UBEM: AI-powered Decision-making Tool for Decarbonization

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UBEM: AI-powered decision-making tool for decarbonization is an accessible, web-based decision-support tool that supports decision-making through comparative what-if scenario analyses. The tool has three key enabling technologies, including building energy models, artificial intelligence, and geographic information systems (GIS), which enables (i) the assessment of building energy renovation strategies through environmental, thermal comfort, and economic indicators while considering the impacts of climate change (2025-2050), (ii) fast and precise energy demand and generation calculations, and (iii) a user-friendly interface for decision support. The tool supports data-driven decisions for sustainable urban development by facilitating the decarbonization of buildings, integrating passive energy, active energy, and PV systems, leveraging digital technologies to promote open-access public data and social equity, strengthening resilience by assessing the upfront costs of various renovation strategies, and informing policies that align urban planning with decarbonization and the clean energy transition.

UBEM– Scenario and Key Performance Indicator (KPI) Dashboards

Heating energy use
https://metu2.maps.arcgis.com/apps/dashboards/d64283215b6f44d68dbc591a2d358f83

Cooling energy use

https://metu2.maps.arcgis.com/apps/dashboards/bf43da39ca5a416590d0af0584cd6293

Indoor Overheating Degree (IOD)

https://metu2.maps.arcgis.com/apps/dashboards/da35b319c52b45688dacb180227c1d2b

Return on Investment (ROI)

https://metu2.maps.arcgis.com/apps/dashboards/2e5cfff701b74dc6b4b63e7e7eeb5e18

CO_2 Reduction

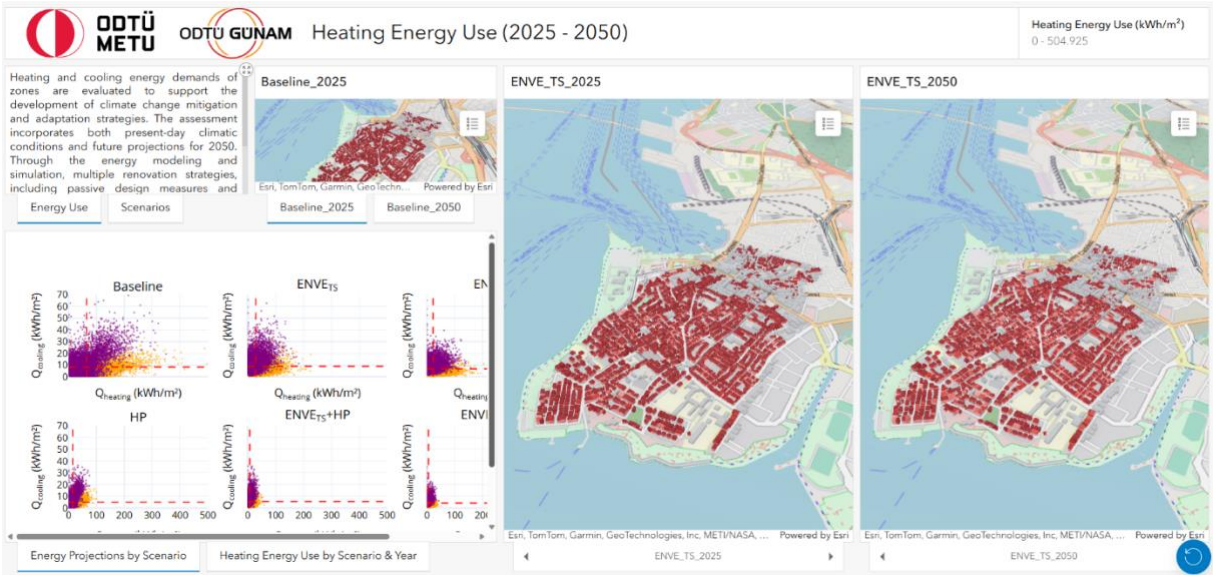
https://metu2.maps.arcgis.com/apps/dashboards/794c1f08cee24a0f84191bf503bf162e

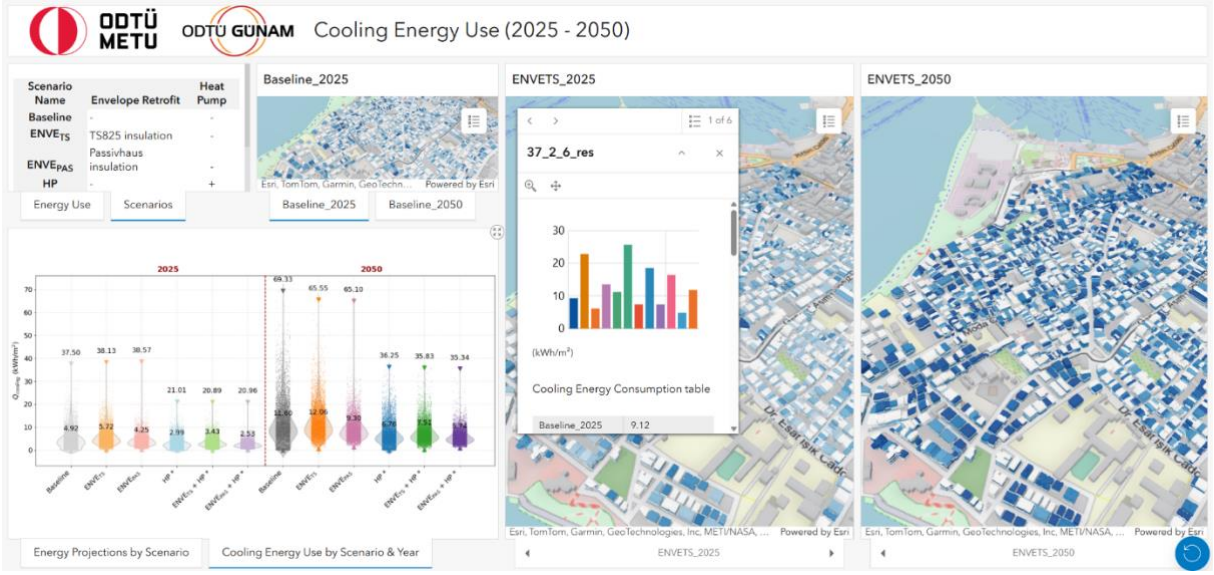
Marginal Abatement Cost

https://metu2.maps.arcgis.com/apps/dashboards/66f91ffec720404b94a906ab898ef013

PV Electricity Generation

https://metu2.maps.arcgis.com/apps/dashboards/499d8949012546939afadc5e44e01014


ODTÜ METU
ODTU GUNAM
Heating Energy Use (2025 - 2050)
Heating Energy Use (kWh/m²)
0 - 504.925
Heating and cooling energy demands of zones are evaluated to support the development of climate change mitigation and adaptation strategies. The assessment incorporates both present-day climatic conditions and future projections for 2050. Through the energy modeling and simulation, multiple renovation strategies, including passive design measures and
Baseline_2025
ENVE_TS_2025
ENVE_TS_2050
Energy Use
Scenarios
Baseline_2025
Baseline_2050
Baseline
ENVE_TS
HP
ENVE_TS+HP
Energy Projections by Scenario
Heating Energy Use by Scenario & Year
ENVE_TS_2025
ENVE_TS_2050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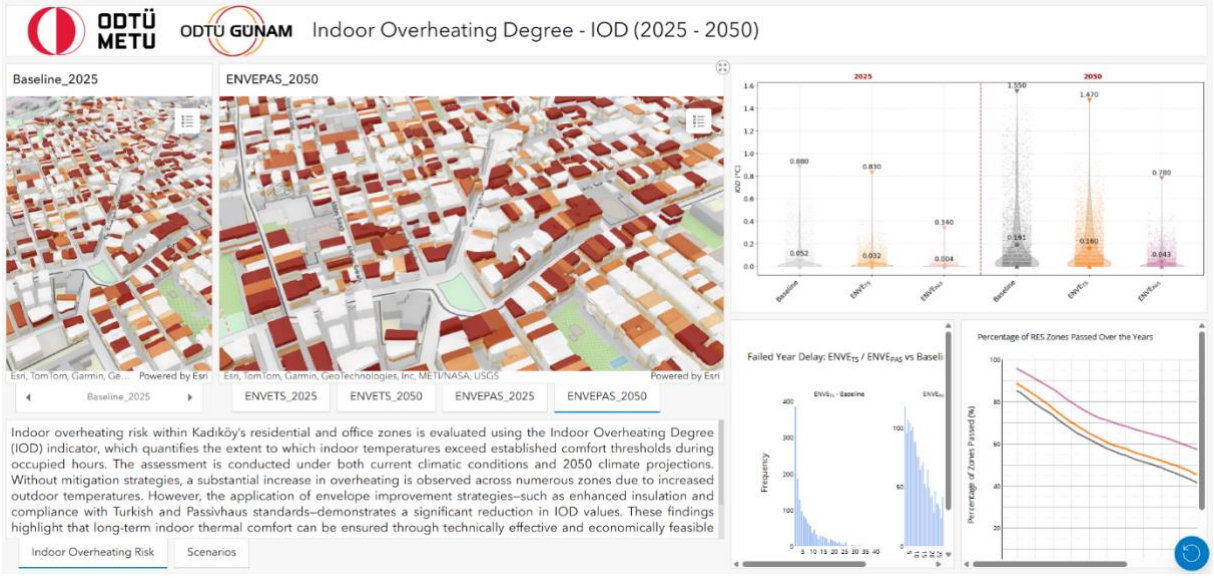
Cooling Energy Use (2025 - 2050)
Scenario Name
Envelope Retrofit
Heat Pump
Baseline
ENVE_TS
TS825 insulation
ENVE_PAS
Passivhaus insulation
HP
Baseline_2025
ENVETS_2025
ENVETS_2050
Energy Use
Scenarios
Baseline_2025
Baseline_2050
2025
2050
37_2_6_res
Cooling Energy Consumption table
Baseline_2025
9.12
Energy Projections by Scenario
Cooling Energy Use by Scenario & Year
ENVETS_2025
ENVETS_2050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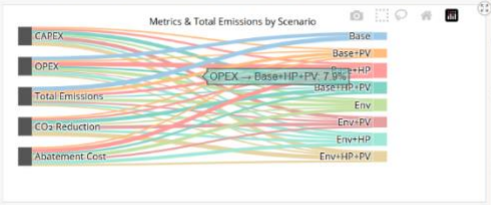
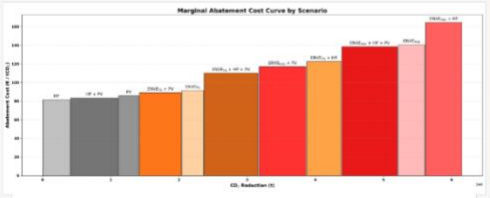
Indoor Overheating Degree - IOD (2025 - 2050)
Baseline_2025
ENVEPAS_2050
2025
2050
Failed Year Delay: ENVE_TS / ENVE_PAS vs Baseli
Percentage of RES Zones Passed Over the Years
Baseline_2025
ENVETS_2025
ENVETS_2050
ENVEPAS_2025
ENVEPAS_2050
Indoor overheating risk within Kadıköy's residential and office zones is evaluated using the Indoor Overheating Degree (IOD) indicator, which quantifies the extent to which indoor temperatures exceed established comfort thresholds during occupied hours. The assessment is conducted under both current climatic conditions and 2050 climate projections. Without mitigation strategies, a substantial increase in overheating is observed across numerous zones due to increased outdoor temperatures. However, the application of envelope improvement strategies–such as enhanced insulation and compliance with Turkish and Passivhaus standards–demonstrates a significant reduction in IOD values. These findings highlight that long-term indoor thermal comfort can be ensured through technically effective and economically feasible
Indoor Overheating Risk
Scenarios

ODTÜ METU ODTÜ GUNAM

Marginal Abatement Cost per kg CO_2

Various scenarios are compared by their marginal abatement cost per kilogram of CO2 to support the development of climate change mitigation and adaptation strategies. Comprehensive diagrams illustrate the proportional distribution of key financial and environmental metrics for each renovation scenario, including initial investment, operational costs, total emissions, CO2 reduction, and abatement cost. Each scenario's marginal





Marginal Abatement Cost per kg CO2 by Scenario

ENVE_TS

Esri, TomTom, Garmin, GeoTechnologies, Inc, METI/NASA, US... Powered by Esri

ENVE_TS

ENVE_TS + PV

Esri, TomTom, Garmin, GeoTechnologies, Inc, METI/NASA, ... Powered by Esri

ENVE_TS + PV

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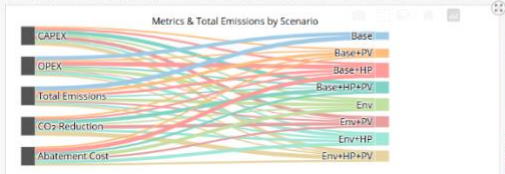
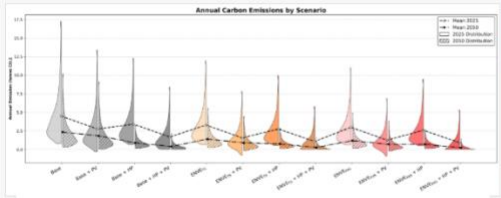
CO_2 Reduction Scenario Comparisons

CO_2 REDUCTION
0 - 426,284.213

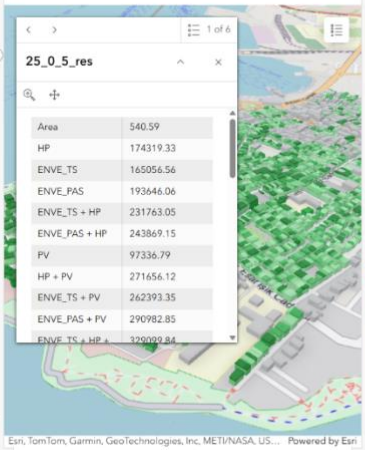
CO_2 reduction of multiple climate change mitigation and adaptation strategies is evaluated to support urban-scale decision-making. Our tool presents this analysis via a dynamic Sankey diagram, showcasing multi-objective metrics like investment and





Emissions

ENVE_TS



Esri, TomTom, Garmin, GeoTechnologies, Inc, METI/NASA, US... Powered by Esri

ENVE_TS

ENVE_TS + PV

Esri, TomTom, Garmin, GeoTechnologies, Inc, METI/NAS... Powered by Esri

ENVE_TS + PV

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Return on Investment

ENVE_TS

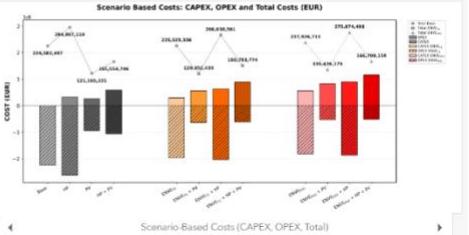
Esri, TomTom, Garmin, GeoTechnologies, Inc, METI/NA... Powered by Esri

ENVE_TS

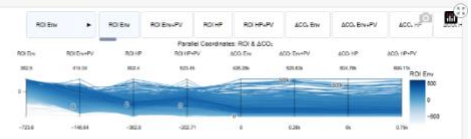
ENVE_TS + PV

Esri, TomTom, Garmin, GeoTechnologies, Inc, METI/NASA, USGS Powered by Esri

ENVE_TS + PV



Scenario-Based Costs (CAPEX, OPEX, Total)



Building on energy and comfort assessments, our tool provides a comprehensive, financial viability analysis for various building renovation scenarios at the urban scale. It features a dynamic Sankey diagram illustrating critical financial metrics like initial investment , ongoing operational costs, and projected savings across different renovation strategies. Complementing this, a detailed payback period graph plots and compares the investment recovery timeline for each scenario. These powerful visualizations offer crucial insights into long-term economic effectiveness and comparative Return on Investment (ROI) for sustainable urban solutions. The module's aim is to assist investors and decision-makers with clear, comparative economic data, guiding them to confidently identify the most financially beneficial renovation scenarios for enhanced building performance and urban scale desicion making.

Return on Investment | Scenarios | Sankey Distribution | ROI Vs CO2