
ISTANBUL
UP2030

Content

UP2030 PROJECT

1. General View

UP2030 aims to help cities achieve their **climate neutrality** goals by using urban planning and design as key tools for transformation. The project assists city stakeholders and local governments in integrating climate neutrality into everyday practices and long-term strategies. To support this, an innovative methodology known as the 5UP approach is created and implemented, combining scientific insights with practical tools and methods through collaborative development.

DATE	planning and design approaches, standards, codes and policies for urban transformations
SKILL	city's stakeholder ecosystem to co-develop urban planning and design enabled transformation pathway
GRADE	our neighborhoods using built & natural environment prototypes, supportive models & tools for planning and design
SCALE	governance arrangements, financial mechanisms, policy development & decision-making for urban planning
TAKE	activities to raise awareness and transfer knowledge across European cities and beyond

UP2030 looks at mainstreaming the climate neutrality agenda using urban planning and design to improve the overall quality of life in cities. The project strategically focuses its prototyping at the **neighborhood level**, since this scale is vital for addressing challenges, fostering reinvestment, and advancing climate innovation. UP2030 will support local governments in creating an innovation-enabling city environment through the development of appropriate policy frameworks, inclusive participation processes, promotion of sustainable behaviors, capacity building within municipal departments, new governance models, and financial support mechanisms. Ultimately, the project will guide cities and stakeholders in aligning their efforts with the core values of **equity, resilience, climate neutrality, and sustainability.**

UP2030 is being implemented in several pilot cities across Europe and beyond, with each city adapting solutions to its local context. These cities include **Belfast, Budapest, Granollers, Istanbul, Lisbon, Milan, Muenster, Rio de Janeiro, Rotterdam, Thessaloniki, and Zagreb.** By piloting innovative urban planning and sustainability strategies, these cities will serve as models for future climate-neutral urban development. [1]

[1] UP2030 Project, "About the Project," https://up2030-he.eu/

2. Climate Change

Climate change refers to a long-term shift in the typical weather patterns that define Earth's local, regional, and global climates. Since the mid-20th century, human activities—particularly the burning of fossil fuels—have been the primary driver. This process increases the concentration of **greenhouse gases** in the atmosphere, which trap heat and raise the planet's average surface temperature. [2] The current global energy system is the largest contributor to climate change, responsible for about 75% of all greenhouse gas emissions. [3]

As the planet continues to warm at an alarming rate, rethinking how we produce and consume energy is essential. The urgent need for **climate action** stems from the escalating impacts of climate change, which pose severe threats to ecological systems, human health, and global economic stability. **Energy renovation strategies** are equally crucial to build resilience against unavoidable climate impacts and protect vulnerable communities worldwide. [4]

2 NASA, "What Is Climate Change?" NASA Science, https://science.nasa.gov/climate-change/what-is-climate-change/.

3 United Nations Development Programme (UNDP), "What Is a Sustainable Energy Transition and Why Is It Key to Tackling Climate Change?" Climate Promise, https://climatepromise.undp.org/news-and-stories/what-sustainable-energy-transition-and-why-it-key-tackling-climate-change.

4 Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022: Impacts, Adaptation and Vulnerability* (Geneva: IPCC, 2022), https://www.ipcc.ch/report/ar6/wg2/.

Among the most affected by climate change are urban areas. Cities are particularly vulnerable to its increasing impacts due to their high population densities and extensive infrastructure. These impacts include increased frequency and intensity of **extreme weather events** such as heatwaves, heavy precipitation leading to urban flooding, and prolonged droughts, which strain urban systems and infrastructure. [5] Furthermore, coastal cities face additional threats from sea-level rise and storm surges, necessitating robust adaptation and resilience strategies to protect populations and critical assets. [6]

In this context, **decarbonization** plays a critical role in mitigating further climate risks. It refers to the process of reducing or eliminating carbon dioxide (CO_2) emissions, primarily from energy generation, industrial processes, and transportation sectors. The primary objective is to achieve net-zero greenhouse gas emissions to stabilize global temperatures. [7] This transition typically involves shifting towards renewable energy sources, enhancing energy efficiency, and implementing storage technologies. [8]

5 IPCC, Climate Change 2022.

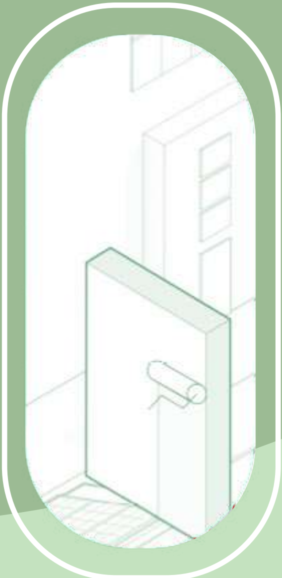
6 Solecki, William, Karen C. Seto, and Shobhakar Dhakal, "Urbanization, Key Risks and Vulnerabilities," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*, ed. C. B. Field et al. (Cambridge: Cambridge University Press, 2014), 535–612, https://www.ipcc.ch/report/ar5/wg2/.

7 United Nations Framework Convention on Climate Change (UNFCCC), "Adoption of the Paris Agreement (FCCC/CP/2015/L.9/Rev.1)," 2015, https://unfccc.int/documents/9097.

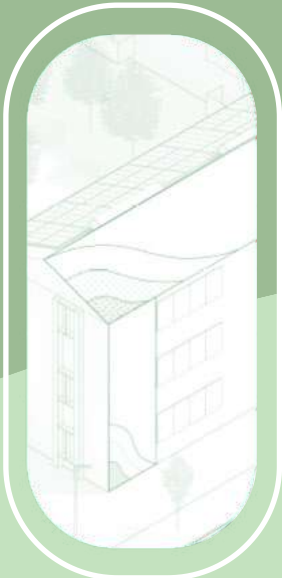
8 International Energy Agency (IEA), *Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach* (Paris: IEA, 2023), https://www.iea.org/reports/net-zero-roadmap-2023.

3. Energy Renovation Strategies

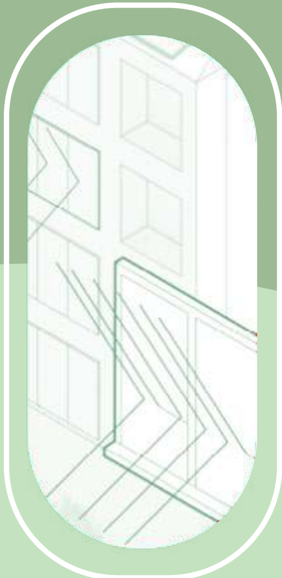
Façade Improvements



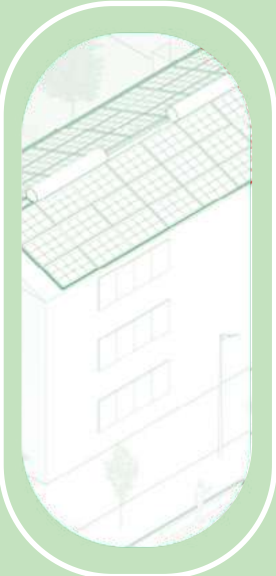
Façade Improvements



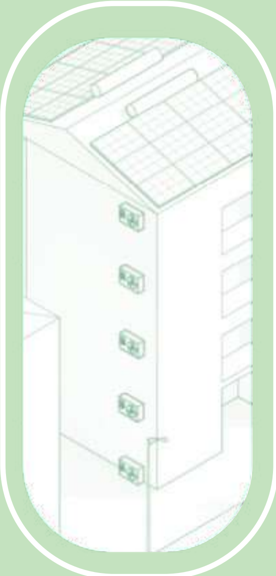
Façade Improvements



Photovoltaic Panel Installation



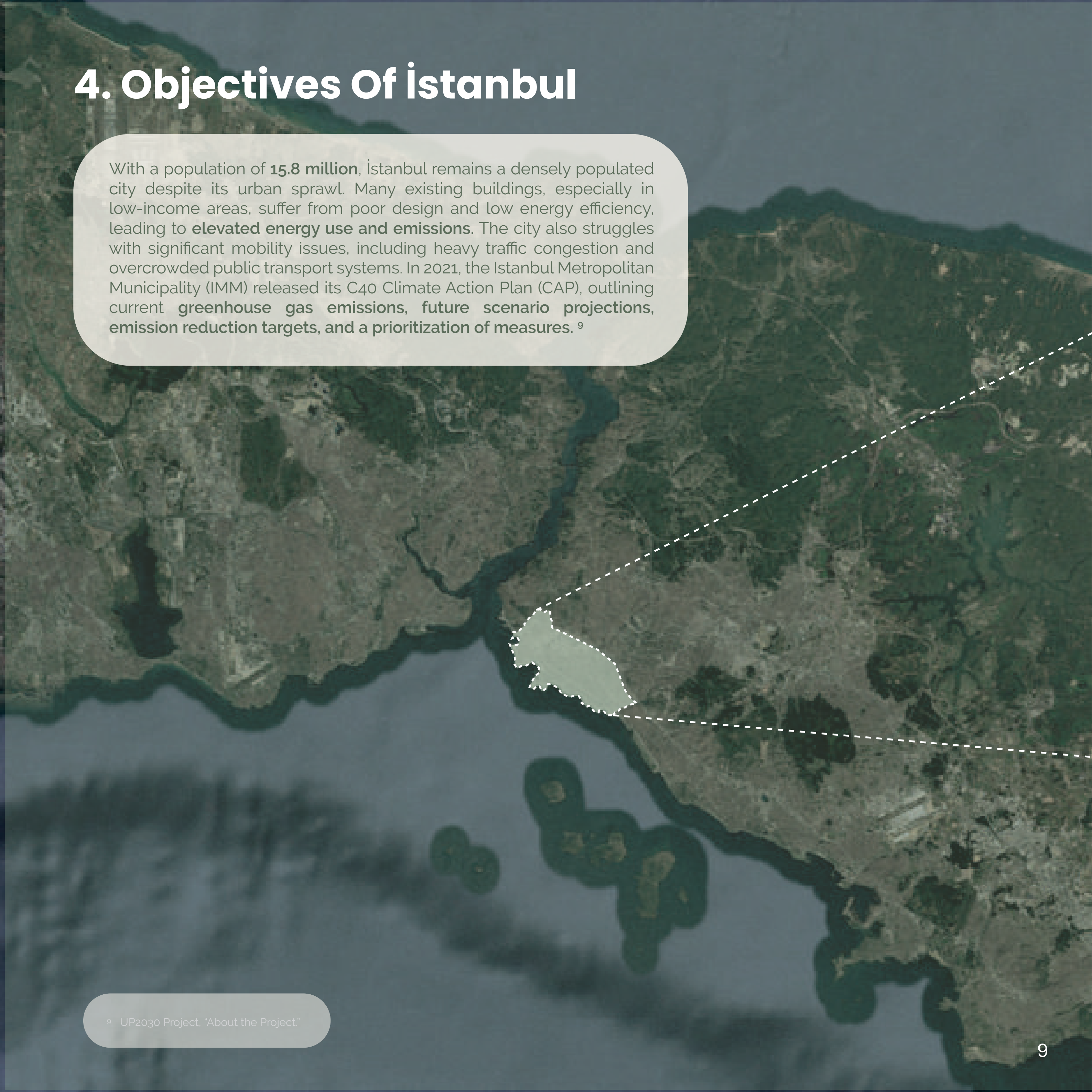
Heat Pump



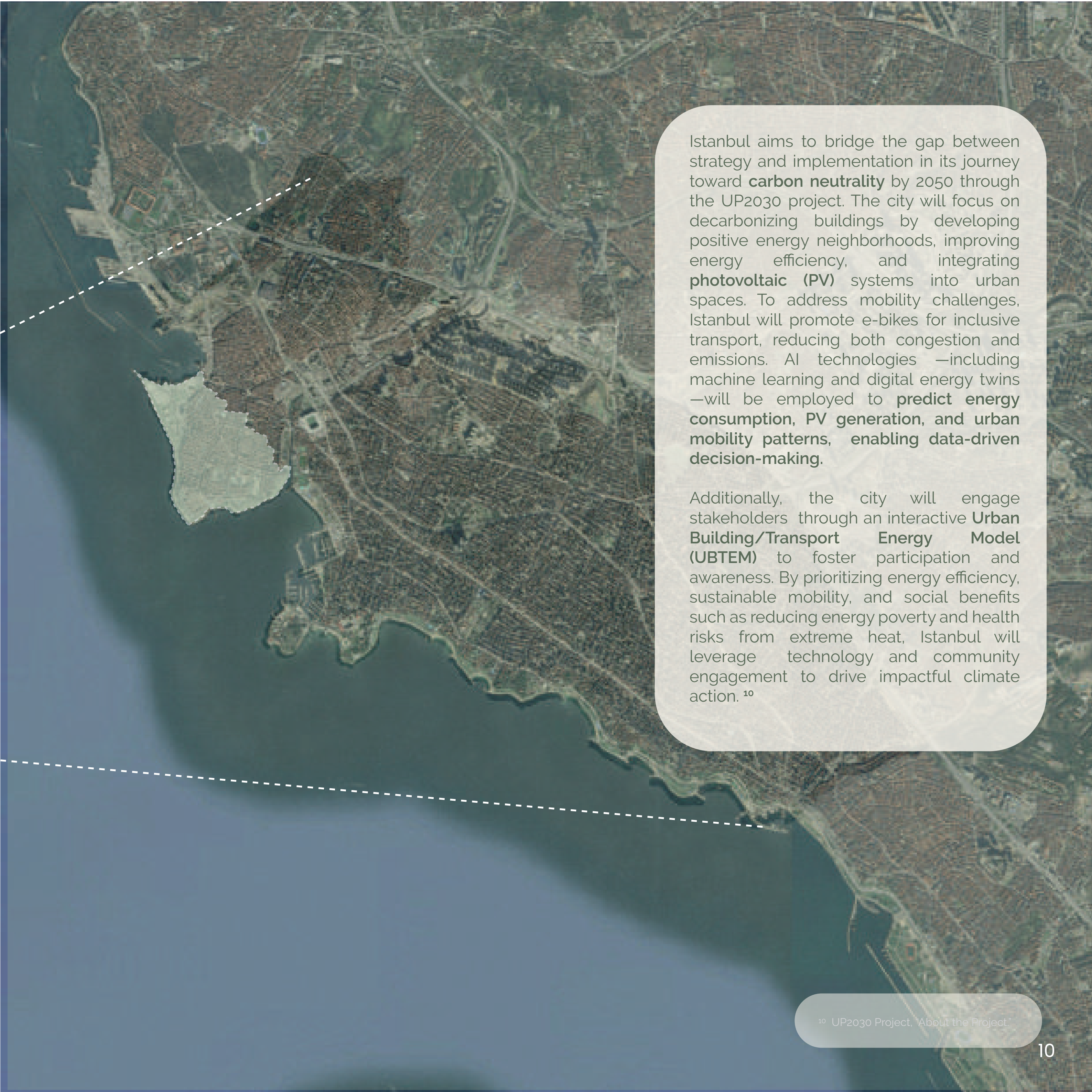
Solar Powered E-scooter Charging Station

4. Objectives Of İstanbul

With a population of **15.8 million**, İstanbul remains a densely populated city despite its urban sprawl. Many existing buildings, especially in low-income areas, suffer from poor design and low energy efficiency, leading to **elevated energy use and emissions.** The city also struggles with significant mobility issues, including heavy traffic congestion and overcrowded public transport systems. In 2021, the Istanbul Metropolitan Municipality (IMM) released its C40 Climate Action Plan (CAP), outlining current **greenhouse gas emissions, future scenario projections, emission reduction targets, and a prioritization of measures.** [9]



[9] UP2030 Project, "About the Project."



Istanbul aims to bridge the gap between strategy and implementation in its journey toward **carbon neutrality** by 2050 through the UP2030 project. The city will focus on decarbonizing buildings by developing positive energy neighborhoods, improving energy efficiency, and integrating **photovoltaic (PV)** systems into urban spaces. To address mobility challenges, Istanbul will promote e-bikes for inclusive transport, reducing both congestion and emissions. AI technologies —including machine learning and digital energy twins —will be employed to **predict energy consumption, PV generation, and urban mobility patterns, enabling data-driven decision-making.**

Additionally, the city will engage stakeholders through an interactive **Urban Building/Transport Energy Model (UBTEM)** to foster participation and awareness. By prioritizing energy efficiency, sustainable mobility, and social benefits such as reducing energy poverty and health risks from extreme heat, Istanbul will leverage technology and community engagement to drive impactful climate action. [10]

[10] UP2030 Project, "About the Project."

4.1. Kadıköy- Pilot Area

Kadıköy, one of Istanbul's central districts, has been selected as a pilot area to serve as a model for urban decarbonization and environmentally conscious design. The district is set to experience significant transformation through the integration of advanced technologies such as **photovoltaic (PV) panels, energy-efficient heat pumps, and façade upgrades.** These measures aim not only to reduce carbon emissions but also to enhance indoor comfort and overall building performance.

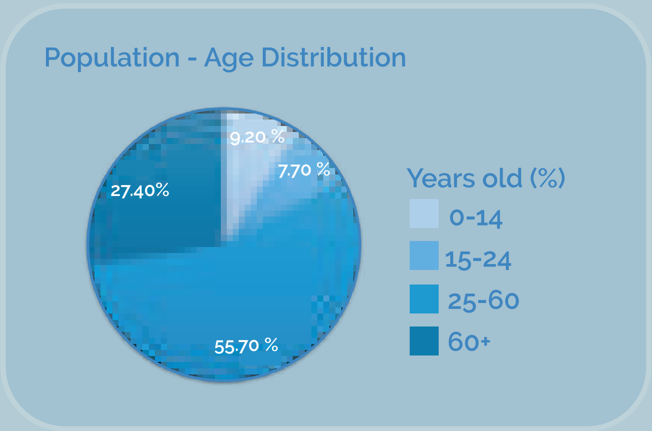
To support this transformation, the UBEM/UBTEM toolset—an AI-driven system—is being developed. This set of tools combines data on **building energy performance, renewable energy integration, and micro-mobility solutions.** The objective is to promote climate-aware urban planning and decision-making, enabling a comprehensive and scalable pathway toward decarbonization at the district level and beyond.

Current Situation of
CAFERAĞA
Neighnourhood

1. Demographic Status Of Caferağa Neighbourhood

Caferağa Neighborhood, one of the oldest neighborhoods in Kadıköy, has one of the highest daytime populations. It also has the highest percentage of people living alone (9%). Moda Cape and the historic Moda Pier are located in this neighborhood, and the coastline is actively used throughout the year. In Kadıköy higher-income groups are mainly concentrated along the southern coastal strip of the district—particularly in the Caferağa, Osmanağa, Fenerbahçe, Caddebostan, and Suadiye neighborhoods.

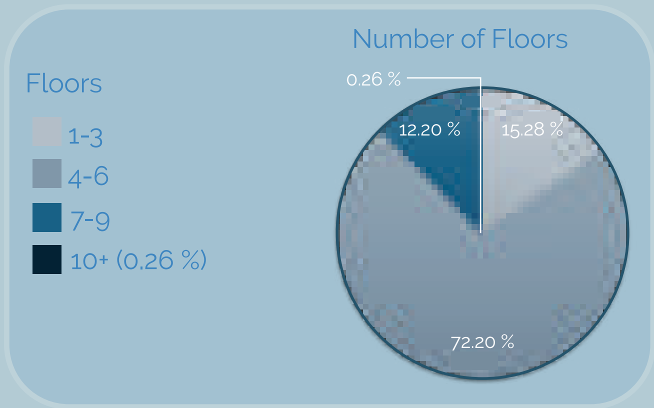
The population in Caferağa neighbourhood is predominantly aged 25–60 (55.7%), followed by a significant elderly group aged 60+ (27.4%), while children (0–14) and youth (15–24) represent only 9.2% and 7.7%, respectively—indicating an aging demographic and a relatively small younger generation. In terms of gender, the population consists of 55.8% males and 44.2% females. [11]

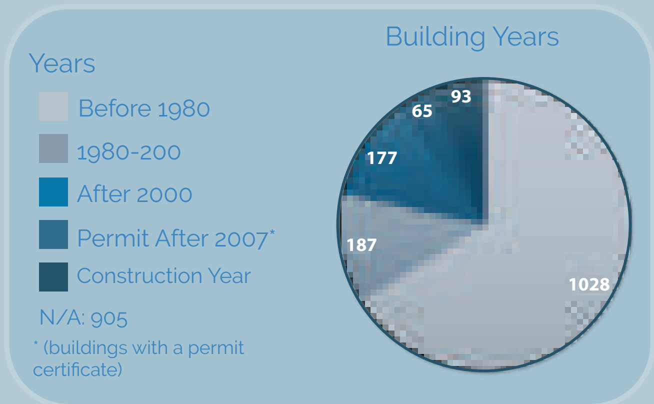


[11] Kadıköy Municipality, *Kadıköy 2030 Current Situation Report* (İstanbul: Kadıköy Municipality, 2021), https://anlat.kadikoy.bel.tr/kbpanel/Uploads/Files/kadikoy2030_mevcut_durum_raporu.pdf.

2. Building Stock Of Caferağa Neighbourhood

The Caferağa neighbourhood consists of 2,399 buildings, which include 13,702 residences and 4,174 workplaces. A total of 129 buildings have been identified as risky structures. The majority of buildings (1,028) were constructed before 1980, indicating an aging building stock in the area. Between 1980 and 2000, 187 buildings were constructed, while 177 were built after 2000. Additionally, 93 buildings have permit certificates issued after 2007, and for 65 buildings, the construction year is not recorded. It is also noted that data for 905 buildings is unavailable. Additionally, the majority of buildings in Kadıköy (72.2%) have 4–6 floors, while 15.28% have 1–3 floors, 12.2% have 7–9 floors, and only 0.26% exceed 10 floors. [12]





[12] Kadıköy Municipality, Kadıköy 2030 Current Situation Report.

3. Socio-Economic Vulnerability

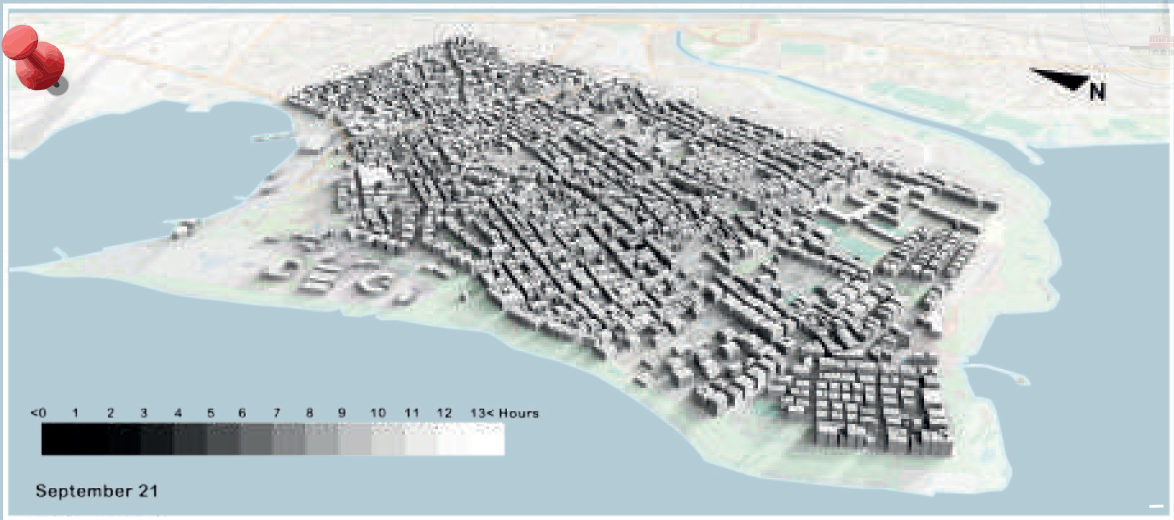
Kadıköy exhibits varying levels of socio-economic vulnerability. The northern and northeastern parts of Kadıköy—particularly Fikirtepe and its surrounding neighborhoods—show very high socio-economic fragility. These areas are known for urban transformation projects, dense populations, and economic disparities, all of which contribute to elevated vulnerability levels. In contrast, coastal and central parts of Kadıköy, including Moda, Caddebostan, and Bağdat Avenue, demonstrate low to very low socio-economic fragility—likely due to higher income levels, better infrastructure, and improved living conditions.

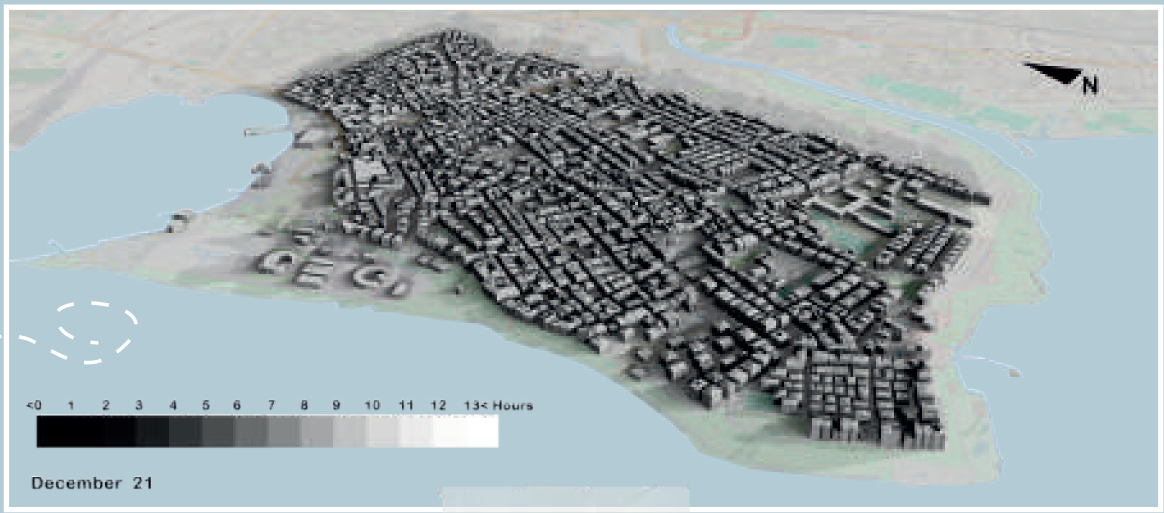
Caferağa, located centrally in Kadıköy, is classified as an area with low socio-economic fragility, as indicated by the lighter shades on the map. This status aligns with the neighborhood's relatively high-income residents, strong commercial activity, and well-maintained infrastructure. The presence of cultural spaces, restaurants, and a vibrant urban environment contributes to economic stability, making Caferağa one of the more resilient neighborhoods in Kadıköy. However, rising property prices and gentrification may affect socio-economic diversity over time, potentially increasing long-term vulnerability.

[13] Kadıköy Municipality, Kadıköy 2030 Current Situation Report.

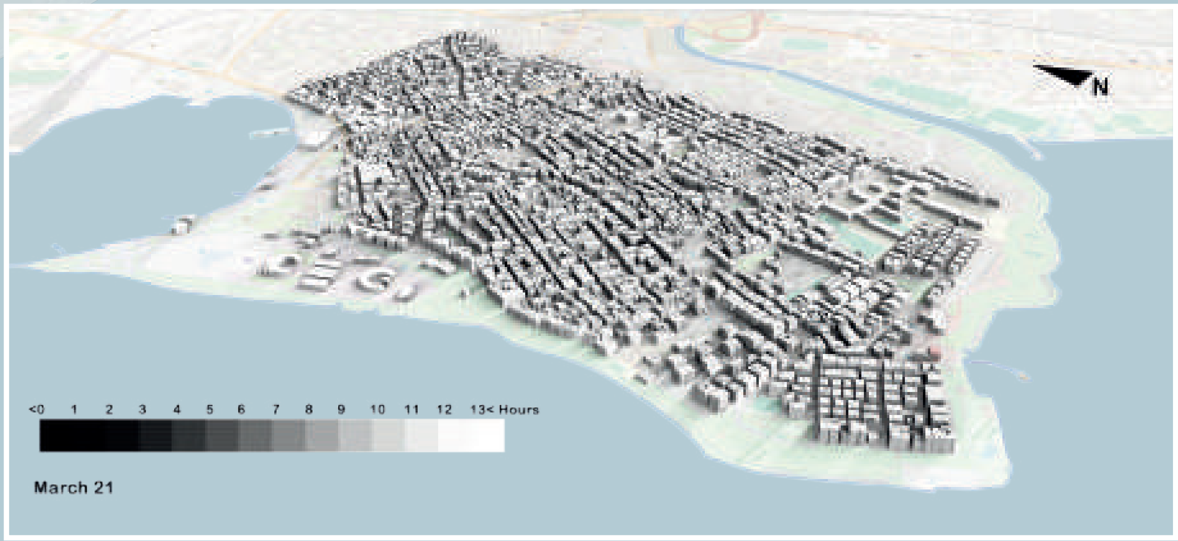
[14] Gazete Kadıköy, "Yeldeğirmeni Kitap Oldu," background image on this page, https://www.gazetekadikoy.com.tr/cevre/yeldegirmeni-kitap-oldu.

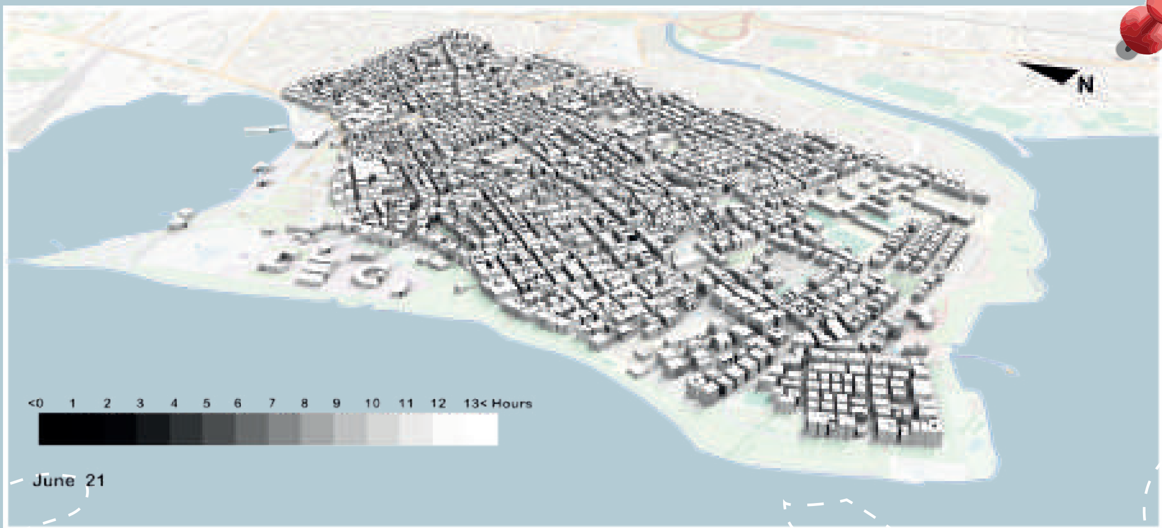
4. Caferağa Sunlight Hours Analysis





The daylighting analysis of the Kadıköy Caferağa neighborhood, based on representative days of the year, shows that rooftops within the dense urban fabric receive significantly more sunlight due to their uninterrupted exposure, unlike confined spaces such as narrow streets.





Furthermore, open-fronted south-facing façades—particularly those located in open spaces like school complexes and public parks—also demonstrate strong solar potential, receiving more sunlight than façades facing other directions. As a result, rooftop solar installations, including photovoltaic (PV) panels, represent a highly effective strategy for enhancing urban sustainability in the neighborhood.

PHOTO-VOLTAICS

1.Rooftop Modelling

Kadıköy's roofscape presents a diverse and dynamic urban fabric, reflecting the district's architectural variety and evolving cityscape.

The majority of rooftops consist of simple two-surface (gable) and four-surface (hip) structures, which dominate the residential and commercial areas. However, scattered throughout the district, more complex multi-surface roof designs can also be observed, particularly on larger buildings or structures with intricate layouts. Additionally, terrace roofs are present in some areas.

Despite the diversity in rooftop structures, the aim of the project is to identify suitable roof areas for the installation of solar panels. Traditionally used for satellite dishes, air conditioning units, and other technical equipment, these surfaces are now being repurposed to enhance renewable energy integration. This initiative seeks to improve urban sustainability by promoting a more efficient and environmentally responsible use of rooftop spaces.

1.1. Modelling Process

The rooftop modeling process for buildings in Kadıköy was conducted using a combination of methods to ensure accuracy and completeness, depending on the availability and quality of data. The primary objective was to generate precise 3D representations of rooftops, which would serve as a foundation for further spatial analyses and urban energy or planning studies.

For buildings where high-quality point cloud data was available, a detailed modeling approach was applied. Processing raw point cloud data to generate accurate roof surfaces poses significant challenges, especially in distinguishing elements such as chimneys, antennas, and other obstructions.. To address this complexity, a three-step workflow is employed :

1 Non-roof elements —such as mechanical equipment or satellite dishes — were identified and removed to create a cleaner dataset.

2 Local segmentation was conducted to partition the roof surface into meaningful sections. A segment-growing process was then applied to refine the segmentation and maintain continuity across surfaces.

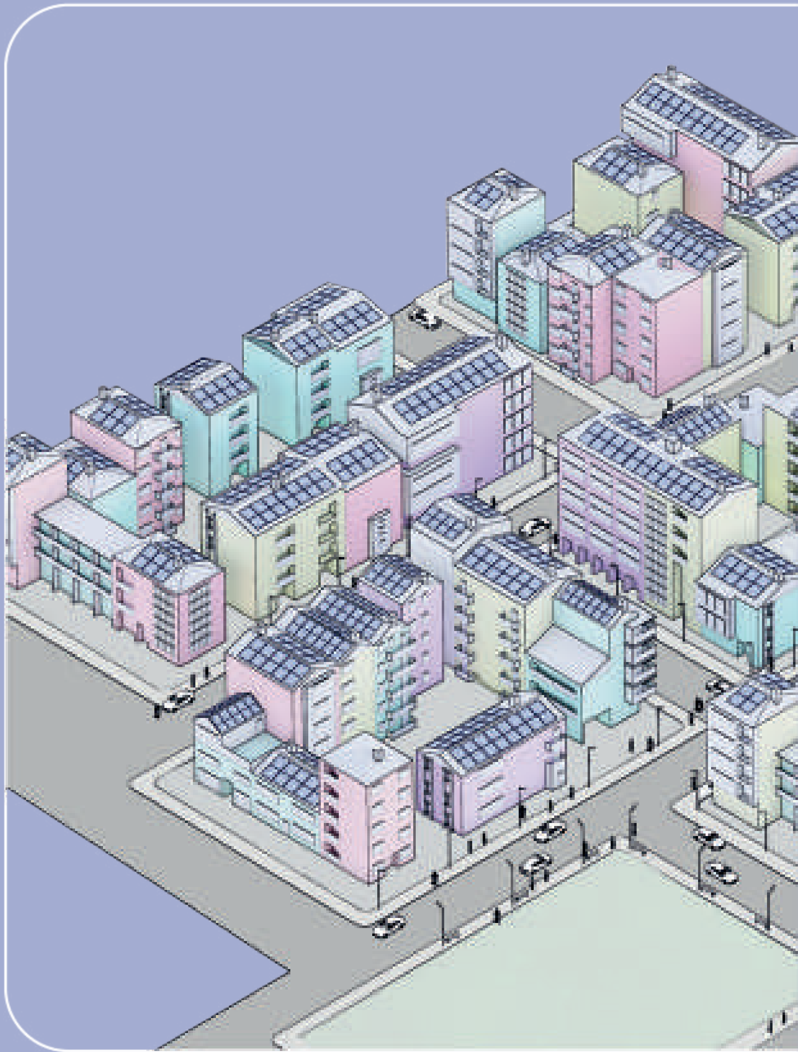
3 Fine-scale noise and irregularities were filtered out, followed by a boundary refinement step to enhance the geometric precision of roof edges.

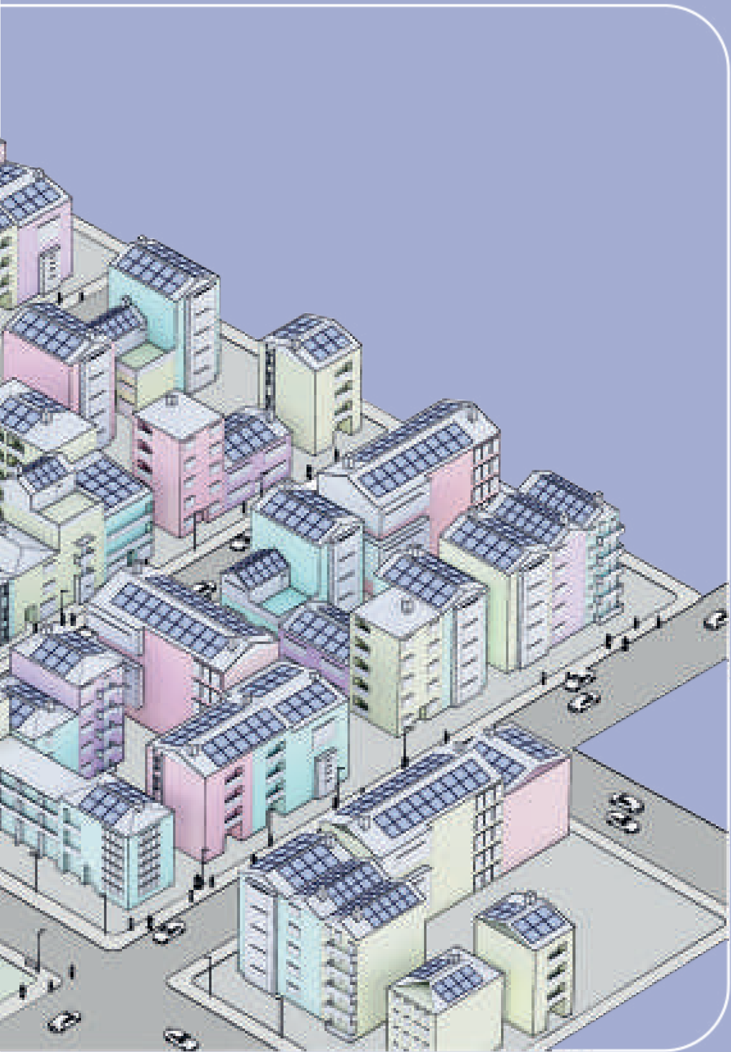
The modeling process utilized specialized software tools including Recap Pro and Rhino, ensuring that the resulting roof geometries closely reflected real-world conditions. Using this technique, 384 out of 2,454 buildings in Kadıköy were successfully modeled with high spatial accuracy.

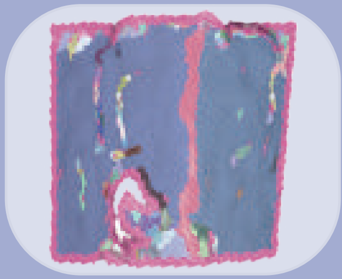
1.1. Modelling Process

For the remaining 2,070 buildings, where point cloud data was not available, roof modeling was conducted using Google Maps satellite imagery. This method enabled the extraction of roof shapes from aerial images; however, it also presented several limitations. Challenges included low-resolution imagery, obstructed views caused by cloud cover or tree canopies, and inconsistencies due to ongoing demolitions or renovations. Despite these constraints, all 2,070 buildings were successfully modeled, providing a reasonably accurate representation of their rooftop geometries.

Following the completion of the roof modeling phase, the workflow transitioned from Rhino to ArcGIS Pro, facilitating more advanced spatial analyses and geospatial data integration. This shift enabled a deeper investigation of urban form, rooftop typologies, and potential applications in energy efficiency, urban resilience, and environmental studies. Although certain data limitations persisted, the combination of both modeling approaches yielded a comprehensive and structured 3D dataset of Kadıköy's roofscape—offering valuable insights for future urban research and planning initiatives.



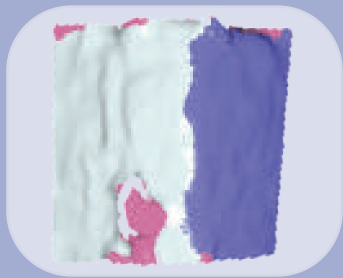




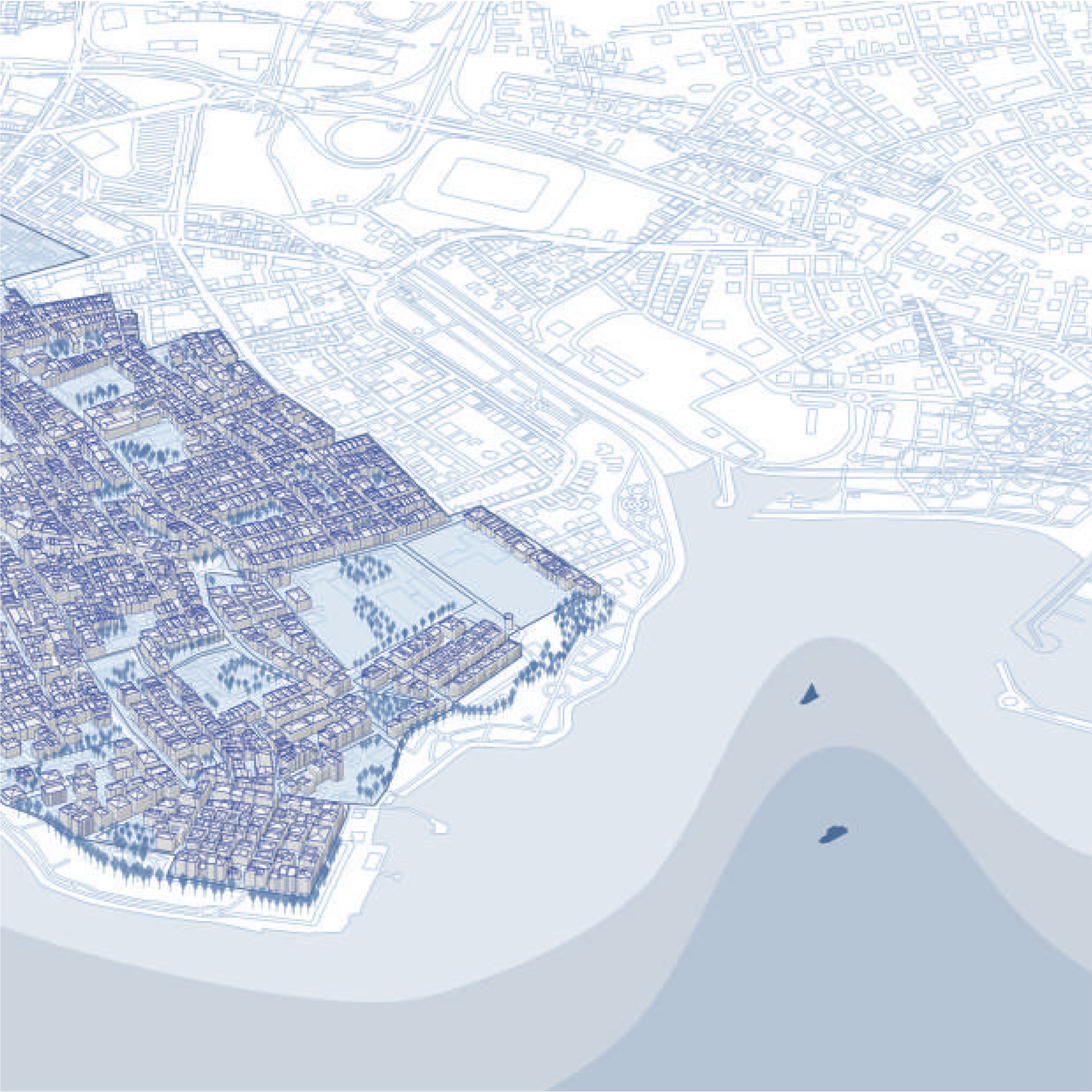
Multi Modal Fitting

Segment Growing (1)

Segment Filtering



Segment Growing (2)




BUILDINGS

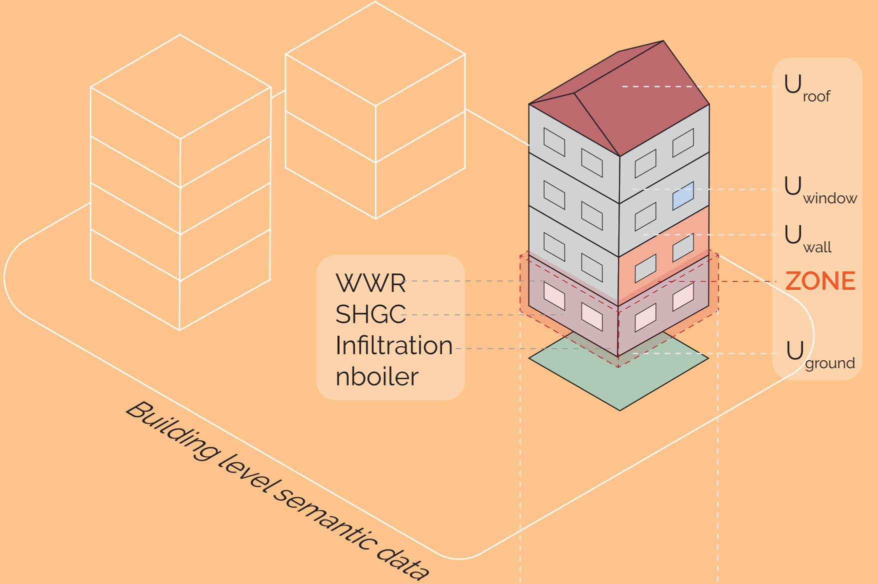
1.Urban Building Energy Modeling

1.1. 3D Modeling

For the development of the UBEM tool, 2,455 residential buildings consisting of 12,016 zones are modeled and simulated in Kadıköy, Istanbul. Simulations are performed at the zone level, assuming each floor as a single thermal zone. The selected neighborhood includes diverse building thermal characteristics due to varying construction years between 1960 and 2024. The total area of the neighborhood is 1.21 km², and residential buildings have an average of 4.89 floors. The 3D building geometries and their programs are acquired from the city GIS database and the National Address Inquiry System. In each building, a floor is modeled as a single thermal zone.

1.2. Building Data

Semantic data must be assigned to the buildings and their zones following 3D modeling as it offers crucial information and the contextual conditions required to create precise energy models. Semantic data can be divided into building-level data and zone-level data.

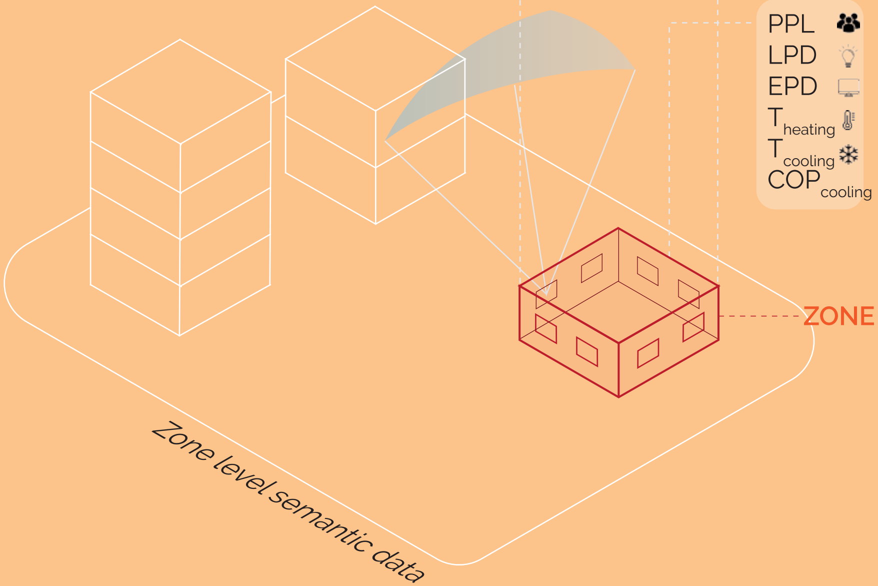


Building level semantic data

Building-level data include envelope materials (URoof, UWall, UWindow, UGround), boiler efficiency (ηboiler), window-wall ratio (WWR) in four directions, Solar Heat Gain Coefficient (SHGC), and facade infiltration rate.

Zone level semantic data

Zone-level data varies from zone to zone, including internal loads (lighting power density (LPD), equipment power density (EPD), people density (PPD)), heating setpoint (THeating), cooling setpoint (TCooling), and air conditioning efficiency (COPcooling).



Following, using eppy, a Python library that can parse and edit EnergyPlus files[15], all building-level and zone-level semantic data are assigned accordingly.

[15] Santosh, eppy (Python package), 2014, https://pypi.org/project/eppy/.

1.3. What is Urban Building Energy Modeling (UBEM)?

Urban Energy Modeling is a computational approach that simulates and evaluates energy consumption, production, and efficiency across entire urban areas, including buildings, infrastructure, and human activities. Urban energy models integrate spatial and temporal data at the urban scale to capture the interactions among building stock, climate, land use, and user behavior. It combines simulations of energy consumption and daylight analysis allowing planners to evaluate the effects of interventions such as energy retrofits and renewable energy applications across multiple sustainability metrics 16.

These models use detailed inputs such as building geometry, material properties, climate data, and usage schedules to estimate energy demand, assess energy performance, and optimize energy-saving strategies. In today's era—characterized by increasing challenges such as climate change, biodiversity loss, pollution, and resource depletion—UBEM has become an essential tool for achieving net-zero emission targets and supporting urban sustainability goals 17. The UP2030 project, for example, integrates such modelling approaches to transition from project-based decarbonization strategies to comprehensive, vision-driven urban planning, involving all city stakeholders, including citizens, in the decision-making process.

16 Kong, D., A. Cheshmehzangi, Z. Zhang, et al., "Urban Building Energy Modeling (UBEM): A Systematic Review of Challenges and Opportunities," *Energy Efficiency* 16, no. 69 (2023), https://doi.org/10.1007/s12053-023-10147-z.

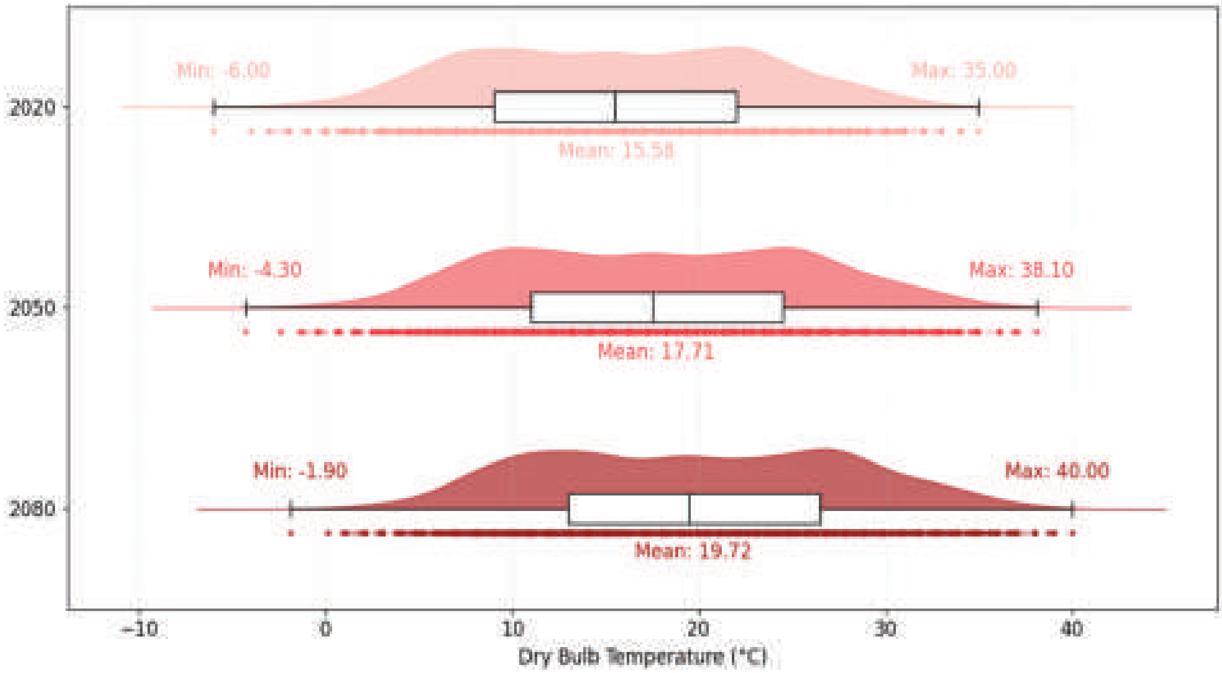
17 Kamel, E., "A Systematic Literature Review of Physics-Based Urban Building Energy Modeling (UBEM) Tools, Data Sources, and Challenges for Energy Conservation," *Energies* 15, no. 22 (2022): 8649, https://doi.org/10.3390/en15228649.

2.Future Weather File Generation

The typical meteorological year (TMY) file of Istanbul obtained during 2007-2021 is used to perform baseline simulations that represent current weather conditions (W2025). Then, two weather files (W2050 and W2080) are generated for 2050 and 2080 climatic conditions using the 'Future Weather Generator'. Future Weather Generator is a tool that is used to create future weather files based on the morphing method and the latest climate data model (EC-Earth3).18 Four Shared Socioeconomic Pathways (SSP), including SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5, are implemented in the tool.

For the development of UBEM, the SSP5-8.5 scenario represents a climate with intensive fossil fuel-driven development, leading to very high greenhouse gas emissions and severe climate impacts is selected to ensure that buildings are prepared for the most extreme climate scenarios during decision-making. Below, the graph shows the distribution of dry bulb temperatures for the years 2020, 2050, and 2080, illustrating the projected impacts of climate change on urban thermal conditions.

Dry Bulb Temperature (2020, 2050, 2080)



[18] Eugénio Rodrigues, Marco S. Fernandes, and David Carvalho, "Future Weather Generator for Building Performance Research: An Open-Source Morphing Tool and an Application," *Building and Environment* 230 (2023): Article 109123, https://doi.org/10.1016/j.buildenv.2023.109123.

3.Simulation-based Analysis

The developed UBEMs are used to calculate performance objectives, including (i) heating energy consumption (Qheating), (ii) cooling energy consumption (Qcooling), and (iii) indoor overheating degree (IOD). We use EnergyPlus V9.4 as the simulation engine. Performance objectives are calculated for each zone using weather files W2025, W2050, and W2080. The calculated results serve as input data for AI-based prediction models.

Qheating

The annual heating energy consumption (kWh/m^2) is calculated for each zone. The boiler efficiency values (ηboiler), previously provided in the dataset, are applied to account for the building's heating system.

Qcooling

The annual cooling energy consumption (kWh/m^2) is calculated for each zone. The coefficient of performance (COP) values, previously provided in the dataset, are used to account for the building's cooling system.

Indoor Thermal Comfort

As the impacts of climate change intensify, maintaining comfortable indoor temperatures,especially in cities like Istanbul,is becoming increasingly difficult, particularly in buildings that rely on natural ventilation and lack active cooling systems. Rising outdoor temperatures pose a serious threat to indoor thermal comfort, which directly affects people's health, well-being, and productivity.

To better understand and track these risks, this study uses a measure called the Indoor Overheating Degree (IOD), originally proposed by Hamdy (2017) [19]. IOD helps us evaluate how often and by how much indoor temperatures go beyond what is considered comfortable. It does this by comparing the actual indoor temperature to an adaptive comfort limit, which is based on the recent history of outdoor temperatures, a method aligned with recognized standards like CIBSE TM52 and BS EN 15251.

In this research, we calculate the IOD for residential and office spaces during the warmer months, from May 1st to September 30th, focusing only on hours when the spaces are occupied. For each day, we sum the hourly differences between the indoor temperature and the upper comfort threshold to see how far and how long the space has been too warm. The higher the IOD, the more uncomfortable, and potentially unsafe, the indoor environment becomes.

To explore long-term solutions, we examine IOD under various building design scenarios and future climate projections. This allows us to assess whether building design strategies can help buildings remain thermally comfortable without needing air conditioning. If buildings can delay or even avoid the need for mechanical cooling, it not only benefits occupants but also reduces energy use and greenhouse gas emissions. This makes IOD a valuable tool not just for assessing comfort, but for planning sustainable responses to the challenges posed by a warming climate.

19 Hamdy, Mohamed, Salvatore Carlucci, Pieter-Jan Hoes, and Jan L. M. Hensen, "The Impact of Climate Change on the Overheating Risk in Dwellings—A Dutch Case Study," *Building and Environment* 82 (2014): 273–91, https://doi.org/10.1016/j.buildenv.2014.06.007.

3.1. The Results of Baseline and Energy Renovation Strategies

Using Eppy, 2455 buildings for each year (2025, 2050 and 2080) are simulated. As a result, 36,048 zone's Qheating, Qcooling and IOD values are calculated.

Baseline results represent the current state of buildings in the studied neighborhood. These results are available for all three performance metrics across the three target years (2025, 2050, and 2080). The detailed baseline simulation results will be presented in comparison with the results of retrofit scenarios.

The proposed energy renovation strategies aim to: (i) reduce heating energy demand, (ii) reduce cooling energy consumption, (iii) mitigate indoor overheating degree (IOD), and (iv) transition from low-efficiency boilers to heat pumps to support decarbonization. In line with these objectives, several energy renovation scenarios have been evaluated, including:

Baseline_year: Represents the existing condition of the apartment units, reflecting the current state without any interventions.

ENR1_year: Refers to an energy renovation scenario in which thermal insulation levels are improved in accordance with Turkish standards.

ENR2_year: Corresponds to a renovation strategy where the building envelope performance meets the Passive House standard.

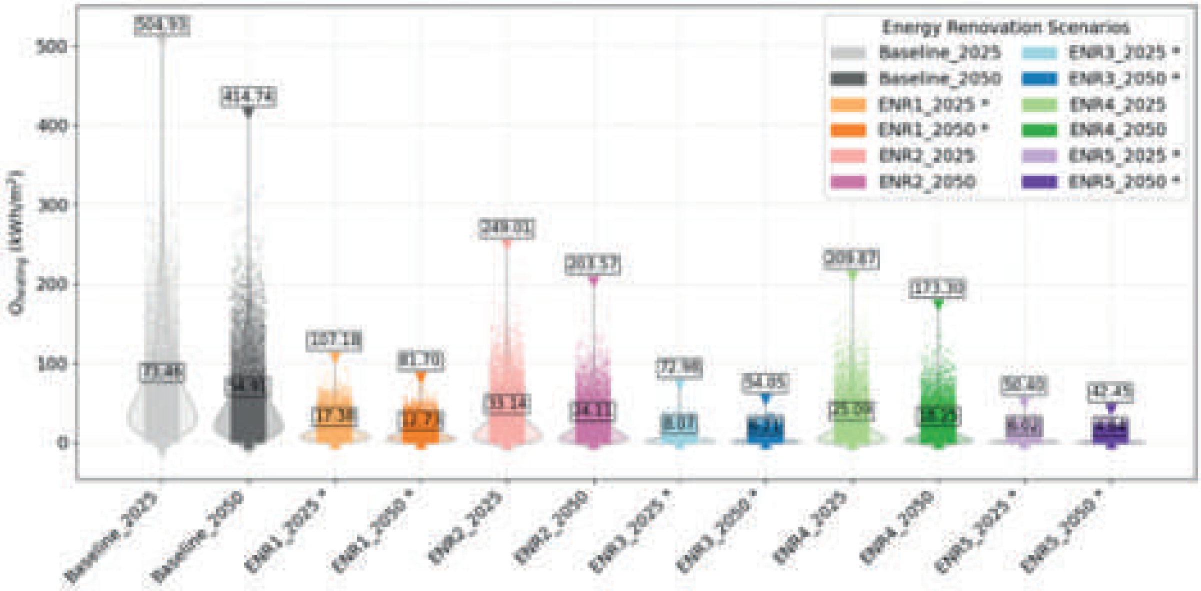
ENR3_year: Involves the installation of a heat pump system on top of the baseline configuration, without any improvements to the envelope.

ENR4_year: Builds upon ENR1 by integrating a heat pump into the envelope improvements.

ENR5_year: Reflects a scenario in which a heat pump is added to the ENR2 configuration.

These retrofit scenarios are designed to assess potential improvements in energy efficiency and indoor thermal comfort across varying building configurations and future climate conditions.

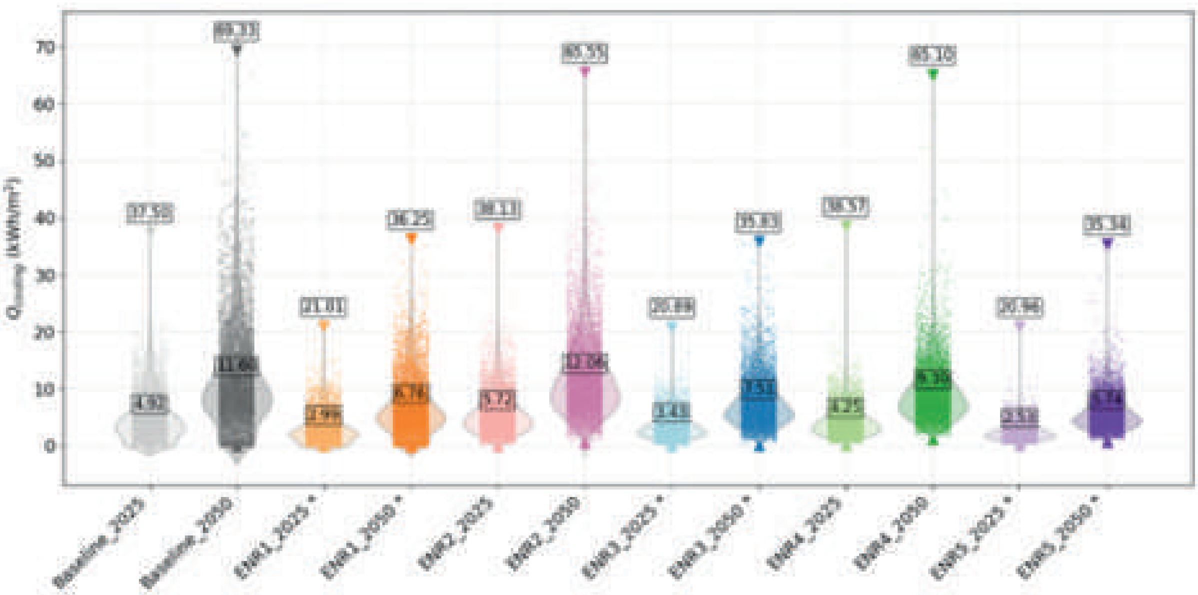
Distribution of Annual Heating Energy Demand



The distribution of annual heating energy demand Qheating (kWh/m²) under different retrofit scenarios for the years 2025 and 2050 is analyzed. On the left side of the vertical dashed line, scenarios relying on natural gas boilers are presented. These include the Baseline, ENR1, and ENR2 configurations, each shown for both 2025 and 2050. The Baseline scenarios reflect the current building conditions without energy renovation strategies. The average Qheating is observed as 73.46 kWh/m² in 2025 and decreased to 54.91 kWh/m² in 2050, reflecting the long-term impact of improved energy performance and climate change.

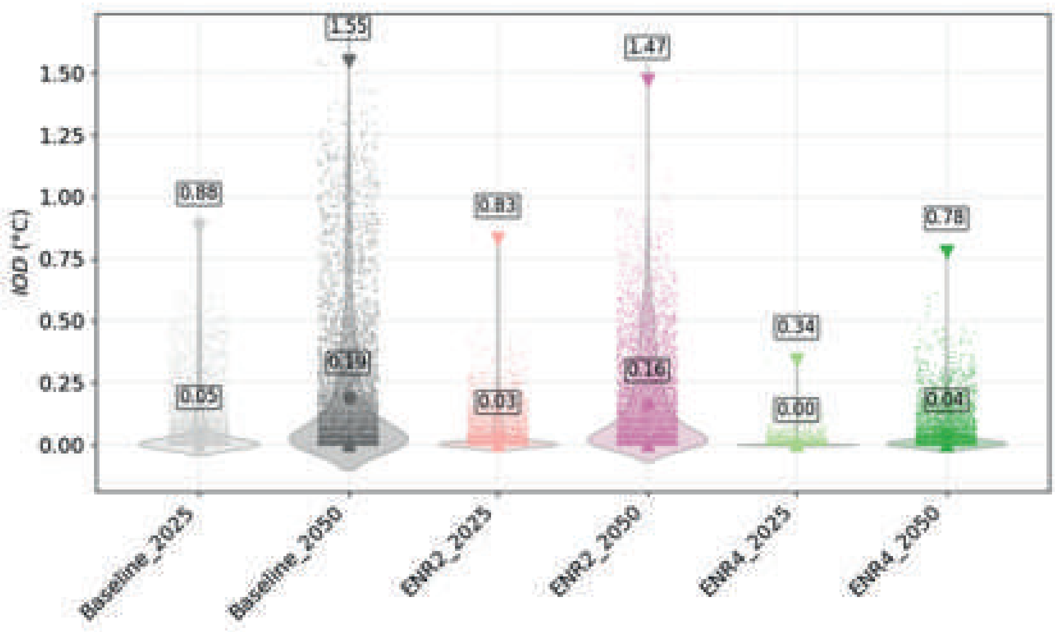
Energy renovation strategies yield significant reductions. The results demonstrate that both envelope upgrades and transitioning to heat pump technologies significantly reduce heating energy demand, with combined strategies (e.g., ENR5) offering the most substantial energy savings, especially under future climate conditions projected for 2050.

Distribution of Annual Cooling Energy Demand



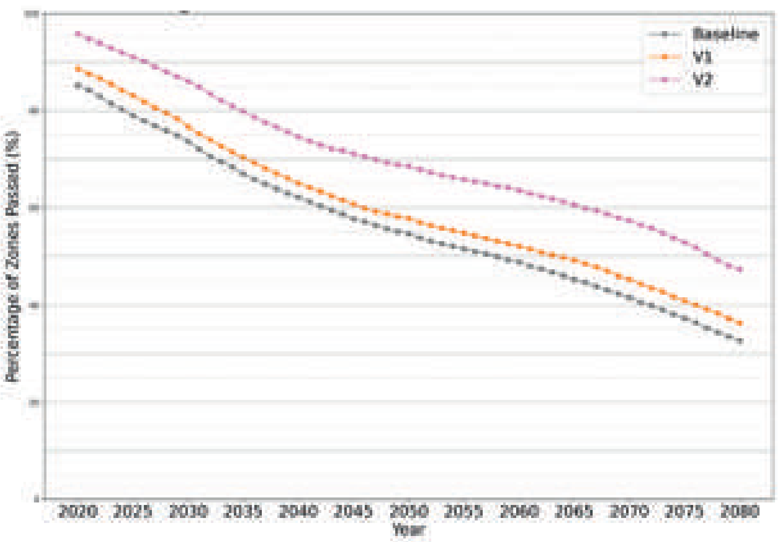
The results present the distribution of annual cooling energy demand (Qcooling, in kWh/m²) across different renovation scenarios for the years 2025 and 2050. In the Baseline scenarios, a notable increase in Qcooling is observed from 4.92 kWh/m² in 2025 to 11.60 kWh/m² in 2050, highlighting the impact of rising outdoor temperatures.

Overall, a downward shift in median cooling demand is observed across all energy renovation strategies by 2050, indicating the long-term benefits of both envelope improvements and heat pump integration in adapting to climate change.



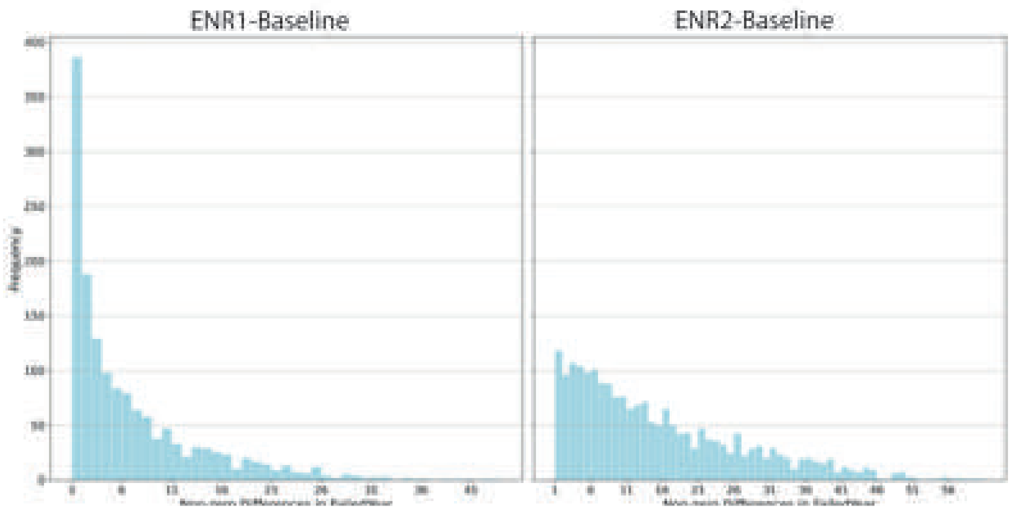
The results also show the distribution of IOD values (in ˚C) across baseline and energy renovation scenarios (ENR1 and ENR2) for the years 2025 and 2050 under natural gas-based systems. While the baseline scenario shows a significant increase in median IOD from 0.05˚C in 2025 to 0.19˚C in 2050, ENR1 and ENR2 scenarios consistently yield lower median values, with ENR2 achieving the best performance (approaching 0˚C in 2025 and 0.04˚C in 2050). These results highlight the effectiveness of envelope improvements, especially those aligned with Passive House standards, in mitigating overheating risks under future climate conditions.

Percentage of RES Zones Over the Years for Different Scenerios



In addition to using hourly IOD values as a comparative tool to assess different building energy retrofit scenarios, the overheating risk can be assessed via CIBSE overheating risk test, which declares the residential space as failed when the number of occupied hours in which the indoor operative temperature exceeds the upper temperature limit more than one degrees constitutes more than 3% of the occupied hours. In the Baseline Scenario, 85% of the unconditioned residential passess the CIBSE overheating criteria in 2020, but by 2050 and 2080, this percentage gets 54% and 32%. Energy retrofit scenarios helps delay the year in which the overheating risk occurs in some cases.

Delayed Overheating

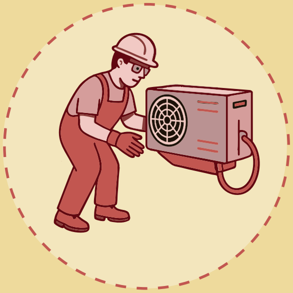


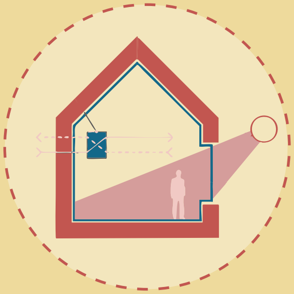
The distribution of for how many years the overheating is delayed as a result of retrofitting scenarios for V1 (left) and V2 (right) can be seen in figure, showing the shift towards long periods of delay with retrofitting to an improved insulation in the building envelope and even longer periods of delay with meeting the Passivehaus standards.

3.2 The techno-economic analysis of energy retrofit packages

As the global energy landscape shifts toward sustainability, it is more critical than ever to evaluate both the economic and environmental impacts of energy-efficient systems. By carefully calculating financial metrics such as investment costs, payback periods, and long-term savings, stakeholders can better understand the economic viability of these systems and plan their resources accordingly. A combined assessment that includes both lifecycle cost analysis and emission reduction potential provides a balanced, forward-thinking approach to sustainable building design and renovation. This dual perspective is crucial for policymakers, stakeholders and urban planners who aim to make informed, effective decisions that contribute to both economic resilience and climate action.

Kod	Senaryo
Base	Baseline
ENR1	Baseline + Heat Pump
ENR2	Envelope
ENR3	Envelope + Heat Pump
ENR4	Passivehouse
ENR5	Passivehouse + Heat Pump
Base_PV	Baseline + PV
ENR1_PV	Baseline + Heat Pump + PV
ENR2_PV	Envelope + PV
ENR3_PV	Passivehouse + PV
ENR4_PV	Envelope + Heat Pump + PV
ENR5_PV	Passivehouse + Heat Pump + PV





All cases include annual operational savings, net present value, return on investment, payback period, emission reduction, and abatement cost, which are explained on the following page. In scenarios involving envelope retrofit, the replacement of mechanical systems at the required intervals has been considered and included in the total costs.

3.3 Economic Calculations and Evaluation Metrics

Utility bills

Natural gas and electricity bills were calculated with data obtained from official institutions. For the calculation of natural gas bills, hourly pricing received from IGDAS; for electricity bills, tariffs received from EPDK were applied and annual bills were calculated for both.

Investment Costs

The initial investment costs of each system were found and calculated from official sources based in Türkiye. Different unit prices for insulation, heat pump and solar panels were integrated and included in the calculations.

Cash Flow

The ordinal value of savings obtained each year after the investment expenditure in the first year of investment. It is calculated on an annual basis based on cost differences.

Discounted Payback Period

It shows how many years it will take for the investment to pay off, after considering that future savings are worth slightly less each year.

Net Present Value

This term is a fundamental financial metric used to evaluate the profitability of an investment or project. It calculates the present value of future cash flows generated by the investment, discounted back to the present time.

CO2 Reduction

It calculates the cost of reducing one kilogram of CO_2 emissions. It can be seen how much a project helps reduce a building's carbon footprint.

Return On Investment

It shows the percentage of return on a project based on the amount spent, and helps compare different investment options.

Abatement Cost

These are the costs of reducing environmental damage, such as investing in renewable energy systems, upgrading to energy-efficient appliances, or adopting carbon capture and storage (CCS) technologies.

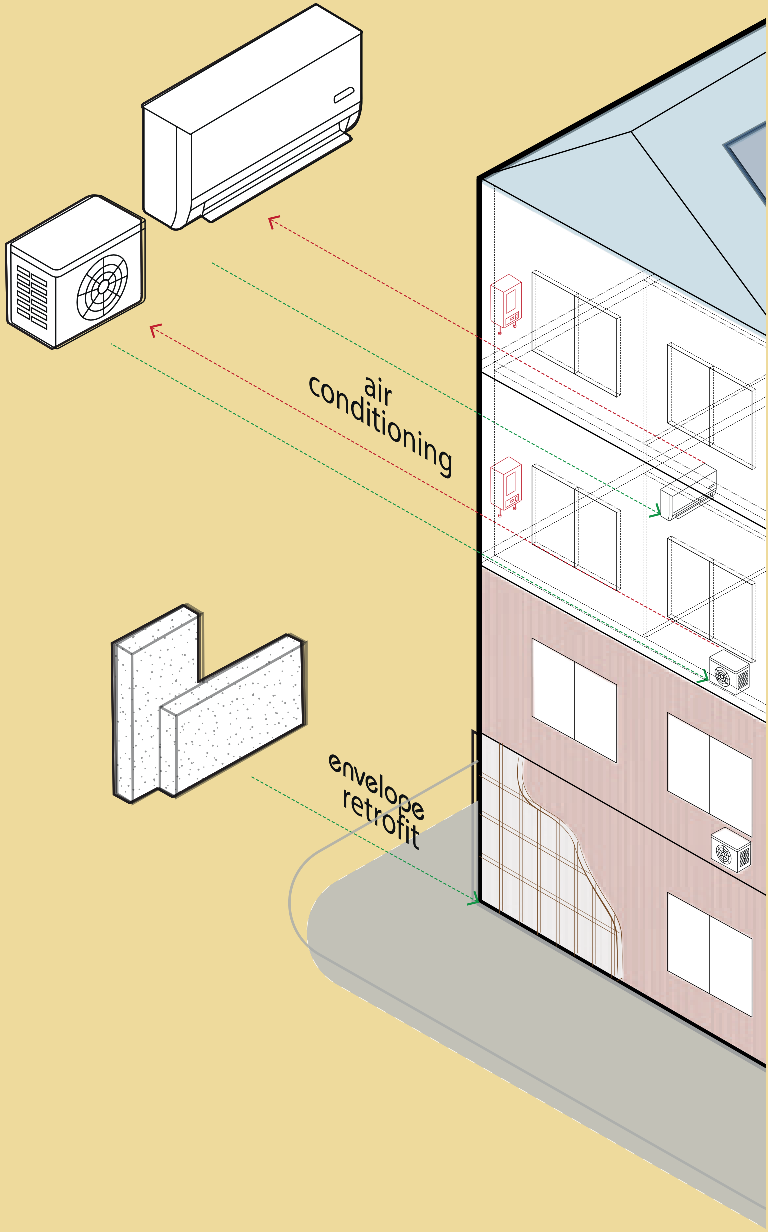
Split AC

To reduce thermal comfort due to overheating in current buildings, the integration or replacement of Split air conditioners is considered in this project.

Features:
- Consists of one indoor and one outdoor unit
- Quick cooling with adjustable temperature control
- Moderate electricity consumption

Advantages:
- Easy to install
- Affordable initial cost
- Effective for small spaces

Disadvantages:
- Uses refrigerants with global warming potential
- Less efficient than centralized or passive systems



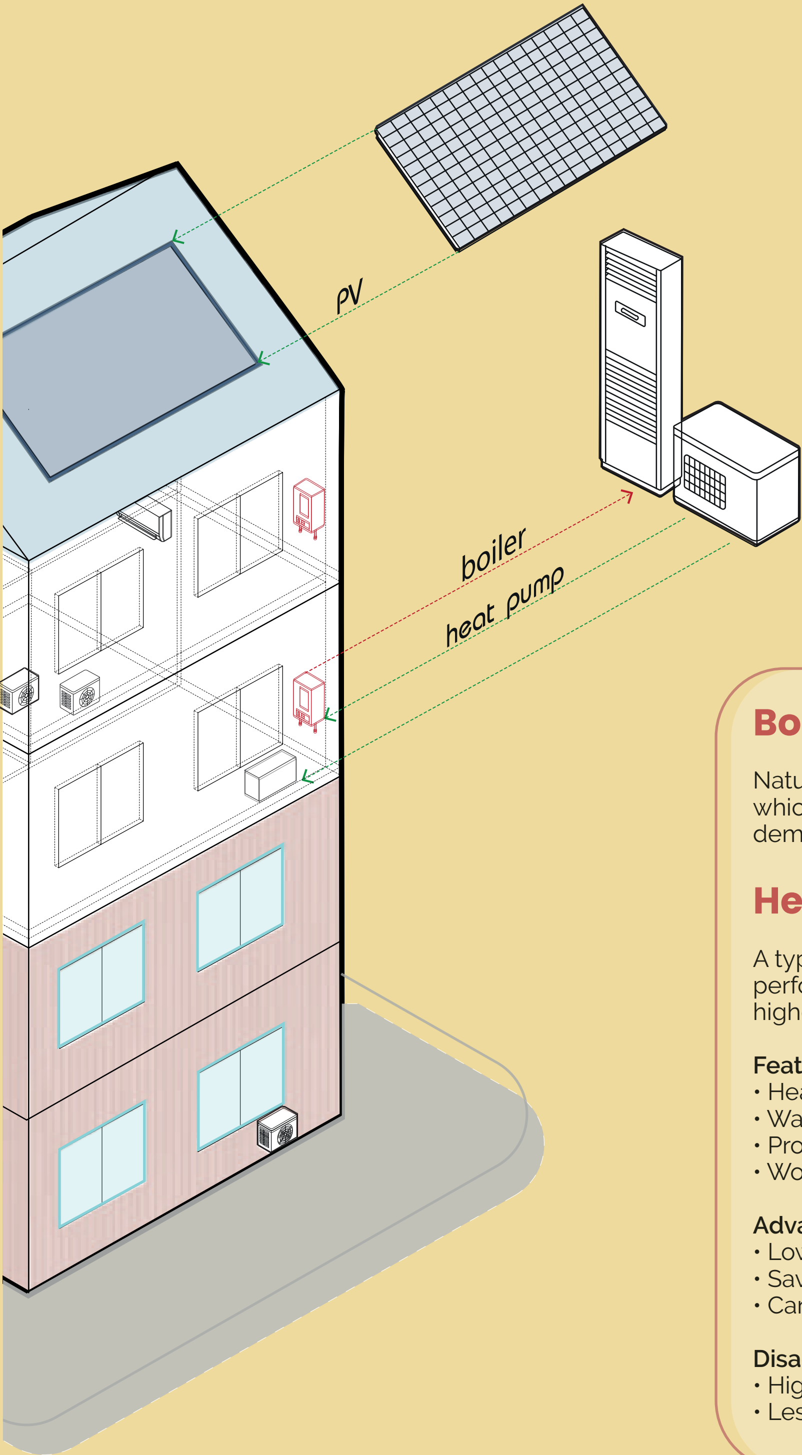
Insulation

Insulation reduces heat transfer between indoor and outdoor environments. It helps maintain stable indoor temperatures by limiting heat loss in winter and heat gain in summer.

Features:
- Installed to the building envelope (walls, roofs, floors)
- Enhances thermal comfort
- Reduces heating and cooling energy demand

Advantages:
- Improves energy efficiency
- Lowers utility bills
- Reduces carbon emissions

Disadvantages:
- Initial cost may be high for deep retrofits
- It deteriorates over time



PV Panel

Photovoltaic (PV) panels generate electricity by converting solar radiation into direct current (DC) through the photovoltaic effect. They produce no greenhouse gas emissions during use, and require minimal maintenance over their lifespan.

Features:
• Electricity generation (rooftop systems, BIPV)
• High-efficiency cell technology
• Compatible with MPPT-supported inverters
• Long lifespan (25+ years)

Advantages:
• Carbon-neutral energy production

Disadvantages:
• Dependent on sunlight duration for production

Boiler

Natural Gas is burned inside the boiler to heat water, which is then stored in the tank or water is heated on demand and sent directly wherever it's needed.

Heat Pump

A typical domestic heat pump has a coefficient of performance (COP) that its energy output is four times higher than the electrical energy required to operate it.

Features:
• Heating and hot water in homes
• Wall-mounted or outdoor unit
• Provides 3–4 units of heat per unit of electricity
• Works well with low-temperature systems

Advantages:
• Low carbon emissions
• Saves energy and reduces bills
• Can run on renewable electricity

Disadvantages:
• Higher installation cost
• Less efficient in very cold weather

3.4 Emission Calculations

How we estimate CO_2 emissions ?

Emission calculations are performed to assess the environmental impact of each energy efficiency and renewable energy scenario over time. Annual CO_2 emissions are estimated by combining energy consumption values with the relevant emission factors for electricity and natural gas.

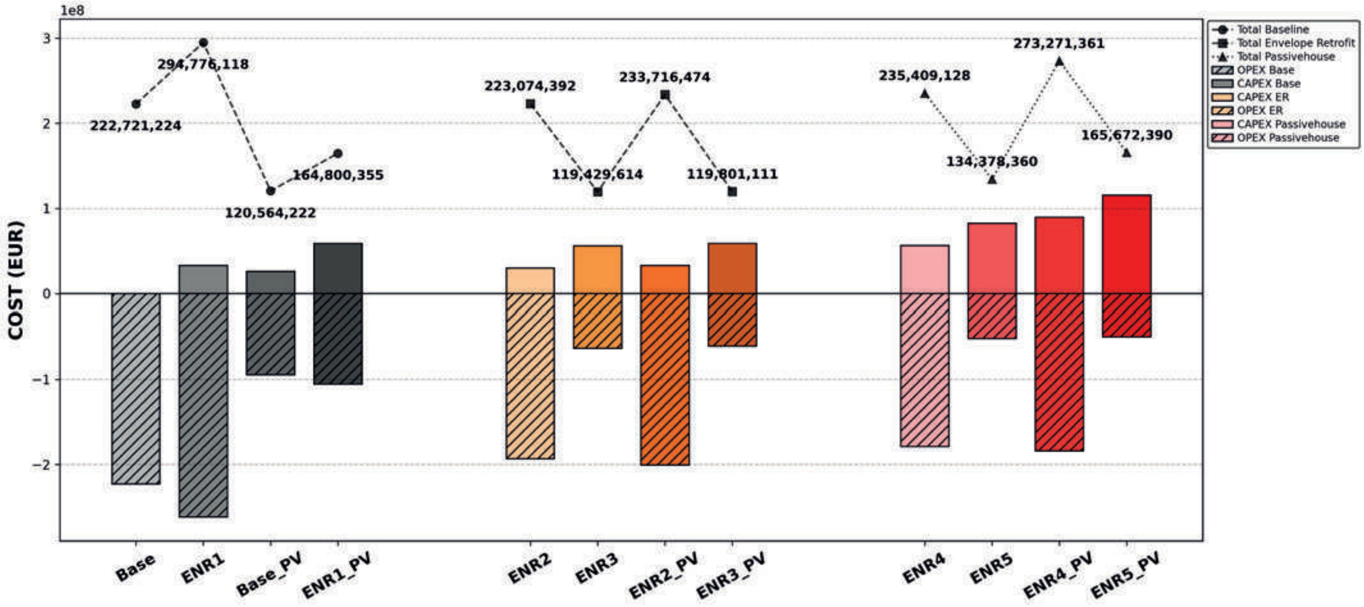
For natural gas, a fixed emission factor of 0.202 kg CO_2/kWh is applied, in line with standardized values provided by international authorities such as the IPCC and DEFRA. This factor is based on an average energy content of 10.55 kWh per cubic metre and reflects the typical combustion characteristics of natural gas.

Emissions are calculated by multiplying the annual energy consumption (electricity or gas) by the corresponding emission factor for each year. This methodology provides a consistent and transparent framework for quantifying the environmental benefits of different retrofit and system upgrade strategies, allowing reliable comparison across scenarios and time horizons. All emission factor values and underlying assumptions are documented based on publicly available, scientifically recognised sources.

20 Oitheblog. "asdasDSCF6023.jpg," background image, https://oitheblog.com/wp-content/uploads/2017/02/asdasDSCF6023.jpg.

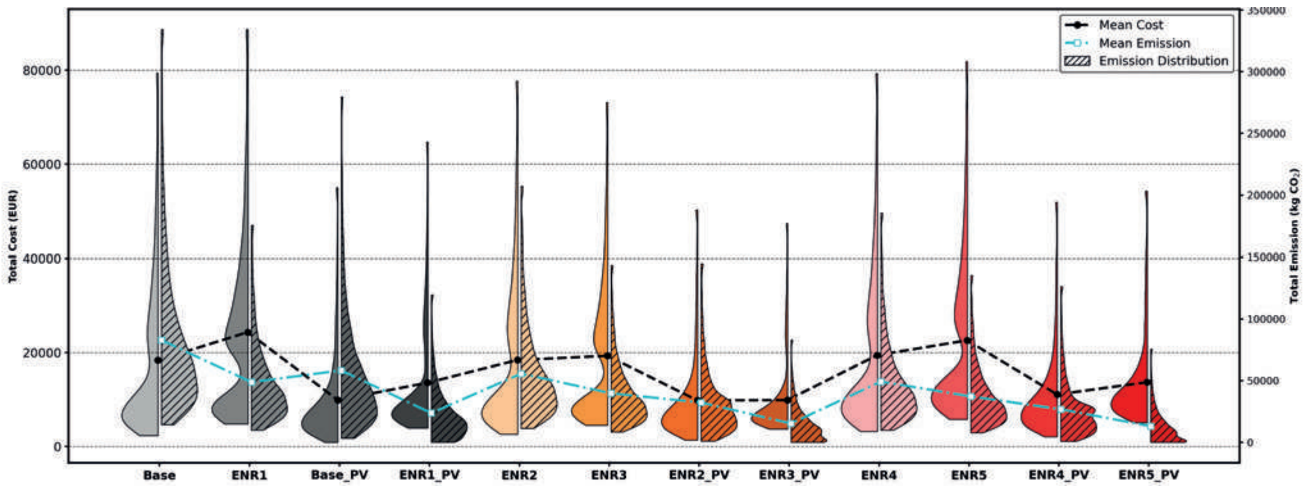
4. Techno-economic results

Scenario Based Costs: CAPEX, OPEX and Total Costs (EUR)



The graph compares **capital and operating costs** across the baseline and a series of envelope-upgrade scenarios, with and without photovoltaic integration. In the base case, there is no CAPEX with the highest operating expenses, while adding a heat pump (ENR1) drives both CAPEX and OPEX above baseline levels. Envelope retrofit (ENR2) requires only moderate capital cost yet begins to lower operating expenses, and combining that retrofit with a heat pump (ENR3) achieves the most efficient mid-tier balance between investment and savings. Passivehouse interventions (ENR4/ENR5) deliver the higher operational cost reductions but demand the largest capital commitment, and photovoltaic integration consistently shows higher OPEX savings across all scenarios—making PV especially compelling when sufficient capital is available. Ultimately, mid-level envelope measures (ENR2/ENR3) offer the strongest cost–benefit profile, whereas only photovoltaics and heat-pump deployments become economically viable primarily under limited budgets ; without strong commitment to lowering carbon emissions.

Total Cost and Emission by Scenario



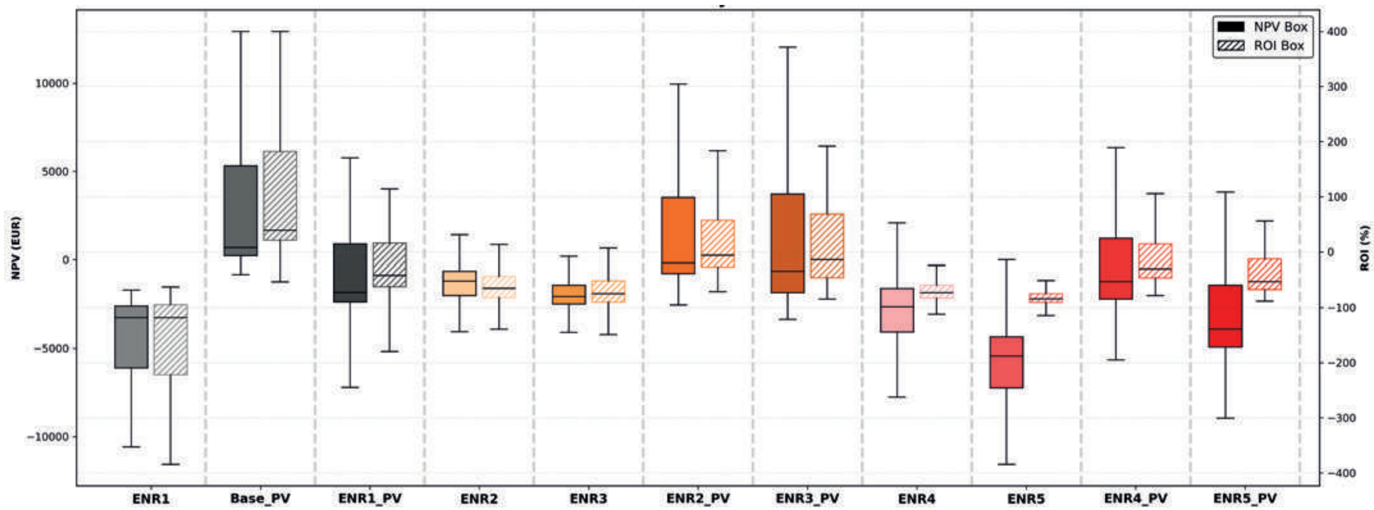
The graph overlays total-cost and CO_2-emission distributions for all twelve scenarios, showing how each interventionshifts both investment costs and environmental impact. Under the Base case, average cost is moderate (around €18 000 per building) but emissions are highest and widely accumulated nearly 300 tCO_2. Introducing a heat pump (ENR1) pushes mean cost up(to ~€25 000) while cutting emissions by roughly one-third.

Adding PV (ENR1_PV) reverses much of the cost increase and lowering emissions again, yielding a tighter, lower-emission profile. Envelope retrofits further compress emission spreads—with ENR3 centering around 50 tCO_2—at only a modest incremental cost. Their PV variants (ENR2_PV/ENR3_PV) deliver the lowest combined profiles, clustering cost near €10 000–15 000 and emissions beneath 30 tCO_2. Passivehouse renovations (ENR4/ENR5) drive emissions toward zero for many buildings but at the highest cost levels; coupling them with PV (ENR4_PV/ENR5_PV) contains cost growth to mid-range values while locking in near-zero emissions. Overall, the optimum spot emerges at the ENR3_PV scenario which balances the lowest emissions with restrained capital and operating expenses.

NPV and ROI by Scenario

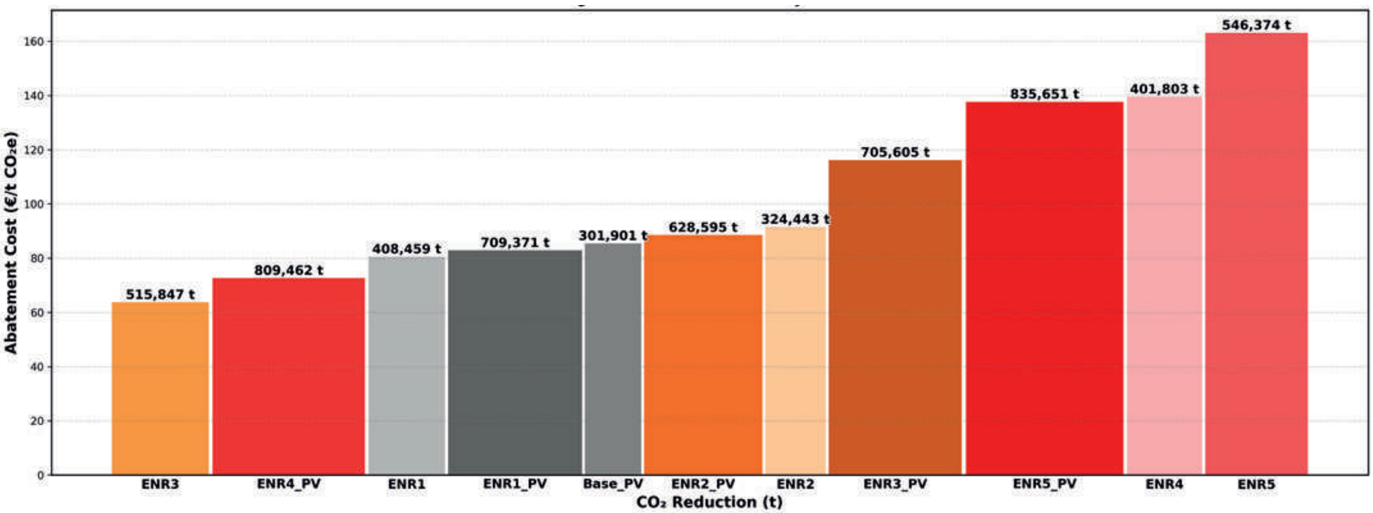
This graph presents box-and-whisker distributions of net present value (NPV) and return on investment (ROI) for all energy renovation scenarios. Without photovoltaics, none of the retrofit scenarios achieve a positive median NPV or ROI—adding a heat pump (ENR1) or performing envelope and heat pump upgrades alone (ENR2/ENR3) actually worsens the economical aspects.

Once Photovoltaics is introduced, however, two optimum scenarios emerge: the Base_PV and ENR2_PV scenarios both shift firmly into positive, with median NPVs above zero and ROIs in the 20–80 % range. ENR3_PV approaches near break-even, while the Passivehouse based scenarios (ENR4/ENR5) remain financially unattractive even with PV support. In short, modest retrofits paired with solar—particularly the Base_PV and ENR2_PV options offer the most compelling economic returns.

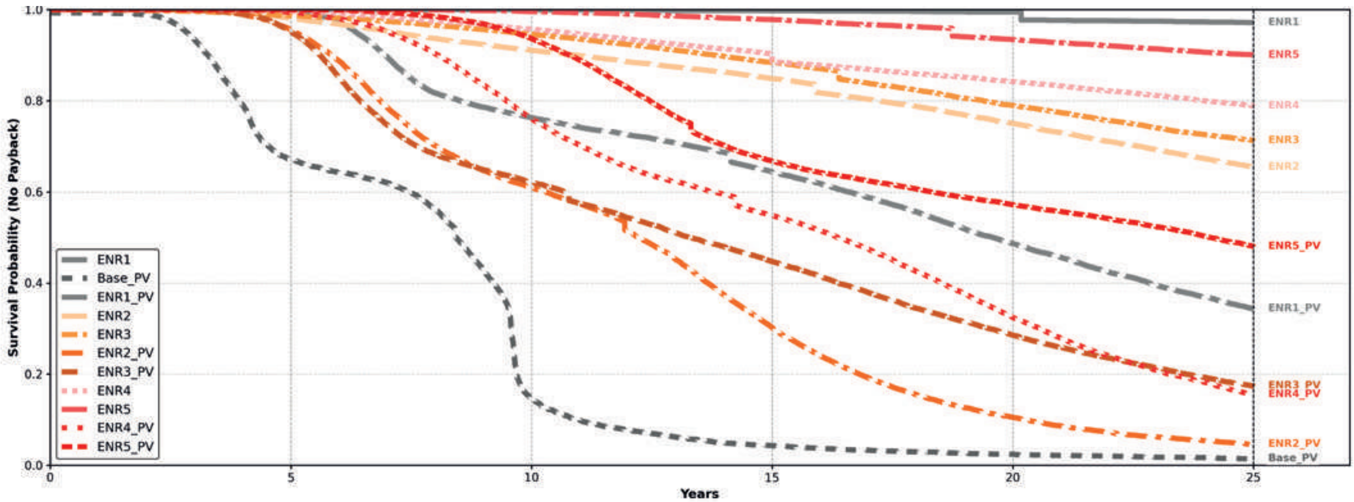


Marginal Abatement Cost Curve by Scenario

This graph plots each scenario's marginal abatement cost—measured in €/tCO_2e—against its total carbon reduction potential. The envelope retrofit with heat-pump (ENR3) emerges as the most cost-effective option, at roughly €65 per tonne for about 516 kt of savings. Integrating PV into that package (ENR3_PV) boosts total reduction to ~706 kt but raises unit cost to ≈€116/t. Baseline + PV (Base_PV) and the ENR1 variants fall in the €80–€85/t range for 300–700 kt abated, while a modest envelope-only upgrade (ENR2) and its PV counterpart sit around €90/t for roughly 324 kt and 629 kt, respectively. Passivehouse measures command the highest costs—ENR4 at ~€140/t for 402 kt and ENR5 at €138/t. In sum, mid-tier retrofits deliver the lowest abatement prices, whereas Passivehouse solutions only justify their higher unit costs if maximizing absolute carbon reduction is the primary objective.

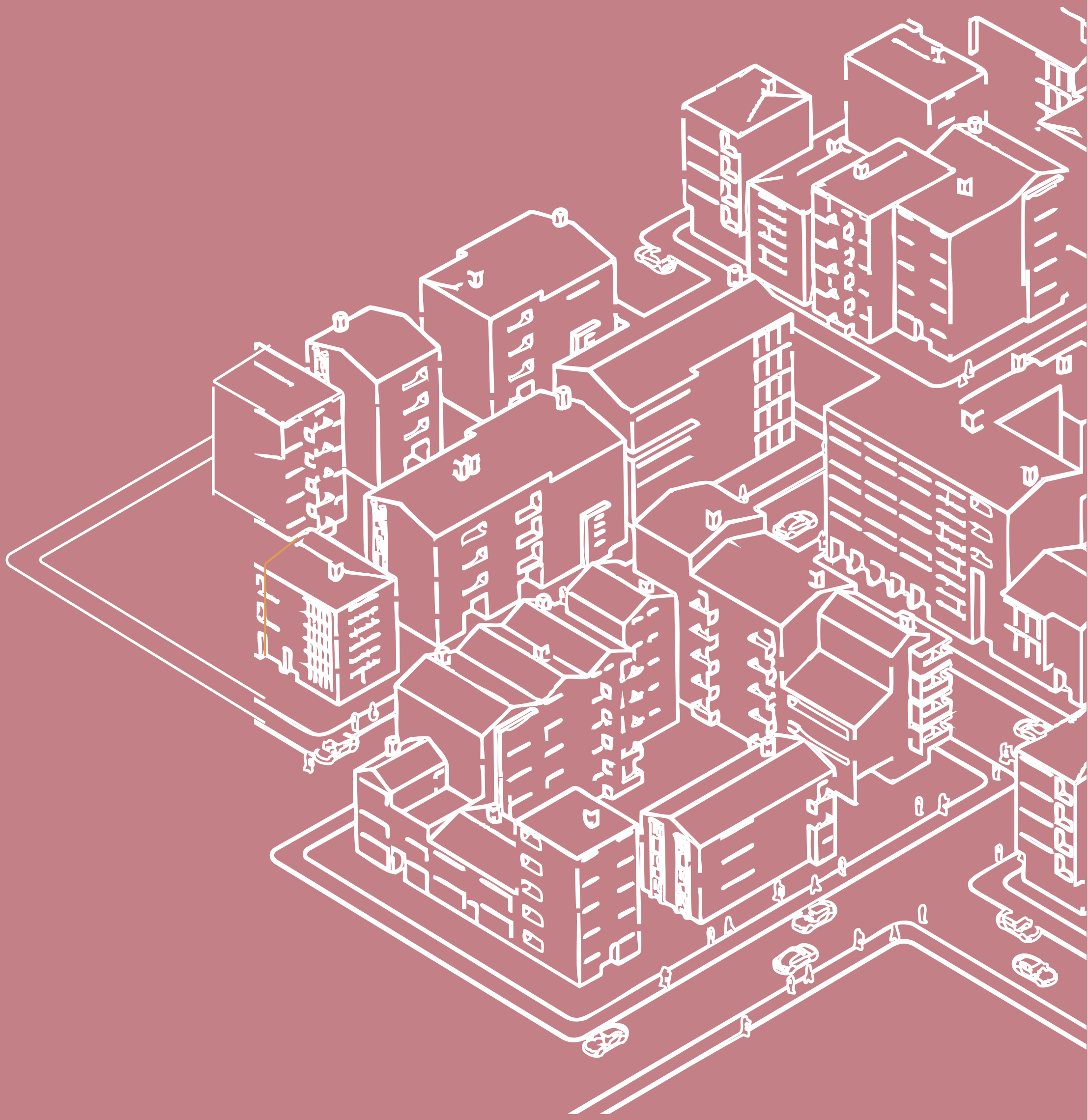


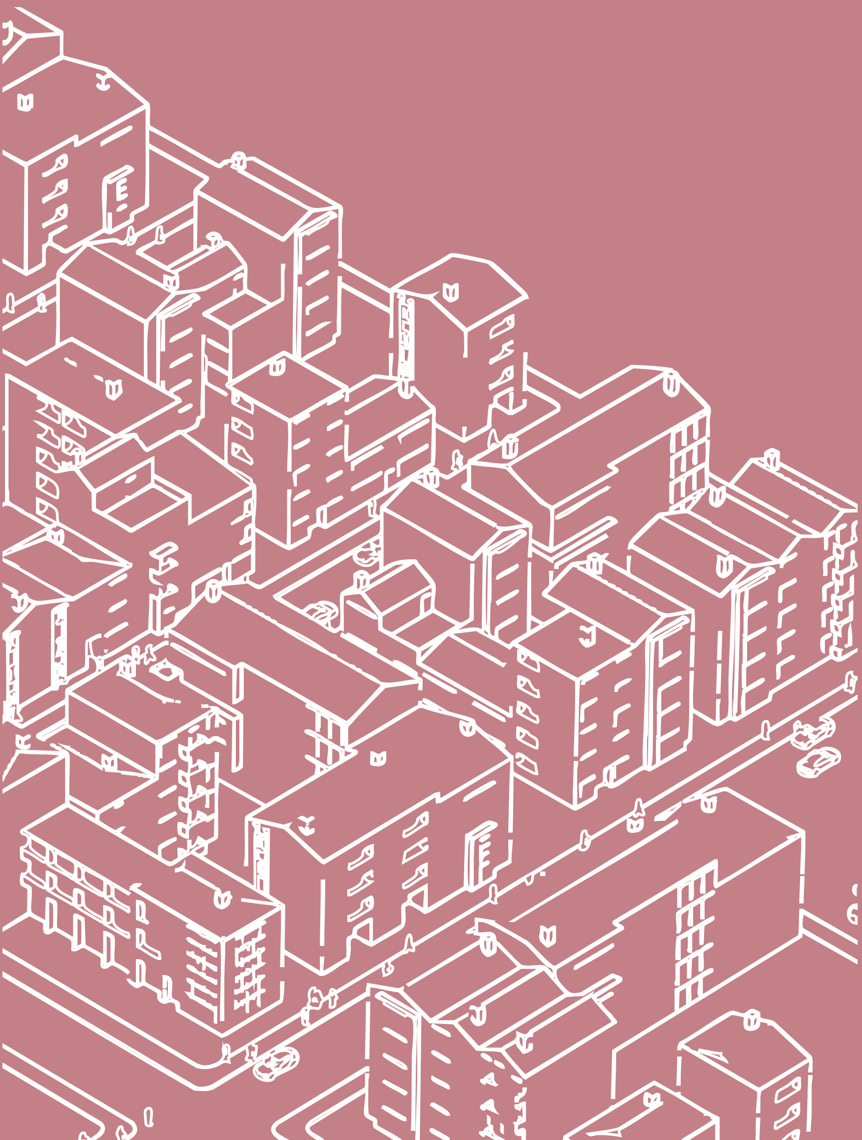
Payback Survival Curves by Scenario



The payback-survival curves plot the fraction of buildings that have not yet recouped their upfront investment over a 25-year horizon. Photovoltaic integration dramatically accelerates payback: the Base_PV curve reaches below 50 % around year 9, followed by ENR1_PV and ENR2_PV, which cross the median payback threshold near years 10–12. Envelope retrofits scenarios without PV (ENR2/ENR3) exhibit more gradual declines—only half of projects break even by years 15–17—while their PV-added versions(ENR3_PV) reduces several years off this timeline. Only heat-pump retrofits (ENR1) and standalone envelope upgrades (ENR2/ENR3) show even slower capital recovery. At the Passivehouse scenarios (ENR4/ENR5) maintain survival probabilities above 0.8 well past two decades, reflecting very long payback periods; adding PV (ENR4_PV/ENR5_PV) steepens their curves but still follows mid-level payback periods. Overall, modest envelope and PV pairings deliver the fastest payback, whereas extensive Passivehouse investments require extended timelines to break even.

AI-BASED MODELS



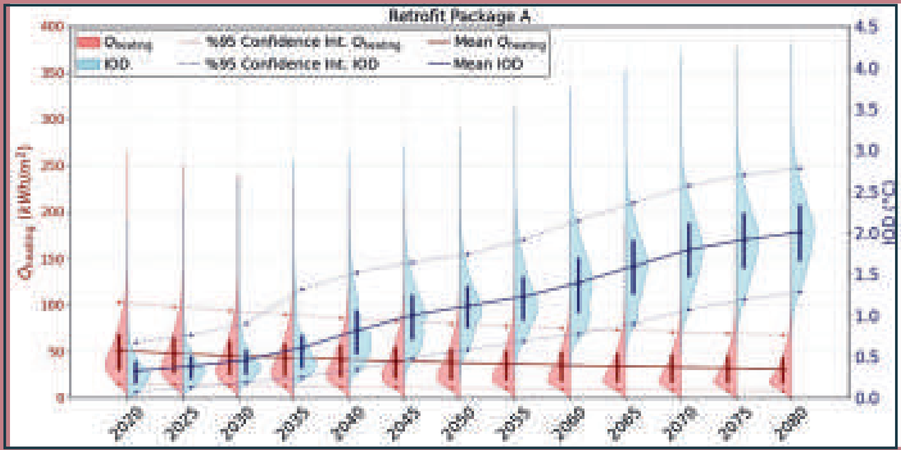


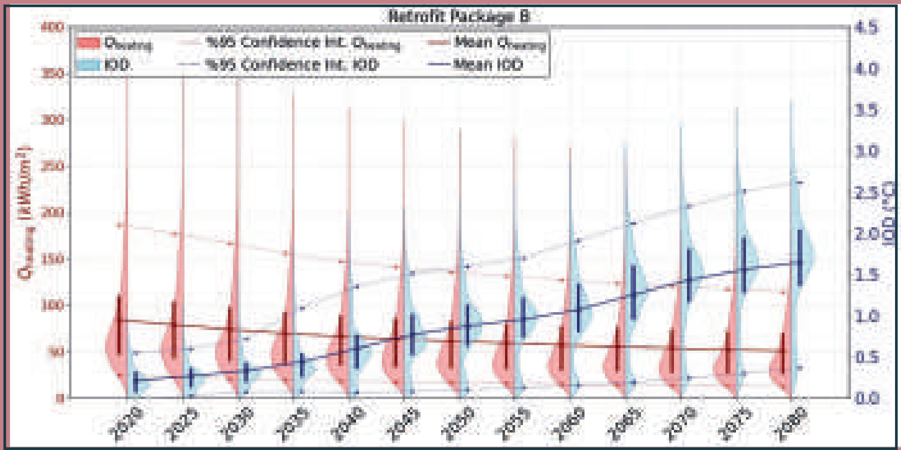
Artificial intelligence (AI) contributes to energy management in buildings and urban systems by supporting data-driven decisions that improve efficiency and sustainability. AI can analyze consumption patterns and occupant behavior within buildings to help forecast and adjust heating and cooling. At the urban scale, AI helps optimize energy distribution networks through smart grid technologies.

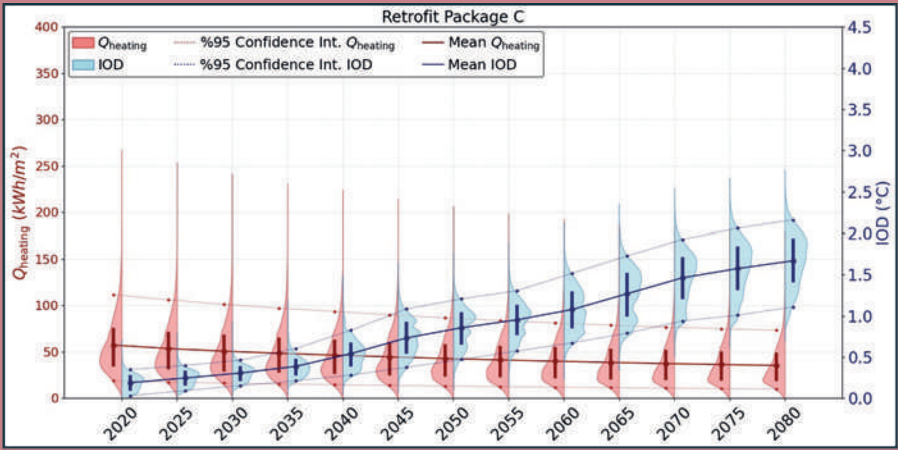
Machine learning (ML) plays an essential role in enhancing the speed, and scalability of building performance assessments, especially in the context of long-term climate change impacts. Traditional simulation-based tools, while accurate, are often computationally intensive and limited to discrete scenarios. One key advantage of ML is its ability to uncover hidden patterns in complex datasets where multiple input variables interact non-linearly. In the domain of urban building energy modeling (UBEM), inputs such as building geometry, thermal properties of envelope materials, occupancy patterns, and climate variables are all interrelated. ML models trained on such data can generalize performance outcomes even for unseen years or retrofit strategies, supporting long-term planning and climate adaptation studies. Ultimately, ML contributes not only to the acceleration of building energy assessments, but also supports large-scale and long-term decision-making for sustainable urban planning and climate adaptation.

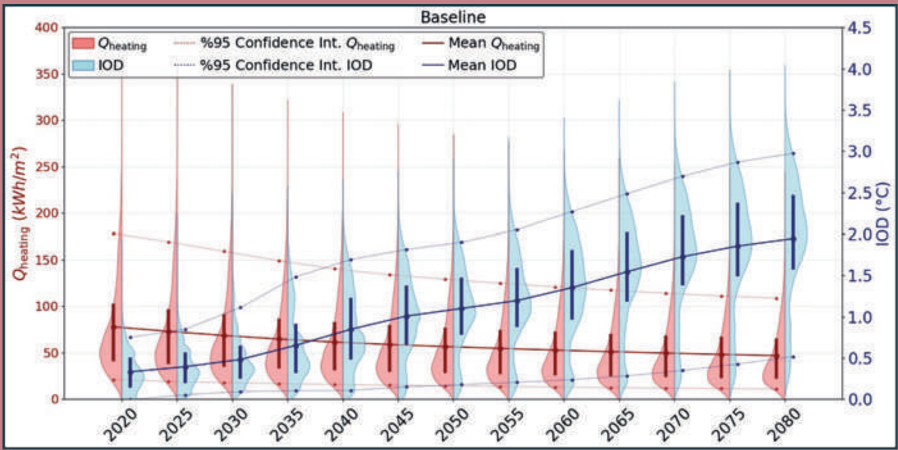
Among various ML algorithms, Multi-Layer Perceptrons (MLPs) are often utilized for prediction of building energy consumption, the evaluation of different retrofit strategies and long-term predictions. MLPs are a form of artificial neural network known for their ability to approximate any continuous function, making them highly suitable for regression problems involving building energy use and thermal comfort. They can model complex, nonlinear relationships between multiple inputs and outputs.

Here, the ML model is trained to support long-term prediction of building energy consumption and indoor thermal discomfort under climate change scenarios. Hybrid UBEM-based ML models are trained to predict key performance indicators: annual heating energy consumption (Qheating) , cooling energy consumption (Qcooling), indoor overheating degree (IOD) for residential and office zones using current weather and future weather files.









The ML models are developed using a high-resolution, zone-level UBEM of a residential district in Kadıköy, İstanbul. This model includes detailed geometric, envelope, and occupancy-related parameters, and utilizes future weather files generated with morphing techniques based on IPCC climate scenarios. A large dataset is created through EnergyPlus simulations, which is then used to train MLPs These models can approximate heating and overheating outcomes with high accuracy (R^2 ≈ 0.98 for Qheating and ≈ 0.96 for IOD), while being over 400 times faster than full simulations.

The trained ML models are also used to evaluate the long-term impact of three retrofit strategies (envelope improvement, solar heat gain reduction, and a combined package) across multiple climate years. Results indicate a consistent decrease in heating demand and a notable increase in overheating, especially under extreme climate scenarios. Overall, the ML-based framework enables fast, and robust prediction of building performance at the urban scale, offering a promising decision-support tool for energy planning and climate resilience.


E-SCOOTER

1. Data Analysis

The methodology for optimizing the placement of EV charging stations is fundamentally data-driven in the unique mobility and energy landscape of Kadıköy. Two primary sources of geospatial data was utilized. The first and most critical dataset consists of extensive e-scooter trip records from 2022. The analysis focused on the end-points of these trips, as they provide a highly detailed, real-world proxy for parking demand across the district. This dataset reveals not just where people go, but also shows the thousands of locations they choose to park, creating a comprehensive map of mobility demand. However, raw data points alone are insufficient to identify strategic locations.By performing a spatial density analysis which allowed to identify "hotspots", areas with a high concentration of parked scooters shown in the next figure. Each transparent dot represents a single parking location, and the resulting darker, more intense colors clearly indicate the neighborhoods and street segments with the highest parking frequency. This density map serves as a crucial input, guiding the placement of charging stations toward areas of proven demand. The second dataset incorporates a forward-looking, sustainable energy perspective. The buildings across Kadıköy that includes their geographic coordinates and estimated photovoltaic (PV) potential. were surveyed and their locations where charging stations can be located with significant sources of clean, renewable energy were identified.

By synthesizing these two distinct datasets, one representing current user demand and the other mapping future energy opportunities, an a rich, multi-layered understanding of the urban environment were created which were used for the foundation for the optimization algorithms.

Parking Locations of E-scooters in Kadıkoy

2. Optimization Model

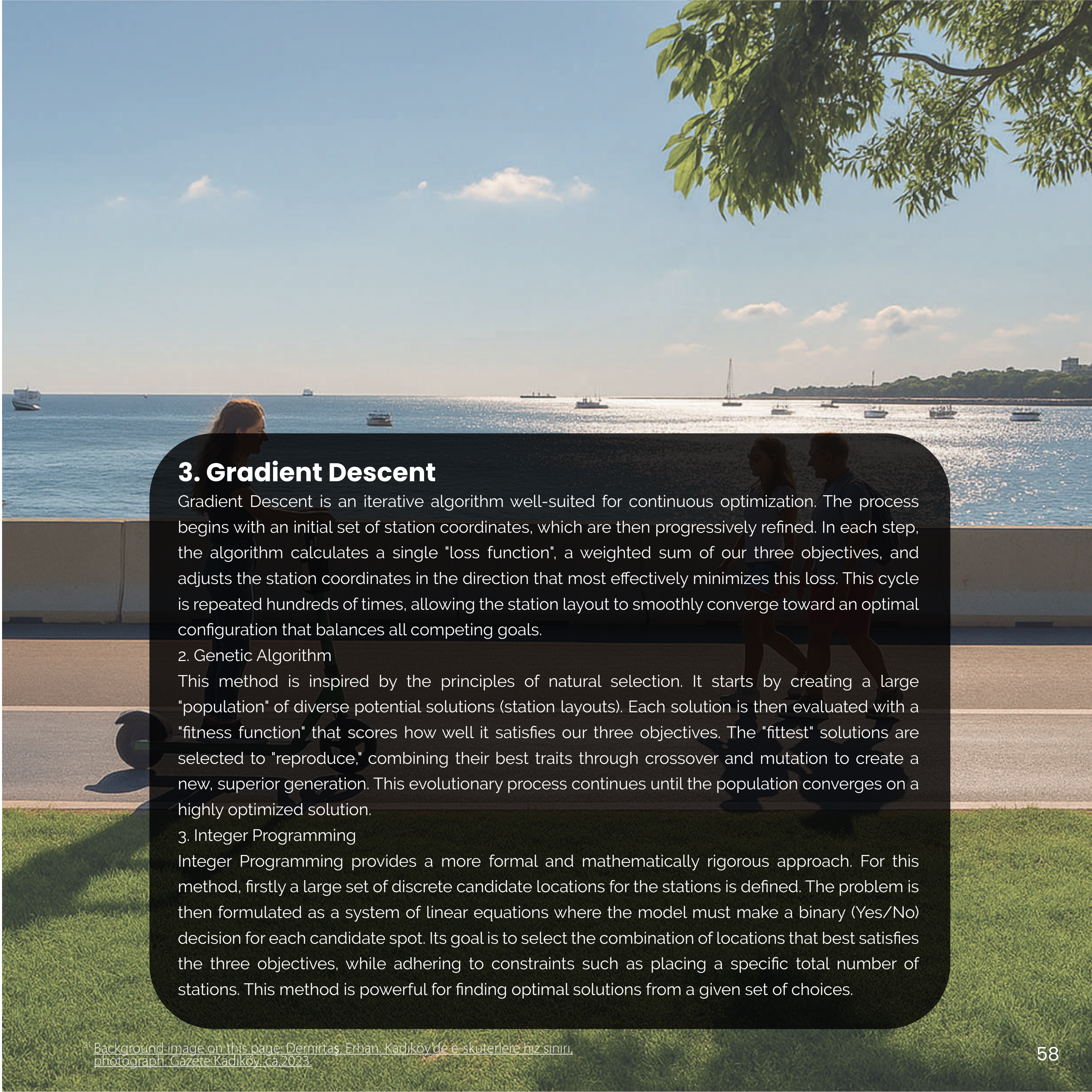
To determine the most effective charging station locations in which stations areconvenient for users, well-distributed across the district, and aligned with renewable energy sources, three distinct and powerful optimization techniques were used: **Gradient Descent, Genetic Algorithm, and Integer Programming.**

Optimization process is guided by three fundamental objectives:

Minimize Proximity to Parking Demand: The primary goal is to place charging stations as close as possible to areas with high parking density. The model penalizes solutions where stations are far from these parking spaces. This objective's influence is weighted by the parking density, ensuring that more popular parking areas are close to charging stations.

Maximize Distance between Stations: To avoid clustering and ensure broad coverage across Kadıköy, this objective pushes stations away from each other. The model rewards solutions where the minimum distance between any two stations is larger.

Minimize Proximity to PV Potential: To promote sustainability, the third objective is to locate stations near buildings with high potential for solar power generation. The distance to these buildings is weighted by their energy generation capacity, making buildings that can produce more solar energy more attractive locations.



3. Gradient Descent

Gradient Descent is an iterative algorithm well-suited for continuous optimization. The process begins with an initial set of station coordinates, which are then progressively refined. In each step, the algorithm calculates a single "loss function", a weighted sum of our three objectives, and adjusts the station coordinates in the direction that most effectively minimizes this loss. This cycle is repeated hundreds of times, allowing the station layout to smoothly converge toward an optimal configuration that balances all competing goals.

2. Genetic Algorithm

This method is inspired by the principles of natural selection. It starts by creating a large "population" of diverse potential solutions (station layouts). Each solution is then evaluated with a "fitness function" that scores how well it satisfies our three objectives. The "fittest" solutions are selected to "reproduce," combining their best traits through crossover and mutation to create a new, superior generation. This evolutionary process continues until the population converges on a highly optimized solution.

3. Integer Programming

Integer Programming provides a more formal and mathematically rigorous approach. For this method, firstly a large set of discrete candidate locations for the stations is defined. The problem is then formulated as a system of linear equations where the model must make a binary (Yes/No) decision for each candidate spot. Its goal is to select the combination of locations that best satisfies the three objectives, while adhering to constraints such as placing a specific total number of stations. This method is powerful for finding optimal solutions from a given set of choices.

[21] Background image on this page: Demirtaş, Erhan. Kadıköy'de e-skuterlere hız sınırı, photograph. Gazete Kadıköy, ca.2023.

UBEM / UBTEM :

AI-POWERED
DECISION MAKING TOOL
FOR DECARBONIZATION

UBEM/UBTEM :
AI-POWERED DECISION MAKING TOOL FOR DECARBONIZATION

• User-friendly
• Intuitive interface
• Various decision-makers
• Analyze heating/cooling energy use and indoor thermal comfort

Real Data

• Open-source data repositories

• Municipality records

• Continuous long-term predictions (years 2025 to 2050)

• Future global warming scenarios

• CO_2 intensity of the electricity grid

- Accurately predicts key performance indicators:

i. Energy use

ii. Occupant thermal comfort

* Economic performance metrics
(roi, abatement cost, net present value, cash flow,etc.)

• Rapidly estimates the impact of different energy renovation scenarios

• Assesses their implications across various future years

• Enables informed decision-making for planners and stakeholders

1. Urban Building Energy Models (UBEM)

• A data-driven decision-support tool designed to facilitate the decarbonization of cities

• Provides advanced modeling, simulation, and AI/ML-based predictive analytics for evaluating building energy performance

• High-resolution building-level energy demand modeling at the urban scale and GIS-based visualization

• Enables comprehensive assessment of the building stock under various renovation strategies and projected climate change impacts through different scenarios

Scenarios

(i) Forecasts energy demand for 2025 and 2050, under climate change scenarios

(ii) Supports active/passive renovation strategies to reduce energy consumption

(iii) Helps create Positive Energy Districts (PEDs) by integrating renewables

(iv) Assesses Indoor Overheating Degree (IOD) for thermal comfort evaluation

2. Urban Building Transport Energy Models (UBTEM)

• Supports decision-making for the optimal placement of e-mobility charging stations. Based on :

(i) previous data on parking locations

(ii) potential PV electricity generation

• Focuses on urban transport systems - *e-mobility-*

• Helps find the optimal locations of charging stations using different algorithms

• Helps decarbonizing e-vehicles

Algorithms

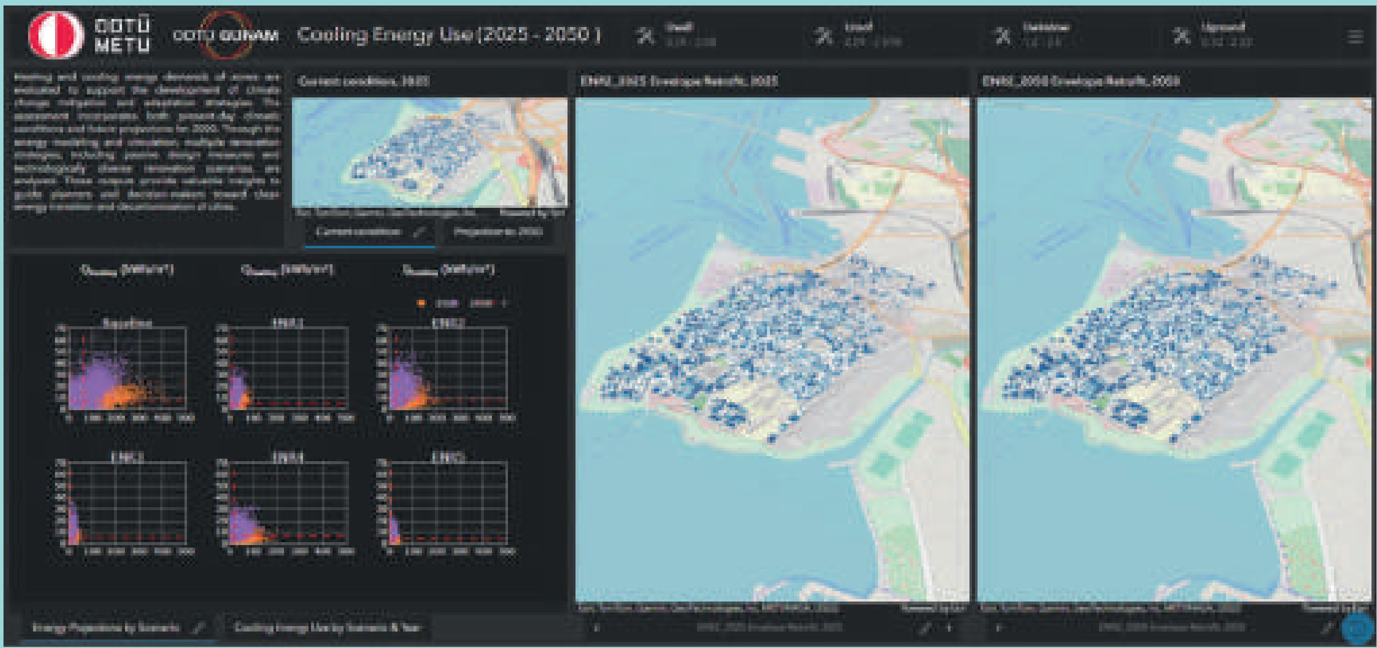
(i) maximizing the distance between charging stations

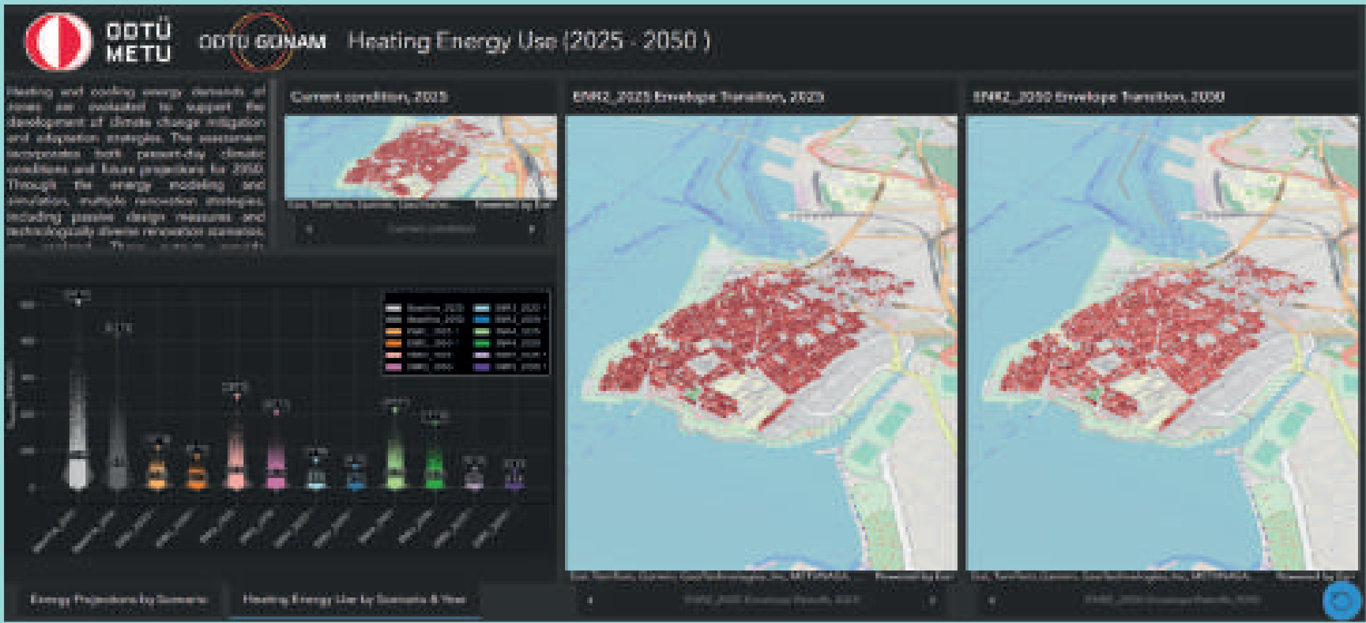
(ii) minimizing the difference between parking spots and charging points

(iii) placing stations close to areas with high PV potential

3. Tool Development Process

This project was initiated to address a critical need: providing municipal officers and contractors with a sophisticated tool for analyzing multi-objective metrics related to energy renovations. The primary objective was to visually articulate how strategic investments in passive solutions could contribute to long-term climate change impact. The project involved simulating various energy renovation scenarios, encompassing combinations of ***heat pumps, photovoltaic systems, advanced envelope renovation technologies, and PassivHaus strategies.*** Each simulated scenario provided information about potential emission reductions, cost efficiencies, and enhancements in occupant comfort through the stabilization of overheating degrees.





The development of the tool progressed through several distinct phases:

i. Five different energy renovation scenarios were designed
ii. Each supported by extensive simulations of energy consumption, overall effectiveness, and associated costs
iii. Highly detailed 3D model of the selected urban district was created using point cloud and existing municipality data
iv. Pairing the scenario datasets with the corresponding physical units within ArcGIS Pro
v. Publishing the 3D scenarios as web-accessible scenes and interactive dashboards via ArcGIS Online

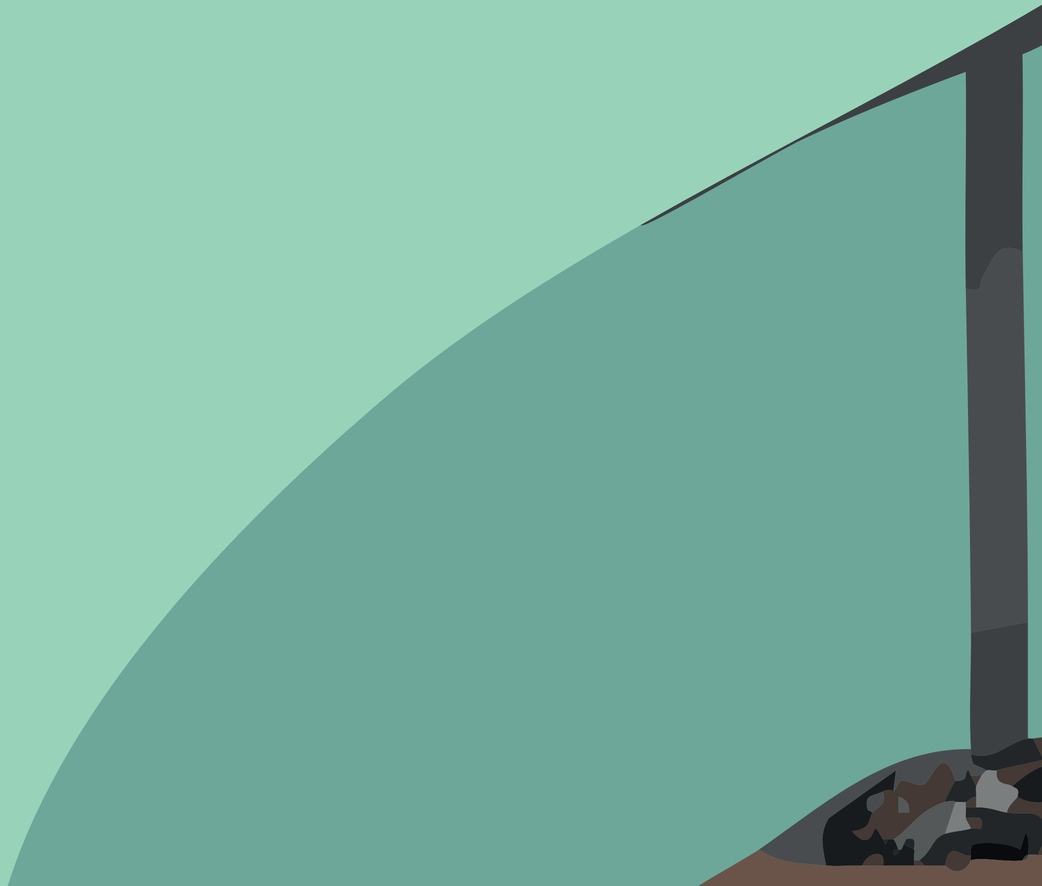
The comprehensive web tool stands as a pivotal resource, designed to aid urban planning by raising awareness and enabling experts, officers, and third-party stakeholders to compare the effectiveness and investment implications of diverse energy renovation scenarios, fostering a more sustainable future for our communities.

ArcGIS

[22] Esri, "ArcGIS," logo, https://www.arcgis.com/index.html.

[23] Esri, "ArcGIS Pro Overview," logo, https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview.

PV-INTEGRATED URBAN FURNITURE



Presents a novel approach to urban furniture design by integrating PV technology with public infrastructure to address challenges related to energy, sustainability, and social engagement The proposed solution blends design aesthetics with renewable energy production and public interaction, aligning with climate resilience goals and smart city strategies.

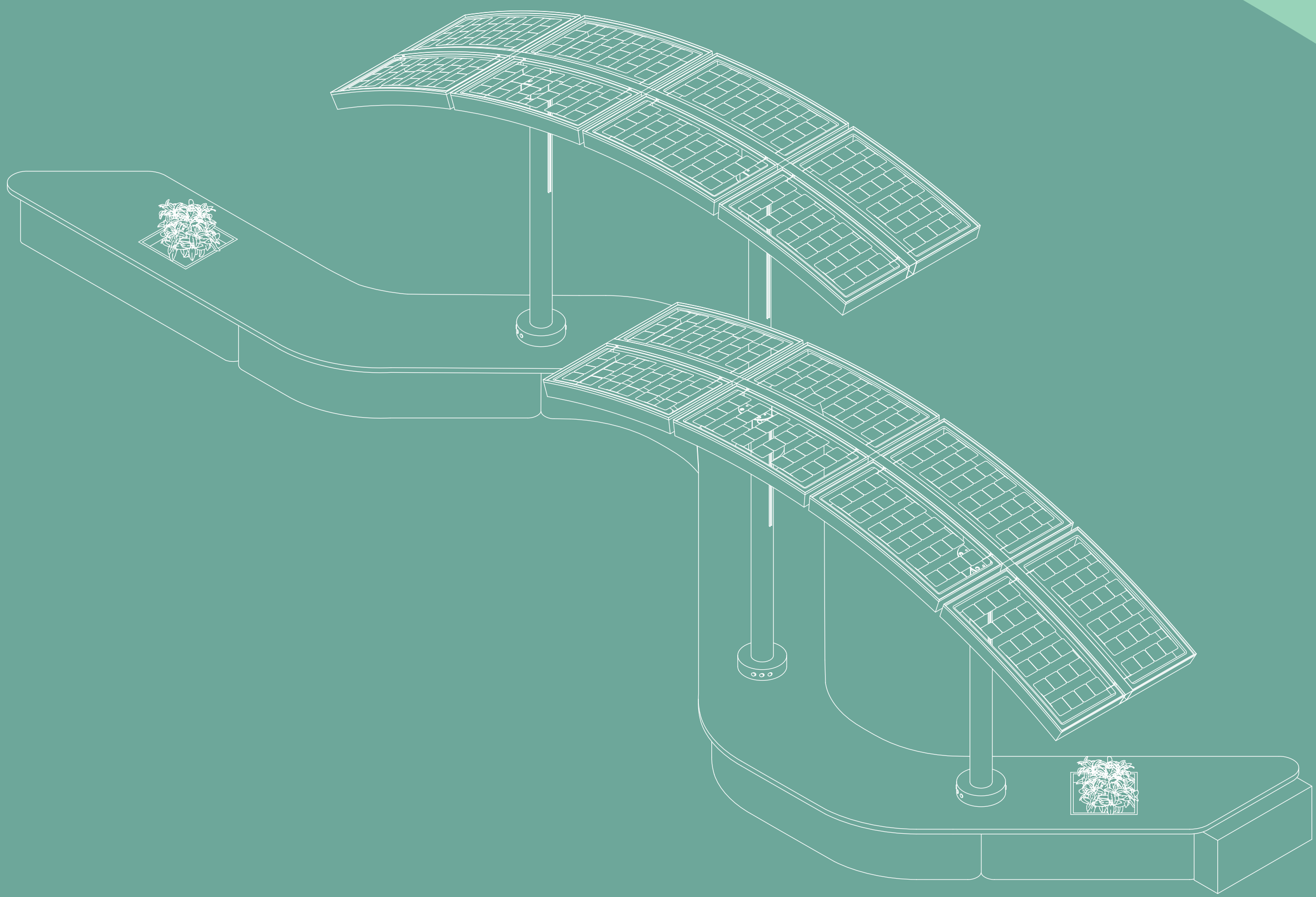
1. Objectives of Urban Furniture

By generating approximately 1.6 MWh of solar electricity per unit annually, the PV-integrated urban furniture substantially advances urban sustainability by reducing CO_2 emissions and dependency on fossil fuels. Its modular configuration enhances the functionality and accessibility of public spaces by incorporating durable seating, high-efficiency LED illumination, and USB charging interfaces to support extended use. Furthermore, each installation serves as a didactic platform for experiential learning on photovoltaic technology, climate mitigation, and the energy transition. Finally, the infrastructure underpins community-driven energy initiatives through structured workshops, targeted pop-up events, and participatory monitoring programs, thereby cultivating elevated energy literacy and civic engagement.

2. Design and Technical Overview

2.1. Design Features

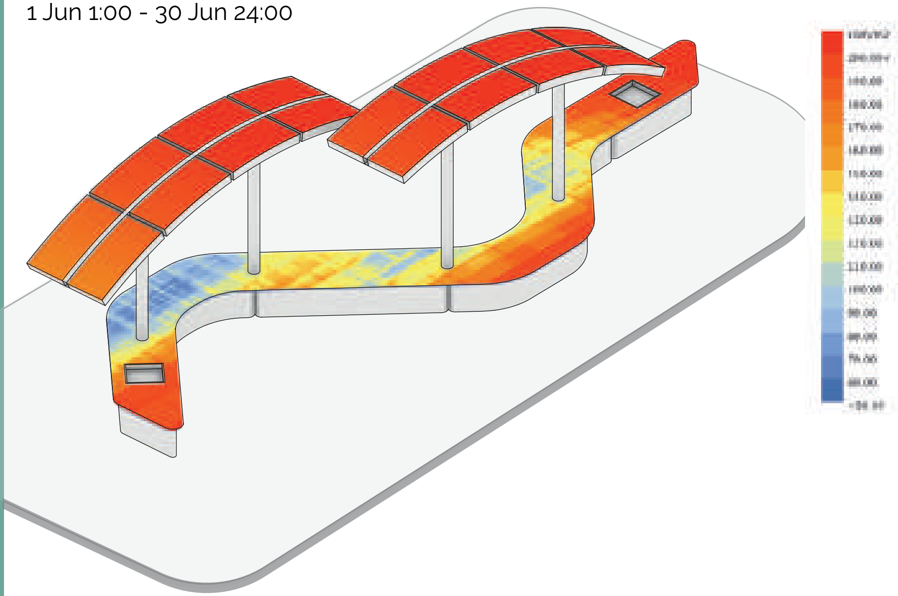
The furniture incorporates a clean, modular aesthetic with ergonomics suitable for all users. Materials include corrosion-resistant steel, laminated safety glass, and a 3D concrete bank suitable for outdoor use with a long lifespan and minimal maintenance.



2.2. Total Radiation Analysis

In April, the total radiation is 849 kWh, while in July it reaches 1330 kWh. In the figure it is showed that increased exposure to radiation, remains compatible with the overall project objectives due to its alignment with primary decision criteria.

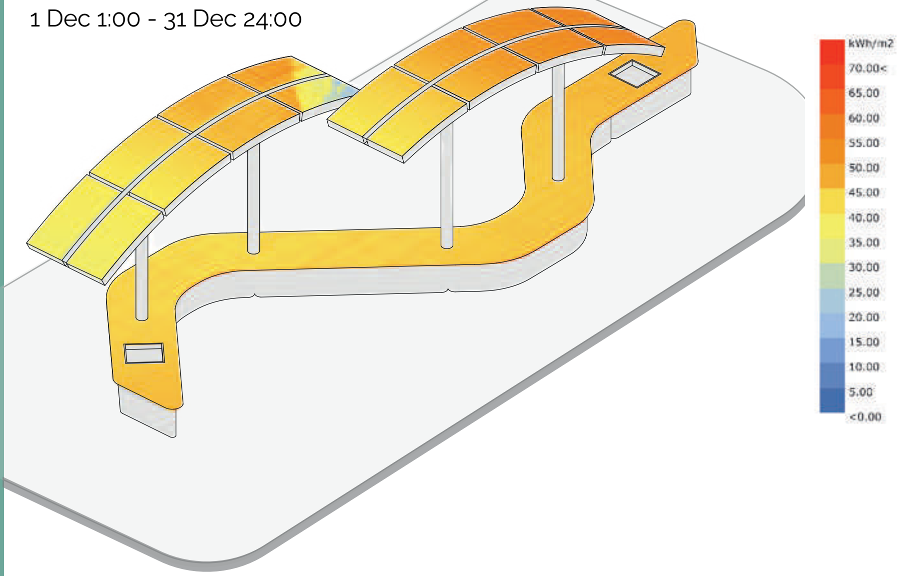
Radiation Analysis
Sabiha_Gokcen_Intl_AP_IB_TUR_2019
1 Jun 1:00 - 30 Jun 24:00



2.3. Solar Adjusted Radiant Temperature

The analysis compares conditions with and without the PV panel roof between May and September. Without shading, the human body is exposed to direct sunlight, while the PV roof provides protection, significantly reducing solar-adjusted radiant temperature. This type of analysis helps assess thermal comfort in outdoor spaces.

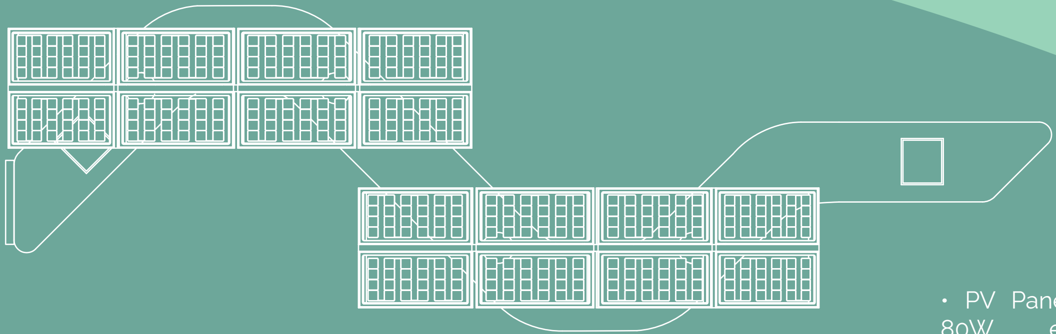
Radiation Analysis
Sabiha_Gokcen_Intl_AP_IB_TUR_2019
1 Dec 1:00 - 31 Dec 24:00



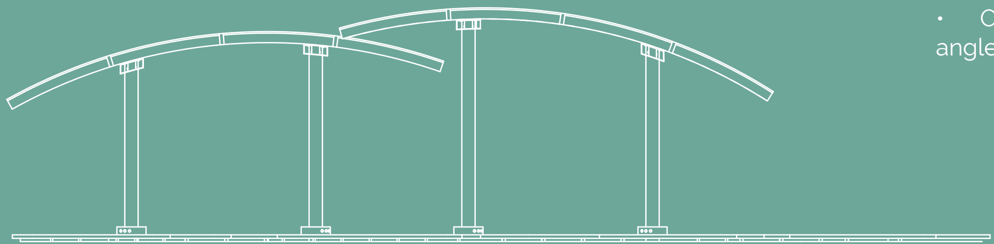
2.4. Applicability

The 3D-printed concrete structure is supported by steel elements carrying a PV panel roof made of 10 identical, double-curved panels. The central axis divides the roof, but the lack of mirrored elements creates small gaps between panels.

3. PV Integration



TOP VIEW



FRONT ELEVATION

- PV Panel Dimensions: 60x135 cm, 80W each, frameless and semi-transparent
- Total Area: 14 m²
- Total Power: 1280W
- Expected Output: Approx. 1,600 kWh/year based on Istanbul conditions
- Orientation: South-facing, 25° tilt angle

4.Manufacturing Stages

4.1. Smart Components

The furniture is optionally equipped with:

- USB charging ports powered by PV
- LED lighting
- MPPT tracking, temperature, and irradiance sensors
- IoT connectivity using low-energy transmission (LoRa or NB-IoT)
- Energy storage

4.2. Sustainability and Environmental Impact

The urban furniture helps reduce carbon emissions, eliminates the need for fossil-based energy in public services, and fosters clean energy literacy. The design emphasizes:

- Use of recycled and recyclable materials
- Durability exceeding 25 years
- Estimated annual CO_2 savings of 700 kg per unit

WORKSHOPS

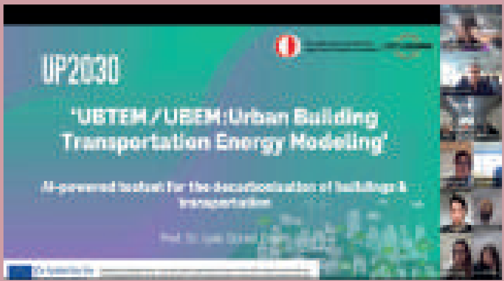
1. Needs and Barriers Workshop

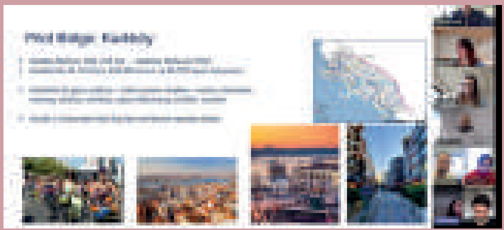
This workshop discussed the key insights from stakeholders to support Istanbul's transition toward carbon neutrality at the neighborhood level. Bringing together local authorities, citizens, experts, and businesses, the workshop identified critical barriers—such as regulatory hurdles, financial constraints, and infrastructure limitations—as well as opportunities, including urban transformation initiatives, public awareness, and international collaboration. It also outlined actionable solutions, like enhanced legislation, financial incentives, micro-mobility infrastructure, and renewable energy integration. These findings form the basis for targeted, context-sensitive strategies that foster collaboration, innovation, and sustained progress in reducing urban carbon emissions.

2. Action Workshop

The Action Workshop, at the Gazhane Museum in Istanbul, brought together stakeholders and citizens from Kadıköy to co-develop strategies supporting a climate-neutral future. Discussions focused on energy efficiency in buildings, short-term climate risks, and ways to raise public awareness of renewable energy and solar-powered urban furniture. Key proposals included rooftop solar, smart lighting, community incentives, educational campaigns, and interactive tools to promote behavioral change. Insights from the workshop directly contribute to the UP2030 roadmap by grounding pilot actions in local priorities and ensuring community-centered, visible, and sustainable urban transformation.

3. Vision Workshop





Following initial evaluations by METU, GÜNAM, and IBB, Kadıköy was selected as the UP2030 pilot area due to its rich data availability and its relevance to vulnerable groups. The project's foundation was strengthened through a vision workshop and survey, which revealed low public awareness of climate goals but a strong interest in solar energy adoption. Key gaps in stakeholder visibility and community engagement informed clear recommendations: boost awareness campaigns, incentivize renewable technologies, and clarify stakeholder roles. Building on these insights, Kadıköy's pathway toward sustainability was shaped through integrated spatial analysis, participatory visioning, and adaptive planning. Spatial assessments illuminated the interplay of land use, mobility, and environmental dynamics. The carbon neutrality vision was co-developed with stakeholders, emphasizing resilience, inclusivity, and the transition to clean energy. Actions targeting barriers such as historical constraints, energy inefficiency, and limited micro-mobility were rigorously evaluated using benchmarking criteria to avoid maladaptation. Together, these steps ensured that Kadıköy's transformation is inclusive, data-driven, and technically sound, paving the way for a resilient and carbon-neutral urban future.

4. Public Awareness Activities

Several community awareness activities were conducted, including the "Women's Ferry Event" focusing on vulnerable groups, the "Climate Officers Event," and participation in World Environment Day, where the UP2030 project was promoted through a dedicated stand and outreach by project staff wearing specially designed t-shirts. The team engaged with professionals and citizens, reaching approximately 1000+ people throughout these different activities.

With Gratitude to Our Team

The Istanbul UP2030 publication is the result of a committed group who have been working together on this project for a long time. Every page reflects the shared effort and care of everyone involved, from leadership and editors to designers.

We thank our Lab Directors, **Prof. Dr. İpek Gürsel Dino** and **Prof. Dr. Sinan Kalkan**, for their support and guidance. We also appreciate our collaborators—**Doç. Dr. Onur Taylan, Prof. Dr. Murat Göl, and Doç. Dr. Çağla Meral Akgül**—for their contributions and perspectives.

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Stakeholders

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Best regards,
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