Case Study Report

Rethinking Smart technologies and inclusiveness in Cities:

The case study of Eskişehir Tepebaşı Municipality in Turkey

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Abstract

Planning a smart city is an ambition that requires more than just a vision to change. Strategizing and developing action plans are the first building blocks for such a transformation. Nevertheless, ensuring effective outcomes and sustainability of the transformation calls for adopting an approach that employs smart diagnosis to support decision-making. In addition, promoting social and environmental justice as part of the transformation process cannot be achieved without mainstreaming gender sensitivity via effective public participation instruments. Strong leadership that adopts a smart approach facilitates achieving better outcomes with less resource, improving citizen satisfaction, and supporting local economic growth.
This case study report analyses how Tepebaşı Municipality, located in the city of Eskişehir, has demonstrated with its smart urban regeneration project that spanned the period of 66 months how to couple technological advancements with good urban governance to achieve smartness as well as social and environmental justice i.e. a dual approach that involves gender mainstreaming by increasing citizen's participation in decision making. Eskişehir Tepebaşı Municipality has achieved a revolution by implementing a sustainable Urban Regeneration Model by addressing one of the greatest challenges of the 21st century to transform a traditional city into a smart city. It thus has a crucial role in enabling the needed transformational change with the vision of environmental and social justice.

Keywords

Smart city, sustainable, energy, mobility, ICT, citizen-centric approach

1. Introduction: Challenges of transitioning into sustainable smart city development

Localising global goals for climate change adaptation and mitigation requires an approach that is tailored to the local context. Transitioning into a low-carbon future in cities presents major technological, economic, and social challenges including policy reform at multiple governance levels to create the framework conditions that facilitate the adoption of new innovative solutions. This requires a flexible and progressive, yet stable positive policy environment. Promoting efficiency in resource consumption, for example, in the energy and transport sectors cannot be achieved without capacitating local authorities with knowledge and tools to plan and implement effective local measures.

Local administrations face considerable challenges to develop smart cities. The development of a smart city ultimately relies on the ability to introduce the necessary changes by local administrations, which

usually lack the needed capacity. Attracting highly skilled personnel to work for local authorities is difficult since local authorities cannot offer work conditions similar to that in the private sector. Despite the incentives available at the EU regional and national levels, the lack of implementation capacity at the local level deems those incentives inapplicable due to the prevailing administrative burdens and obsolete regulations.

Furthermore, financial barriers and lack of capital are among the main obstacles to the implementation of low-carbon and renewable energy technologies in urban areas. Access to capital or the lack thereof hinders the implementation of renewable energy and energy efficiency projects that require relatively high upfront costs. In comparison, traditional technologies, despite their often considerably higher lifecycle costs, are widespread due to their low initial cost.

Another significant challenge to mainstreaming smart city planning is the lack of channels for citizen participation, which results in the lack of integration of public concerns, needs, and values in decision-making. Smart city solutions should respond to a need or a problem, therefore, imposing technology that is not proven to correspond to the citizens' needs may lead to failure. Smart city planning, for example, should take advantage of co-creation approaches that, while time-consuming, bring benefits in terms of uptake of innovative solutions and their impact.

Several approaches have been employed to overcome the challenges hindering the implementation of smart cities initiatives. The complex nature of smart urban development highlights the need of forging multifaceted and integrated Private Public Partnerships (PPP). Furthermore, assessing multilevel governance structure in cities ensures the provision of the necessary level of competences at the local level. An example of that is the Horizon 2020 Smart City projects of the future, which focuses on solving large-scale problems at the district and city level using new business models such as PPPs.

Following the previous introduction, the next section discusses the case study of Eskişehir Tepebaşı municipality in Turkey that was implemented as part of the Horizon 2020 Smart City projects of the future. With its smart urban regeneration project that spanned the period of 66 months, Tepebaşı municipality demonstrated how to couple technological advancements with good urban governance to achieve smartness as well as social and environmental justice.

2. Background and context: Transitioning into the smart city of Tepebaşı

Tepebaşı is a municipality located in Eskişehir in the mid-western side of Anatolia with a population of 335,000. Adopting an integrated approach that is complemented by ICT and smart strategies has catapulted Tepebaşı municipality to the forefront as a model for a sustainable smart city. It is one of the first municipality in Turkey to meet its specific targets for the 17 SDGs of the 2030 agenda. It is also the first municipality in Turkey to deliver its sustainable energy action plan (SEAP) interim report that demonstrated the level of excellence in seven areas. ICT and smart strategies were deployed in several action fields, which are low energy districts, sustainable mobility and integrated infrastructure, and society.

2.1 Regenerating existing cities into sustainable cities with REMOURBAN

REgeneration MOdel for accelerating the smart URBAN transformation (REMOURBAN) is a major Future Cities demonstrator project that has received funding from the European Union's Horizon 2020 research and innovation programme. This Model plays an important role regarding the local efforts in Tepebaşı to achieve the European Green Deal's goal of making Europe climate neutral by 2050.

As part of REMOURBAN, the rigorous tasks were conducted including identifying the main non-technical barriers for improving urban sustainability, addressing strategies for optimizing the regulation frameworks, and promoting innovative public procurement procedures including an intelligent combination of funding instruments and funding commitments.

REMOURBAN project involves 22 partners from 7 countries, including researchers, building manufacturers, district owners, public authorities, industrial partners, SMEs, dissemination and exploitation experts, and investors. The project's duration was 66 months with a total eligible cost of 23.8 million Euros including a contribution of 21.5 million Euros by the European Commission (EC). The investment of the REMOURBAN actions of 5 Million Euros was dedicated for the demonstration site in Tepebaşı, which was co-funded by the European Commission (79%), by the Tepebaşı Municipality (17.4%), and by the private sector (3.6%).

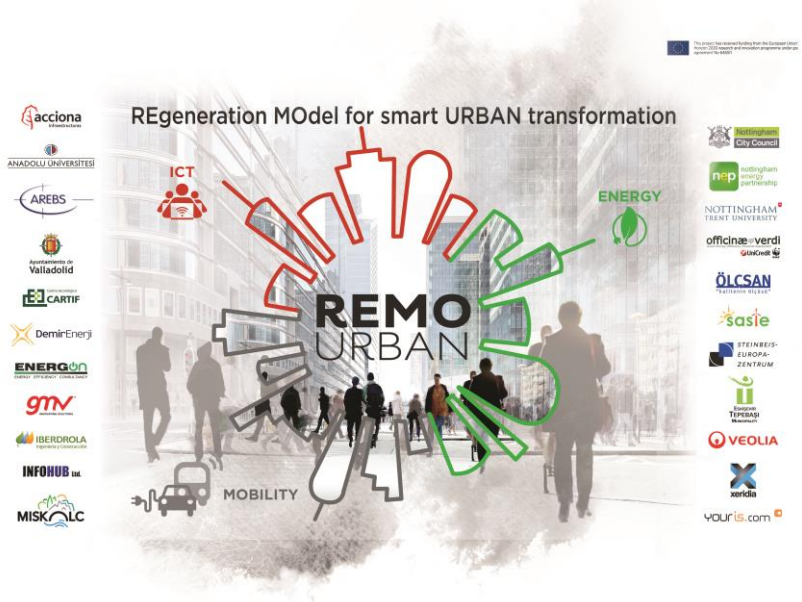

Figure 1. 22 partners from 7 countries, source: Tepebaşı Municipality

REMORUBAN consortium is composed by 5 cities, 3 research institutions, 5 large industries, and 9 SMEs. A highlight of the implemented powerful strategy is citizen engagement, which focused on replicability. REMOURBAN emphasises active citizen participation by engaging a relevant number of citizens beyond the consortium throughout the different stages of the project. This strategy helped guarantying social acceptance of the changes undertaken as part of the project's implementation, including raising awareness of the benefits resulting from the project. This strategy was the starting point for the development of a citizen engagement framework whose main objective was to have a model for citizens engagement based on innovative current practices developed by cities and stakeholders. Accordingly, citizen engagement activities were organized into a "3-level" framework and the most engaging ones were selected (figure 2).

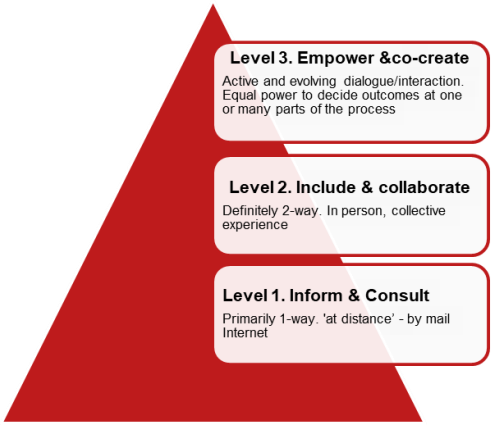

Figure 2. Citizen Engagement framework, source: Tepebaşı Municipality

2.2 Lighthouse city of Tepebaşı: Employing smart diagnosis and decision-making tools of REMOURBAN

REMOURBAN aimed at designing and validating a sustainable urban regeneration model that leverages the convergence area of the energy, mobility and ICT sectors. This Model accelerates the deployment of innovative technologies, organizational and economic solutions to significantly increase resource and energy efficiency, improve the sustainability of urban transport and drastically reduce greenhouse gas emissions in urban areas in the Lighthouse cities of Nottingham (UK), Valladolid (Spain) and Tepebaşı/Eskişehir (Turkey). Furthermore, the Model maximises the replication potential in two Follower cities, Seraing (Belgium) and Miskolc (Hungary). New interdisciplinary opportunities to make cities smarter are available in the common area where energy production, distribution and use, mobility and transport, ICT work together and are intimately linked.

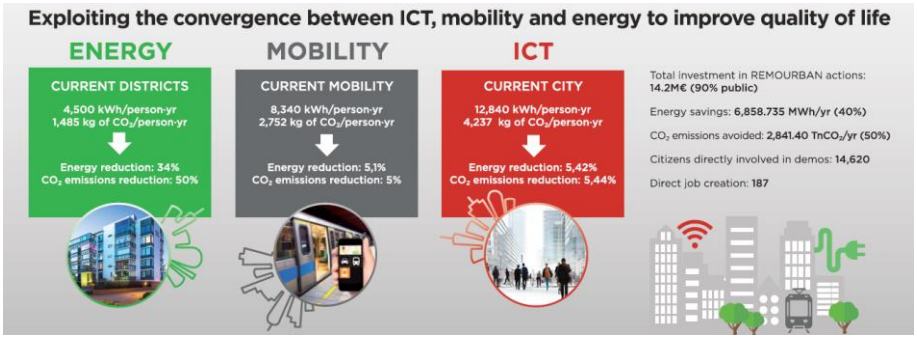

Figure 3. REMOURBAN Urban Regeneration Concept, source: Tepebaşı Municipality

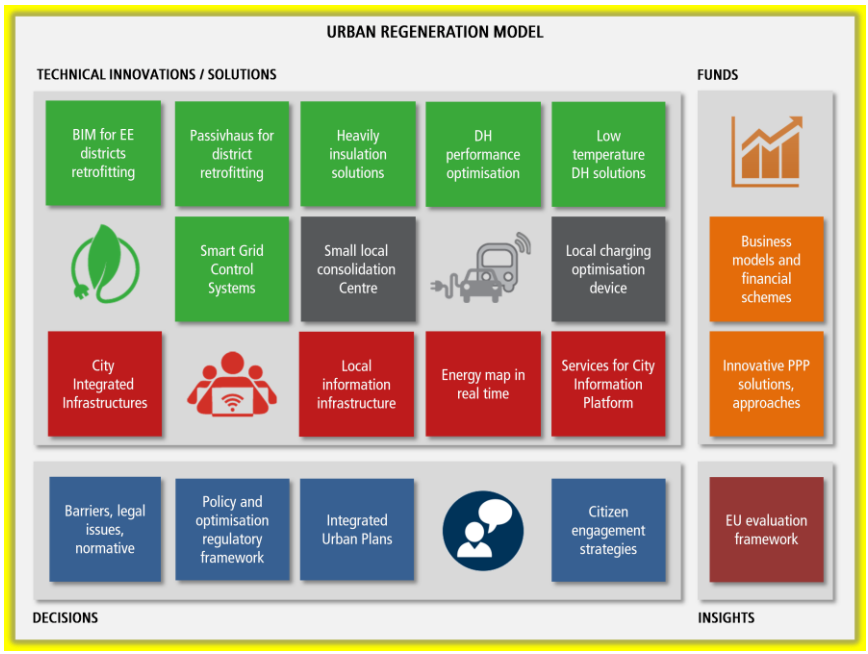

Figure 4. REMOURBAN Innovations, source: Tepebaşı Municipality

Public administrations and local governments can also benefit from capacity building on new business models for city renovation and strategies to address non-technical barriers and defining goals and objectives. To this end, public administrations and local governments are provided with integrated decision-support tools to help implement the methodology and evaluate the progress in making their cities smarter and more sustainable.

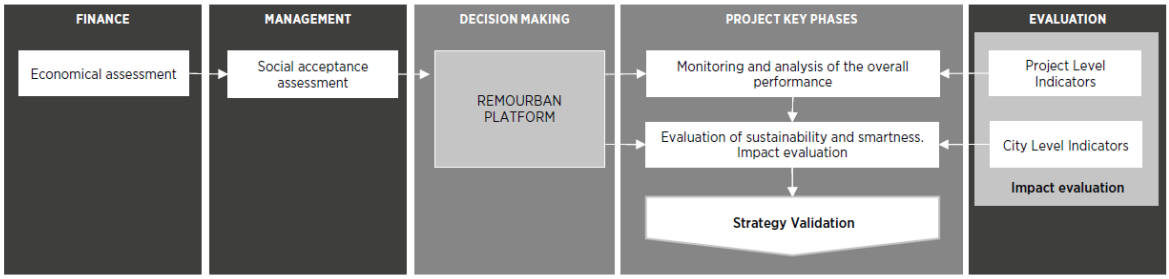

Figure 5. REMOURBAN Frameworks, source: Tepebaşı Municipality

The Urban Regeneration Model has been implemented, tested and fine-tuned in real-life conditions (figure 6). It is a 3D model consisting of four phases of the decision-making process, which are Strategy design, Actions design, Implementation plan, Assessment. The four phases encompass three key priority areas, which are Sustainable Buildings and Districts, Sustainable Urban Mobility, Integrated Infrastructures and processes as well as three key frameworks that include City Transformation Management, Evaluation, and Financing.

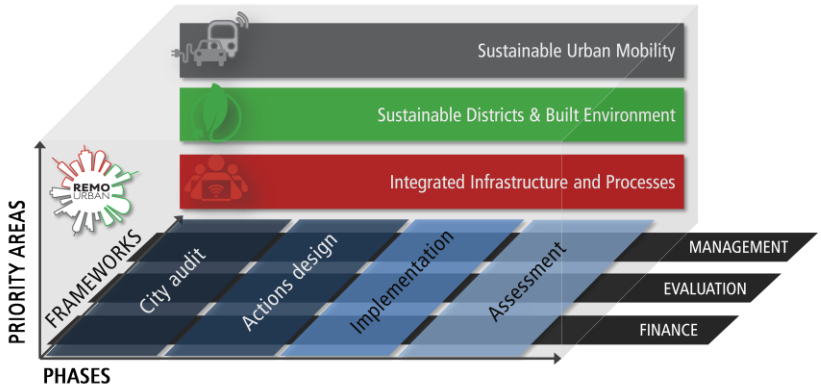

Figure 6. REMOURBAN Urban Regeneration Model, source: Tepebaşı Municipality

2.3. Life Village in Tepebaşı: Demonstrating the transformation

The establishment of the "Life village" was a fruit of articulate integration of the citizens' needs in the planning of the city. It is a district of approximately 30,000 m^2 with 57 dwellings and an overall gross floor area of 10,570 m^2. The building typology consists mainly of semi-detached villas. Despite it being relatively new construction, the district building stock is not energy efficient, similar to most buildings built before the Energy Efficiency Law that was enforced recently in Turkey.

In this respect, the retrofit intervention in the district within the framework of the REMOURBAN project is highly relevant as it created an exemplary demonstration site for hundreds of thousands of residential buildings with similar characteristics both in Eskişehir and across Turkey. This demo site presents a smart and sustainable alternative to urban development in Eskişehir with a total refurbished area of 10,570 m^2.

Life Village has been established with the aim of providing better public services to citizens. As such, the Municipality along with non-governmental organizations provides health and social services via a number of public facilities including Alzheimer Care Centers, Disabled Assembly Atelier for mentally disabled citizens, Physiotherapy and Rehabilitation Center, Nursing Home for visually impaired citizens, Art Residence, Primary School, Day Care Center, Health Care Center, Nursing Homes for healthy senior citizens, and Multiple Sclerosis (MS) Association Center.

Figure 7. Life Village in Tepebaşı, source: Tepebaşı Municipality

3. The Approach: Delivering urban transformation and renovation

As discussed previously in section 2.1, Lighthouse city Tepebaşı delivered city transformation and renovation by using smart diagnosis and decision-making tools of REMOURBAN. The following sections (3.1 -3.4) elaborate on the actions and measures implemented in Tepebaşı as part of REMOURBAN except Tepebaşı Municipality Service Building and Atatürk Aquatic Sports Center.

3.1. Energy efficient buildings and Low Energy Districts

The main service building is the first energy-efficient low-carbon building in Eskişehir. Its solar panels generate 20% of the electric energy per year with a capacity of 95 kW.

Figure 8. Tepebaşı Municipality Service Building, source: Tepebaşı Municipality

Several other public buildings followed in the transition into energy efficiency. Atatürk Aquatic Sports Center, for example, was established by Tepebaşı Municipality as the first public energy-efficient building with LEED Gold Certificate in Turkey. Solar panels generate 10% of the electric energy and 20% of the heating energy, with a total capacity of 20 kW. Other measures implemented to reduce energy consumption and carbon footprint of the building include rainwater harvesting, employing natural lighting, and greywater system that provides water for shower, washbasin waters and toilets.

Figure 9. Atatürk Aquatic Sports Center, source: Tepebaşı Municipality

Significant energy savings were achieved via building renovation of near-passive buildings in Life Village as well as the realisation of a central district heating/cooling and hot water system. For example, a significant reduction in the energy needed for heating and cooling was achieved by optimising the building envelope via effective thermal insulation.

Low carbon solutions were achieved for thermal energy supply and optimized electric facilities by means of decentralized electricity generation and smart grid management. As a result, near-zero energy and zero-emission districts were achieved. Furthermore, renewable energy sources are employed for central district heating and cooling that in turn employ air sourced heat pump and chiller. The biomass boilers allow for combining heat and power (CHP) as well as polygeneration and thermal storage. In addition, critical loads served via battery storage can be housed in the same building as the central heating plant and solar thermal collectors harness solar energy for domestic hot water.

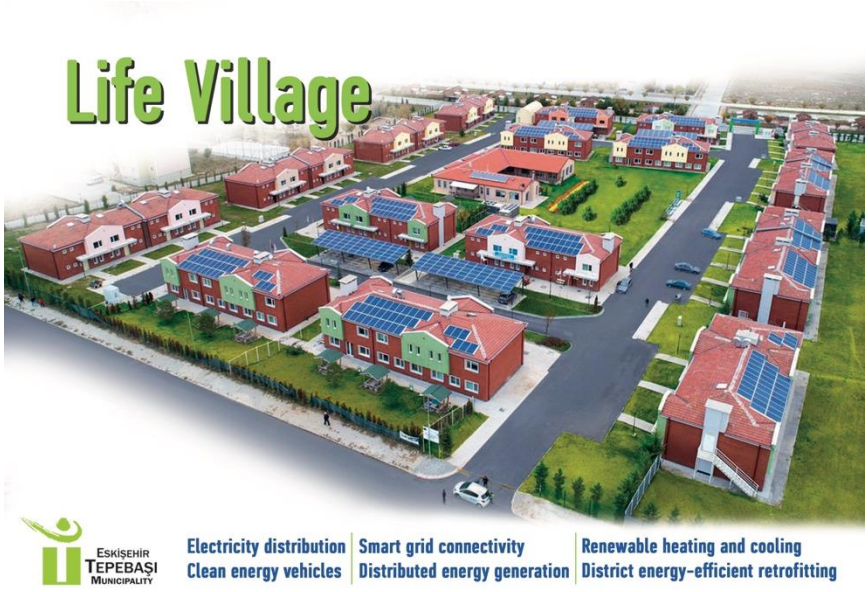

Figure 10. Life Village, source: Tepebaşı Municipality

A 150 kW PV system generates around 70% of the power needs of the demo-site. The PV system consists of a 100 kW rooftop building Integrated Photo-Voltaic (BIPV) on roof in addition to 50 kW carport canopy on ground. As a result, 174.900 kWp PV system power is providing 233,492 kWh Annual production and 163.4 tons/year CO_2 are avoided.

Figure 11. Rooftop Building Integrated Photovoltaic system plus Carport Canopy on the ground, source: Tepebaşı Municipality

In terms of lighting fixtures, Tepebaşı has deployed the intelligent lighting system that balances the citizens' need to feel safe by ensuring well-lit public spaces, while cutting back on the district's overall energy costs. All lighting fixtures within buildings and street lighting in the district were replaced by low energy LED lighting with smart applications.

3.2. Sustainable Mobility

The sustainable mobility action plan included various measures such as the introduction of clean energy vehicles, renewed transport infrastructures, and promotion plans for reduced energy consumption and CO_2 emissions for sustainable mobility.

To promote sustainable mobility, the Municipality undertook essential actions to substitute conventional fuel vehicles with renewable fuel vehicles both for personal and commercial use. Furthermore, electric-charging infrastructures were upgraded, and e-multimodality strategies with promotion plans were introduced. This includes an integrated bike rental system, free parking for electric vehicles, and municipal info kiosks for travel information.

Figure 12. Sustainable Mobility & Transport in Tepebaşı, source: Tepebaşı Municipality

6.2 km of bicycle lanes were established and integrated into the urban transportation network via nodes and bike parks at the city rail stations. Smart electric bike infrastructure was also established including 30 electric bikes and 45 electric bike charging stations in three locations to ensure accessibility to all citizens. Furthermore, 45 electric bike-charging and parking stations and 5 electric vehicle charging stations were deployed. To facilitate door-To-door Multimodality Transport, advantageous ticketing options (bikes + public transport system and public transportation smartcard) were introduced. Mobile applications for citizens are also available as an information interface for the bike system.

With the support of REMOURBAN, Tepebaşı added 30 electric bikes, 4 electric buses, and 22 hybrid vehicles to the municipality fleet.

Figure 13. 30 electric bikes, 4 electric buses and 22 hybrid vehicles, source: Tepebaşı Municipality

3.3. Integrated Infrastructures

Information and Communications Technology (ICT) enabled the deployment of integration strategies of the urban infrastructures with a variety of targets. For example, an advanced building energy management and monitoring system provide automatic occupancy control, CO_2 sensors, and comfort controllers. In terms of Neighbourhood energy management system**,** ICT enables smart control of all heating/power production and consumption via data analytics and energy saving interventions. Furthermore, user-controlled monitoring is installed in all buildings to encourage energy conscious behavioural change. Other monitoring tools for energy efficiency include an advanced monitoring and energy performance visualisation ICT platform. Urban data is assessed and analysed by Smart City

Monitoring Portal. The city management system "City on Cloud" collects energy and mobility data from the demo site as well as from other smart city applications such as energy monitoring system for electric meters, solar panel system, vehicle tracking system, e-bike management system, smart street lighting system. Through the building management system, energy data is monitored by thermal comfort and Heating, Ventilation and Air Conditioning controls.

3.4. Society and citizen engagement

The engagement of citizens and local stakeholders has been key for the development and success of REMOURBAN. Tools for community insight and engagement included a citizen engagement strategy, social media strategy, stakeholder platform, and a strategy for the development of the integrated urban plan. This approach facilitated arriving at a strategic vision endorsed by all stakeholders and supported by long-term policies and respective regulatory frameworks as the basis for an effective and efficient implementation process.

Citizen-driven Tepebaşı encouraged the pro-active inclusion of the citizens' needs to guarantee social acceptance and gender sensitivity of the changes undertaken as part of the project's implementation, including raising awareness of the benefits resulting from the project. Citizen engagement enabled building strong and strategic partnerships with local stakeholders to promote the reduction of greenhouse gas emissions and energy consumption thus ultimately improve the living environment. As part of leading role of Tepebaşı municipality, a re-skilling center was established to act as a smart city and community demonstration site, with the smart and renewable energy urban management system in place. More than 6,000 citizens were involved directly and indirectly in the demonstration. To achieve gender sensitivity in the project's activities, tools for outreach and active participation of the community were diversified. An example is the engagement of the youth by offering university students project-based internships at the demo site, during which they were mentored by experts and competent employees of Tepebaşı municipality.

Tepebaşı selected three best practices from their citizen engagement activities, covering the fields of energy, mobility, ICT that have proven to be more impactful and insightful for replication by other municipalities. The backbone of each best practice is a combination of descriptive content, recommendations, and assessment. To better understand the level of complexity of each best practice, the partners involved in its implementation have rated its replicability potential, impact, and factors of success on a 4-point scale.

Among the highly-rated citizen's engagement activities were three surveys conducted to determine the satisfaction of the citizens living in Tepebaşı demo site as well as rating the transportation vehicles offered by the Tepebaşı municipality at the city-level within the scope of the REMOURBAN Project. These surveys addressed a representative sample of the population of 2,500 citizens.

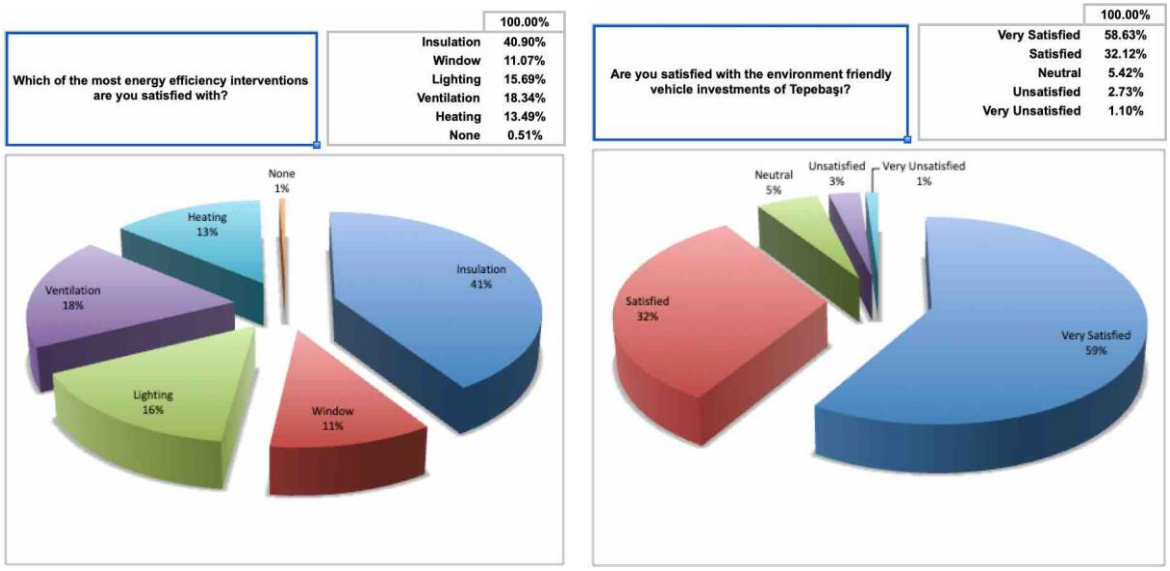

Figure 14: Results of citizens' satisfaction survey concerning Tepebaşı demo site and the transportation vehicles offered by the Tepebaşı Municipality at the city-level within the scope of the REMOURBAN Project, source: Tepebaşı Municipality

Since dissemination and replication of the outputs of this project were one of its most important objectives, it was important to raise awareness about the project's impacts among the local population on the one hand and among other municipalities in Turkey and around the globe on the other. This included targeted capacity development and training of engineers, representatives of the private sector and academia as well as decision-makers from the political scene. Several Mayors, Deputy Mayors, Councilors, Members of Parliament, and decision-makers visited the demo site and were informed about the REMOURBAN Project, which presented an opportunity to understand practical barriers and opportunities for replication.

4. Results

Tepebaşı is progressing towards the localisation of the 17 Sustainable Development Goals of the 2030 Agenda by designing an integrated local development strategy with specific targets.[i] The adopted integrated approach that is complemented by ICT and smart strategies has catapulted Tepebaşı municipality to the forefront as a model for a sustainable smart city. Tepebaşı municipality's main vision is to create a healthy, sustainable, and livable environment for all of its citizens and is committed to using new technology and acting more efficiently. Tepebaşı is also committed to reform the policies and operating procedures to support the city's goals of the Tepebaşı Smart Sustainable City Development.

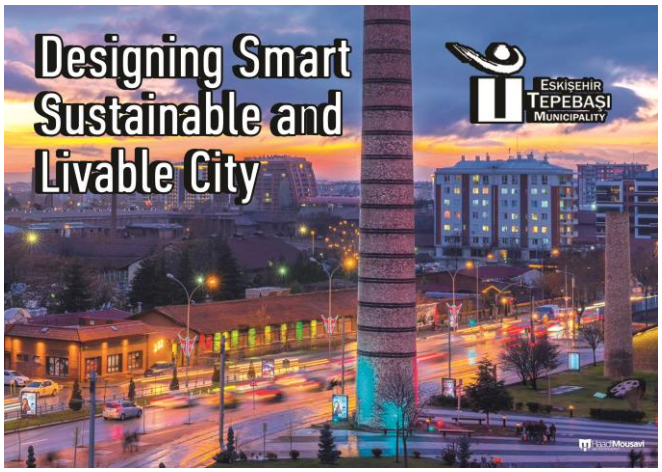

Figure 15. Designing Smart, Sustainable and Livable City, source: Tepebaşı Municipality

Tepebaşı signed the Covenant of Mayors in 2013 and committed to reduce carbon emissions 23% by 2020 and has prepared the Sustainable Energy Action Plan (SEAP) in 2014 to achieve the Covenant of Mayor's target, Strategic Action Plan, Rural Development Action Plan and Healthy City Action Plan, and Sustainable Strategic Plan. Tepebaşı Sustainable Climate Action Plan is currently under preparation. Tepebaşı is also committed to the Global Covenant of Mayors and pledges to reduce its carbon emissions by 40% by 2030.

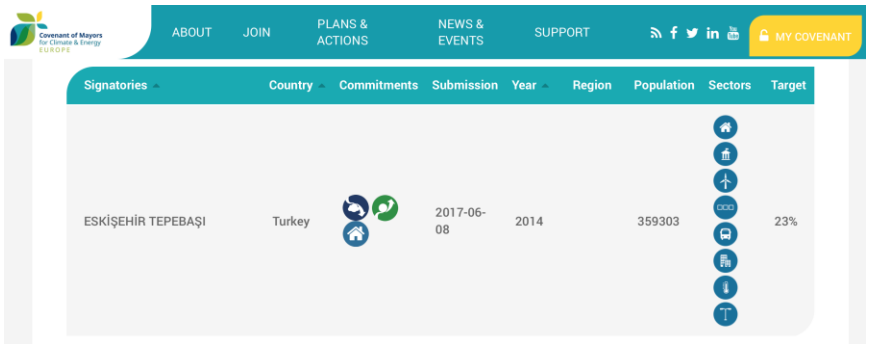

Figure 16. Covenant of Mayors in 2013, source: Tepebaşı Municipality

Figure 17. Local municipal plans adopted by Tepebaşı Municipality, source: Tepebaşı Municipality

In May 2021, Tepebaşı was awarded the "Mitigation Badge" by the Global Covenant of Mayors by fulfilling the goals of adaptation to climate change and reducing greenhouse gas emissions.

Figure 18. Tepebaşı is recognized for its action on climate mitigation, source: Tepebaşı Municipality

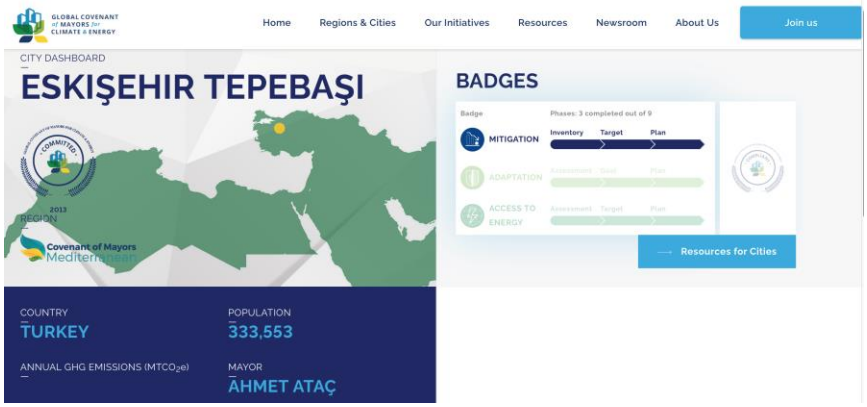

Figure 19. Tepebaşı was awarded the "Mitigation Badge" by the Global Covenant of Mayors, source: Tepebaşı Municipality

Within the sustainable and integrated smart city project REMOURBAN, Tepebaşı generalized the energy-efficient implementations, increased the usage of clean and renewable energy resources, contributed to combating climate change, and provided a high-quality life for its citizens. As a result, there was a 53% reduction in building energy consumption and 63% reduction in Greenhouse Gas (GHG) emissions. Meanwhile, in transportation, there was a 70% reduction in energy consumption and 70% reduction in GHG emissions. The annual final energy saving is 1,559 MWh. The total CO2 emission savings amount to 476 tonnes of CO_2 per year.

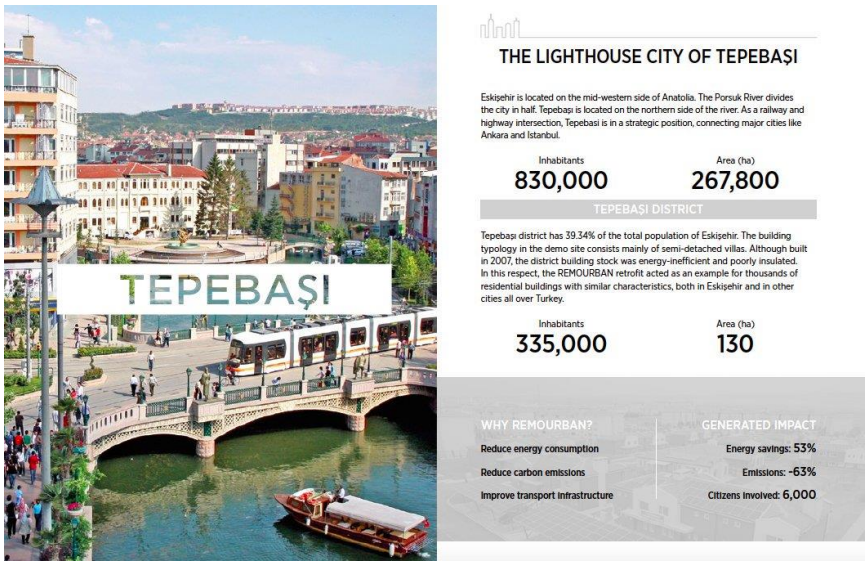

Figure 20. SCEW-REMOURBAN, source: Tepebaşı Municipality

	Existing Building		After Interventions	
	Energy Demand (kWh/m2yr)	CO2e (kgCO2/m2yr)	Energy Demand (kWh/m2yr)	CO2e (kgCO2/m2yr)
Heating	141,28	28,03	26,61	2,12
Cooling	84,24	17,93	63,22	5,02
Lightning	30,87	16,42	12,88	6,85
DHW	11,17	2,22	9,457	1,39
Others	11,96	6,36	19,86	10,57
Building	279,52	70,96	132,03	25,95
	Energy Demand (kWh/yr)	CO2e (kgCO2e/yr)	Energy Demand (kWh/yr)	CO2e (kgCO2e/yr)
Transport*	88,45	23,83	26,53	7,15

*Distrcit Transportation only

Figure 21. Significant savings in energy demand and CO_2 emissions as a result of the interventions in Tepebaşı, source: Tepebaşı Municipality

4.1. Lighthouse Projects Cooperation Manifesto: A replicable model

This Model for transformation is replicable since it emphasizes monitoring and evaluating the gradual transformation the city undergoes thus drawing empirical evidence required in future replication processes. To replicate the smart city solutions implemented in Tepebaşı under the REMOURBAN Lighthouse project, the Lighthouse projects cooperation manifesto was signed in 2017.[ii]

The political support conveyed across the highest decision-making levels contributed to building citizens' trust in the project and its impacts. The demo site visits have generated a wide range of positive repercussions in local, national, and social news, representing good opportunities for showcasing smart replicable solutions. A remarkable interest in the first smart city project of Eskişehir was registered as the results from REMOURBAN project were shared with other municipalities. This indicates a high potential for the replication of the solutions implemented within the project. REMOURBAN has therefore provided feedback, recommendations, and good practices to help other cities and their partners pave the way for smarter and more sustainable cities.

[i] In 2018, Tepebaşı was the winner of the "Smart City" award with the REMOURBAN Project at the 2nd International Urban, Environment and Health Congress held in Cappadocia with the theme of "Cities of Tomorrow". Tepebaşı was also the winner of the "Global Model of Smart City" award in 2019 with the REMOURBAN Project at the 14th Global Forum on Human Settlements held in Ethiopia with the theme of "Sustainable Development of Cities and Human Settlements in the Digital Era". Furthermore, Turkey unveiled the 2020-2023 National Smart Cities Strategy and Action Plan in 2019 that aims at keeping pace with global advancement on manageable cities. Tepebaşı's smart city strategies, approaches, and implementations are described in this plan among the best practices.

[ii] Since 2014, the European Union has funded a total of 15 smart city projects involving 42 Lighthouse cities that are facing diverse challenges, such as ensuring secure, affordable and clean energy, supporting smart electro-mobility and implementing ICT supported solutions. The European Union's smart city projects pledged closer cooperation in their efforts towards low carbon and resource-efficient urban spaces to deliver and replicate smart city solutions.