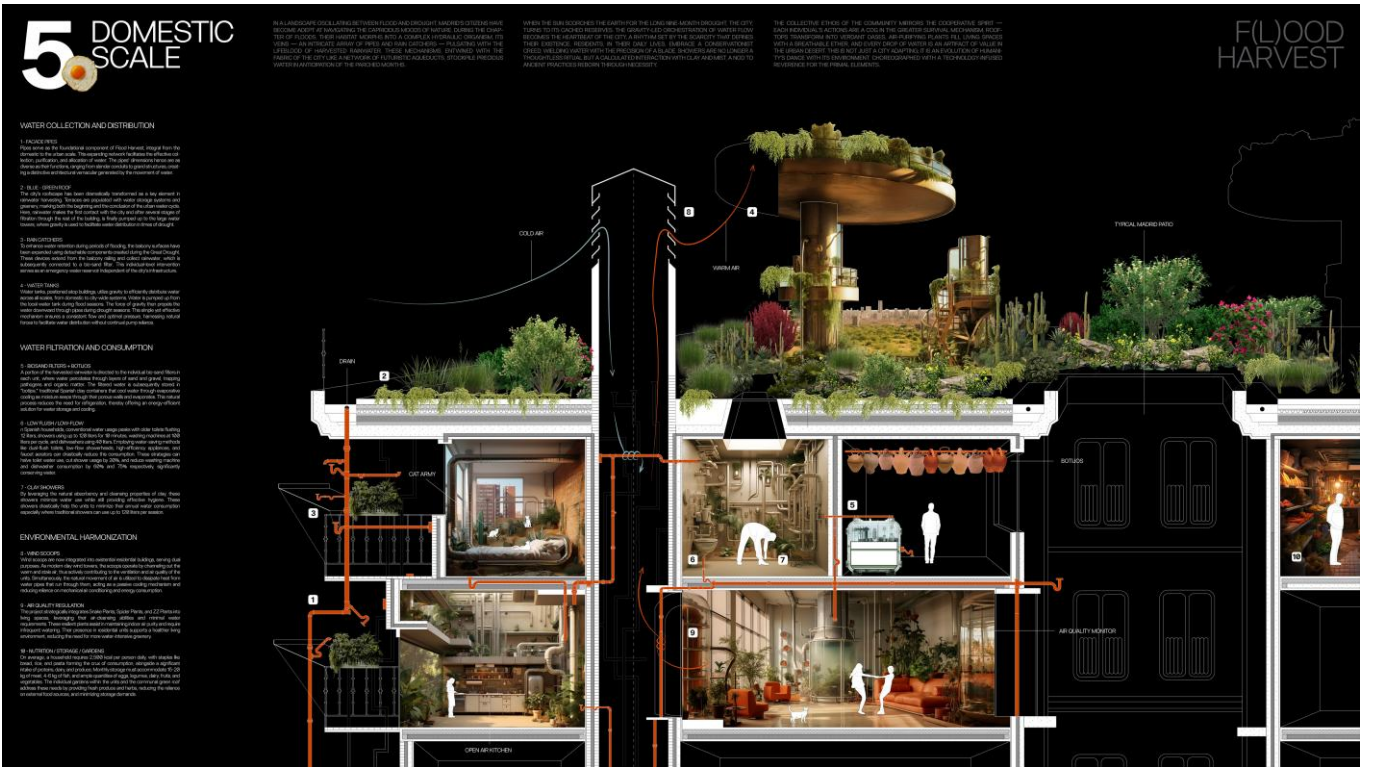
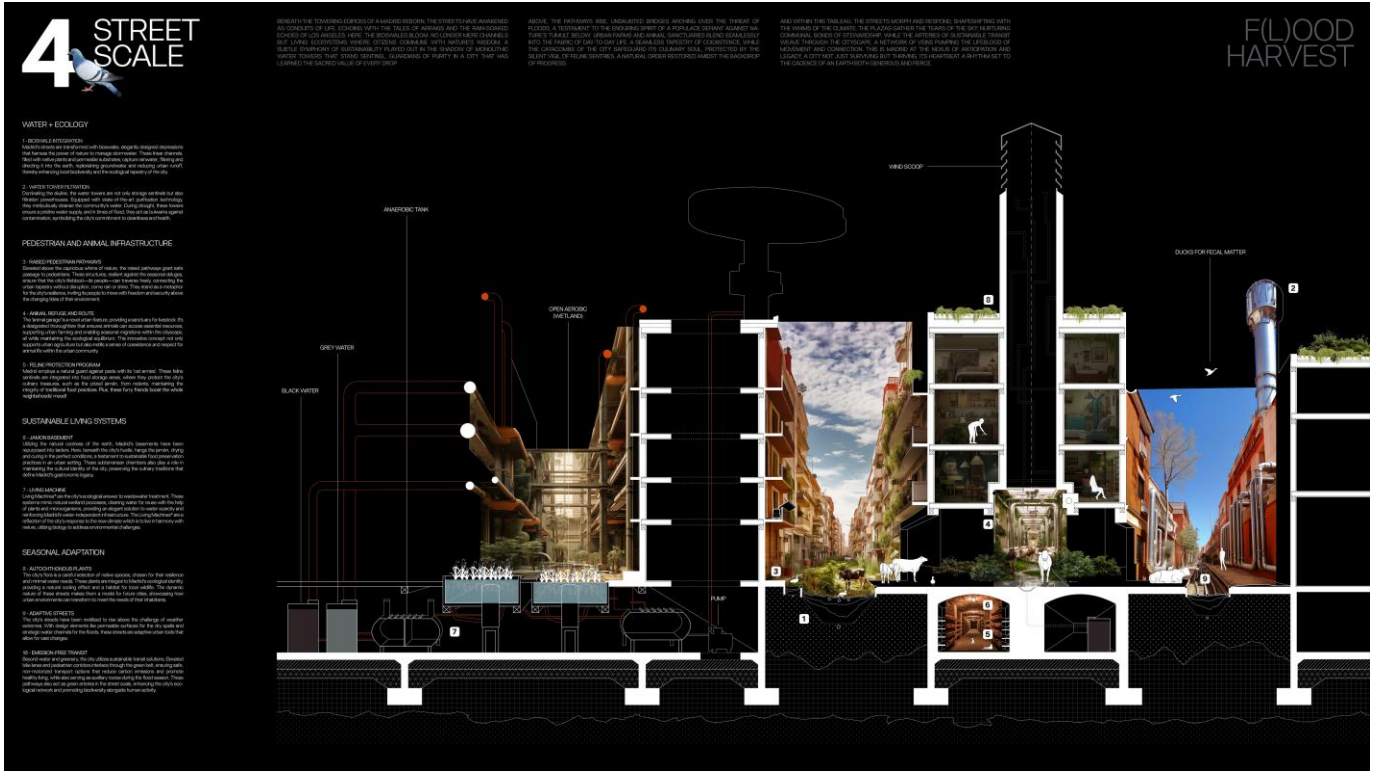


Figure 7: Section perspective (originally A0 format) from *Energetic Madrid* focused on the scale of the plaza. (Source: Ghofrane Benajiba, Daniela Figueroa, Nathan Robert, and Tristan Sartorius, November 2023).

Flood Harvest, by Alara Aykanat, Yusuf Bozkurt, Daphné Fournel, and Martin Jitenski focused on the domestic scale (Figure 8), the scale of the street (Figure 9), superblock, neighborhood (Figure 10), and city scale to establish a two-faceted water infrastructure capable of managing severe drought and flooding conditions. Set 150 years into the future wherein the extreme scenarios of predictive models for flooding and water scarcity were taken into account, this project was an extensive exploration of the sociocultural, political, economic, as well as infrastructural dynamics that could emerge in such circumstances (Figure 11). Blue-green roofs, water retention and detention systems, rainwater harvesting, low-water plumbing fixtures, wind scoops, localized food production and storage, bioswales, water plazas, localized blackwater/greywater remediation, autochthonous landscaping, permeable hardscaping, multimodal (and interspecies) street design, and revitalized wildlife and riparian corridors were some of the elements put in play within the project narrative.



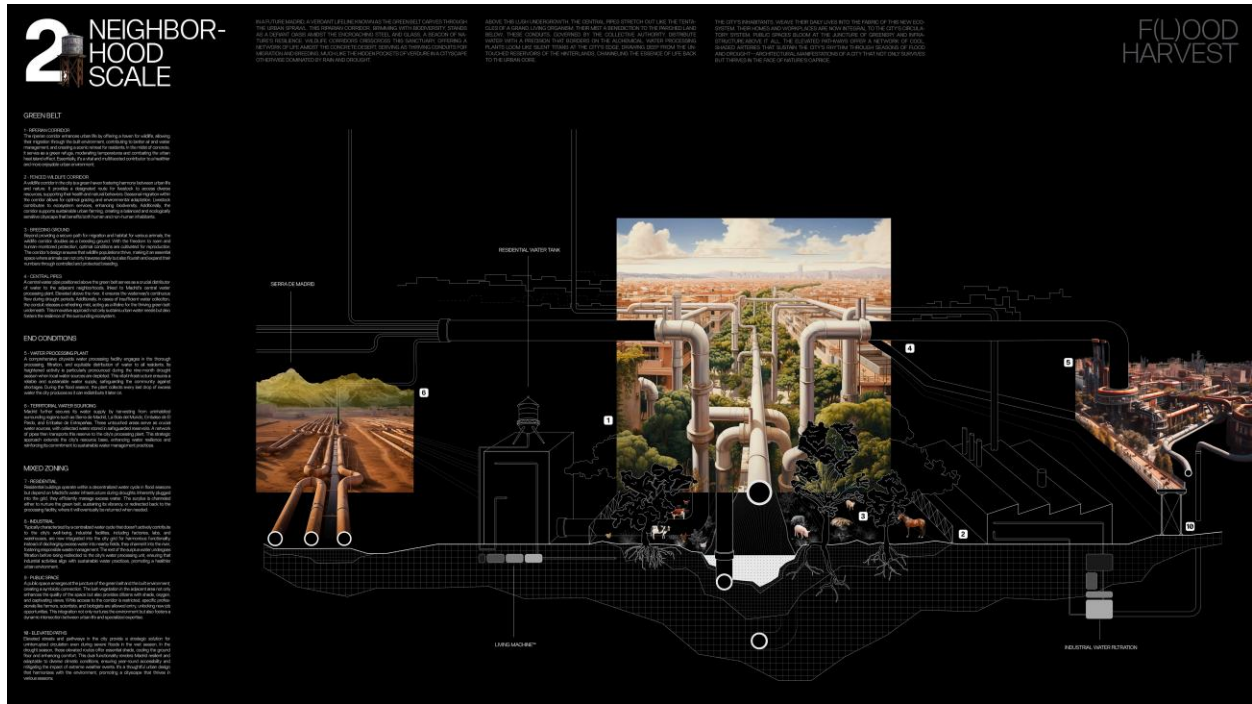


Figure 10: Section-perspective (originally A0 format) from F(lood) Harvest focused on the scale of the neighborhood. (Source: Alara Aykanat, Yusuf Bozkurt, Daphné Fournel, and Martin Jitenski, November 2023).

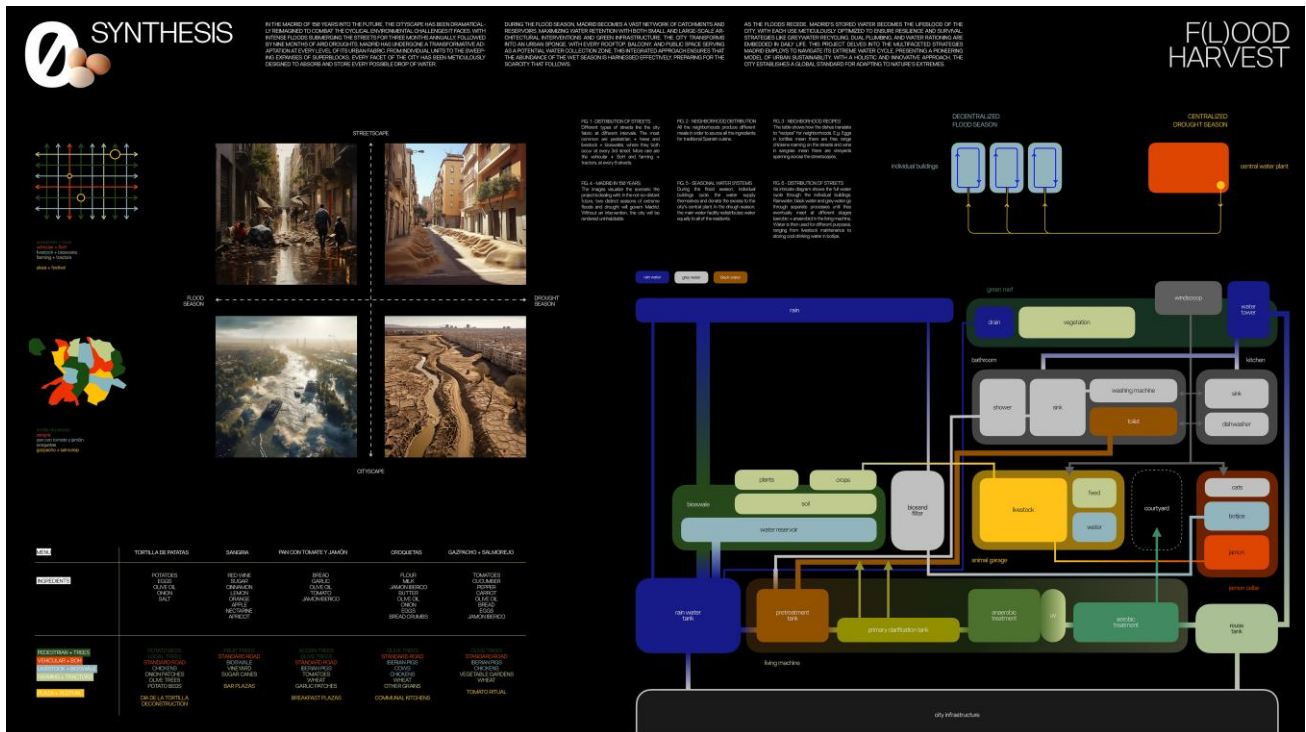


Figure 11: Section-perspective (originally A0 format) from F(lood) Harvest depicting how the overall system behaves, and what it aims to achieve. (Source: Alara Aykanat, Yusuf Bozkurt, Daphné Fournel, and Martin Jitenski, November 2023).

Waterkeepers, by Nadine Fahmy, Malek Fleifel, Roché Rabie, and Carolina Schönburg, homed in upon the scale of the building (Figure 12), boulevard (Figure 13), block, plaza, and city (Figure 14) to establish a flood and drought tolerant water infrastructural system for Madrid while also overlapping with fifteen-minute city ideals. The main systemic elements utilized include green roofs and facades, localized water retention and detention tanks, decentralized greywater/blackwater remediation systems, rainwater harvesting, bioswales, permeable hardscaping, water plazas, soil-based carbon sequestration, urban timber production, and revitalized riparian and wildlife corridors.

The model of the city that emerged was one that combined nature-based stormwater and drought management systems and mixed-use fifteen-minute city ideals, with significant capacity for soil-based carbon sequestration.

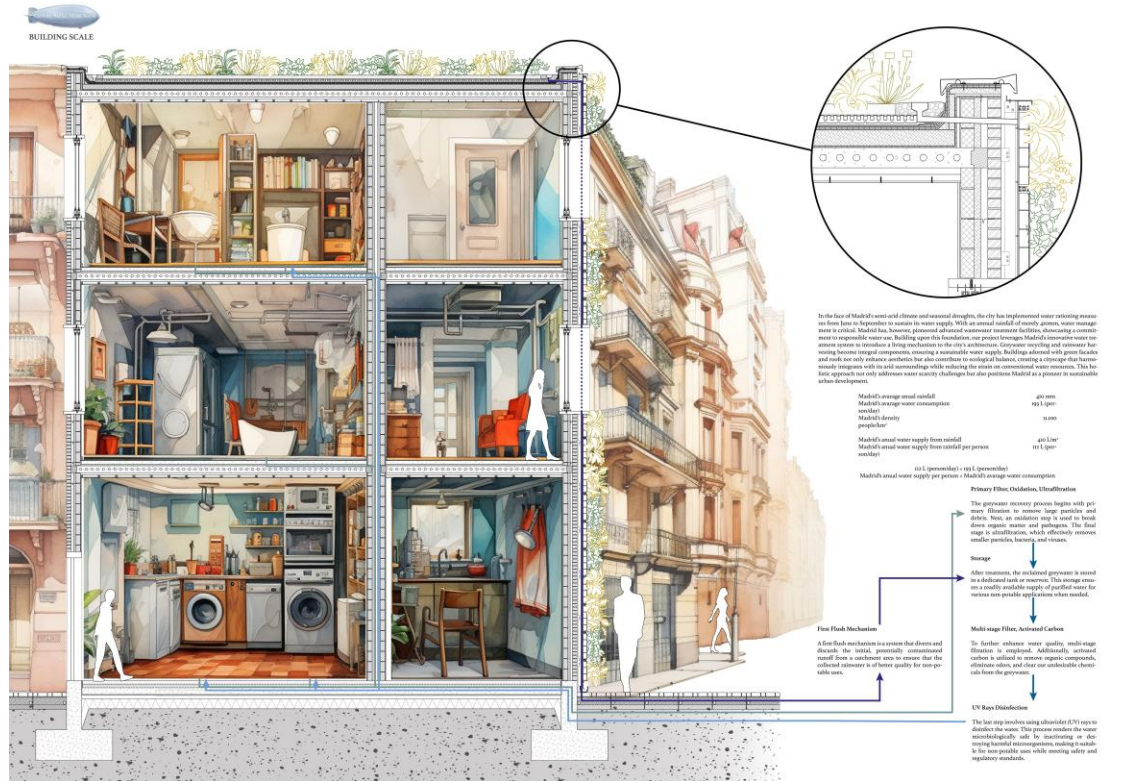


Figure 12: Section perspective (originally A0 format) from *Waterkeepers* focused on the scale of the building. (Source: Nadine Fahmy, Malek Fleifel, Roché Rabie, and Carolina Schönburg, November 2023).

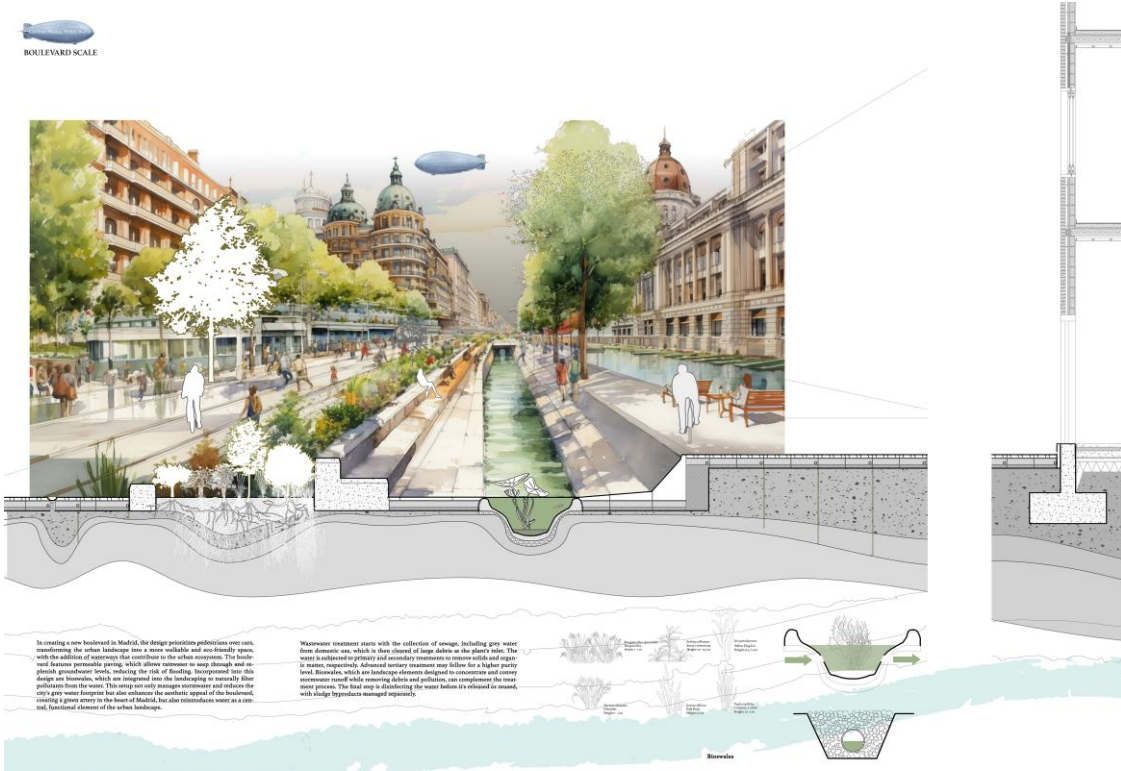


Figure 13: Section perspective (originally A0 format) from *Waterkeepers* focused on the scale of the boulevard. (Source: Nadine Fahmy, Malek Fleifel, Roché Rabie, and Carolina Schönburg, November 2023).

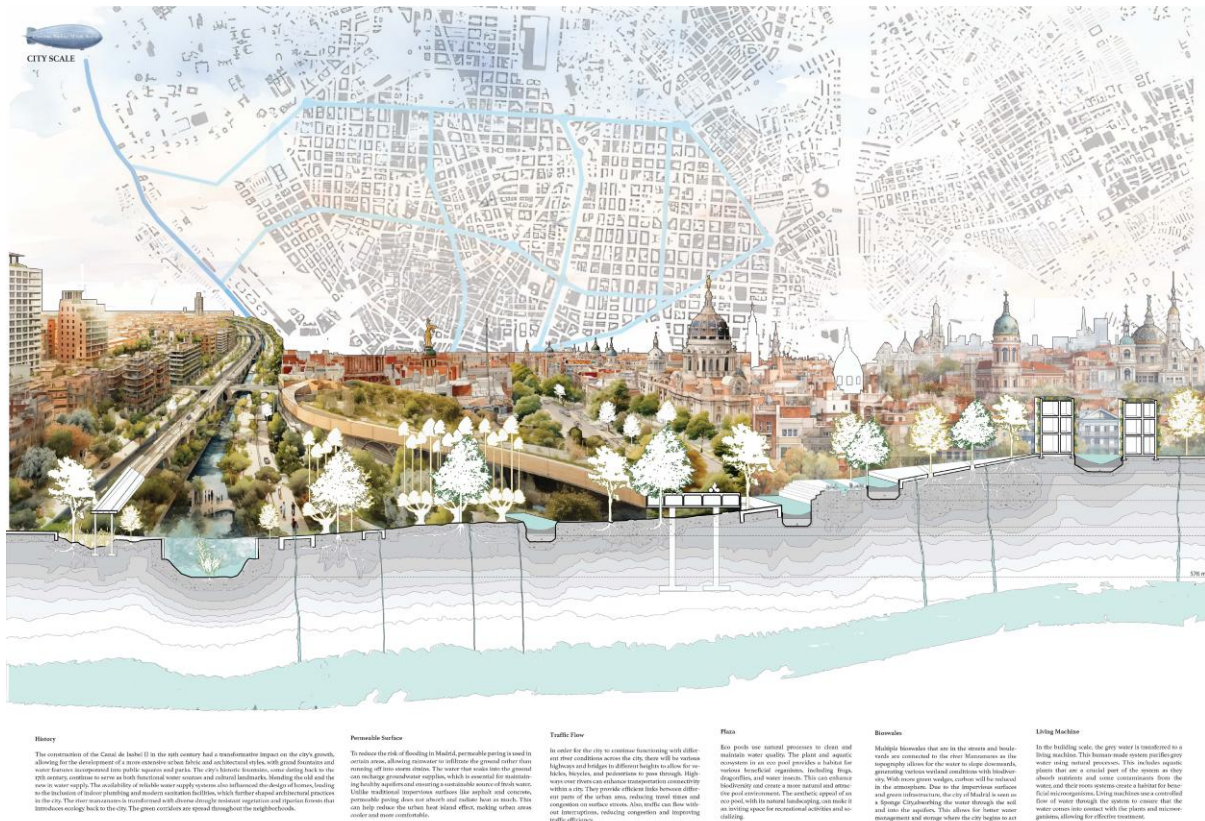


Figure 14: Section perspective (originally A0 format) from *Waterkeepers* focused on the scale of the city, depicting how the cross-scalar system works, and what it aims to achieve. (Source: Nadine Fahmy, Malek Fleifel, Roché Rabie, and Carolina Schönburg, November 2023).

In the context of these three sets of deliverables, three outcomes were observed from the use of AI, particularly when compared to the prior year which did not lean on artificial intelligence in any format. First, the overall quality and detail of the final deliverables were at a significantly higher level when compared to the prior year's course. Second, despite varying stances among students regarding the intellectual ownership of AI-generated content, there was no observable difference, when compared to the prior year, in the students' sense of ownership or authorship over the final executed work. Third, perhaps contrapuntally to the prior point, AI clearly behaved in a coauthorship capacity throughout the iterative design process—not as a black-boxed computational prosthetic, but rather as a grey-boxed structure with which the students were engaging in active dialogue, even if without explicit recognition.

Particularly intriguing, was that the image generation process created a dynamic that the students could not control in full. AI-produced visuals were always embedded with unexpected urban spaces, infrastructural conditions, aesthetic parameters, unrealistic built environmental collisions, etc., that lay beyond the boundaries of the initial prompts. These anomalies in turn tended to alter or inform existing conceptual paths, narratives, and strategies that had been set in motion by the student groups. As the students themselves noted, this back-and-forth interaction between human and synthetic author, pushed the final deliverables to be more layered and more intricate than what would have been achieved if the AI platforms had not been embedded within the iterative design process.

There were no *new* infrastructural ideas that emerged from the use of AI in this manner. However, there were unexpected overlaps between infrastructure and urban life that arose through the process. Across the breadth of the deliverables seen above, water and energy systems are leveraged in ways that directly impact the physical fabric of the city in a manner that is deeply tied to human (and non-human) life. Very little of the infrastructure is hidden from view. This is a particular point of intrigue within the discursive landscape of urban infrastructure, wherein the visibility and sociocultural (and by extension socioeconomic) impacts of infrastructure are often a critical hurdle in terms of its public acceptance—with blue-green-gray infrastructure being one of the few exceptions to this (Toth, 2020).

4. Discussion

This paper offers a brief glimpse into how one architectural studio attempted to utilize AI platforms for visualization and conceptual-narrative refinement. Some of the observations from this human-synthetic case study were as follows.

First, AI platforms trained on large language models (e.g., ChatGPT) proved quite useful as exploratory research tools for navigating the baseline fundamentals of various built environmental issues. However, when delving into these topics at a finer granularity, such platforms began to lose their perceived utility due to their inclination to generate farcical data points.

Second, the hallucinations that AI platforms generated—i.e., the farcical or misleading data produced when there were shortcomings in the datasets the platforms utilized (Alier et al., 2024, 9)—did however prove productive in a range of unexpected ways. In the context of ChatGPT, these hallucinations led to the humbling of the platform and the severing of the technological dependence that the student body had initially felt towards it. ChatGPT emerged as a secondary, as opposed to a primary, research tool that needed to be gauged with a critical, discretionary eye. Rather than an infallible and omnipotent source of information, ChatGPT was characterized as an aged uncle with significant depths of knowledge, but also the tendency to veer off onto fictional tangents.

Third, AI platforms often emerged as a critical mediating voice within studio discussions. Whether within the context of student-on-student or faculty-on-student exchanges, AI became a readily accessible alternate point of view that was mobilized to disentangle entrenched bifurcated positions or subvert innate hierarchies within the studio construct.

Fourth, ChatGPT or comparable AI platforms proved to be highly capable thought processors (Kolata 1996), through which students could check developing conceptual narratives or ideological structures for anomalies or contradictions.

Fifth, while not universally recognized as such by the students, AI noticeably took on a coauthorship capacity across the overarching structure of the studio. The content produced via the AI platforms, but more importantly the errors, unrealistic collisions, fallacies, etc., they generated, framed new areas of investigation for the student groups. While these new avenues did not create any novel approaches to urban infrastructure, they did lead to noteworthy efforts in terms of how said infrastructure took shape across the various scales of the urban fabric, and more importantly, how infrastructure could become visibly integrated with human and non-human life in the city. Much of the infrastructural interventions took on an active protagonistic role within the urban fabric—a role which much of the broader discourse concerned with urban infrastructure notes is a point of vulnerability for getting short and long-term public support behind such critical, but heretofore mostly invisible, urban systems (Toth, 2020).

5. Conclusion

The entwinement of AI with built environmental authorship is still in its early days. It is unclear where the discourse concerning the subject is headed, as well as how the pedagogical approach to the human-synthetic relationship can be framed, let alone leveraged. However, much of the discourse concerning the built world and artificial intelligence, particularly at larger scales, tends to presume a dominantly quantitative role for synthetic actors. The case study of the fifth-year architecture studio presented herein attempts to offer a qualitative counterpoint to this predominantly quantitative discursive landscape.

Some of the outcomes presented fall within the predictions and boundaries of the existing discursive landscape. Others however are rather unexpected and lie outside of the presumed boundaries of said landscape. Of particular intrigue within the context of architectural studio pedagogy are the second, third, and fourth points noted in the prior Discussion section—namely, the actual utility of hallucinations generated by AI platforms; how AI can serve as a much-needed mediating and hierarchy-disrupting voice within the context of the studio; and how AI can be leaned upon to test, challenge, and refine conceptual narratives mid-development.

Whether emerging internally within a student's own thought processes, generated via discussions between students and students, or discussions between students and faculty, studio culture seems to frequently produce polarized *either-or* structures (organizational or intellectual) that are inherently not conducive to resolving complex problematics. Across the board, AI appears to be a rather efficient and blunt tool for disrupting such counterproductive structures.

While it is unclear how and whether artificial intelligence should be more thoroughly leveraged within pedagogical structures of courses dealing with built environmental investigations, what is evident through the course of this research is that the relationship between generative AI platforms and human actors cannot be contained to non-reciprocating structures. Even if the reciprocal relationship that forms between human and synthetic actors is not explicitly recognized as such by the human counterpart, there is a clear impact upon the learning process via the synthetic counterpart, at a level of significance at which collaboration as a descriptive term is rather unavoidable.

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