ANALYZING CORE COMPONENTS OF SMART CITIES BY FOCUSING ON THE RENEWABLE ENERGY: CASE STUDY OF SUSTAINABLE URBAN FURNITURE FOR ÇORLU REPUBLIC PARK

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ABSTRACT

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Master Program in Design Studies

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Smart cities aim to adapt the living conditions in the best way by using the human and technology factors, which are among their basic components. At this point, the components of smart cities show some changes according to the economic, social and cultural values of the countries, and the investments made for these components reveal new smart city versions. Çorlu, with its strategic location and investment targets, has high potential to become a smart city that can stand out on smart energy in Turkey. The Covenant of Mayors for Climate & Energy agreement signed for this purpose is an example of this. In this framework, to propose smart urban furniture for Çorlu Cumhuriyet Park, a triple city comparison was made with Songdo and Antwerp, which are similar in terms of being a commercial area and population structure. As a result of the analyzes made, it has been seen that the factors such as renewable energy technologies that can be integrated into the city add value to the identity of the city and contribute to this process by raising public awareness. For this purpose, a smart lighting design that generates electrical energy with kinetic flooring is presented for Çorlu Cumhuriyet Park. The designed smart lighting aims to increase sustainability and environmental awareness by contributing to the renewable energy production of the citizen by using the indicators in the piezoelectric floor tiles and lighting and the daily activity in the park.

Keywords: Smart Cities, Sustainability, Kinetic Energy, Smart Lighting.

ÖZET

AKILLI ŞEHİRLERİN TEMEL BİLEŞENLERİNİN YENİLENEBİLİR ENERJİ ODAKLI ANALİZ EDİLMESİ: ÇORLU CUMHURİYET PARKI SÜRDÜRÜLEBİLİR KENT MOBİLYALARI ÖRNEĞİ

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Akıllı şehirler, temel bileşenlerinden olan insan ve teknoloji faktörünü bir arada kullanarak, yaşam koşullarına en iyi şekilde adapte edebilmeyi amaçlamaktadır. Bu noktada, akıllı şehirlerin bileşenleri ülkelerin ekonomik, sosyal ve kültürel değerlerine göre birtakım değişiklikler göstermektedir ve bu bileşenlere yönelik olarak gerçekleştirilen yatırımlar yeni akıllı şehir versiyonlarını ortaya çıkarmaktadır. Çorlu, stratejik konumu ve yatırım hedefleri ile Türkiye'de akıllı enerji üzerine öne çıkabilecek bir akıllı şehir olması için yüksek potansiyele sahiptir. Bu hedefe yönelik olarak imzalanmış olan Covenant of Mayors for Climate & Energy anlaşması da bunun bir örneği olarak karşımıza çıkmaktadır. Bu bağlamda, Çorlu Cumhuriyet Park'ına akıllı kent mobilyası önerisinde bulunmak için, ticaret bölgesi olma ve nüfus yapısı gibi özellikleriyle benzerlik gösteren Songdo ve Antwerp ile üçlü şehir karşılaştırması yapılmıştır. Yapılan analizler sonucunda şehre entegre edilebilecek yenilenebilir enerji teknolojilerinin şehrin kimliğine değer katması ve halkın bilinçlendirilmesi yoluyla bu sürece katkı koyması gibi etkenlerin en iyi şekilde kullanması gerektiği görülmüştür.

Bu amaçla, Çorlu Cumhuriyet Parkı için kinetik yer döşemesi ile elektrik enerjisi üreten bir akıllı aydınlatma tasarımı sunulmuştur. Tasarlanan akıllı aydınlatmanın amacı kinetik yer döşemesi ve aydınlatmadaki göstergeler ile parktaki günlük aktiveyi kullanarak vatandaşın yenilenebilir enerji üretimine katkısını sağlayarak sürdürülebilirlik ve çevre bilincinin arttırılmasıdır.

Anahtar Kelimeler: Akıllı Şehirler, Sürdürülebilirlik, Kinetik Enerji, Akıllı Aydınlatma.

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CHAPTER 1: INTRODUCTION

1.1. Definition of the Study

Sustainability, scientific prowess, and technological know-how are essential variables for developed and developing economies that compete with each other. Cities behave like living organisms for their residents and users. Increasing resource scarcity and competitiveness change the building blocks for the development of cities over time. Countries develop strategic plans to deal with this change in a controlled manner. Examples of these plans are different sectors such as development, defense, import-export, education, economy, and energy. Countries planning on energy do not just include clean environment and zero-carbon policies. The use of renewable energy sources is the subject of deeper and contentious issues such as the independence of the country's economy. The use of technology on renewable energy sources has led to new techniques in topics such as energy-saving and energy management.

The concept of *Smartness*, which has developed over time with technology, can be seen in many reflections throughout many fields. Smartness is applied in different dimensions in cities, corresponding to the concepts of improvement and restructuring. What makes one smart city different from another is the percentage of investments made on these dimensions. For this reason, investments in renewable energy have brought the needs of consumers to the forefront in line with more current demands in recent years. As a reflection of this, ICT, IoT's, and smart grids are adapted to use, have taken their place in the chain of awareness, information, and information collection for years. Although these smart systems are widely used in some cities, they do not always guarantee success. Target-oriented cities may lack efficiency in the long run, leading to the missing of social goals. Therefore, the integration of smart systems should go through the evaluation of human and technological dimensions that complement each other. The importance of social/cultural criteria in urban growth is achieved by a sense of place and use of space. The creation of these areas brings with it the reflection of green and gray urban nature contrast. For this reason, how smart systems support the needs of the city and promote people's participation in the life cycle of common areas has become a subject that requires meticulous planning.

The fact that renewable energy sources are now shown as the lowest-cost source of energy production technology and do not emit air pollutants or are low makes it a great choice proposal for climate and health, making it more attractive on its integration into the environment. However, the biggest advantage of renewable energy use for the future is that it is a critical solution for predicted power cuts. Cities have the potential to actively fight against climate change at the national and global levels. Yet sustainability has a wide spectrum and is not an issue that municipalities can address by themselves. Thus, to support the use of renewable energy resources and to find renewable energies in smart parks, the government must meet some of the criteria.

In line with these reasons, the primary research of this thesis is to encourage cities in Turkey to become smart energy initiatives and present a prominent proposal to develop into a smart city. Smart city initiatives in Turkey have not yet come to the fore with examples that have reached the desired maturity. Local cities should take their place in the competitive market effectively with the smart cities 2.0 versions and the industry 5.0 foresight. To undertake this task, Çorlu, which has a high potential, has been discussed. Çorlu has strategic importance due to its location and stands out with its industry. It is expected that the types of energy used in the city will be regulated in line with the Covenant of Mayors for Climate & Energy Europe agreement signed by the mayor of Çorlu in 2019.

To guide the research, comparisons of different Smart City examples that currently exist in the world were made. The energy scenarios and natural resource management strategies of the countries were examined. In Çorlu, a smart lighting system has been proposed for Republic Park as an example of smart city usage to increase environmental awareness of individuals by the proposed design and to contribute to renewability. With this aim, a smart lighting system working with piezoelectric floor tiles, which can generate electricity from human movement, has been designed. By this design, citizens are encouraged to partake in physical activity and to gain awareness about renewable electricity generation. The proposed design aims to bring the human factor to the forefront and ensure that the user-oriented approach forms the central theme of the plan to be implemented kinetic energy system.

1.2. Aim of the Study

This study aims to present a useful proposal that can be used in practice to be environmentally sensitive to the living conditions of smart energy technologies for sustainability in smart cities. Therefore, in the case of Çorlu Cumhuriyet Park, a framework has been created in line with these purposes to propose smart lighting design;

(i) Analyzing smart cities in the world and Turkey by putting smart city components forward,

(ii) To examine smart energy systems and renewable energy types by examining the energy scenarios in the world and Turkey,

(iii) To analyze the usage areas of smart and renewable energy systems in cities, to examine the examples of integration of these systems to the urban furniture used in common public areas,

(iv) To show the urban furniture reflections of renewable energy applications and smart systems on Çorlu.

1.3. Method of the Study

In Çorlu Cumhuriyet Park, area analysis was carried out in different periods, and the amount of equipment in the park was determined and photographed. The mayor of Çorlu was interviewed, and the Covenant of Mayors for Climate & Energy Europe agreement was reached. The project drawings of the Republic Park, which were obtained by interviewing the Çorlu Parks and Gardens directorate, and the diversity of the lighting systems used in the park were determined. Trakya Development Agency reports were accessed by meeting with Çorlu Chamber of Industry officials. Information was collected for the analysis of the field study by communicating with the relevant authorities. To create clues that will give ideas for the design proposal for Çorlu Cumhuriyet Park, Antwerp, and Songdo cities, like Çorlu in terms of population, industry, and trade, triple city comparisons were made. Intelligent systems and their application areas and finally their application areas in these cities are examined.

CHAPTER 2: DEFINITIONS AND CORE COMPONENTS OF SMART CITIES

2.1. Definitions of Smart Cities

By becoming more energy-efficient, cities are critical proving grounds for utilizing sustainable and low carbon economies. The need for this is driven by city residents' ever-increasing higher quality of life expectations (Estevez, Lopes and Janowski, 2016). Municipal leaders and city planners re-evaluated their urban planning designs to enable growth in cities to sustainability obligations (Hunter, Vettorato and Sagoe, 2018). These include sustainable cities, eco-regions, eco-cities, resilient cities, digital cities, virtual cities/information cities, knowledge-based cities, low-carbon cities, low-carbon eco-cities, smart energy cities, and smart cities (de Jong et al., 2015). There are several references to smart cities in recent literature, referring to the way spaces are increasingly used. Although the concept of the smart city emerged in the 1990s, relatively few people know what a smart city is (Albino, Berardi and Dangelico, 2015). Hollands (2008) notes that the label smart city is vague as it means many different things to many people, i.e.,

> *"utilization of networked infrastructure to improve economic and political efficiency and enable social, cultural, and urban development"* (Hollands, 2008).

Smartness is used in a wide variety of meanings (creative, digital, intelligently networked, virtual), and different interpretations, projects and these visions are associated with the term smart city (Vanolo, 2016). Smart cities represent a conceptual model of urban development based on human, collective and technological capital to develop urban agglomerations (Angelidou, 2014). The term Smart City has become a catch-all term in the minds of thinkers and planners for all that is good and great to define their hopes and aspirations for future city life, services, and governance. Smart City brings a sustainable, greener city and increased quality of life (Bakıcı, Almirall and Wareham, 2012).

> *"A city is smart when the smart management of natural resources promotes a sustainable economy and a high quality of life"* (Caragliu, Del Bo and Nijkamp, 2011).

As a prerequisite, traditional transport and modern (ICT) communication infrastructures should be supported by participatory governance. Another interpretation is that being a smart city means using resources and technologies in innovative and coordinated ways to develop liveable and sustainable city centers (Barrionuevo, Berrone and Ricart Costa, 2012).

The most common features of proposed smart cities are;

(i) *"A city's networked infrastructure that enables political efficiency and social and cultural development,*

(ii) *An emphasis on business-led urban development and creative activities for the promotion of urban growth,*

(iii) *Social inclusion of various urban residents and social capital in urban development,*

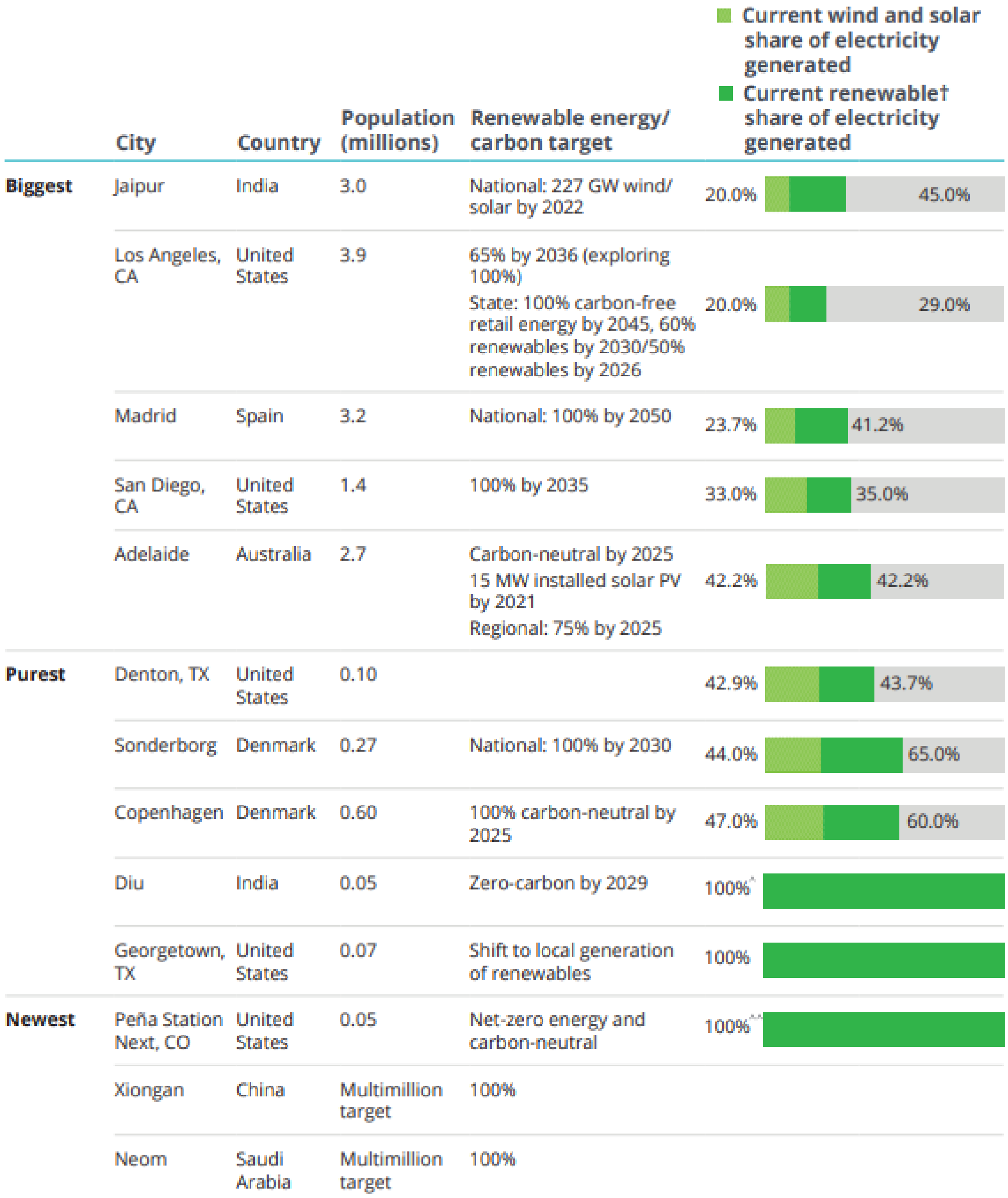
(iv) *The natural environment as a strategic component for the future"* (Albino, Berardi and Dangelico, 2015).

Smart city planning is based on understanding producer and consumer behavior by bringing together uncoordinated and often unintegrated digital elements. In this case, the unplanned planning we are used to, the construction of cities through evolution, is far from the concept of cities (Komninos et al., 2018). The ideas for smart cities are taken by focusing on some basic ICTs. This is because smart city paradigms are participating in society and using technology for innovation and human capital development to solve problems (Ercoskun, 2016). To rephrase it, smart city solutions are developed with little focus, not on-demand, and smart city programs are applied to hundreds of cities around the world in different concepts under this basis (Komninos, 2011).

For example, Tokyo, a digital city, conducts integrated studies on smart grid-connected solar panels and energy efficiency. Initiating urban mobility to reduce the number of cars and services, Toronto has focused on carbon reduction. Similarly, Vienna has invested in the technologies it uses for transportation and land use planning. In contrast, Barcelona has become one of the cities that use solar heat for the charging infrastructure of electric vehicles. This initiative has made it a leading low-carbon city. London is famous for sustainability innovations such as a congestion tax and robust transport systems, and it also has Europe's largest Wi-Fi network.

On the other hand, Berlin is successful in the field of innovation with the virtual power plant it has created with electric vehicles. Copenhagen was chosen as the European Green Capital in 2015, 40% of the citizens regularly use bicycles, and a carbon-neutral target has been set until 2025. These cities have entered the top 10 in the global ranking with their initiatives and investments on criteria such as innovation, environmental sustainability, and improving the quality of life (Greco and Bencardino, 2014). People-centered smart cities are associated with developed countries. In addition to the most successful smart cities mentioned above, Deloitte (2020) listed smart cities in its energy-based roadmap by dividing them into three types: Biggest, Purest and Newest. Cities designated as Purest pick up where the Biggest Cities left off and are the cities that account for at least 42.2% of the energy mix from solar and wind, regardless of size. The cities designated as Newest are designed from the ground up as Smart Cities and are powered entirely by renewable energy.

	City	Country	Population (millions)	Renewable energy/ carbon target	Current wind and solar share of electricity generated	Current renewable† share of electricity generated
Biggest	Tokyo	Japan	13.5	20% by 2020	1.0%	9.0%
	Chicago, IL	United States	2.7	100% by 2025 for municipal buildings State of Illinois: 25% by 2025	2.0%	5.0%
	Birmingham	United Kingdom	1.1	60% reduction in CO2 emissions by 2027 (from 1990 level) National: 30% by 2020	3.8%	4.4%
	Singapore	Singapore	5.5	350 MWp solar by 2020	3.9%	3.9%
	Paris	France	2.3	100% by 2050 (25% by 2020/45% by 2030)	4.2%	18.0%
	Calgary	Canada	1.2	30% by 2036	4.7%	9.4%
	Manchester	United Kingdom	2.8	Carbon-free by 2038	6.3%	13.1%
	Seoul	South Korea	10.3	1 GW PV by 2022 National: 20% by 2030	6.6%	8.3%
	Bangalore	India	11.0	Regional: 6 GW by 2021 National: 227 GW wind/ solar by 2022	10.0%	25.0%
	Nelson Mandela Bay	South Africa	1.2	National: 35.6% solar and wind by 2030	10.0%	10.0%
	London	United Kingdom	8.6	Zero-carbon by 2050, 1 GW solar by 2030/2 GW solar by 2050 National: 30% by 2020	10.9%	24.6%
	Toronto	Canada	2.8	75% renewable or low-carbon energy by 2050	12.0%	36.0%
	Hamburg	Germany	1.8	35% by 2022 Halve CO2 emissions by 2030/80% reduction in CO_2 emissions by 2050 (from 1990 level) National: 65% by 2030	14.8%	29.9%



	City	Country	Population (millions)	Renewable energy/ carbon target	Current wind and solar share of electricity generated	Current renewable† share of electricity generated
Biggest	Jaipur	India	3.0	National: 227 GW wind/ solar by 2022	20.0%	45.0%
	Los Angeles, CA	United States	3.9	65% by 2036 (exploring 100%) State: 100% carbon-free retail energy by 2045, 60% renewables by 2030/50% renewables by 2026	20.0%	29.0%
	Madrid	Spain	3.2	National: 100% by 2050	23.7%	41.2%
	San Diego, CA	United States	1.4	100% by 2035	33.0%	35.0%
	Adelaide	Australia	2.7	Carbon-neutral by 2025 15 MW installed solar PV by 2021 Regional: 75% by 2025	42.2%	42.2%
Purest	Denton, TX	United States	0.10		42.9%	43.7%
	Sonderborg	Denmark	0.27	National: 100% by 2030	44.0%	65.0%
	Copenhagen	Denmark	0.60	100% carbon-neutral by 2025	47.0%	60.0%
	Diu	India	0.05	Zero-carbon by 2029	100%^	
	Georgetown, TX	United States	0.07	Shift to local generation of renewables	100%	
Newest	Peña Station Next, CO	United States	0.05	Net-zero energy and carbon-neutral	100%^^	
	Xiongan	China	Multimillion target	100%		
	Neom	Saudi Arabia	Multimillion target	100%		

Figure 1. The Biggest, Purest, and Newest smart renewable cities are paving the way for other smart cities (Source: Deloitte, 2020).

In general, the plans of the cities considered as *smart* are to build renewable systems using developing technology because it is an inevitable need to develop renewable energy resources according to the energy needs and consumption demands of growing cities.

There has been a concerted effort to define and plan for smart cities in Turkey since 2000; various municipal, government, and private organizations have come together to define and draw legislations for said cities. Some organizations that bring together the public and private sectors for smart cities in Turkey are Smart Municipal Summits, Smart Cities Congress, Smart Cities Transformation Movement Project, Smart City Fair, and Smart Cities Automation System. But the most critical and prominent goals developed on Smart Cities and investments are,

> *"10. Development Plan, Annual Programs and National Science and Technology Policies 2003-2023 Strategy Document-Vision 2023, Information Society Strategy and Action Plans, which are among the relevant strategy documents"* (Varol, 2017).

In the early 2000s, investment in public services with technology based on reducing the effects of the local economic crisis in Turkey has seen a dramatic increase. Smart city applications were followed as later studies in this process. According to the Ministry of Development report, it is stated that, in 2013, there were smart applications in 40 leading cities. These efforts include some basic practices, although it is indicated that methods are active only in three or four cities (Babaoğlu and Çobanoğlu, 2019). In Turkey, studies carried out by TNGIS-Turkey's National Geographic Information Systems and The Ministry of Environment and Urbanization developed National Urban Information System Standards to create efficient and better services by using non-human automatic resources for metropolitan areas especially concerning transport and energy use (Kayapınar, 2017). Smart applications developed by Communication firms are an important place in the smart city applications. These are smart applications serving local government such as smart stop, smart parking lot, smart intersection, priority pass, traffic electronic control system, smart lighting, smart irrigation, remote meter reading, smart waste collection, wireless internet, smart security. The fact that the 4th Industrial Revolution is happening today shows that some technologies will come to the fore for smart cities. These are;

> *"Development of high-speed active network devices, cloud computing, next-generation internet network, next-generation networks, close contact and remote interactive RFID technology, internet of things and the landing of autonomous vehicles to cities"* (Alkan, 2015).

Some examples of smart projects and their applications in Turkey:

Table 1. Smart city projects in Turkey (Source: Ercoskun, 2016).

Name of the municipality	Status
Yalova	ICT Valley Project continues.
Fatih-İstanbul	GIS digital inventory has been completed; Smart City Project team has been built
Kadıköy-İstanbul	GIS digital inventory has been completed; system has been integrated with e-municipality applications.
Beyoğlu-İstanbul	GIS digital inventory has been completed; system has been integrated with e-municipality applications.
İzmir	UIS has been completed; 3D applications are integrated with the system.
Ankara with Android and IOS.	GIS digital inventory has been completed; public transportation system has been built and integrated.
Bursa	UIS has been completed. Web-based 3D city guide is on use.

After the great Marmara earthquake in Turkey, Turk Telekom decided to provide a robust Internet infrastructure for natural disasters in 2000 Yalova as a pilot city and ICT projects in Yalova, international conferences, in the meetings and platforms focused on best practices. After Yalova, certain districts of Bursa, Kocaeli, Ankara and Istanbul have become a laughingstock in ICT Valley projects (Velibeyoglu and Yigitcanlar, 2009).

Other smart city projects in Turkey, in addition to the table, is as follows:

(i) Çorum e-municipality smart city smart junction systems,

(ii) Erzurum/Yakutiye e-municipality smart city guides smart city automation system,

(iii) In cooperation of Eskişehir/Tepebaşı municipality and the European union Smart Cities and Innovation Project improvement in transportation, communication, and information technologies between 2015 and 2019 through Life Village Project,

(iv) Decision-making on environmental problems and community involvement through Hayat municipality, the European Union STEP Project, Smart Cities, Smart Teenagers and Wise Citizens (Akgül, 2013).

Apart from these smart city initiatives in 2015 city of Karaman by Türk Telekom Group, plans to become Turkey's first smart city with the implementation project called Akıllı KenTT. In this project, goals such as establishing the system architecture and expanding the internet platform were determined in cooperation with Innova. Since all smart applications running the SmartKenTT project are managed on a single platform and by a single operation center, it differs from other city initiatives. Antalya has been chosen as the second city to be implemented in line with the same goals. In line with the project, it was aimed to create a free wireless internet zone of 22km in Antalya in the first stage, to provide services such as free internet service in public transportation vehicles, smart stop, smart lighting, smart irrigation, and smart health. Thus, the target was determined to reduce traffic accidents by 60%, traffic waiting time by 25%, public lighting and irrigation costs by 30-35%, and reduce carbon emissions by 40% (Öztuzsuz, 2015). Pilot projects test the feasibility of the planned program. Still, cities need to develop long-term plans by setting their own smart sustainable goals, and Turkish cities have many more projects to take on within the Smart category (Ercoskun, 2016).

2.2. Components of Smart Cities

Lombardi et al. (2012) different forms of urban life are separated into six parts of a smart city: smart environment, smart living, smart people, smart economy, smart governance, and smart mobility. Traditional regional and neoclassical theories of urban growth and development are associated with the six dimensions. Especially regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and citizen participation in the governance of cities (Lombardi et al., 2012).

This table shows the frequency of terms used for smart city dimensions in articles written;

Table 2. Detailed description of the components of the smart city according to the relevant aspects of urban life (Source: Bozkurt et al., 2020).

Dimension		Terms/Subtopics
Word frequency		
All articles	10% articles	
Environment		energy, sustainability, architecture, environment, waste, building, light, air, power, road, electricity, grid, consumption, energy_efficiency, pollution, water, emergency, waste_management, street, green, suitable, built, carbon, emissions, heat, nature, ecosystem, solar, temperature, build, place, urbanization, centre, construction, low_power, metropolitan, city_projects
1472	102	
Governance		service, management, governance, policy, strategy, planning, city_concept, stakeholders, operational, managing, international, authorities, countries, organizations
858	105	
Mobility		traffic, parking, transport, vehicle, mobility, car, congestion, transportation_systems, bus, logistics
612	34	
People		citizen, innovation, people, human, population, european, inhabitants, residents, personal, university
405	47	
Living		privacy, health, social, quality_life, community, live, urban_areas, urban_development, society, social_media, residential
396	53	
Economy		economic, sharing, business, knowledge, industry, economy, supply, companies, business_models, facilities
209	23	

Smart environment addresses the efficiency and sustainability aspects of urban life, such as efficient energy and water use, recycling rates, green space use, greenhouse gas emissions, intensive energy consumption, and the ambitious CO2 emissions reduction strategy (Albino, Berardi and Dangelico, 2015). Smart living improves the quality of life by transforming the home, workplace, transportation, and energy infrastructure into smart environments. Cultural amenities refer to the quality of life and individual safety within health conditions as a single and integrated concept. They include housing quality, educational facilities, tourist attractions, and social cohesion (Giffinger, 2015). Smart cities need smart people to be truly innovative and sustainable in terms of education and people's access to information in urban life (Toppeta, 2010). Human and social capital, flexibility, creativity, tolerance, cosmopolitanism, and participation in public life are criteria that determine the types of people needed in a smart city (Monfaredzadeh and Berardi, 2015).

On the other hand, the smart economy is directly related to industry because of public spending on R&D and education and the unemployment rate. Competitiveness is a holistic concept. Economic growth, quality of human capital, cultural aspects, and quality of governance are necessary to ensure the future competitiveness of the smart city (EIU, 2013). Smart mobility refers to local and supra-local accessibility, availability of ICT, modern, sustainable, and safe transportation systems (Atzori, Iera and Morabito, 2010). A smart city must make full use of existing ICT facilities to enhance its economy and competitiveness and build a prosperous and integrated city. Using technology for better planning to facilitate decision-making and support democracy is all about smart governance (Neirotti et al., 2014). Factors influencing smart management include participation in decision making, availability of public and social services, transparent leadership, policies and perspectives, and integrity of management systems and policy processes, quality vision (Chourabi et al., 2012).

As cities have different social, economic, environmental, and technological infrastructures, combining them in a single urban project is not easy due to other bureaucratic and political systems. Therefore, cities need to find their technical and digital capabilities in the urban context to leverage IoT platforms and build this infrastructure. This includes the need for infrastructure and installation maintenance efforts to adapt to complex urban scenarios (Sharma, Singh and Kumar, 2020; Mocnej et al., 2021). Regardless, the first role of IoT technology in urban planning is to provide transparency in democracy and allow citizens to participate in the decision-making process (Ioppolo et al., 2016; Gil, Cortés-Cediel and Cantador, 2019). Because planning smart solutions (governance, economy, environment, etc.) on a city scale with citizen participation accelerates activities and increases quality efficiency (Ruhlandt, 2018).

It is emphasized that urban contexts, supported as examples of holistic and integrated urban planning, are characterized by many incompatible components and are generally fragmented and disconnected (Cugurullo, 2017). In this context, the Digital Single Market strategy, with its adoption by the European Commission (EC), represents one of the main pillars in creating a single digital market, improving technology, and providing better and safer uniform access by providing more social participation (European Comission, 2015a). With the development of technology, various headings of environmentally sized urban solutions applied for smart cities are as follows;

(i) Waste management provides systems, such as e-waste, that allow real-time determination of waste type and quantity by addressing environmental and health issues using cloud solutions to optimize time and resources. (Ahad et al., 2020; Aazam et al., 2016).

(ii) Energy efficiency refers to energy consumption and all technologies that can be reduced. That is sensor-equipped street lighting, public and private buildings equipped with consumption monitoring systems, and the predictive urban infrastructures needed to manage urban events efficiently (Chui, Lytras and Visvizi, 2018; Ghiani et al., 2018; Shahidehpour, Li and Ganji, 2018).

(iii) As an alternative to fossil fuels, renewable energy sources guarantee the balance of energy prices and their use for urban processes (public transport, heating of public and private buildings) (Strielkowski et al., 2019).

(iv) Water management includes solutions that provide data on the consumption and quality of water distribution systems, which are essential for urban sustainability and efficiency (Ler and Gourbesville, 2018).

(v) Biodiversity conservation includes revitalization measures for abandoned urban and industrial areas and initiatives to protect green and urban areas (Morimoto, 2010). Support for urban agriculture and infrastructure in land use optimization (Kim, Miller and Nowak, 2018). The aim is to reduce air pollutant emissions through ICT, sensors, and monitoring stations that can provide high-resolution video and images to monitor air and noise pollution, environmental quality (Peng, Bohong and Qinpei, 2017).

A large percentage of the population in developed countries lives in cities; it is estimated that by 2050, about 66% of the total world population will live in cities. This situation has proven that the concept of Smart City has emerged to ensure sustainable urbanization (Ibrahim, El-Zaart and Adams, 2018). In addition, the world population is estimated to exceed 9 billion by 2040. This means that energy demand will increase by 30% by 2040 (IEA, 2020). The problems of meeting the needs of the growing population and the adequacy of energy resources have led cities to find more rational solutions. This is because the urban metabolism often consists of the input of goods and the output of waste with consistently negative externalities that exacerbate social and economic problems (Albino, Berardi and Dangelico, 2015). When urban metabolism is examined in this context, it should be contemplated that it consists of two main dimensions, one concrete and one abstract, defined as the process of material and energy exchange between urban systems and the world (Céspedes Restrepo and Morales-Pinzón, 2018). These interactions are studied from the perspective of social-ecological systems, together with the basic processes of natural resource use, their transformation, and waste production (Ríos-Osorio, Salas-Zapata and Ortiz-Lobato, 2012). It also examines its participation in the flow of matter and energy, including the cycles. As technology develops, depleted resources can change indefinitely, which encourages the idea that the city's sustainability will not function independently of the ecosystem (Castillo and Pitfield, 2010).

Cities rely on external resources for their resident consumers. As one of the more current interpretations of urban sustainability, it promotes a more people-centered approach, where cities must respond to people's needs with sustainable solutions for social and economic spaces (Turcu, 2013; Berardi, 2013). The role of a single city makes it socially and economically important in the global arena and has a great impact on the environment (Mori and Christodoulou, 2012). In this context, capturing material and energy flows is vital for the city's metabolism and contribution to sustainability (Cui, 2018).

CHAPTER 3: SMART ENERGY TYPES AND APPLICATIONS

3.1. Renewable Energy Alternatives

Some factors have shaped the changes in the energy sector since 1970, and the determining factor is the uncertainty in the oil market (Yergin, 2012). Energy-related problems in the world are associated with the change in flexibility of traditional energy. It must manage these complex energy systems by characterizing energy needs with synergies between different energy sectors (Bak, Lindgaard and Lund, 2014). Two characteristics that countries should overcome in dealing with these difficulties for their future energy system are;

(i) Renewable based (Mathiesen, Lund and Karlsson, 2011) and

(ii) Being smart (Santacana et al., 2010).

The first feature respectively supports the fossil-free transformation of an energy system while adopting a combination of local clean energy sources such as wind, hydro, and solar (Ericsson and Nilsson, 2006). Second, it needs to guarantee optimum management of different energy networks such as electricity, cooling, heating, and gas with synergistic operations (Lund et al., 2018). Fossil fuels have mainly met the increase in energy demand globally in the past four decades. As of 2018, the world's primary energy consumption was generated by oil (33.6%), coal (27.2%), natural gas (23.9%), hydroelectric (6.8%), nuclear energy (4.4%), and renewable energy accounted for 4% (BP 2019). In the long-term transformation of the production and consumption of energy resources, a trend has begun that has made them the focus of attention for decades, converting renewable energy resources into electricity and using (Cherp et al., 2018). Renewable energies are estimated to have the fastest growth rate in the electricity sector. They will meet around 30% of electricity demand by 2023, with 16% hydroelectric being the largest renewable source to meet global electricity demand, while wind (6%), solar power (4%), and bioenergy (3%) (IEA, 2017). Technological development efforts in renewable energy have led to a significant increase in renewable resources in the global energy portfolio. Renewable energy accounted for 9.5% of total primary energy consumption worldwide in 2015 and is expected to increase to 63% by 2050 (Gielen et al., 2019). Wind energy, the first affordable renewable energy type, is considered to be one of the cleanest energy sources as it contributes approximately 0.2% to global energy production (Wang and Wang, 2015). In addition, wind energy is expected to increase in total production among renewable energy sources. It is estimated that by 2050, 18 percent of the electricity used in the world will be provided by wind energy (IEA, 2020). It is estimated that geothermal will contribute approximately 3% of electricity demand and 5% global heat demand by 2050 (Shortall, Davidsdottir and Axelsson, 2015). Various forms of enhancement energy are used from ocean dynamics, such as wave, wave current, tide, ocean surface thermal energy, for energy conversion from oceans, river water, water channels, and waterways, which are sources for the extraction of hydrokinetic energy (Lago, Ponta and Chen, 2010). The intelligence of energy is broader than the concept of being renewable. This model, called the Internet of Energy, is based on the principles of smart power generation, smart power grids, smart storage, and smart consumption. For instance, it turns any clean, green, sustainable, renewable, and conventional energy together with ICT smart energy (Mohanty, Choppali and Kougianos, 2016).

Although the Internet of Energy (IoE) seems to be a very new idea, it is primarily based on the old-fashioned information and communication technologies (ICT) and internet advances, rules, and general legacy. IoE covers millions of energy-generating installations and appliances and home appliances that report to the electrical grid using a peer-to-peer or server-based network to receive, analyze and send information (Vrba et al., 2014). Therefore, in the near future, renewable high smart grids enable two-way information home energy flow to power all system users (Dudin et al., 2019). To design the future high renewable energy electricity system, up-to-date analysis of the current state of technological development and the energy market is considered. Accordingly, it is predicted to be based on smart grids supported by Energy Internet (IoE) (Newbery et al., 2018). The term smart grid describes electricity generation, electricity transmission, electricity distribution, and electrical control systems (ILO, 2019). A smart grid is based on the bidirectional exchange of information and energy within electricity networks. It can optimize, save and transmit energy exactly where needed, i.e., based on a bidirectional exchange of information and energy (De Silva, Alahakoon and Yu, 2016).

The future smart grids are predicted to contain large shares of renewable energy sources (RES). Generating electricity from renewable energy sources provides direct and indirect economic benefits and reduces CO2 emissions and environmental impact. Moreover, renewable power generation integrated with the smart grid system is one of the best options for future energy security. The smart grid system improves the efficiency of power distribution by eliminating the distortion of power supply for communication and modern information technology (Strielkowski et al., 2019).

Global subsidies for conventional fuels and nuclear energy are still high, despite concerns about the benefits of renewables and environmental quality. Most of the expansion of renewable capacity is taking place in countries with large subsidy systems whose investors can afford the relatively high cost of renewable energy technologies. Many aspects such as electromagnetics, materials science, computer science, automation and the like are associated with smart grid generation, conversion, transmission, and electricity consumption (Kabalci, 2016). With breakthroughs in materials science and power electronics, the advantage of some advanced technologies is obvious, which will further expand highly renewable systems such as smart grids and DC transmission. DC transmission is likely to become the most important mode of power transmission in the future (Luca de Tena and Pregger, 2018). This segment is produced by solar, wind and gas turbines, and this segment represents more than a quarter of the advanced RES-focused energy market. The future high renewable electricity grids powered by IoE will significantly benefit from the optimum solution applied to smart homes, electric vehicles, solar panels, wind turbines, and peer-to-peer (P2P), flow (Strielkowski et al., 2019).

Human kinetic energy is seen as a promising sustainable energy source to solve the IoT's energy bottleneck (IoT). Harvesting of kinetic energy IoT research is in its infancy compared to technologies developed in harvesting other types of energy. Power management strategies should be determined to improve the energy efficiency obtained from the hardware source of the IoT and obtained from human movement;

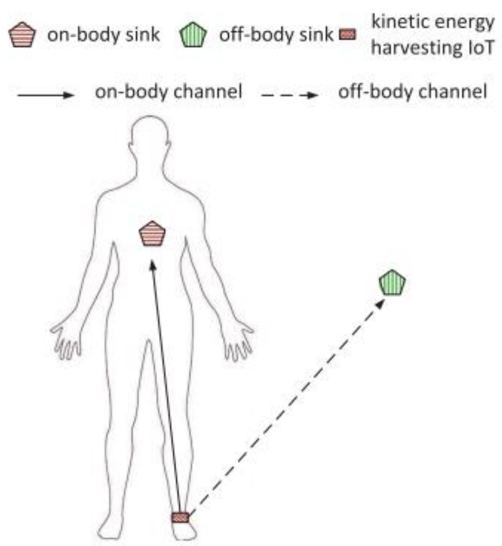


Figure 2. Deployment of the sender and sinks (Source: Ju, Li and Zhang, 2018).

this strategy requires two main problems to be solved to achieve energy efficiency. First, the IoT whose kinetic energy is collected must choose the most suitable sink to send the data. For low-power wearable IoT systems, there are generally two types of available pools for practical applications. One is the upper body sink, usually located on the chest. The other is an external sink, usually a static Base Station (BS). After selecting the optimum pool, the transmission power control is expected to obtain an energy-efficient wireless transmission power and at the same time provide the necessary reliability; therefore, to achieve optimum energy efficiency for kinetic energy harvesting IoT, it is necessary to develop the transmission power control algorithm with the common selection of sink (Ju, Li and Zhang, 2018).

According to World Energy Council, the definition of energy sustainability is based on three fundamental dimensions: Energy Security, Energy Equity, and Environmental Sustainability. Together they form the trilemma. Achieving high performance on all three dimensions requires complex, interconnected links between the public and private sectors, governments and regulators, economic and social factors, national resources, environmental concerns, and individual behavior (WEC, 2019). The strategies for each dimension of the Energy Trilogy in terms of electricity supply are as follows in order;

(i) Increase the mix of RE by 20% by 2025 to increase the reliability, availability, efficiency, and quality of electricity supply,

(ii) The affordable pricing of electricity and benefits to both producers and consumers,

(iii) Accelerating the decarbonisation of electricity, including advanced technologies and renewables. (Jørgensen, Hussain and Aris, 2019).

Renewable energy means to increase the share of local energy resources, and another expression is to favor the production of energy derived from local natural processes over fossil resources. The use of renewable energy is related to changes in energy supply resulting from fuel switching, including changes in technology (Mosannenzadeh, Di Nucci and Vettorato, 2017). Renewable energy is an ancient power source invented centuries ago, different from the people's belief, and used in ancient Iranian water and windmills, Roman-Greek solar concentrators, and other usage patterns have entered until today (Bahrami and Abbaszadeh, 2013).

3.2. Wind

Wind energy is mainly converted into mechanical energy using horizontal axis wind turbines (HAWTs) and vertical axis type wind turbines (VAWTs). Investments and efforts to develop make HAWTs the wind turbines with the largest market in the world. This situation has restricted the application of VAWTs with lower power coefficients; therefore, small-scale VAWTs are preferred in urban areas with more complex wind flow as their usage area (Ghasemian, Ashrafi and Sedaghat, 2017). According to the research, it is seen that the application of slope movement in the design of the VAWT increases the average net power coefficient of wind turbines by 1.5% to 15%. To be specific, it provides additional formation through the effect of slope motion on wind turbine aero dynamics. In this way, it is essential to increase the energy yield and future utilization efficiency of wind turbines installed in high places and require high-cost installation and maintenance services (Su et al., 2021).

To prevent damage to the wind turbines during strong winds, some wind must be wasted, so power control is used in all wind turbines. This indicates that wind turbines must be designed to draw maximum energy from the wind and provide full output power (Hansen et al., 2006). Because wind energy generates electricity without air pollution and gas emissions, a report prepared ten years ago by the United Nations International Panel on Climate Change concluded that the installed capacities should be increased by 20% by 2050 due to the critical role wind energy plays (IPCC, 2012). Today, some developing countries invest their investments in fossil-based energy production rather than wind. Yet, the sale and use of wind turbines is the functional building block of the transition to a renewable energy system (Zwarteveen et al., 2021). Spain is one of Europe's leading markets, with 23 GW of wind power installed at the end of 2017 (IRENA, 2018). Lu et al. (2009) An analysis was completed by determining the wind potential of Spain as the threshold and consequently the wind potential of 59 countries. Almost ten years later, Jung et al. (2018), because of the scenarios used to estimate global wind capacity, it seems possible that 53 countries have a greater or equal wind potential compared to Spain. As a result of these two studies, the data were combined, and the wind potential of 68 countries was listed according to the total installed wind energy as follows ;

Table 3. 59 high wind countries identified by Lu, McElroy, and Kiviluoma (2009) and 53 high wind countries identified by Jung, Schindler, and Laible (2018).

0 GW	0–0.1 GW	0.1–1 GW	1–10 GW	>10 GW
Afghanistan	Chad	Mongolia	Morocco	Brazil
Angola	Eritrea	Kazakhstan	Norway	Canada
Congo	Indonesia	Iran	Chile	France
Iraq	Syria	Tunisia	Uruguay	United Kingdom
Libya	Iceland	Argentina	South Africa	Spain
Madagascar	Nigeria	Czech Republic	Japan	India
Mali	Saudi Arabia	Ethiopia	Ireland	Germany
Mozambique	Somalia	Ukraine	Mexico	United States
Niger	Namibia	New Zealand	Netherlands	China
Oman	Algeria	Egypt	Australia	
Paraguay	Russia	Pakistan	Denmark	
Sudan	Colombia		Poland	
Tanzania	Kenya		Turkey	
Turkmenistan	Bolivia		Sweden	
Uzbekistan	Mauritania			
Zambia	Venezuela			
Greenland[a]	Belarus			

[a] No data available on Greenland in International Renewable Energy Agency (2018).

Listed above grouped by installed wind power capacity by the end of 2017 (IRENA, 2018).

Table 4. Pros and cons of wind energy (Source: Energy Sage, 2019a).

Pros of wind energy	Cons of wind energy
Renewable & clean source of energy	Intermittent
Low operating costs	Noise and visual pollution
Efficient use of land space	Some adverse environment impact

Wind power generation does not release harmful gases into the atmosphere, saving oxygen in the atmosphere. Simple technologies are enough to install wind turbines, which makes them attractive compared to other alternatives. Disadvantages such as visual pollution, noise, and vibrations that it causes in the region where it is installed are decreasing with the developing technologies (Özarslan and Bayraç, 2018). In practice, wind generators convert 30% of the maximum possible power. The main disadvantage of wind power generation is the conversion of only part of the wind energy into mechanical energy, depending on the aerodynamic power of the blades (Terziev, 2019).

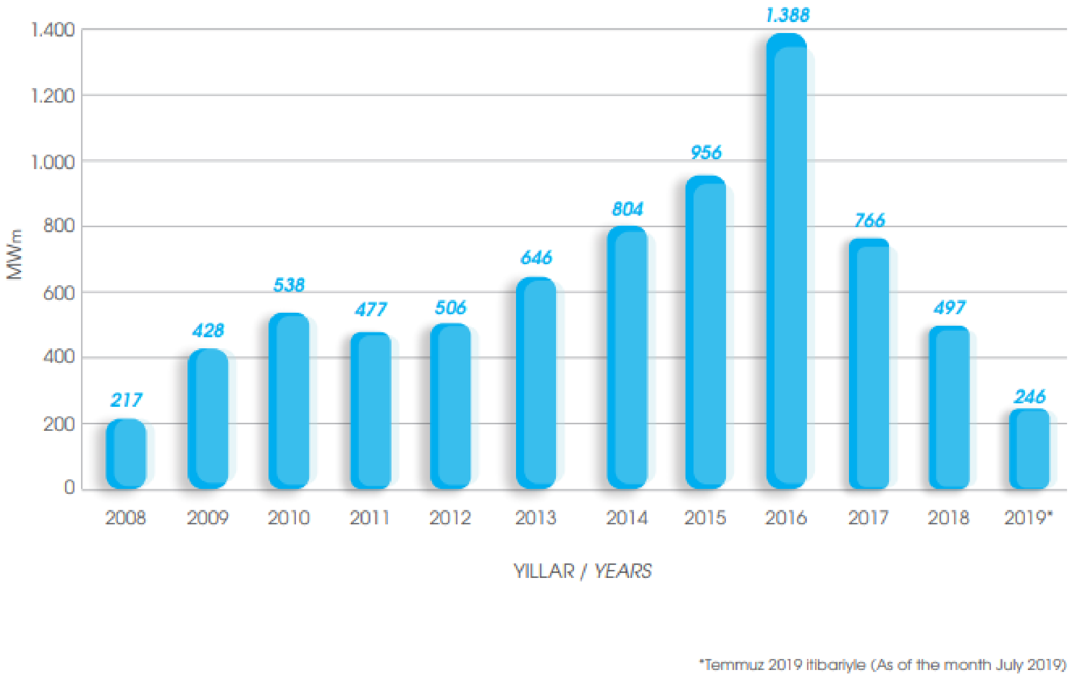


Figure 3. Annual installations for wind power plants in Turkey (Source: TÜREB, 2019).

In Turkey, the preferred power plants based on renewable energies are wind and solar power plants (Ozcan and Ersoz, 2019). Wind energy obtained from the collisions at different temperatures of air masses is a natural, clean, and trouble-free renewable energy type (Şengül et al., 2015). Turkey currently has 99 wind power farms, and the total installed power of said farms is 3933MW (Genç et al., 2020). Turkish scientists based on estimates made in 2011 has said that Turkey will be one of the world's largest wind energy producers in the world. According to these predictions, Turkey's wind energy potential is seven times Germany's twice Spain's potential. But installed current power capacity in Germany is approximately 8.5 times Turkey’s (Karagöl and Kavaz, 2017).

The fact that Turkey is bordered on three sides by seas gives it a significant advantage in strong wind capacity. Turkeys first wind farm was established at Çeşme-Germiyan (1.7 MW), second wind farm was established at Çeşme-Alaçatı (7.2 MW) (Koçaslan, 2010).

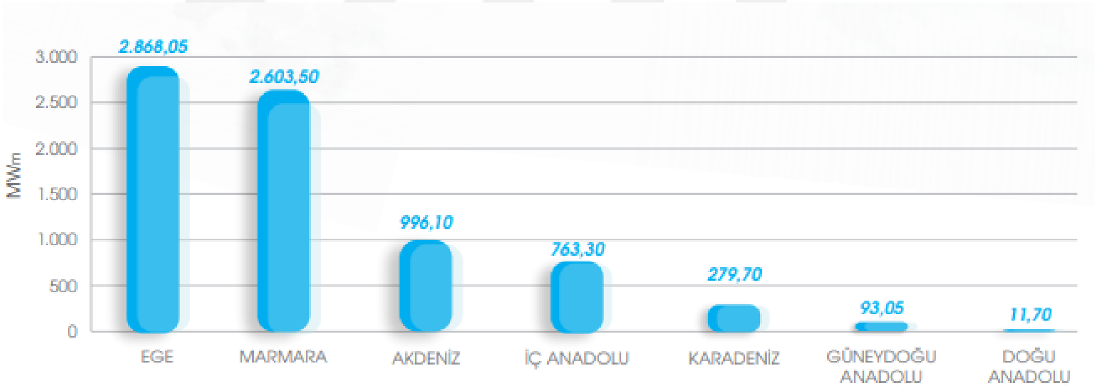


Figure 4. Operational WPP’s according to regions (Source: TÜREB, 2019).

The best place for wind energy production in Turkey is the region the Marmara Sea, the Mediterranean coast, and central Anatolia. Nevertheless, due to its geographical location, Turkey comes under the influence of many different air masses that have the potential for wind energy. In this case, strong northerly winds on the Balkan Peninsula and the Black Sea provide a high energy gain in winter (Ilkılıç, Aydın and Behçet, 2011).

3.3. Solar

Part of the energy produced by the reactions in the sun is radiation that reaches the earth. The process of converting this incoming radiation into electricity with solar panels defines solar power, and solar energy is a clean source of energy produced without gas emissions (Kabak and Dağdeviren, 2014). In 2018, to reduce carbon emissions by 70% by 2050, there is a need to increase solar photovoltaic (PV) from 0.5-0.6 TW to 8.5 TW by that date (IRENA, 2019).

Table 5. Pros and cons of solar energy (Source: Energy Sage, 2018).

Pros of solar energy	Cons of solar energy
Lower your electric bill	Doesn't work for every roof type
Improve the value of your home	Not ideal if you're about to move
Reduce your carbon footprint	Buying panels can be expensive
Combat rising electricity costs	Low electricity costs = lower savings
Earn money back on your investment	Findings local solar installers can be difficult

The main challenge PV systems face is meeting the energy supply cost-effectively during cloudy daytime conditions or when there is no sunlight at night (Denholm et al., 2015). Adding a battery energy storage system (BESS) to solve this situation (Denholm, Margolis and Eichman, 2017) or using techniques that control energy storage and accumulation power by distributing power output with concentrating solar thermal power (CSP) (Lunz et al., 2016; Yagi, Sioshansi and Denholm, 2019). Estimating the losses that can occur in the conversion of solar energy to electricity and determining the requirements for the panel are critical to achieving the desired efficiency of solar energy (Cheng, Cao and Ge, 2012). Along with this, various environmental and technical factors affecting the performance of the panel requirements installed for solar energy are as follows;

(i) *"Temperature factor,*

(ii) *Dirt and dust factor,*

(iii) *Conversion loss of from direct current to alternating flow (DC-AC),*

(iv) *Sun angle factor,*

(v) *Wiring and incompatibility losses"* (Ozcan and Ersoz, 2019).

Asia accounts for more than half of the PV capacity globally. It is followed by Europe, North America, Mid-East, and North Africa (MENA) regions, respectively (BP, 2020). However, even if Asia is projected to maintain installed PV capacities up to 2050, it has lower insolation and high pollution rate than other regions with high insolation

Compared with other renewable energy sources, solar energy in Turkey has the most potential energy source (Bayraktar, 2016) and surpasses Spain, France, and most European countries in terms of production potential. Turkey's photovoltaic solar energy installed capacity reached 4.8 GW level from the end of 2015 to the middle of 2018, showing an almost 20-fold increase reached. The issue that is expected to be the leading player in solar energy production is the low production price of the PV unit and system and the development of the future electricity infrastructures of these technologies (Amran and Radzi, 2020). Recent pro-energy laws in Turkey have led to falling technology costs by increasing investments in the area (Karagöl and Kavaz, 2017).

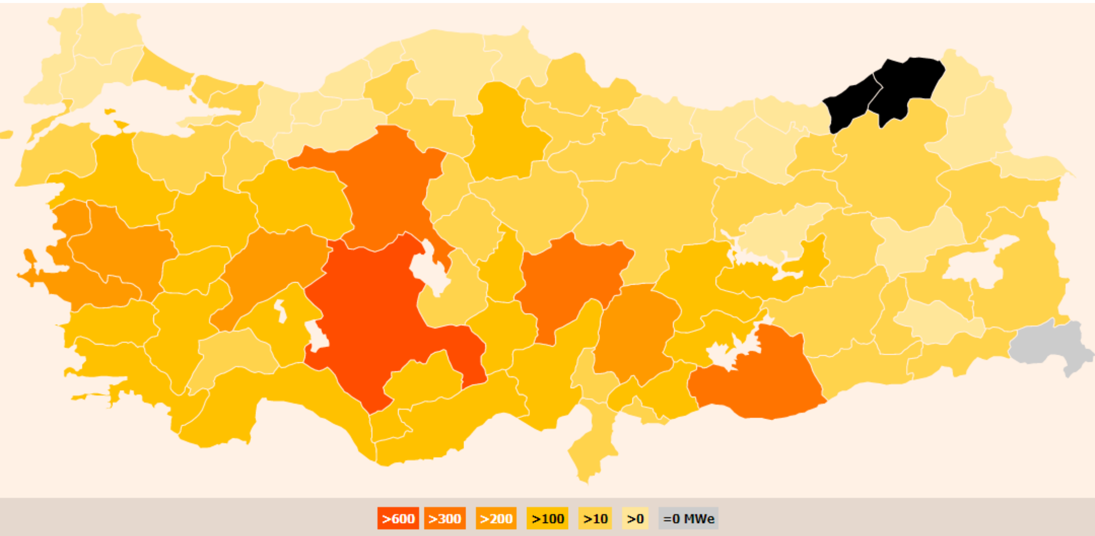


Figure 5. Turkey's solar energy potential map (Source: Enerji Atlası, 2021).

When analyzed on a regional basis, the Black Sea region is the most inefficient, but despite this, the values seen in the Black Sea are higher than the points of Germany with the highest potential (Dinçer, 2018). While Southeast Anatolia is the most fertile region, the Mediterranean region is the second most efficient region in solar energy production. Photovoltaic generators are suitable for all regions except the Eastern Black Sea Region (Erdin and Ozkaya, 2019).

3.4. Geothermal

Geothermal energy is produced by harnessing the earth's internal temperature and is an inexhaustible, renewable type of thermal energy. It is used for direct power generation and heating energy without endangering the environment (REN21, 2017). The use of geothermal resources for power generation dates back thousands of years. Geothermal power generation is more limited than heat generation because the high temperature of 100-150 degrees required for geothermal power generation is mainly achieved in higher gradients or rocks around the hydrothermal system (Huenges, 2010).

Table 6. Pros and cons of geothermal energy (Source: Energy Sage, 2019b).

Pros of geothermal energy	Cons of geothermal energy
Reliable source of power	Location dependent
Small land footpring	High initial costs
Usable for large and small-scale installations	Can lead to surface instability

It is assumed that the increase in energy prices after the depletion of resources such as oil and gas will not affect geothermal resources. As a result, geothermal energy is expected to gain momentum in the coming years. Meanwhile, there is a possibility that excessive generation of heat sources will cause reservoirs to deteriorate or even dry up (Rybach and Mongillo, 2006). 80% of the direct use of geothermal energy is geothermal heat, which contributes to bathing and swimming pools. The remaining 20% is used for applications such as heat consumption, water heating, agriculture (greenhouse heating, heating of agricultural ponds and agricultural drying), industrial process heat and snow melting (Soltani et al., 2019). Depending on the geothermal heat demand, heat is extracted from different depths. To illustrate, while horizontal geothermal heat exchangers extract heat from a depth of 1-2 meters, underground wells are less than 4-50 meters deep, energy pipes collect heat at 5-45 meters, and borehole heat exchangers are 10-250 meters deep (Sanner, 2001.).

By 2019, thirty countries have added geothermal capacity to the overall energy mix, with about 14.6 GW of installed capacity worldwide. While the US maintains its global lead, Indonesia, the Philippines, and Turkey follow. As of the end of 2018, two-thirds of newly installed capacity is in Turkey (294 MW) and İndonesia (139 MW) (REN21, 2019). With the discovery of the geothermal field in Kızıldere in 1960, Turkey has reported that 95% of its geothermal potential are suitable for direct use (Mertoğlu, Şimşek and Başarır, 2016). Geothermal energy, which has been developed in water-dominated hydrothermal fields since the 1960s, is one of the world's top five indirect uses in Turkey, such as greenhouse and residential heating between 2002-2007 (Şimşek, 2015). Turkey has the second-largest geothermal capacity in Europe and is the third-largest geothermal market in Europe (Fridleifsson et al., 2008). 78% of Turkey's geothermal potential is in Western Anatolia, 9% in Central Anatolia, Marmara Region 7%, 5% in Eastern Anatolia, and other regions 1% (Kırlı and Fahrioğlu, 2018).

3.5. Hydropower

Hydropower, derived from the energy of flowing water, is the largest renewable energy source in the world, generating about 17% of all electricity in the world and producing two-thirds of the electricity generated from all renewable varieties (IEA, 2018). Reliable hydropower generation is an important complement to the energy shares of intermittent sources such as wind and solar photovoltaics. It is a robust and successful alternative to fossil fuel-based technologies (IHA, 2018). The first use of hydro-energy began in the Near East, which dates to more than 2000 years, by using the energy of the water moving from high to low (Reynolds, Elrick and Clothier, 1985). Energy production from hydro-energy gained importance towards the end of the 19th century and accelerated industrialization (Manzano-Agugliaro et al., 2017). Countries with high mountains and high rainfall potential (such as Canada, the USA, and Norway) have contributed to the developing hydropower sector by implementing large-scale hydropower projects (Cross et al., 2013). A global boom in dam construction is expected due to investments in hydropower by several European countries, including Scotland, Germany, and surrounding Alper, Fennoscandia, and the Baltic regions (Zarfl et al., 2014).

Table 7. Pros and cons of hydropower (Source: Energy Sage, 2019c).

Pros of hyropower	Cons of hydropower
Renewable energy source	Some adverse environmental impact
Pairs well with other renewables	Expensive up-front
Can meet peak electricity demand	Lack of avaible reservoirs

Another issue where the investments in hydro energy have been developed is that they try to reduce the ecological effects of hydropower (Newbold et al., 2015). To put it anoher way, despite a global decline in biodiversity and the preservation of natural landscapes on a local scale, the arrangement of each river channel's solution must be handled differently (Nilsson and Berggren, 2000). It is regarded as the most reliable and economical energy source for hydroelectric renewable energy sources available in Turkey (Kucukali and Baris, 2009), and Turkey has the highest potential for electricity generation from hydropower in Europe (Kentel and Alp, 2013).

The average annual rainfall is 643 mm in Turkey, varying from 250mm to over 2500'mm in the northeastern Black Sea in Central Anatolia (Kankal et al., 2014). Turkey's freshwater reserves are divided into 25 river basins; more than 95.0% of the country's hydroelectric potential is divided into 14 river basins (DPT, 2001). 67.26 TWh of the country's electricity demand, 24.58%, is met by hydroelectric resources. The contribution of hydropower in meeting electricity demand is expected to increase to approximately 116.0 TWh by 2023, which means that between 22.0% and 27.0% of the annual electricity demand will be met by hydroelectric power generation (Akpinar et al., 2012).

3.6. Biomass

The main components of the energy source biomass are all organic substances of plant and animal origin, which are carbohydrate compounds. The energy obtained from these sources is called biomass energy. In other words, it is also defined as the mass of biological origin and non-fossil organic matter that can be renewed in less than 100 years (Kaygusuz, 2009). In the use, a distinction is made between classical and modern. The use of wood, plant, and animal wastes falls into the classical category, especially in underdeveloped countries. The extraction of process heat, electricity, liquid or gaseous fuel from materials such as organic-containing domestic, urban, and industrial wastes/wastewater, energy crops, forestry energy products, forest wastes, animal/agricultural wastes and algae describes modern biomass use (Acaroglu, Akdeniz and Boyar, 2009).

Table 8. Pros and cons of biomass (Source: Energy Sage, 2019d).

Pros of biomass	Cons of biomass
Renewable	High costs
Waste reduction	Space requirements
Reliability	Some adverse environmental impact

Biomass power generation is presented as one of the basic options for a sustainable and renewable resource to reduce the need for fossil fuels. This is because biomass is cited as a powerful substitute for fossil resources. Since biomass can be obtained as a solid fuel such as pellets and wood chips, a gaseous fuel such as biogas, and a liquid fuel such as biodiesel and bioethanol, it is dispersible and easy to store (Saracoglu, 2010). This advantage allows biomass to be used for transportation, heating and cooling, all other domestic purposes, and industrial processes, unlike some renewable energy sources that generally contribute only to electricity generation (Ozcan, Öztürk and Oguz, 2015). Biomass plays a vital role in the global energy economy, and with increased use, it is considered a critical element in future low-carbon scenarios (Ulutaş and Karaca, 2018). In the biomass World market, Europe has made 47.6% of the investments in production technologies; Asia-Pacific is dominated by Japan, which uses 60% of solid waste to incinerate. And China has the fastest growth in the biomass market, more than doubling its waste-to-energy production capacity. Canada and EU countries aim to meet 25-50% of their energy needs from biomass by 2050. Turkey's 2023 target of 100MW of energy recovery from biomass goal is far behind, USA's 235-410 MTEP, Germany with 11-21 MTEP, and Japan with 9-12 MTEP (IEA, 2020). Turkey and Germany have the same population levels, and Turkey's land area is twice that of Germany, but energy production from biomass in Germany is about 20 times that in Turkey (IEA, 2019).

Turkey has bright sun, and conceptual space availability provides water resources and climatic conditions of the offer abundant supply of biomass material. Turkey biomass resources in agriculture, forestry, animal, and urban organic waste, and so on. Considering that it provides from the substances, its distribution is as follows;

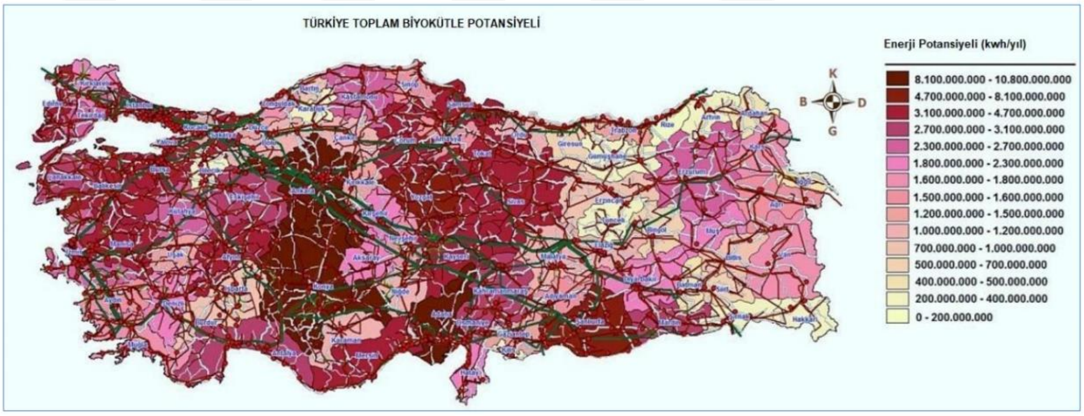


Figure 6. Biomass potential distribution by provinces in Turkey (Source: Toklu, 2017).

Turkey's potential energy value of agricultural waste per year will vary between 15.6 to 20 million toe, animal manure potential 1.17 million toe and municipal waste solid potential is 7.52 million TEP (Ozgur, 2008). Turkey's annual energy potential of biomass from agricultural, wood wastes, animal wastes, and other biomass energy produced from waste has been identified as an average of 32 milton toe per year (Demirbas, 2008). The results of another survey carried out frequently in Turkey, sheep, and poultry manure-derived biogas potential of 3.30 billion m3/year and landfill gas potential was determined as 600 million m3/year (Ediger and Kentel, 1999). Turkey's total biomass potential was ranged between 14.6 to 32 million toe in 2018, and biomass energy generated was 3.1 million toe. Currently, Turkey cannot access for use 78% to 90% of the available biomass potential. The reason is substantially reduced, and the use of biomass in Turkey is a slow transition from classical to modern biomass. Turkey's biomass potential has not been utilized enough by modern methods (İlleez, 2020). According to a survey conducted in Turkey, a large part of the combustion energy value of biomass energy was achieved by using chicken waste (53-55% of total). Rest is made up of greatness by combustion values resulting from industrial wood production wastes, sewage sludge organic wastes, timber wastes, and agricultural wastes are followed respectively (Gürel, 2020). According to the General Directorate of Energy Affairs report, biomass meets approximately 1% of the total electricity generation (TSKB, 2020).

3.1.6. Wave Energy

The Earth's surface consists of 70% seas, and oceans provide a high potential of wave energy potential of 80000 terawatts (Melikoglu, 2018). In recent years, interest in wave energy has increased worldwide because if this high potential of wave energy can be utilized, approximately 1/3 of the world's energy needs will be met (Doukas et al., 2014). While the high initial costs for generating wave energy and complicated installation processes in the ocean are not preferred by investors (Falnes, 2007). Therefore, ongoing research on wave energy, optimization of already developed systems and development of new systems are generally aimed at increasing production output and minimizing costs. European countries and America are rapidly expanding their investments in wave energy and in systems based on solar and wind energy. Studies on the use of energy from wave power began in 1980 and have emerged with various patented designs to date (Falcão, 2010). Wave energy generating systems are still in the developmental stage; converters currently used are not commercial, the most common type of WEC (The European Marine Energy Centre Ltd., 2020). Wave energy converters aim to generate emission-free and environmentally friendly electricity (Erselcan and Kükner, 2020).

Renewable resources of marine origin mentioned in the literature (Ürün and Soyu, 2016);

(i) *"Sea wave energy,*

(ii) *Temperature gradient energy,*

(iii) Energy of sea currents in the straits and

(iv) The tidal energy".

Nonetheless, there is no sufficient tidal energy source in Turkey. Therefore, of the four options, only sea wave energy and energy derived from currents in the straits can potentially be used (Ürün and Soyu, 2016).

There are three main reasons for wave generation in the sea;

(i) Earthquakes and subsidence on the seabed,

(ii) Tidal events (Gravitical pull of Noon and Sun),

(iii) Winds and storms.

The waves created by the winds have a certain height and speed, and their duration is 3-5 seconds on average. The only difference from hydroelectric power plants is that instead of storing water, the potential of the wave created by the wind is used (Uihlein and Magagna, 2016).

Table 9. Net wave power of some regions rich in wave energy (Source: Mørk et al., 2010).

Bölge	P_{net} (GW)
Avustralya ve Yeni Zellanda	574
Güney Amerika'nın batısı	324
Avrupa'nın kuzeyi ve batısı	286
Asya'nın güney doğusu ve Malenezya	283
Kuzey Amerika'nın batısı	207
Güney Amerika'nın doğusu	202

The places in the world between 40-60 degrees latitude of the Northern and Southern Hemispheres are the richest areas in terms of wave energy. Contrastingly, the relatively smaller land population in the southern hemisphere, corresponding to latitudes 40-60 degrees, has stronger waves than the northern hemisphere (López et al., 2013). Wave powers of other countries: Ireland 21GW, Portugal 10 GW, Denmark 3.4 GW, Sweden 1 GW, UK GW, and the total wave power of France, Italy, Spain, and Greece on the Mediterranean side is 30GW (Vicinanza, Contestabile and Ferrante, 2013). Because seas surround Turkey on three sides with a large wave energy potential, this potential is estimated to be 18.5 billion kWh (Drew, Plummer and Sahinkaya, 2009). Despite Turkey's wave potential, it is not appropriate to set up systems on each coast. Turkey has a total length of 8210km coast, and about one-fifth have wave energy technical potential (Hepbasli, Ozdamar and Ozalp, 2001). The most appropriate location for generating wave energy in Turkey are: The west of the Black Sea, the north of the Bosphorus, and the southwestern coasts of the Aegean Sea (Sağlam and Uyar, 2005). As a result of scientific research on the Black Sea's wave energy potential, the wave energy potential was increased based on 15 years of numerical data. As a result of the negotiations made by the Black Sea Development Agency (BAKKA) with the Australian based company CSG Exploration and Production Services, it was announced in the announcement dated 27.03.2017 that a free pilot plant installation was requested in Zonguldak (Batı Karadeniz Kalkınma Ajansı, 2017). This development is of great importance for the future of wave energy application in the Black Sea. Another significant development for the production of Turkey wave energy National Boron Research Institute (BOREN) and Turkey Electro Industries Inc. (TEMSAN) launched on 15.02.2008 in cooperation with the Wave Electricity Production from Energy of the project called Sakarya is carried from the town of Karasu (Kapluhan, 2014).

3.1.7. Kinetic Energy

It plays a vital role in collecting kinetic energy from the ecologically sustainable alternative, solving the energy crisis, protecting energy resources for a long time, and protecting the environment from dangerous emissions (Maamer et al., 2019). Wave energy (Xie et al., 2020) and wind power (Santhakumar, Palanivel and Venkatasubramanian, 2017) systems based on obtaining energy aimed at sound energy (Wang et al., 2018), vehicle vibration energy (Wang et al., 2020), energy wasted during human movement (Izadgoshasb et al., 2019), and many environmentally friendly energy alternatives such as energy-based on rapid impact vibration (Zhang et al., 2016). Human kinetic energy depends on traditional ambient energy sources, i.e., the sun (Yang et al., 2013) and the wind (Ha et al., 2020). In comparison, it provides renewable energy from our daily life and shows improved energy availability. There are different types of vibration energy to harvest (Bischur and Schwesinger, 2012).

Williams and Yates's generic model of kinetic energy harvesters was first introduced (Williams and Yates, 1996). Kinetic energy collectors, also called vibrational energy generators, harvest electrical energy through one / several different mechanisms, including electromagnetic, electrostatic, piezoelectric, or magnetostrictive materials (Kaźmierski and Beeby, 2011).

Table 10. Comparison of different conduction mechanisms of kinetic energy collectors (Source: Kaźmierski and Beeby, 2011).

Type	Advantages	Disadvantages
Electromagnetic	• No external voltage source • No mechanical constraints needed • High output current	• Difficult to integrate with MEMS fabrication process • Poor performance in micro-scale • Low output voltage
Piezoelectric	• Simple structure • No external voltage source • Compatible with MEMS • High output voltage • No mechanical constraints needed	• Thin films have poor coupling • Poor mechanical properties • High output impedance • Charge leakage • Low output current
Electrostatic	• Easy to integrate with MEMS fabrication process • High output voltage	• Mechanical constraints needed • External voltage source or pre-charged electret needed • High output impedance • Low output current
Magnetostrictive	• Ultra-high coupling coefficient • High flexibility	• Non-linear effect • May need bias magnets • Difficult to integrate with MEMS fabrication process

Table 11. Types, lifetime, and technical characteristics of piezoelectric types (Source: Moussa, 2019).

Company Name-Product	Product Dimension	Energy Generated	Life span by years
Waynergy Floor	40 x 40 cm	10W per step	20
Sustainable Energy floor (SEF)	75 x 75 cm OR 50 x 50 cm	Up to 30 watt	15
Pavegen tiles	V3 Tile 50 cm each edge	5Watts / footsteps	20
Sound Power	50 x 50 cm tile	0.1 watt per 2 steps	20
PZT ceramic (Lead zirconate titanate)	Manufacturing in a small size	8.4mW	20
Parquet PVDF layers	Layers	2.1mWs per pulse with loads of about 70 kg	20
Drum Harvesters - Piezo buzzer Piezoelectric Ceramics	Vary	Around 2.463 mW	20
hybrid energy floor- which integrate the human power with the solar energy	1 x 2-meter tile 75 x 75 cm tile	Can generate up to 250 kWh per year, per tile up to 250 kWh per year, per tile	20

The word piezo means weight in Greek, and the primary meaning of the word piezoelectric, namely weight power refers to materials with different geometrical voltages forms an electric field. In 1880, Pierre and Jacques Curie found direct electrical energy in single gem quartz. Quartz was found to produce an electric charge when under tension; this area is known as piezoelectric (Uchino, 2017). The use of piezoelectric technology began in 1971 when Paul Langevin, a French physicist, installed and launched a submarine detector based on the effect of piezoelectricity. The success of this innovation by Langevin allowed the use/combination of piezoelectric materials in various applications and uses (Kour and Charif, 2016).

Different types of piezoelectric transducers can collect vibration energy, including monomorphic, bimorph, stack, or membrane (Feenstra, Granstrom and Sodano, 2008). Each configuration has its advantages and limitations (Mak et al., 2011). The most widely known energy harvesting techniques are to generate energy without the mechanical stress or strain caused by traffic (Anton and Sodano, 2007). Continued demand to diversify piezoelectric energy use (Wang et al., 2017), the installation cost-effectiveness of energy harvesting equipment is decreasing, and studies are still ongoing (Song et al., 2019). Interest in energy harvesting has rapidly increased, as in recent years the achieving the summit of smart cities has become the main goal of all governments in developed and developing countries to tackle climatic and environmental pollution, and vibration energy harvesting using piezoelectric materials is of great interest (Moussa, 2019).

3.2. Smart Energy Applications in Cities

The criteria for a smart city depend on the investment in energy production matching the potential of energy use. In energy production, renewable energy consumption plays a crucial role. This situation offers a mutual gain in two ways;

(i) By reducing global warming with the reduction of pollution generated within the country in the production of energy,

(ii) Generating affordable and sustainable energy for use in the formation of smart cities (Mekhum, 2020).

This brings the prominence of renewable energy sources and the search for new local clean energy sources. With the increasing trend of renewable energy sources worldwide, a significant trend towards 100% renewable energy has begun, aiming at sustainability to protect the environment (Child et al., 2019). The energy identity of countries is evaluated through the economic growth of energy (Johansson and Goldemberg, 2002). There is a direct correlation between economic growth, energy demand, and higher energy demand due to the growing population, which causes higher economic growth (Bhattacacharyya, 2011). The two guiding steps of the strategy that a region, city, and municipality will create to switch to 100% renewable energy are as follows;

(i) Knowing how to deal with problems that are not logically embedded in either local or global action.

(ii) Through local communities positioning themselves in national and international contexts (Thellufsen et al., 2020).

This positioning goes through scenarios that countries or local communities create to prepare themselves for the future. The scenario enables the development or depiction of the path that leads from today to the future (Jungk and Müllert, 1996; Gordon and Glenn, 2017) and it is one of the most basic concepts underlying the work to be done on the proposed projects and requires accurate analysis (Schoemaker, 1991; Hafezi et al., 2019). For example, open access technologies appear to be the most critical role player in renewable energy. This is the basis of scenarios analyzing international energy efficiency in the energy World (Blueprints, Modern Jazz, and Unfnished Symphony) was due to accurate analysis and performance (Alola, Alola and Akadiri, 2019). Energy scenarios span various periods from 20 to 100 years, differing by multiple drivers, modeling techniques, and historical assumptions (Goldemberg, 2000). Therefore, as a typology, energy scenarios are categorized as predictive, exploratory, and normative. The combination of policy changes, international policy trends, economic development and technological innovations follow each other in the relationship between the parameters of these differences in energy scenarios (Bhattacharyya and Timilsina, 2010; Cao et al., 2016).

To create broader and long-term sustainable development projects in renewable energy solutions, they need to break down their internal barriers with many areas such as urban planning, energy, transportation, and waste management (IRENA, 2019).

Brazil	Under the co-ordination of the Ministry of Mines and Energy, the Energy Research Office (EPE) published the National Energy Plan to 2030 based on LTES developed by in-house modelling teams at EPE. EPE is currently developing the national energy plan to look further forward to 2050.
Canada	The National Energy Board (NEB) publishes Canada's Energy Future based on LTES, while Environment and Climate Change Canada (ECCC) publishes LTES for both international and domestic reporting purposes. Both the NEB and ECCC have in-house modelling teams. These activities are supported by data from Statistics Canada and Natural Resources Canada (NRCan)
Chile	The Ministry of Energy publishes a long-term energy planning document every five years with a 30-year time horizon, based on LTES developed by in-house modelling teams.
Denmark	The Danish Energy Agency (DEA), a government agency under the Ministry of Energy, Utilities and Climate, annually publishes the Danish Energy and Climate Outlook and the Power and Gas Infrastructure Outlook based on LTES developed by its System Analysis Department. The System Analysis Department also produces the National Energy and Climate Plan requested by the European Union.
Finland	The energy and climate strategy in Finland up to 2030 was developed by cross-ministry joint work and supported by LTES modelling teams from the VTT Technical Research Centre of Finland and four other research organisations. LTES play an important role in the forthcoming Long-term Energy and Climate Strategy of Finland, which seeks to formulate sustainable pathways to carbon neutrality.
Germany	The Federal Ministry for Economic Affairs and Energy (BMWi) and the German Environmental Agency (UBA) use various LTES procured from research institutions. These LTES usually reflect the renewable energy-related targets of the Energy Concept 2010. The Federal Network Agency (BNetzA) uses LTES as a starting point for transmission grid planning.
Japan	The Ministry of Economy, Trade and Industry (METI) co-ordinates the development of the Strategic Energy Plan, which comprises LTES for 2050 using inputs from the expert panel appointed by the government and considering the energy mix from the outlook for 2030.
Mexico	The Federal government has published the National Energy Strategy, in which the vision for 2050 is established based on LTES with 15- and 30-year time horizons developed by in-house modelling teams at the Mexican Secretariat of Energy (SENER).
The Netherlands	The Netherlands Environmental Assessment Agency (PBL) publishes the Dutch National Energy Outlook, providing four Ministries (Economic Affairs and Climate; Interior; Infrastructure and Water Management; and Finance) with LTES developed by in-house modelling teams. From 2019 onward, this Outlook will be renamed the 'Climate and Energy Outlook' and will have legal status as reference for policy progress as stated in the new Climate Law.
United Arab Emirates	The Ministry of Energy and Industry (MOEI) launched the National Energy Strategy 2050, informed by LTES developed by in-house modelling teams. It has developed the Future Lab to communicate LTES results to high-level political leaders.
United Kingdom	The Department for Business Energy and Industrial Strategy (BEIS) maintains a national energy system model with a 2050 planning time-horizon in close co-operation with academia to inform policy development – the Clean Growth Strategy is a good example.

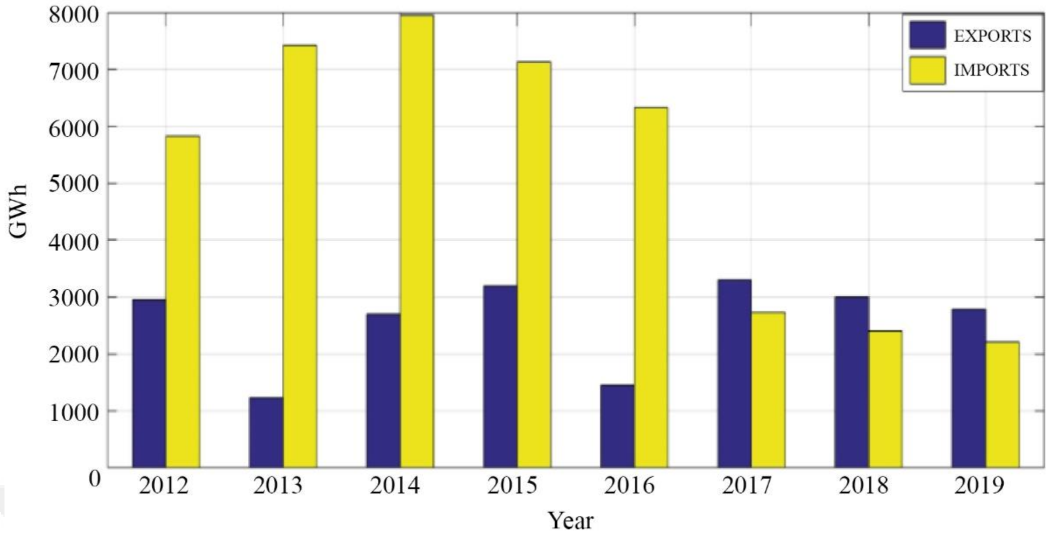
Figure 7. How countries use and develop scripts (Source: IRENA, 2019).

Accordingly, today, many cities, municipalities, and local communities have been involved in designing strategies to transform the energy supply into a renewable energy system in the future by anticipating the energy supply of their regions (Thellufsen et al., 2020). Within these strategies, policies supporting a wide range of clean energy-related technologies have been adopted, including renewable energy, energy efficiency, and energy flexibility (NC Clean Energy Technology Center, 2019). All energy-based plans use different concepts and goals for transition. Like, Decarbonized (Gomez-Echeverri, 2018), net-zero energy (Deng, Wang and Dai, 2014), carbon neutral (Hast et al., 2018), and 100% renewable energy systems (Hansen, Breyer and Lund, 2019). For example, Sweden 2045 (Sweden Government Energy Policy, 2016) , In Denmark by 2050 at the latest (Kosiara-Pedersen, 2019). More than 150 cities have adopted an ambitious renewable energy supply by setting a 100% clean energy target while aiming to achieve zero net gas emissions (Sierra Club, 2019). These cities include Bangladesh, Barbados, Cambodia, Colombia, Ethiopia, Ghana, Mongolia, Vietnam, Hawaii, and California, with target years ranging from 2045-2050 (REN21, 2018).

Renewable energy has three ultimate uses in cities: electricity, transport, and heat. Between the years 2010 to mid-2019, more than 250 cities have set for themselves achievement targets in energy, heating, cooling, transportation, and more than half a dozen other targets in all sectors, intending to achieve said targets between the years of 2020 and 2050 in some cases changing current practices by up to 100% (REN21, 2019). Electricity accounts for almost two-thirds of the growth in renewable energy consumption, followed by heat at 30 percent and transport at 6 percent (IRENA, 2020). According to the same report, United Kingdom its share of renewable energy has tripled, while Germany, Italy, France, and Japan have seen significant growth, mainly in the electricity sector. At the same time, consumption of modern renewables in Indonesia, Pakistan and Nigeria is growing much more slowly than non-renewables. Brazil leads in renewable energy consumption, followed by Canada and China.

World Energy Council’s accordance with the Energy Index Trilemma Turkey ranks 66, Turkey and Europe's 6th biggest electricity market (WEC, 2019). According to the current report, Turkey has a 1% share of world energy production, and its share of energy dependence is 76%. Durmuşoğlu has defined two main goals for renewable energy in Turkey: energy center and energy corridor. The energy center, goal aims to ensure the country's security of supply by increasing the type and use of energy. On the other hand, the energy corridor is to be able to maximize not only energy efficiency but also the use of renewable energy by activating renewable energy sources called green energy resources (2015).

Table 12. Turkey's import and export of electricity (Source: Dawood, 2020).



There was 40.6 GW of installed power in 2006, Turkey's electricity production went up to 91.3 GW output in 2019, and this installed power in the first six months of 2020 was calculated as 92.1 GW.

There are two reasons as to why Turkey's energy profile is occurring in this manner;

(i) High fossil fuel dependency and

(ii) High energy import dependency (Erat et al., 2020).

According to the Organization for Economic Co-operation and Development report, Turkey’s energy demand is expected to double within ten years. According to Wilson (OECD, 2017), this severe problem for the country's energy security needs to reduce its dependence on energy imports and plan a transition away from such dependence. Energy planning is an important tool for sustainable development, and without planning efforts, the optimal balance between energy system production and consumption cannot be achieved. Energy planning and programming of energy production in real conditions occur at the internal stage. These are data collection, modeling and forecasting, and programming (Genç et al., 2020). In 2019 40 % of electricity production was supplied by renewable resources (Hydro, wind, and solar); whilst another 55% was produced by Thermal power stations. The total electricity production in Turkey increased from 191,6 (TWh) in 2007 to 303,3 (TWh) in 2019 (Dawood, 2020). Turkey has adopted several strategic documents and actions to enhance regional growth and development of renewable energy; one of them with the most up to date is a strategic renewable energy plan (MENR, 2019). Turkey's national renewable energy action plan (UYEEP) is a document setting out strategies to encourage the development of new renewable energy; the long-term objectives are;

(i) Increasing the share of electricity generation based on RES to at least 30% of total generation by 2023,

(ii) To provide 20% of the total energy demand from RES

(iii) Contribute to technological and industrial development by reaching higher renewable energy installed capacity by 2023 (Arık, 2016).

Turkey's 2050 plan for achieving 100% renewable energy (RE) will be examined in two main stages;

(i) First stage between 2015-2030 and

(ii) Second stage after 2030.

While the transition from fossil, coal, and gas-based electricity to solar PV and wind power is the goal of the first phase, the second phase is about increasing storage capacities to better balance the rising renewable energy supply share. If Turkey's progress in planned renewable energy targets is achieved, Turkey will likely become a major equipment supplier for renewable energy technologies and equipment (Bayraktar, 2018). Turkey would become in concordance with the Paris deal with the realization of 100% renewable energy supply by 2050 (Kilickaplan et al., 2017). The Paris agreement, which is the global climate agreement by directing investment flows in renewable energy technologies (RETs), is trying to mitigate efforts to limit the global temperature to 2 degrees higher than the pre-industrial level in line with this goal, which shows that achieving the goals set is universally important (Kul, Zhang and Solangi, 2020).

The first criteria used for renewable energy comparison technology are as follows;

(i) "Technical: reliability, efficiency, simplicity,

(ii) Economic: investment cost, investment risk, capacity control,

(iii) Environment: CO2 emissions and impact on the ecosystem,

(iv) *Acceptance of social people and job opportunity* " (Baris and Kucukali, 2012).

The cornerstone of Turkey's electricity produced from renewable sources to relevant legislation enacted in May 2005 Law on the Use of Renewable Energy Sources Electricity Production Purposes *(Figure 8).* The foundation of this law was laid in March 2001 with the Electricity Market Law. In June 2007, the Geothermal Resources and Natural Mineral Water Law laid down the principles of exploration, production, and protection of geothermal and natural mineral waters. In July 2008, Law No. 5784, which includes electricity generation capacity and exemptions from obtaining a generation license, entered into force. In December 2010, Law No. 5346 of 2005 and Law No. 5686 of 2007 were amended with the Law on the Use of Renewable Energy Resources for Electricity Generation, making it easier to obtain licenses by primary and legal entities (Deveci and Güler, 2020).

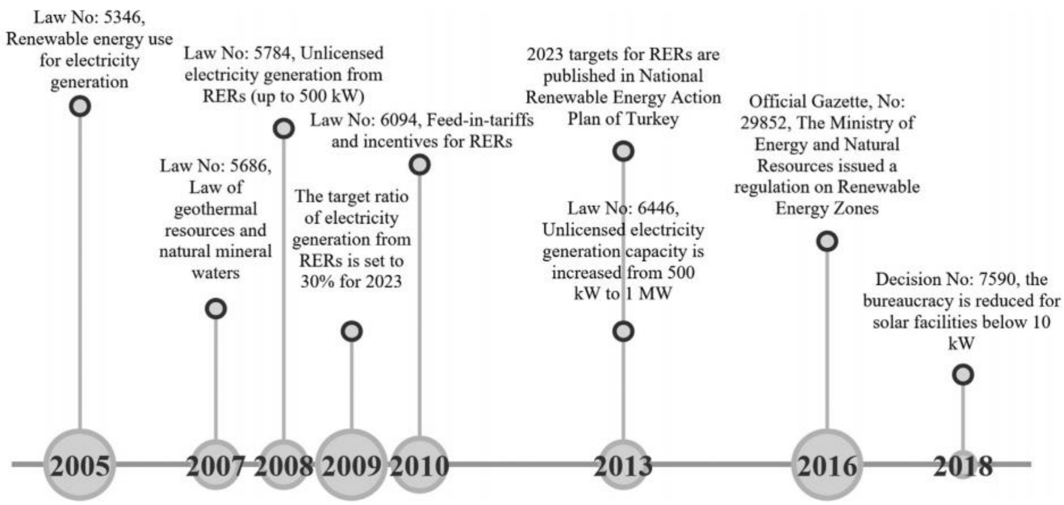


Figure 8. Graphical representation of developed legislation and action plans to promote the dissemination and growth of renewable energy power plants in Turkey (Source: Deveci and Güler, 2020).

With all the preparation work done with the renewable energy policies, Turkey seeks to achieve specific goals. This entails reducing energy dependence by increasing electricity production from renewable energy sources in Turkey (Uğurlu and Gokcol, 2017). A country's energy policy and energy security do not only determine its economic strength in the world. Countries like Turkey that can be dependent on energy imports are more likely to be affected by energy price fluctuations and epidemics. For example, countries like China, Egypt, Brazil, Argentina, Turkey, and Latvia, because of their energy dependence threshold levels, are at risk until 2025 (Hajiyev et al., 2020).

3.3. Smart Energy Applications in Public Green Spaces

Environmental ethics, a branch of philosophy that investigates the moral relations between people and nature, examines the perception, management, and use of natural resources that are cultural in natüre (J. Baird Callicott, 1989). Just as social ethics can direct how people behave towards each other, environmental ethics create awareness of how people relate to the natural resources surrounding them and guide how to manage them (Jax et al., 2013). Hardin's seminal essay on the tragedy of the commons (Hardin, 1968) has started the current debate on public goods (Levin, 2014). Society has been reminded that natural resources are limited and are a critical component of the system that supports the human condition.

Table 13. The mutual barriers of implementing and maintaining common indoor and public outdoor spaces (Source: Jens and Gregg, 2020).

Barriers	Common indoor spaces	Public outdoor spaces
Economic prioritization	Operation and maintenance costs, impaired functionality	Low maintenance, privatization and commercialization
Policy constraints &benchmarks	Standards and benchmarks, legal and regulatory barriers	Lack of valuation and data collection methods
Equipment &support structures	Support structures, equipment, ICT, catering services, furniture	Specific equipment and management rules
Densification &space-efficiency	Utilization rates, existing building configurations	Urban densification, land use patterns and future trends
Environmental discomfort	Overstimulation, noise, crowdedness, privacy, ambiance	Noise and other nuistances, privacy, ambiance
Locational accessibility	Locational accessibility, distances and support facilities	Perceived accessibility, long distances

Public spaces such as parks and squares are an element that fosters a sense of community and facilitates random comparisons between neighbors (Talen, 2000).

There are many definitions of the public sphere in the literature. Ray Oldenburg explains the term he defines as third place as follows;

> *“a generic designation for a great variety of public places that host the regular, voluntary, informal and happily anticipated gatherings of individuals beyond the realms of home and work”* (Oldenburg, 1989).

Well-designed public spaces have the potential to attract more users and a wide range of activities from poor quality areas that tend to be used for essential activities (Gehl, 2006). The *real* public space is recognized as accessible to all groups that provide freedom of movement, temporary claims, and property (Altman and Zube, 1989), (Carr et al., 1992). Public and shared spaces have a strong potential to facilitate increased diversity of functions, activities, and social needs in cities and buildings (Hadavi, 2017). Greenfield standards are often familiar with policymaking but can be difficult to enforce or enforce (Jennings, Larson and Yun, 2016).

A global city comparison based on public green spaces is as follows: Oslo (68%), Singapore (47%), and Sydney (46%) ranked highest, while Istanbul (2.2%), Taipei (3.4%), and Bogota (4.9%) rank lowest (World Cities Culture Forum, 2019). The strategy of minimizing building space has been increasingly important for several decades to ensure countries' economic and environmental sustainability (Kim, Cha and Kim, 2016).

The following are associated with social interactions due to these characteristics of urban green spaces;

(i) It has an open park design to encourage active reinstatement activities and is surrounded by shaded areas that support rest (Peters, Elands and Buijs, 2010),
(ii) Availability of sidewalks (Holtan, Dieterlen and Sullivan, 2014),
(iii) Access to parks through quality transport options (Ward Thompson et al., 2016),
(iv) Functional playgrounds (Bennet, Yiannakoulias, Williams and Kitchen, 2012) and
(v) Scope of organized activities (Plane and Klodawsky, 2013).

Therefore, the characteristics of the built environment and facilities near the urban green areas are associated with social adaptation (Fan, Das and Chen, 2011).

Particularly, the level of participation in the green space may vary depending on the qualities and intended use of the green space. Due to their meaning and role, public outdoor spaces affect the city's quality and identity, which varies depending on the level of design and detail (Moughtin, Oc and Tiesdell, 1999). Structural elements, one of the main elements that make up the identity of cities, are shaped according to social and cultural features and natural factors. While the effect of culture is a part of the urban identity, it plays a role in shaping artificial elements in the aesthetic perception that varies from person to person (Özer, Aklıbaşında and Zengin, 2010). Products created for and adding meaning to the spaces are as important as the natural three-dimensional perceptual environment. For this reason, it is seen as an obligation that the object in the common areas serves the common language as well as the qualities that support the functions it performs. Common language is that the product does not conflict with the aesthetic values of the space and serves the soul of the region (Güneş, 2005). Namely, urban furniture, which is a part of the system based on urban identity, must survive in the city both technically and visually, and this sustainability is not because it is a part of a system, but because it is an

"understandable and accessible language for everyone" (Bayrakçı, 1989).

3.4. Integration of Urban Furniture into Smart Systems

Multi-dimensional situation assessment of the urban reinforcement element is necessary for the success of its application. For example, the design, production, marketing, and selection of the reinforcement element should be placed in the field. Besides environmental awareness, visual and architectural integrity, humanistic approach; Accurate analyzes should be made to meet social needs and the use of materials that can resist ecological differentiation (Başal, 2002). Urban furniture is classified as follows according to its functions (Yıldızcı, 2001);

- *(i) "Surface Paves (Concrete, Stone, Wooden, Asphalt, Brick.. etc.),*
- *(ii) Seating Units (Benches, Chairs, Group Seating Elements),*
- *(iii) Lighting Elements (Road and Area Lights),*
- *(iv) Sign and Information Systems (Orientation and Indication Elements, Info-communication Notice Boards),*
- *(v) Barriers (Dissuasive and Restrictive Elements, Pedestrian and Traffic*

Barriers, etc.),

(vi) *Water Elements (Ponds, Temples, Waterspout, Channels, and Fire Taps),*

(vii) *Superstructure Elements (Bus-stops, Shades, Pergolas),*

(viii) *Commercial Units (Kiosks, Exhibition Nodes, Buffets, etc.),*

(ix) *Artistic Objects (Statues),*

(x) *Other Elements (Flag Poles, Bins, Post Boxes, Public Toilets, Flower Gardens, Ticket Machines, Bicycle Parking Areas, Clocks, Park Meters)".*

Urban furniture is an indispensable element of life as they are units that meet individuals' functional and aesthetic needs by making the space livable and meaningful. For this reason, all details used to shape and functionalize the city in warning, routing, bus stops, and telephone booths such as lighting elements, waste bins, and water elements are considered as urban furniture (Bulut, Atabeyoğlu and Yeşil, 2008). The urban furniture created in the design process of urban reinforcement elements reflects the identity of the cities, their harmony with the architectural structure, and their imaginary features (Sakal, 2007). Therefore, when urban furniture is considered a design product, they should ensure that they establish correct relationships with each other with the spaces they are used (Bayraktar, Tekel and Yalçıner Ercoşkun, 2008). User habits, reactions and internal situations should not be ignored during the design stages to ensure the continuity of the perception and usability of the spaces (Çınar and Çetindağ, 2009). But then the product put forward in the design process should serve a specific purpose, be creative and unique with a conscious thought (Önlü, 2010). The purposeful use is related to functionality, which is considered the design criteria of urban facilities. When making a design, the first thing to be planned is the function of the design (Ertaş, 2007). When the function of the urban reinforcement planned for the specified space is determined, the chaos and object density is prevented (Sakal, 2007). The most significant indicator of the functionality of an urban facility is its suitability for human ergonomics (Hacıhasanoğlu, 1991). Since urban furniture without aesthetic perception will negatively affect the environment, it will not be sufficient to be functional alone. Function, form, and aesthetics should be in a close relationship to increase the space's livability. Thus, new and creative products will become even more desirable. Material selection in urban furniture enriches the design by increasing the visual richness and product function (Ertaş and Bayazıt, 2004). Urban furniture must be resistant to climatic differences since they are in open areas. Therefore, factors such as the correct material selection, long life against environmental conditions, and correct positioning should be considered in the design (Simonds, 1998). Color selection in urban furniture contributes to the aesthetic structure, revealing design, materials, and accessories and adding a different depth to space (Kıran, 1986). Texture, another design criterion, adds character to the product by making an outstanding contribution to the product's structure and product functionality (Kın, 2007).

Integrating renewable energies into urban areas prevents resource depletion by preventing environmental degradation and providing energy efficiency (Rahmani and Bouaziz, 2018). And providing parks improvement determines the positive environmental impacts on global climate change and energy efficiency measures. Renewable energies are an important choice for the sustainable development policies of the states due to their natural raw materials (Hukkalainen et al., 2017). The state must meet these criteria to integrate renewable energies into urban areas (Karunathilake et al., 2018). Having an investment budget for urban green areas,

(i) find solutions compatible with the built environment,
(ii) is accepted by citizens with minimum discomfort,
(iii) to have urban furniture design

One of the goals of urban parks plans with the use of clean and renewable energy is to install many renewable energy equipment in the park to collect renewable energies and make it a sustainable energy exhibition for future generations (Hakimizad, Asl and Ghiai, 2015). According to Trunch and Sutanto (2018), eight basic elements make up the Smart Park. These elements are arranged in hierarchical layers. The first layer starts with receiving and generating data with devices. The second and third layers are the connection channels through which information is exchanged with the transmitted data and the Internet of Things (IoT) platform. The fourth layer is the IoT platform, where multiple data centers store and process information. The fifth layer is the stage that serves specific needs through software applications in various interactive display devices such as smart mobility and smart tablets. The sixth layer is the analytical, technical content of the solutions to achieve the best results with different interactive display modes. The seventh layer represents the combination of results used by AI-powered humans and computers to develop actionable ideas for decision making. The eighth layer is organizational intelligence, which is responsible for enabling smart management for individual park organizations by providing a solid connection between stakeholders and the people who run the park (Trunch and Sutanto, 2018). For instance, these features are neural networks that form Smart Park's artificial brain (Abdelhamid, 2019).

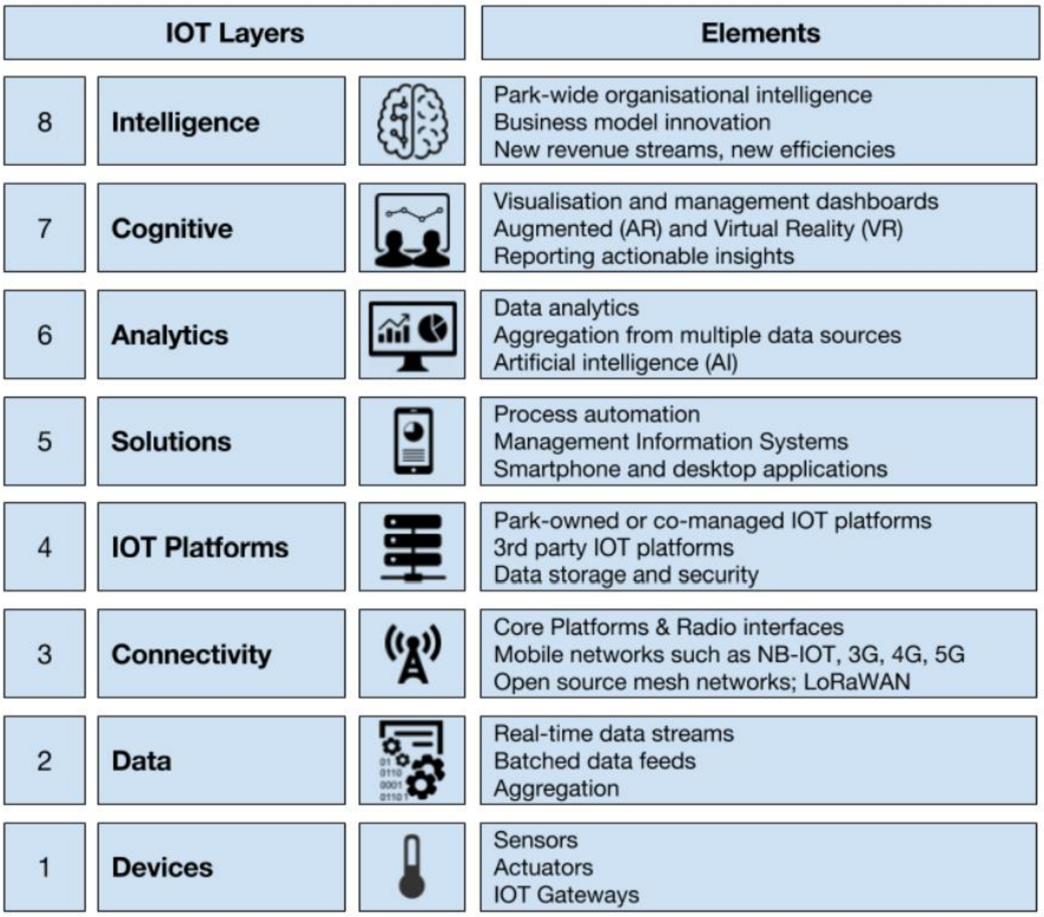


Figure 9. Smart park IoT ecosystem (Source: Truch and Sutanto, 2018).

Smart parks use Internet of Things (IoT) technology and support new approaches of smart technologies in their design and during their life cycle. On behalf of these technologies, environmentally friendly and cost-reducing solutions can be offered, which can be used to maintain and improve parks by conserving energy and water resources. Smart parks, broad information sharing, and high levels of connectivity can ensure human well-being by reducing costs, generating new revenue streams, improving environmental control, and enhancing the visitor experience.

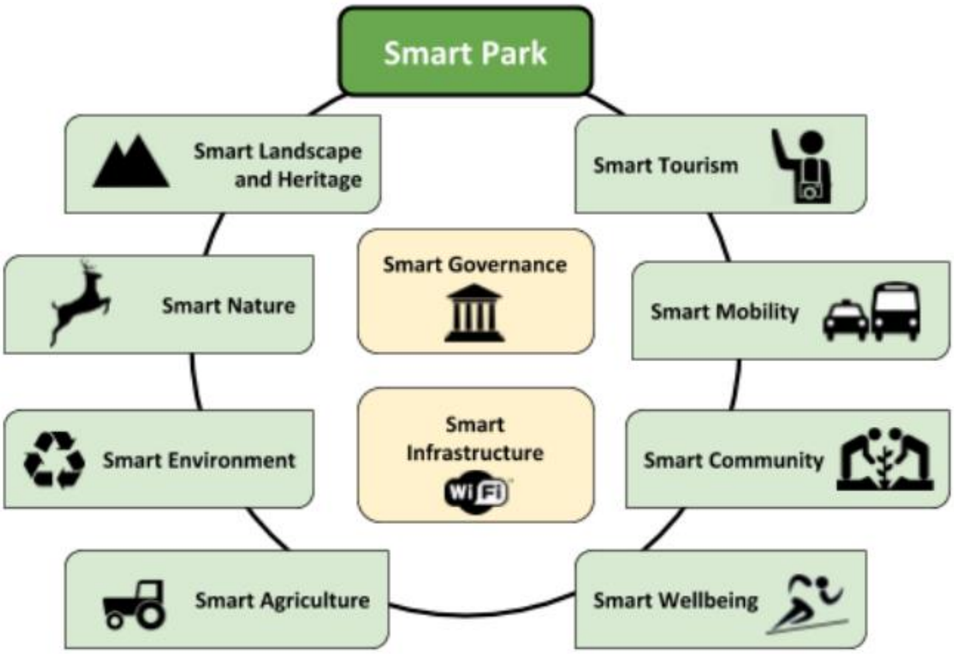


Figure 10. Smart Park model and key dimensions (Source: Truch and Sutanto, 2018).

Smart Environment, one of the fundamental dimensions of the Smart Park, aims to create a healthy and sustainable environment by reducing human impact in the park. Waste management supports the use of renewable energy sources by preventing air, soil, and water pollution (Truch and Sutanto, 2018).

Table 14. Examples for different scale of smart technologies in Smart (Source: Abdelhamid, 2019).

Small-scale technologies having low initial costs		Technologies that provide cost saving for maintenance in the long-term		Technologies that are cost-saving because of their multiple benefits	
Solar shades and umbrellas	This will provide shades for visitors while providing electricity from a renewable energy for powering Electronic devices.	Smart water controllers	Use weather and site conditions to automatically adjust watering to optimize efficiency, which can reduce water use and costs.	Smart benches	They can provide visitor tracking data, solar-powered device charging, and Wi-Fi hotspots.
Pervious paving	It has several benefits such as: water conservation, safety, and reduce maintenance cost	Applying photocatalytic titanium dioxide coating	Adding this coating to different surfaces in parks can lower maintenance costs over time as it reduces the need to clean surfaces.	Sensor networks and the Internet of Things	This technology can be used to improve maintenance efficiency by automatically programming various park features, such as irrigation, lighting, and trash collection.

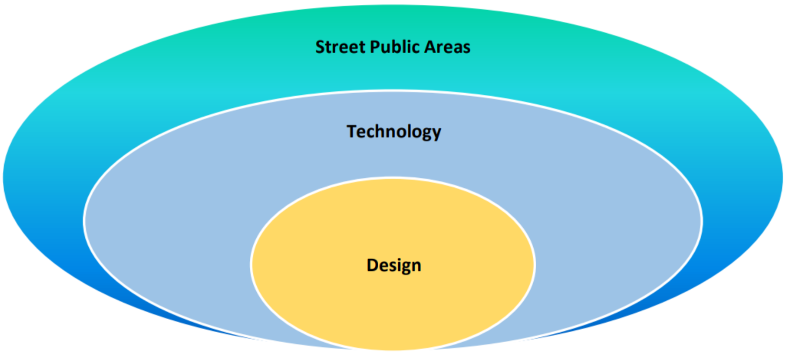
Smart parks use strategies that conserve energy resources and enable the production of clean energy. Parks consume energy for lighting and air conditioning, so parks are good places to deploy energy-efficient technologies. Parks can generate their energy by installing technologies such as solar panels. Energy savings are achieved if they can reduce the air conditioning of park structures and surrounding areas by using green spaces for cooling and providing shaded areas for visitors (Jenerette et al., 2011). Solar panels and other renewable energy technologies can be easily integrated into open spaces in city parks and community buildings, reducing emissions by providing clean energy. Clean energy or energy efficient technologies in parks help save money through lower utility bills. They can also be used as a tool to educate park visitors about sustainability, climate change, and clean energy. Digital sensors with Internet of Things (IoT) technology are used in smart parks; it is possible to record, wirelessly store and transmit information such as lighting, weather, air and water quality, movement, energy, and resource consumption (Burstein, 2018). Urban green spaces have a cooling effect by lowering the ambient temperature and preventing the urban heat island effect. On average, urban parks are about one degree cooler than urban areas that are primarily planted. As cities combat climate change and reduce greenhouse gas emissions, parks serve as ideal places to reduce energy consumption and generate renewable energy. Therefore, energy use is an essential issue in smart parks (Bowler et al., 2010).

All renewable energy technologies consist of four basic components: system, harvest, storage, and control. To be properly integrated, the source characterization and mechanical part of the system must fully comply with the rules of safety, durability and flexibility. Since energy harvesting is an integral part of the system in the design, this is an issue that requires special attention (Tereci and Atmaca, 2020).

Table 15. Renewable energy technologies and integration possibility for recreation areas (Source: Tereci and Atmaca, 2020).

Renewable energy	Renewable energy technology	Harvesting	Storage	Recreation area integration
Solar	PV Solar -thermal	PV panels; Solar collectors	Solar battery, Water storage tank	Lighting, signposts, information kiosks, pergolas, Electrical vehicle charging stations, Solar-powered Trash Compacting Facilities, Energy for furniture and buildings on the area
Wind	Onshore	Wind Turbines Wind Mills or Pumps Wind belt	Wind farm battery storage, grid energy storage	Lighting, Electrical vehicle charging stations, wind tree, Energy for furniture and buildings on the area
Piezoelectric	Piezoelectric cells	Charging pads	Batteries	Walking area and lighting
Hydro energy	Runoff river hydro Storage hydro Pump storage hydro energy	Hydro Dams, Turbines	Pumped hydro energy storage	Energy for equipment and buildings in the area
Bioenergy	Biomass Biofuel	Stirling engines Org. Rankine module, Gasification plants, Backpressure steam turbines, Biogas plants	Heat storage systems, geological storage, batteries	Energy for equipment and buildings in the area
Geothermal	Direct use Geothermal Heat pump Geothermal Electricity production	Ground Source Heat Pumps, Flash Steam Power Plant, Heat exchanger	Water storagetank, Underground Thermal Energy Storage -	Energy for equipment and buildings in the area

Smart cities attempt to economically develop street furniture (smart economy) by using products such as streetlamps and obsolete phone booths for new technological solutions. In this way, cities are implementing ideas to reduce resource consumption by connecting products to city networks and creating new generation infrastructures (Hassein, 2017).



Street Public Areas (Landscape)	Technology	Design
- Urban Planning - Circulation - Street Furniture, Lighting - Transit Facilities - Civil Engineering	- Smartphone Apps - WiFi networking - ICT / ITSM, Real time - Data collection - Data process software	- Public Art - Media Content - Furniture Design - Architecture

Figure 11. Concepts of Smart Street Furniture (Source: Hassanein, 2017).

The principles which determine the quality of wisdom in a city are as follows;

(i) timely data obtained from physical and virtual sensors,

(ii) connectivity between different services and technologies in the city area,

(iii) Intelligence obtained from data analysis and visualization time,

(iv) optimization of processes resulting from these analyzes.

While the overwhelming focus of current research and policy is on smart cities, optimizing such technology flows will benefit any urban area that wants to use data (Harrison et al., 2010).

3.4.1. Smart Lighting

Moreover, the information and communication technology used to improve the efficiency and management of smart cities (ICT) (Praharaj and Han, 2019), in the city's planning, only technological aspects are no longer the only criterion. There is a more accurate transformation process by focusing on user satisfaction and rationality without disabling city users' need for quality of life and sustainability (Nam and Pardo, 2011). Different conceptual scenarios are applied to increase user satisfaction and living standards in smart cities (Silva, Khan and Han, 2018).

One of these is public lighting that plays a role in the development process of smart cities (European Commission, 2015b). Many cities have started their transformation process by renewing their lighting systems. Innovative and more cost-effective control and communication systems have facilitated this situation (Brock et al., 2019). It is a system that influences human behavior in terms of a sense of safety, with applications such as traffic lights, fine systems, etc., by creating awareness, such as practical interventions, energy-saving, and air pollution (Nigten, 2015).

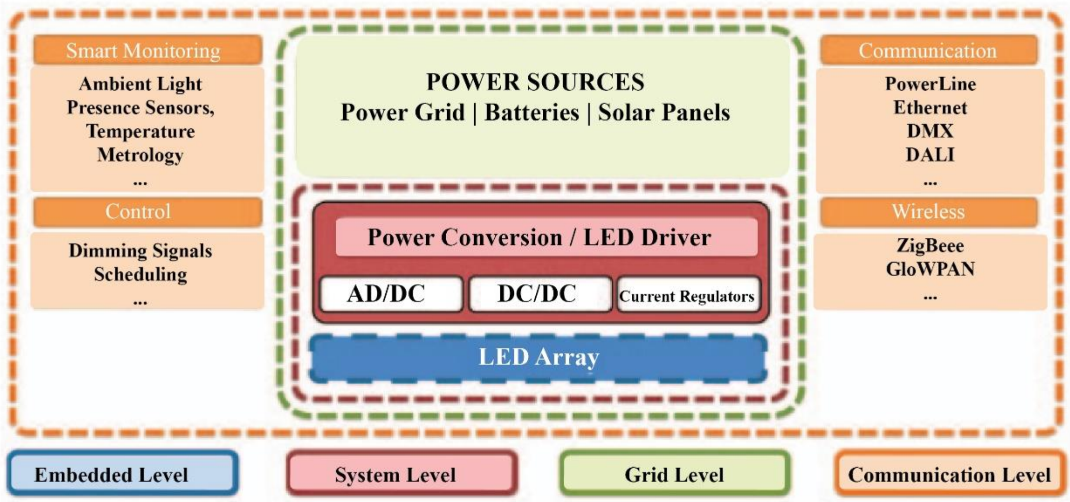


Figure 12. Smart lighting integration levels (Source: Castro, Jara and Skarmeta, 2013).

Intelligent lighting includes the integration of smart functions and interfaces at four complementary levels (Castro, Jara and Skarmeta, 2013). For this reason, the use of lighting systems in smart cities is not only considered as a product that provides light. Smart systems can be sensitively tuned to the city's needs and its people to adapt to the environment and targeted future energy scenarios (Scorpio et al., 2020). There are three categories of smart lighting used in smart cities. These are;

(i) Road lighting

There are photometric requirements that road lighting systems must guarantee. Different visual tasks (recognizing vehicles, people, objects, or signals) to illuminate paths and the needs of types of users (riders, cyclists, pedestrians) should be designed for. The performances of the lighting systems are evaluated by average brightness, average illumination, and uniformity. Therefore, in addition to the visual performance associated with lighting systems, the classes of street lighting should be determined correctly, considering energy consumption (Leccese et al., 2020). For example, in Europe, 60 to 90 million streetlights make up 20% -50% of the urban budget. These are environmentally friendly smart lighting systems that include sensors such as Wi-Fi, photovoltaics, smart LEDs, speakers, image recognition, push-to-talk systems, water, and tide level measurement, charging points, digital street signs, air and noise pollution (Gassmann, Böhm and Maximilian Palmié, 2019).

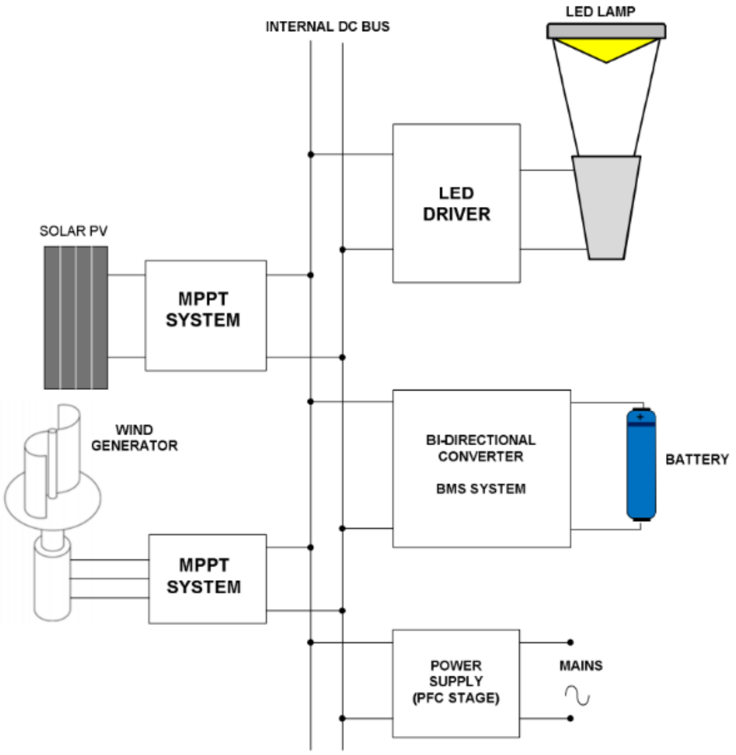


Figure 13. Lighting system with renewable energy (Wind and Sun) reduces energy consumption (Source: Jaureguizar et al., 2013).

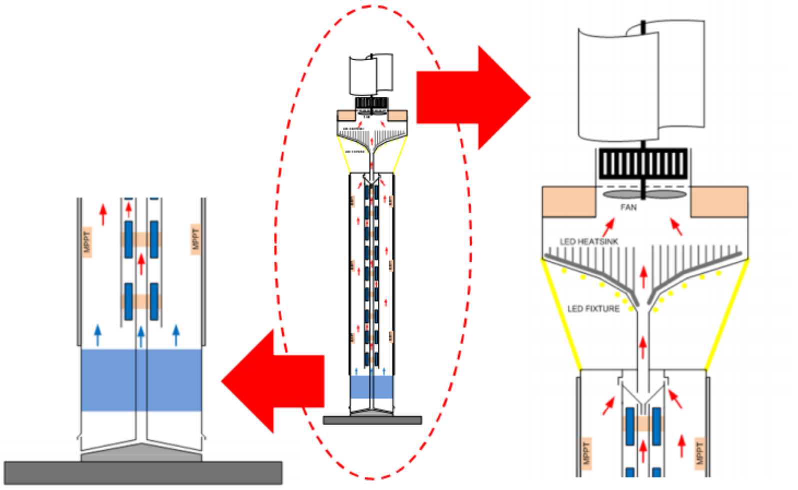


Figure 14. Thermal design and system integration (Source: Jaureguizar et al., 2013).

To ensure the stability of the electrical infrastructure of public lighting, a design presentation regarding its potential use as a power system and smart grid for storing, consuming, or delivering energy has been presented. This concept is called the Lighting Smart Grid (LSG), and various usage possibilities have been evaluated. A set of modules that can be configured to implement multiple roles within the LSG system and an experimental prototype lighting system are presented (Jaureguizar et al., 2013).

(ii) Architectural lighting

The use of artificial lighting in buildings for both functional and aesthetic reasons plays a vital role in the perception of the city (Dietrich Neumann and Kermit Swiler Champa, 2002). The biggest challenge in architectural lighting is to design lighting that emphasizes the shape of the building and emphasizes its characteristic details while concealing less attractive aspects, as the building has daylight. Light can build on its own and has become a communication tool, supporting marketing factors, emphasizing architecture for its use in the city (Słomiński and Krupiński, 2018). Smart cities are increasingly promoting human-computer interaction with the advancement of technology and the development of the range of use.

Accordingly, it supports social interaction by becoming the media facades of buildings using LED communication technology (Han, Lee and Leem, 2019). Together with software and hardware solutions, smart lighting increases their efficiency while maximizing energy efficiency (Hunold et al., 2015).

(iii) Green area lighting

Urban green spaces have become one of the most critical components that increase the quality of life of city users and affect the appearance of the city (Yılmaz and Mumcu, 2016). Green spaces are where people interact in different parts of the city (Thompson, 2002), promotes social cohesion (Kaźmierczak, 2013).

They are places that provide the opportunity to exercise and relax by spending their free time. Therefore, in green areas, lighting systems should have an approach that encourages people to use them as much as possible (Johansson et al., 2014). The lighting includes user perceptions, psychological and vision features for green areas, making external lighting more challenging to plan. The lighting system plays a crucial role in ensuring the success of green spaces (Harrold and Mennie, 2003).

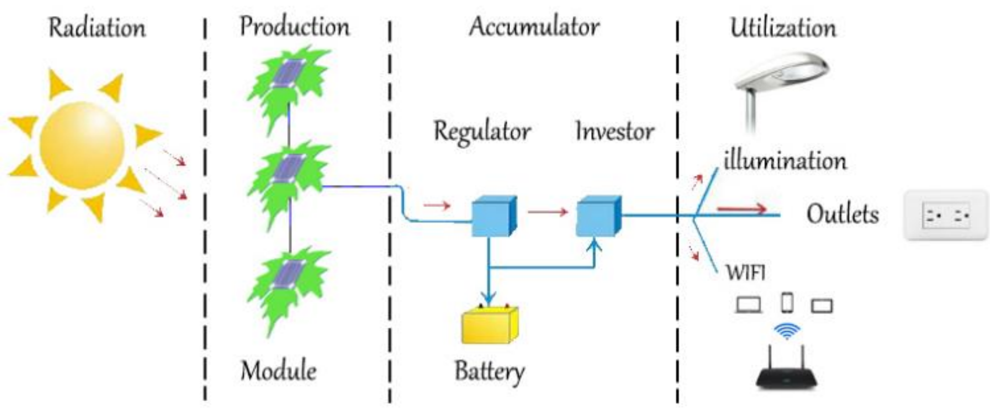


Figure 15. Schematic of electrical connectivity, wifi and lighting (Source: Avila et al., 2018).

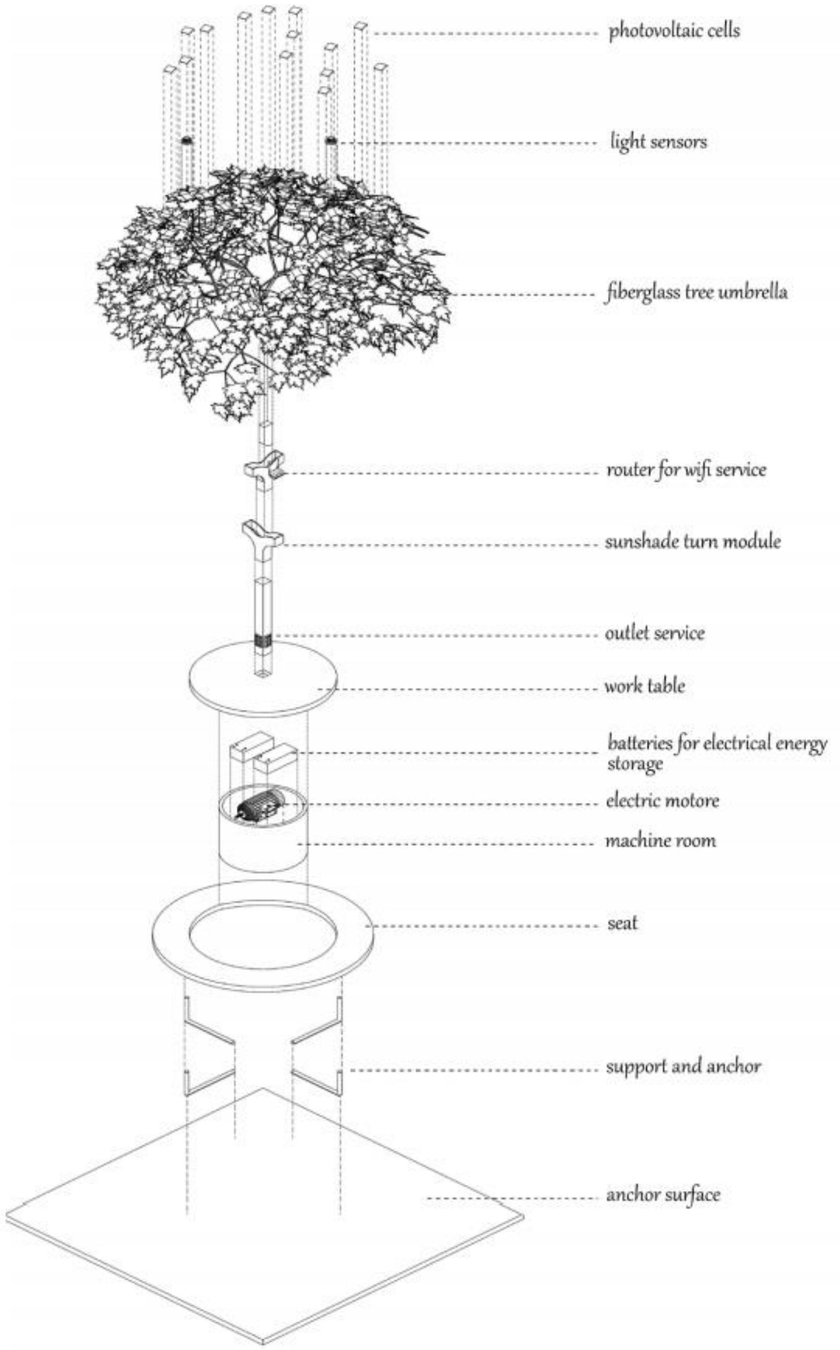


Figure 16. Functional composition of Solar Furniture (Source: Avila et al., 2018).

This design is a piece of tree-type urban furniture that uses sunlight due to heat and light sensors. It is designed in the shape of a tree to serve dry areas, terraces, parks, and places where no trees can be planted. The solar cells that produce clean and sustainable energy can provide connection and wifi service. Providing lighting at a low cost also provides the opportunity to rest/shade during the day (Avila et al., 2018).

3.4.2. Smart Kiosks

Modern smart kiosks are an item of multifunctional smart city furniture that includes hardware and software components to detect different environmental conditions, multi-mode interaction with users, and capture/transmit data for analysis in the cloud. It has functionality like media poles in appearance. Still, it has a traditional pole shape that can restrict display and relationship advertising, and smart kiosks often include the functionality of previous generation-related technologies, including digital signage, media posts, and other navigation technologies (Gómez-Carmona, Casado-Mansilla and López-de-Ipiña, 2018). Smart kiosks are increasingly being adopted due to these various uses in smart cities (Lynn, Rosati and Fox, 2020);

- (i) *"Information points,*
- (ii) *Transaction points,*
- (iii) *Communication points,*
- (iv) *Connectivity points,*
- (v) *Device charging points,*
- (vi) *Sensing points,*
- (vii) *Research points,*
- (viii) *Advertising points".*

Figure 17. Design of Birloki system, in outdoor areas (left one) and indoor areas (right one) (Source: Gómez-Carmona, Sádaba and Casado-Mansilla, 2019).

In the design of smart kiosks, if they are customizable, portable, and interactive, they must offer multiple experiences in terms of visual and information broadcast sound. In New York City and London, kiosks have been launched to meet the local utility role of providing free Wi-Fi access at speeds of up to 1 Gb per second through advertising The CityBridge Link System (Sobolevsky et al., 2017).

Since the Birloki system can be customized and individualized as needed, two different use cases were presented, one for a botanical garden and the other for use in professional centers. Designed for completely different scenarios, Birloki offers two versions of the solution, each providing specific interactive services. The second version of the system is in the testing phase and is currently being used in five professional centers. Future work foresees the further development of the system architecture and a lighter software solution to be used on less powerful devices (Gómez Carmona, Sádaba and Casado-Mansilla, 2019).

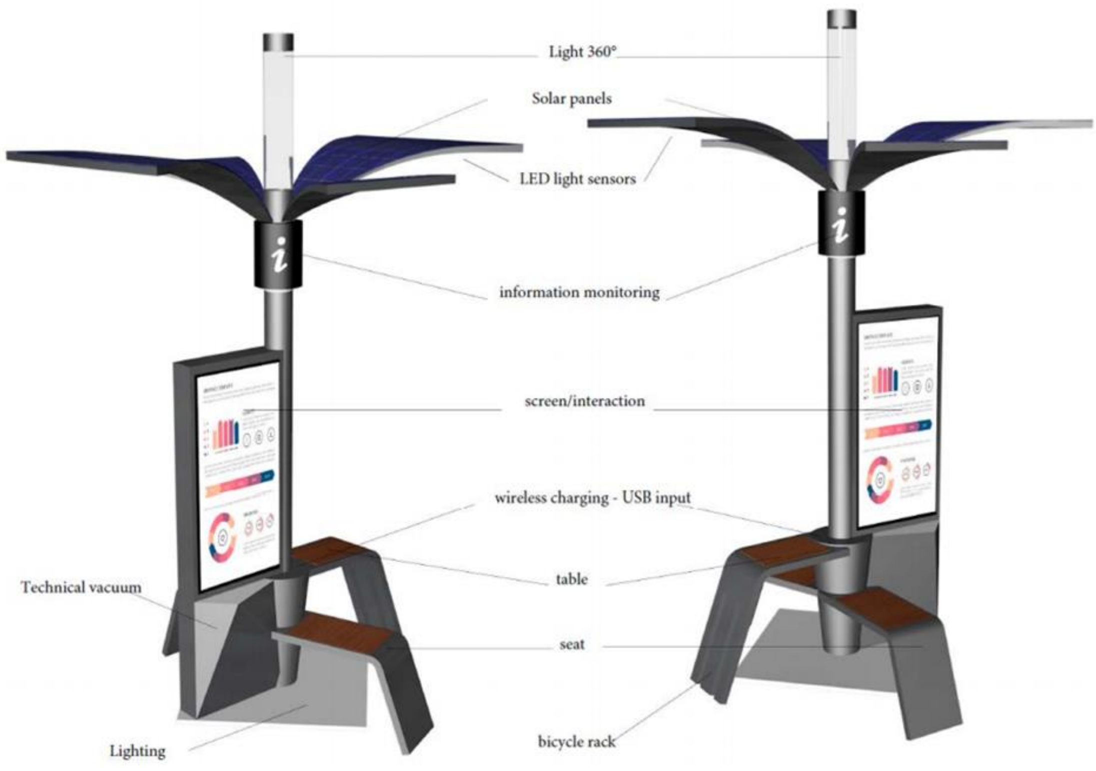


Figure 18. A rendering of the S[m2]ART solution (Source: Ciaramella et al., 2018).

S [m2] ART, another design proposal that emerged with the combination of the integration of renewable clean energy and communication technology in smart cities, was designed to be a communication platform and information center with city users with the energy it provides from solar panels. Access to the platform is provided via individual mobile devices or digital components integrated into the S [m2] ART product. This exemplary study is aimed to strengthen the cooperation model of universities, and industrial partners focused on designing the vision of a smart city (Ciaramella et al., 2018).

3.4.3. Smart Benches

Modern smart street banks have a wide range of functions for different applications. Smart banks are increasingly capable of being fully or partially self-powered using solar panels. In addition to the functionality of the smart bank, there are three factors that its designers should consider. First, determining the location of the smart banks and the direction in which they should be oriented in order for their use to be successful. Second, the design and layout of the smart banks. It may include or exclude mobility constraints, including sidewalk accessibility, for other street users, taking into account the participation of wheelchair users or people with strollers. Thirdly, smart street benches may have additional equipment to support connectivity functionality, in addition to services for local stakeholders, by accommodating multiple radio access units, power supplies, and antennas (Manholm, Fridén, and Olsson, 2015).

Figure 19. Solar bench at Teurastamo in June 2018 (Source: Martikka et al., 2018).

Five of the smart solar benches designed for use in the city of Helsinki were produced with the SMARTlife project in Finland. A solar panel on and above the bench with the electricity generated is stored in the battery system below. The bench is multifunctional and powerful, and the concrete bench is 2.4 meters long and 1 meter wide. It can charge six different devices at the same time. Sun benches make life, activity is comfortable and non-polluting. This project aims to increase the share of renewable energy and reduce carbon emissions in terms of mobility (Martikka et al., 2018).

3.4.4. Piezoelectric Floor Tiles

Piezoelectric energy harvesting tiles generate electrical energy from mechanical pressure such as a walking motion. The amount of energy generated;

(i) the weight of the person,

(ii) The total deflection of the tile, and

(iii) It depends on the type of movement.

The resulting kinetic energy is converted into electricity which is stored in the battery or used for devices in the park (Sodano, Park and Inman, 2004).

Piezoelectric tiles have two main functions that can be applied in the park;

(i) They can be used in a variety of applications, such as electrical outlets or field lighting,

(ii) Based on the recorded steps, information about the use of the park can be collected.

Piezoelectric materials generate local, clean on-site energy, eliminating the need for fossil fuel power generation. It is supported by a motion sensor to leave the lights on in the absence of visitors, reducing energy costs (Burstein, 2018).

Figure 20. Graphical summary of the experimental result of the research work (Source: Chand et al., 2020).

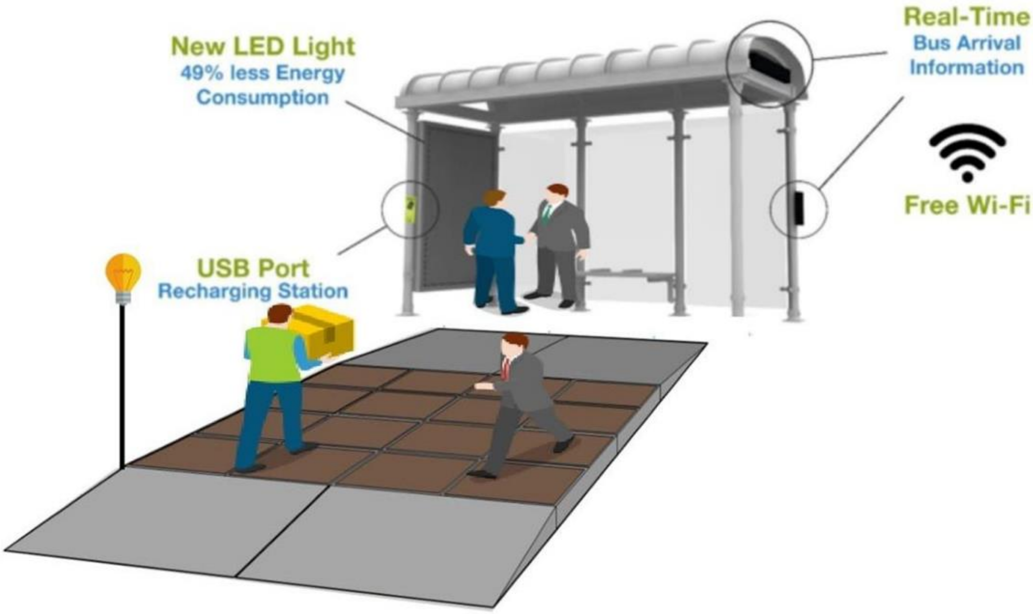


Figure 21. 2012 Summer Olympic Games in London used kinetic harvesting tiles (Source: Pavegen, 2019).

This research study *(Figure 21)* tried to present a non-traditional, environmentally friendly, and renewable energy harvesting system based on human movement and hydro energy. The system collects footstep energy near the road crossing to operate streetlights, billboards, security lights, and emergency lighting systems. A complete model of the system has been realized based on a two-square-sized tile structure where human kinetic energy is converted into electrical energy with mini-hydro generators. Denseysel results concluded that this system could produce 1.4 W output power per step with a 70 kg person walking on the tile structure. The developed system is economically feasible, easy to manufacture, simple in terms of assembly and installation. And because this energy harvesting efficiency is lower in some places, the liquid-based energy harvesting paver has both promising potential and scope of improvement to be considered energy efficient and a robust renewable energy system (Chand et al., 2020).

3.4.5. Other Smart Furniture

Waste bins are a type of smart street furniture with a primary function. When they are not properly designed and positioned, it can negatively affect the visual identity of the street, and accessibility problems may arise. Intelligent waste solutions can be autonomous and robot-based, or stationary. The first of these involves making standardized waste containers available and having robots that transport these containers to central units for compacting and removing according to their type. For example, the EU-funded FP6-Dustbot and subsequent ROBOSWEEP projects resulted in an autonomous street cleaning robot *(Figure 22).* Designed with a similar approach, Lumobot is used for tasks such as sweeping and vacuuming sidewalks, moving snow, clearing sidewalks, and dispersing salt, sand, and gravel *(Figure 23).* There are various stationary waste collection systems, and more conventional smart bin designs are becoming more and more solar-powered waste bins with built-in compactors. Sensors bring the need for collection and record collection activity data for volume, fill rate analysis, and payback. Electronic collection units are another type of urban furniture used by public utilities, street vendors, and public members to store items. Retailers and the public can also use them to deliver or collect goods and products (Lynn, Rosati and Fox, 2020).

Figure 22. Dust cleaner robot (Source: Robotech, 2012).

Figure 13. Snow sweeper robot (Source: Lumebot, 2019).

Bigbelly is a service platform that offers much more than smart waste and recycling and spans public road rights (Street Views and Sidewalks, business development zones, parks, public transport systems, coastal: ports, and beaches). It modernizes the city service, is easy to access, and can hide technology insight. The multi-purpose use of the smart waste system simplifies logistics, reduces unwanted pollution from street scenes, and further enhances the community experience with improved services (Bigbelly, 2017).

Figure 24. Bigbelly smart waste design (Source: Bigbelly, 2017).

CHAPTER 4: CASE STUDY: USING RENEWABLE ENERGY FOR DEVELOPING SUSTAINABLE CITY FURNITURE, ÇORLU REPUBLIC PARK

4.1. Definition of the Case Study

Çorlu's strategic central location, being just far enough from Istanbul on the main corridor to Europe. Being blessed with a mild climate and usable arable lands gave it a leg up in being the hub for the region (Trakya Kalkınma Ajansı, 2011). Over the last 50 years, its population has grown fivefold (Trakyenet, 2019). It has a large industrial base because its location is ideally located for servicing and a distribution center for a very large Metropol like Istanbul and its hinterland. The developed highways, Çorlu airport, train line, and seaports make it a transportation star (Trakyanet, 2018). Çorlu hosts a total of 629 factories with 5 OIZs and 1 free zone (Çorlu Ticaret ve Sanayi Odası, 2019). By contrast, when a circle of 30 km is drawn from the center of Çorlu, the number of factories reaches three times this. As well as many more small manufacturing businesses and industrial expertise have attracted many Professional people of medium to high income. The needs and expectations of the said population will become the driving force from now on for Çorlu.

Çorlu has grown from 59,000 (this was for Çorlu and Ergene Combined) in 1970 to over 273,000 in 2020 (Çorlu alone) (Çorlu Belediyesi, 2021), unofficially the population is around 350,000 (as a lot of the residents have not as yet registered themselves in Çorlu). Expectations are that the city's population will reach one million over the next 30 years. Within the next 50 years, the outer suburb of Istanbul is expected to merge with Çorlu. Fast rail transport will speed up this process as it did in another major metropolis.

People seeking larger living and growing space in healthy but sufficiently developed regional areas that are in transport range to well-paid jobs in Istanbul will lead to new growth in population. The movement towards low-density housing, green belts, hobby farms, and self-sufficiency movements will aid this process. As well as the local middle to upper-class income earners, the same segment from the surrounding towns will also be attracted to the city. Keeping in mind that Çorlu is 193mt above sea level

(Çorlu Chamber of Commerce and Industry, 2019), this fact alone will also attract lots of population from Istanbul, which is expected to be affected by the projected worldwide sea rise events by 2050.

As well as merging with Istanbul Çorlu will over the same period is projected to merge with surrounding towns like Çerkezkoy, Kapakli, Ergene, Marmara Ereğlisi, and even Lüleburgaz. It is best to describe this greater conglomeration as Greater Çorlu and its hinterland. Even today, the individual totals of all these regional towns added together are nudging one million people. Over the next 30 years, the population of the Greater Çorlu region may be between 2 to 3 million people. Çorlu is a city with a destiny, a destiny it can plan and prepare for, making it a World-class great place to reside, live and work or let events take their course and be an average nondescriptive city.

4.2. Justification of the Selected Area

Figure 25. Çorlu's place on the map of Turkey (Source: Çorlu Belediyesi, 2017).

Çorlu is the largest settlement center in Thrace after Istanbul. According to the census of 2019, it is more crowded than Tekirdağ, the provincial center with a population of 270,944 and constitutes 25.6% of the province's population. Çorlu is located in the northwestern part of Turkey, in the region of Thrace. Çorlu is in a central position within the Thrace region and the Ergene basin. It strides in the middle of Tekirdağ, Luleburgaz, Çerkezköy and Silivri. Due to its location, it has been affected by every invasion in Thrace. Çorlu ranks fourth in Tekirdağ province with an area of 899 km2. It is the most developed district of Tekirdağ with its strong transportation connections and strategic importance. The district is predominantly flat land; due to its location in the inner part, the continental climate is dominant. Its altitude is 193 m, and its soils are fertile. Çorlu has rich underground waters and large areas devoted to industry; today, it is a region where mainly chemical, leather, and textile factories are concentrated. The first industrial establishments in the region started with flour and sunflower factories, quarries, and brick production in the 1950s. As a result of the social, political, and economic developments experienced throughout the country in the '80s, the opening to the foreign market was a turning point for Çorlu. After 1990 Çorlu has had one of Turkey's largest internal population immigration receivers. It is a large industrial center with the potential to accommodate more industries and is a candidate for further development. It is expected that Çorlu will be able to host a larger population due to its opportunities. This led to the construction of new residences, regular urbanization, and the continuation of physical and social infrastructure development. The desired goal for Çorlu is;

> *"To become a modern city together with the industry that uses advanced technology and produces goods with high added value."* (Çorlu Chamber of Commerce and Industry, 2019).

The Çorlu District Vision report published by the Trakya Development Agency in 2011 has addressed the strategies determined for Çorlu until 2023. In the report, a regional sustainable future vision was created based on the idea of achieving change by addressing the basic problems, strengths, and strengths, opportunities that can be created, threats. The three basic strategies for Çorlu, which manages its economic power well, mentioned in the report are as follows;

(i) Being thematic corridor: Conduct corridor cluster studies on industrial, service, and logistics sectors in relation to Çorlu's position in the corridors North-South and East-West, develop strategies and explore new integrated development model approaches by improving competitiveness.

(ii) Building a sectoral diversity network: developing a sectoral interaction strategy framework by preparing education, health, and technology coordination programs.

(iii) Creating a regional HUB city: defining the roles and responsibilities of the HUB city and preparing interaction plans (physical, social, informatic connections) (Trakya Kalkınma Ajansı, 2011).

To implement these three strategies and the new approach, the basic principles were established. By determining the infrastructural capacity and eventual needs of Çorlu, especially by predicting the transportation, education, and social amenities situation, the aim is to prefer smart growth in the spatial growth of the city. This is because the dense development that accompanies the rapid population growth exceeds the environmental and infrastructural capacities. A concrete proposal was presented for the technology corridor that can be developed between Istanbul and Tekirdağ. Attention was drawn to careful planning to prevent pollution caused by industry, improper use of water, and capacity utilization of natural resources. Principles have also been set on making Çorlu a more livable and durable city, organizing the economic aspect, sectoral diversification, value creation, and activating the power of Çorlu (Trakya Kalkınma Ajansı, 2011).

According to the wind values determined by YEGM, the wind speed of Tekirdağ is at the level of 6.5-7 m / s. A total of 584 MW of wind capacity has been licensed in the Thrace region. According to the Regulation on Unlicensed Generation in Electricity Market, which was published in the Official Gazette on 21 July 2011, facilities with an installed power of 500 kW and below were exempted from the obligation to obtain a license and establish a company. Therefore, it has been possible to utilize the wind potential in Edirne, Kırklareli, and Tekirdağ regions for unlicensed electricity generation. In the Thrace region, in Çorlu and Çerkezköy districts, there is a significant potential for unlicensed electricity generation from wind and installation of wind power plants. Thrace Region has not been seen as efficient in terms of solar energy. Average radiation was determined as 1400-1450 kWh-M2 / year.

Nevertheless, these values are low compared to the overall potential of Turkey, the level of a radiation-M2 average of 1200 kWh / year, which is higher than in Germany. The electricity generation potential of the Thrace Region from agricultural waste (paddy, sunflower, and wheat) is approximately 284-300 MW. In return, it is possible to produce 1844-200 GWs of electricity annually. This amount corresponds to about 0.9 of the total electricity consumptions of Turkey. Investors who want to establish an unlicensed electricity generation facility with biomass energy follow the same bureaucratic path as wind and solar (Çorlu Chamber of Commerce and Industry, 2014). Edirne, Kırklareli and Thrace Development Agency by July 24, 2014, TR21 Thrace region of Tekirdag province formed and Technology Development Foundation of Turkey Thrace region TR21 Industrial Symbiosis Program Cooperation Protocol was signed. With this project, a collaboration was made on sectoral and environmental analysis, reporting on issues such as cleaner production and industrial symbiosis, local stakeholder analysis (Trakya Kalkınma Ajansı, 2016).

In the inter-provincial competition index ranking, Tekidağ and TR21 Region are in 10th place. TR21 Region ranks 10th in innovation evaluation, and Tekirdağ is in the top 10 among 81 provinces. In terms of the technological infrastructure index, TR21 Region is 9th, and Tekirdağ is 12th. As a result of the analysis, it is seen that Tekirdağ is a leading city in the innovation index ranking (Trakya Development Agency, 2015). Between 2010 and 2018, the total utility model, patent, trademark, and industrial design applications in Tekirdağ province reached 8,160 (Türk Patent ve Marka Kurumu, 2018.).

Çorlu Municipality offers free wireless service at 7 points (Cumhuriyet Square, Uğur Mumcu Park, Atatürk Square, Indoor Marketplace, Book Cafe, Indoor Swimming Pool, Indoor Sports Hall) within the boundaries of the district. In 2019, 35693 citizens benefited from this service. In addition, with the growth of the existing resources of Çorlu and the increase in the service units of the municipality in 2019, the internet infrastructure was restructured for four different internet connections to work in a cross-backed way (Çorlu Municipality, 2019).

The ecological industrial site planned to be built in Çorlu is defined as the *Earning Project of the Future.* It is planned that this ecological industry will produce its energy and water itself, and it will be an environmentally friendly and sustainable project with its wastewater treatment plant. It is foreseen that it will be an attraction center that includes 362 workshops in 6 blocks, 65 shops, 3000-person fair, congress, ball, meeting rooms, cafes, and restaurants on an area of 242,400 square meters. In addition to making a difference in the project's design, it aims to use the latest technologies, reduce environmental pollution, and leave a clean future for the future (NTV, 2021).

In 2019, the mayor of Çorlu Ahmet Sarikurt signed the Covenant of Mayors For Climate and Energy to create a sustainable energy and climate action plan. Within this contract, the conditions for increasing the resilience to minimize the effects of climate change, achieve more use of renewable energy sources, and achieve improved energy efficiency to reduce carbon emissions by at least 40% by 2030 (Appendix A).

4.3. Comparison Songdo, Antwerp and Çorlu as Smart Cities

For Çorlu to become a Smart City in the future, it should be able to determine its long-term strategies in the first place. This path is through knowing your strengths and weaknesses. It is necessary to discuss what kind of Smart City it will be, on which subjects it is successful, and which areas it is insufficient. The project should give the confidence to realize the planned design by the city and be able to inspire greater aspirations in the future. All this can be done with a detailed study and the correct use of potential. Initiatives and developments all over the globe have been made for Smart Cities for years. Urban planners, technology companies, and developers are looking for ways to improve city life, make systems more efficient, and make the city more livable. The extent to which technology will enter our lives for keeping the air clean, minimizing our effect on the environment, or for communication and transportation is a matter of debate (Appleton, 2021). Because what is desired in smart cities is to be highly functional and sustainable, not cities that are inviting to live and have that intangible thing called soul where residents are happy, contented, feel that they are the reason the city exists and not the other way around. Not every Smart City has achieved this happy desired result. For example, smart cities such as Brasilia, Levittown, Celebration, Eco-Atlantic, Sidewalk Labs Toronto, and Songdo are shown as failed smart initiatives (Albert, 2019). On the contrary, cities like Singapore, Dubai, Oslo, London, Copenhagen, and Boston are emerging as successful smart cities in different parts of the world and different fields (Kosowatz, 2020). Hamburg, Groningen, Nantes, and Antwerp are among the cities with high promises and are described as the shining stars of the future in Europe (Maxwell, 2018a).

It would be correct to compare the successful cities of Antwerp in Europe and Songdo in South Korea, which could not achieve the targeted success, to serve as a thesis and antithesis to analyze Çorlu on the way to become a smart city. Looking at the regional location and potential, Songdo is in the Icheon Free Economic Zone (IFEZ) in South Korea, 64 km from Seoul.

Figure 26. Map of new Songdo (Source: Gale International Press Kit, 2015).

Its strategic location in the Northeast Asian trade center has made Songdo an attractive spot within reach of one-third of the inhabitants. Its size is 86 square kilometers, and the size of the commercial district is 9.3 square kilometers. While designing Songdo, successful urban features such as New York's Central Park and Venetian canal systems were considered. It was aimed to add a mixed texture to a brand new city by using the wisdom designed at different points of the world (Newcities, 2014).

Antwerp is the economic center of Belgium and has the second-largest port in Europe. Port activities, diamond trade, and one of the world's largest petrochemical clusters enable it to play an important economic role in Europe and internationally. The city of Antwerp has begun to raise the line of success among some European cities that are more advanced than Antwerp, as the new city council, which came to power in 2013, renewed local interest in economic development.

Figure 27. Map of Antwerp City (Source: Katoen Natie, 2018).

As the main intention, three simple and effective strategic items have been implemented to encourage new initiatives from different groups of people and different sectors and to support the startup mentality;

(i) *"Facilitate whatever initiatives may spring from the private sector in the Benelux region,*

(ii) *Promote theit activities to broader business community and*

(iii) *Fill the gaps wherever necessary"* (Wever and Bulcke, 2016).

A large part of Songdo's efforts to stand out and lead smart cities in the world is made up of investments in UPS (U-city strategy Plan). With the project built between 2008 and 2017, Songdo has aimed to stand out as Korea's new and iconic smart city. In this direction, the smart applications provided are divided into 6 in terms of the targeted sector;

(i) *"Transport*

(ii) *Crime Prevention*

(iii) *Disaster Prevention*

(iv) *Environment*

(v) *Citizen Interaction*

(vi) *Other Services (Home, Store, Learning, Health, Money, and Car)".* (Lee et al., 2016).

The long-term success of the sectors has provided the formation of a private-public partnership (PPP) with U-city Corporation. In this way, effective business models have been created to maximize benefits for citizens by providing efficient smart city construction, system, management, and financing. For Songdo to achieve success in the targeted direction, initiatives to maximize public-private partnerships are implemented (Lee et al., 2016).

While Antwerp is a successful Smart City, it also plays an international role in smart city innovations. In the last few years to make the city smarter;

(i) Security,

(ii) Unemployment,

(iii) Sustainability and

(iv) Focused on bringing technological solutions to social problems such as mobility.

The secret to the city's success is to test the effects on citizens' lives before fully investing in the projects it develops. They use a city center laboratory system to properly integrate smart projects into a real-life urban environment. Thus, citizens can participate in adopting smart city projects developed for Antwerp and find feedback on the use of technology. Calling it *City of Things* comes from the success it has achieved in these projects. After the City of Things project, Antwerp decided to go one step further and develop the IoT House, that is, to create an IoT ecosystem in the city age to settle on the map as an international IoT center. With the IoT House, the focus is on smart city innovation and IoT solutions for e-health, smart port development, industrial 4.0, and making Antwerp a circular economy. The city has three main strategies focused on European reference for the Internet of Things and Capital of Things. These:

(i) Industry 4.0 (Industrial IoT),

(ii) Intelligent logistics and

(iii) Citizen-oriented city initiatives.

To address the skills gap in IoT, studies have been initiated to put IoT graduate programs into action. Although 50% of the population has a job or degree in science or technology, the IoT becoming a vision of the city has created the need for a special inter-university program in the Internet of Things. The Startup Village area offers flexible rental options to support startups and new businesses to achieve international technological success and networking. Another citizen-centric project is the competition where students, residents and visitors living in Antwerp present original ideas for urban challenges. Companies implement these ideas through support and funding. Across Antwerp's different sectors, it unites political and educational institutions, emerging initiatives, and multinational companies, but above all, citizens around a single goal. Antwerp hosts innovative projects to make the city smarter, more liveable, and a better place to work. This makes Antwerp a key player in the development of smart cities (Maxwell, 2018b).

Songdo is a self-proclaimed city built from scratch compared to Antwerp. For this reason, while laying the foundations to becoming a smart city, the systems that constitute their social and environmental values have also been determined. As an environmental and sustainability strategy, energy-independence as much as possible and ecologically supported plans were produced with the least damage to the environment. A pneumatic waste disposal system has been used to eliminate the need for garbage collection. Each building has solar energy, U-valued windows, LED lights, and water-cooled air conditioning systems that reduce energy consumption by 30%. Songdo is built around the central park. It has a 40% green area, wide walking paths, and 25 km of bicycle paths. Charging stations for electric vehicles have been provided throughout the city. Songdo is equipped with the latest technological infrastructures to be a sustainable city, and dimensions of life (real estate, utilities, transportation, education, healthcare, and government) are integrated. Because it is designed to respond to the overcrowded and expensive Seoul, strategies have been developed to attract businesses to become a preferred city for international businesspeople and families. These include building four city universities and hosting professional development programs for local companies. Songdo's principles; Based on Transition-Oriented Development, New Urbanism, Smart Growth, and Green Growth (Newcities, 2014).

Sondo's social use of the human factor began at this point to set it apart from Antwerp. Songdo has invested in logical technological issues that city fathers consider valuable to compete in the global knowledge economy. One of the main reasons why the management style is so socially selective is that the increased cooperation between governments and private companies leads to new managerial practices. As a reflection of this, the city is divided by class lines. Specific activities such as garbage collection and street cleaning services have been devalued compared to knowledge-based work. In the beginning, the necessity of using technological machines in areas such as the production chain was advocated to give people time for their lives. The new moral model, which is formed due to replacing low-level services with technological systems, has opened the door to the classification of knowledgeable citizens as valuable and appropriate to emerging modernity. In contrast, others (advocates of social and professional diversity) are classified as inferior (Benedikt, 2016).

Songdo, a $ 40 billion smart city project known as the International Business District, is recorded as a *cold* city at the end of its historical development and goals. This is not because the number of people reaches the targeted number, but because the technology (sensors, IoT, artificial intelligence devices) used in the urban predominates. People have an important role to play in Smart Cities. Therefore, attention should be paid to prioritize human-centered designs and being socially ethical. Due to the widespread technology, a system that does not make citizens accustomed to human deficiency and alienation should be established. Nevertheless, the energy use per capita in Songdo is 40% less than other cities, and it has green areas equipped with self-sustaining irrigation systems. It is partly in the sustainable sense that it aims with the highest number of green buildings, and 76% of waste recycling shows success (Inghirami, Pontecorvo and Vetturini, 2020).

Antwerp, with a population of 529,247 (City Population, 2020), Songdo has 183,911 (Songdo Snic, 2020). Both of its cities are home to businesses/industries like Çorlu. In this respect, the examination of life-integrated technologies provides a more realistic approach in evaluating issues such as energy use and human life factor. For common features of Songdo and Antwerp smart city;

(i) Having industrial / business areas
(ii) Close population values

(iii) Technological investments

(iv) Education level.

But the biggest common point between these two cities that makes one successful and the other unsuccessful is;

(v) It is the different way they have treated the human factor.

In this direction, for Çorlu to use its potential correctly, to determine and implement the right strategies, it should be evaluated not only in the field of business, technology, education, energy but also in citizen-oriented issues.

The characteristic that is common for Antwerp and Songdo and can guide the future for Çorlu is the human factor. Citizens' perception of renewable energy as a green activity is a difference that will guide smart cities since the theme of smart energy will be based on the government's initiatives and the people's expectations. It is no coincidence that these two cities have experienced two different extremes due to the human factor. Recent studies show that citizens' participation and activities are directly proportional in smart cities (Cardullo and Kitchin, 2019). In line with these research, the duties of citizens in building smart cities are divided into three categories;

(i) Decision-making process; As the basic processes of the Smart City are established, citizens contribute to the decision-making process and become a part of the sustainable local communities.

(ii) Contribution of experience and skills; By using the knowledge of citizens, especially in the fields of construction and applied economics, it becomes a part of the experience,

(iii) Data collection: After the smart city is implemented, collect information through technological devices or mobile devices by benefiting from the experience and life of citizens to properly adapt to the improvement process and new technologies (Joss, Cook and Dayot, 2017).

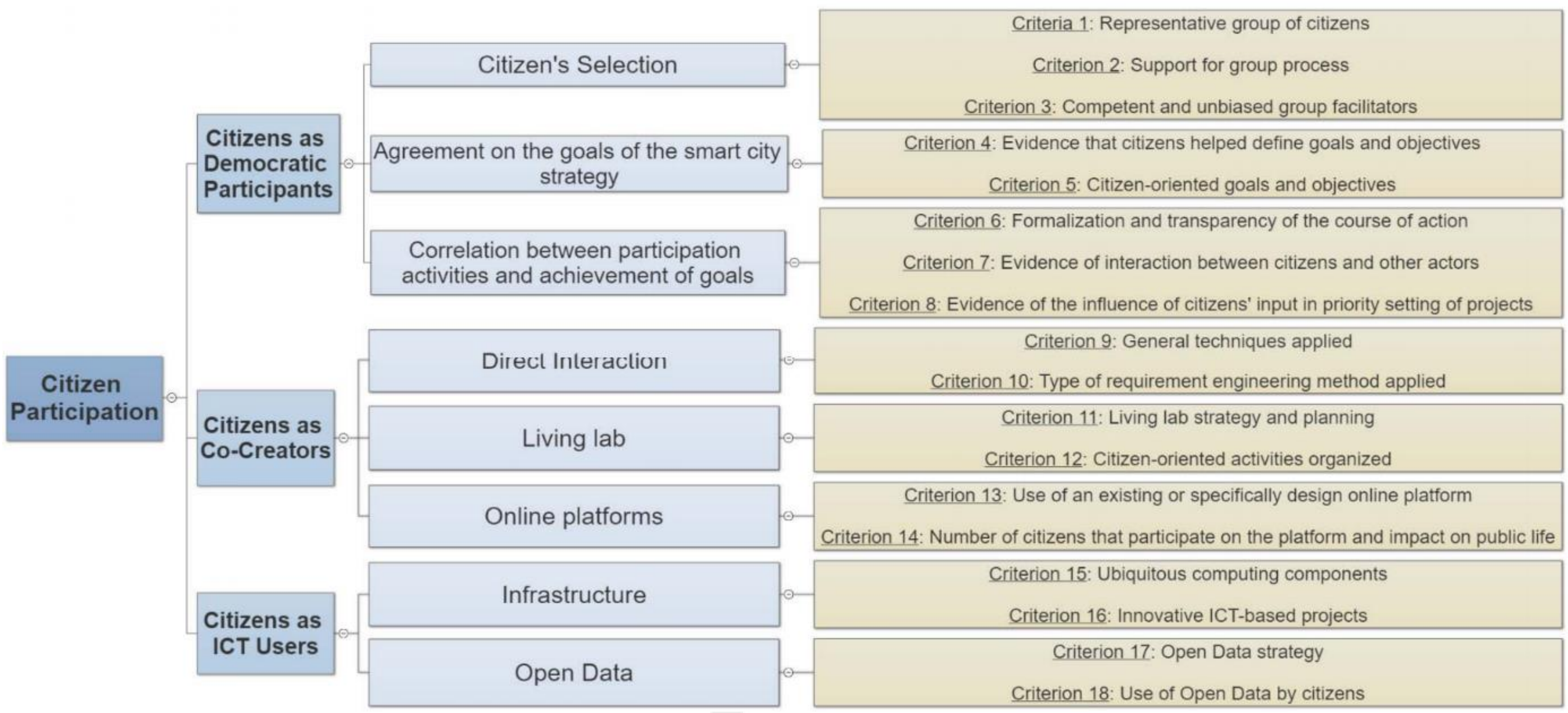


Figure 28. Citizen Participation evaluation framework (Source: Simonofski et al., 2017).

When examined, Antwerp and Songdo also have sufficient infrastructure for ICT use. The IoT's embeddedness, sensors in the city, and Cloud computing bring new technologies and paradigms with it. These technologies are applied in cities, making the city smart, and is the point where cities depart from being a traditional city (Layne and Lee, 2001). The fact that one of the approaches offered while designing Songdo is a high-tech green city is a model of Korea's experience, expertise, and experience in rapid urbanization over the years. High-tech green cities are divided into four; U-cities, Intelligent Transportation Systems (ITS), Geographical Information Systems (GIS), and Low-energy environmentally friendly housing (Pak, 2012). The U-city model is used for Songdo, meaning 24-hour data is collected with equipment such as CCTV, various sensors, and traffic detectors. This information is collected and used for application services and big data analysis to provide useful services to citizens. Therefore, the most striking thing in the city is that the sensors that monitor the citizens are predominant (Lee et al., 2016). Most of the contributions obtained from the citizens are collected with the information obtained from sensors and cameras.

According to Antwerp, Songdo, technology seems to be dispersed in a more coordinated manner in the city. In other words, the movement and information transfer of the citizen is not limited to only sensors and technological infrastructure. In smart city innovations, it is more for Songdo to get the support of the citizen in the decision-making process and benefit from their skills and experience. They used the Antwerp Living Lab concept for years to ensure that citizens are part of smart city innovations. Therefore, it is easier to create and implement the awareness required for citizens to see renewable energy as a green activity. As Hollands (2008) said, smart cities need to do more than use ICT, because smart cities can achieve success with the right integrated system of technological systems equipped to achieve social, environmental, economic, and cultural goals. This passes through a human system suitable for the citizen.

Ensuring this interaction is directly proportional to the living conditions and natural environment the city offers to its citizens (Wachsmuth and Angelo, 2018). He argued that urban sustainability policy characterizes two different strategies for achieving a sustainable smart city, corresponding to two different aesthetic representations of urban nature.

These are;

(i) *Green urban nature; "Is the return of nature of the city in its most verdant from" and*

(ii) *Gray urban nature: "By contrast is the concept of social, technological urban space as already inherently sustainable"* (Wachsmuth and Angelo, 2018).

Songdo uses the strategy of shading the high-tech smart city image that it has aimed at the beginning by placing green images in the city plan to emphasize the sustainability movements. With its sustainable buildings, strategies such as promoting fast and emission-free transportation, it follows a more suitable policy for the sustainable technological strategy of the gray urban nature. Antwerp has windmill farms to protect its green areas, encourage renewable energy, support farmers, agriculture, and greening (Port of Antwerp, 2011). According to Songdo, greener urban enabled it to stay in a strategy close to nature. As a result of being a smart city, there are also points that Antwerp has features that fall under the heading of gray urban nature ideology to ensure energy efficiency (Greenberg, 2014). Properties like density, smart technology, resilience, and livability are why talent planning emerges because of different combinations of features such as today's sustainable growth concept. The addition of green and gray urban nature to this combination registers Gramsci's (1971) idea that the different and contradictory elements that make up that require common sense require the combination. That is, Green and Gray urban nature smart cities serve as mirrors for interconnected features and glass for non-interconnected features. And even this contrast provides a balance in terms of harmony in the world.

Whether the city is green or gray-based affects living conditions and provides the awareness base for renewability and technology. Innovation that develops as a counterpart to the environment offered to the citizen and the initiatives to be made have similar results. Therefore, it is necessary to examine how Antwerp, Sondo and Çorlu use green spaces.

The quality and development of public space for the city of Antwerp occupy an important part of the city projects. Because architecture and public spaces interact with each other and the philosophy of people experiencing the city better, care has been taken to create high-quality public spaces. In this direction, a special public domain procedure, street furniture inventory, and design scenario book was created by the municipality officials (Stad Antwerpen, 2012).

Antwerp has sought to create green spaces ideal for citizens to walk around, read a book, look at art, have a picnic, or exercise. Some of its parks;

(i) Antwerp central park
(ii) Rivieren
(iii) Park spoor noord and
(iv) Nachtegalenpark (Visit Antwerpen, 2018).

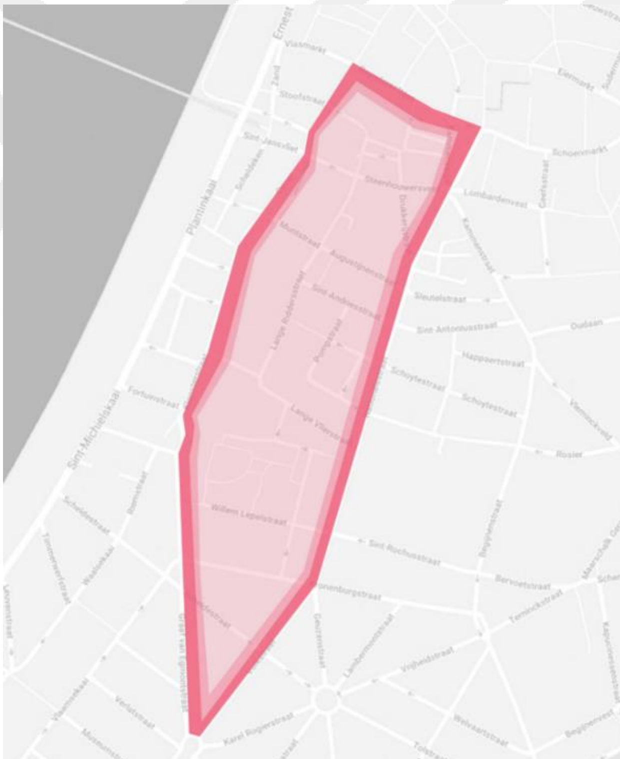


Figure 29. Antwerp Smart Zone (Source: Antwerp Smart Zone, 2021).

Public spaces (parks and squares), which play an important role in people's social lives, must convey a sense of security to be preferred as meeting places and to encourage use. And to enable the most efficient use at night, the choice of lighting is important. Sint-Andries as Anverp Smart City, it has created a Smart Zone in the region to implement the work that technology has done to make the city more pleasant, sustainable, and safe. The use of Antwerp's pilot projects in the Smart Zone brings more projects, such as billboards, traffic lights to be developed for lighting. In this way, by working together with citizens, technology adapted to lifestyles will be created.

The smart lighting system, developed for use in the Antwerp Smart Zone, aims to provide the best possible lighting. Due to the developed motion and sound sensors, the area provides illumination when the sports fields are used. As extra illumination is provided for people walking at night, the light of the lamps is increased when rain sensors detect the visibility distance. The red-light ring showing the possibility of rain, on the other hand, allows it to serve as a weather station (Antwerp Smart Zone, 2019).

Figure 30. Usage examples of smart lights in Antwerp (Source: Imec City of Things, 2018).

Internet of Things technology, integrated in different components of sustainability, manifests itself in the smart lighting infrastructure in Antwerp. Smart energy systems and smart lighting infrastructure send usage data to the Cloud for storage and analysis. These systems automatically control and optimize the use of light, resulting in low costs resulting from use in cities (Braem et al., 2019). This smart lighting, called SHUFFLE, is designed to reduce unnecessary energy consumption, and prevent light pollution.

Figure 31. SHUFFLE smart lighting and modular systems (Source: Schreder, 2019).

SHUFFLE provides the possibility to combine five different modules. The versatility of the column aims to add and remove modules when a new service requirement arises in the future. Equipping options of lighting columns;

(i) 360 or 180-degree lighting modules with warm white LEDs
(ii) Color light ring indicator
(iii) LUCO IoT node
(iv) Motion detector
(v) Noise detector
(vi) Air sensors
(vii) Smart Cameras

(viii) Street microphones
(ix) Charger
(x) WLAN modules

The flexible and modular design requires very little maintenance and offers full energy efficiency at an affordable price for Smart Cities. STUFFLE, which was used only in the Smart Zone and to illuminate the basketball court, started to spread to different parts of the city with the option of equipping its columns for the purpose. It is used as a sustainable solution by adapting to harsh environmental conditions such as seashore and pier with a special coating (Schreder, 2019). Green areas that citizens did not find safe to use due to vandalism in Antwerp in the 19th century (Tritsmans, 2014), nowadays, it has become a success story with the settlement of technologies that encourage people to move outside and make life easier.

Songdo is a city built from the ground up that has enabled real estate developers to equip the city with new and cutting-edge technologies. From the very beginning, Songdo is the largest private real estate city developed on an area of 5.77 square kilometers reclaimed from the ocean (Viser, 2014). As it were, Songdo served as a living organism that grows and undergoes mutation, adapting to the changing living conditions in the world. In environmental terms, the fact that Songdo was built around the park and 40% of the city was allocated to open spaces facilitated introducing a new model to create a green city (Whitman et al., 2008). According to Lichá (2018), it is no coincidence that concepts such as green & smart were highlighted in the creation of Songo city. The strategy of entering South Korea's sustainable competitive market has brought contradictory capitalism with it. Nevertheless, despite the improvable features, the adoption of ICT and IoT technologies in Songdo, the use of systems such as pneumatics and recycling of rainwater to the city, which absorb waste and transform it into energy to run the city, has enabled Songdo to create a prominent project on the eco-city candidacy (Kelkar, 2017).

Some of the parks in Songdo are;

(i) Haedoji (sunrise) park

(ii) Songdo Nuri Park

(iii) Michuhol Pak

(iv) Moonlight Park and

(v) SolChun Park.

Figure 32. Masterplan of Songdo (Source: Whitman et al., 2008).

Despite that, the park in Songdo's heartland and around which Songdo was built is Central Park (Kayla, 2017). Songdo Central Park was inspired by New York Central Park and the canal system in Venice. With the entertainment centers and cafes around, it is intended to serve as a place where festivals can be held and host people's daily sports and meetings. For example, it is designed to be environmentally friendly and focused on a living community with both business and entertainment potential (Rugkhapan and Murray, 2019).

Songdo U-city has divided its services into two;

(i) Public (traffic, crime prevention, facility management, disaster prevention, environment, and providing information to citizens) and

(ii) Special services (home, store, learning, money, health, and car).

Therefore, Central Park is also home to spread sensors, lighting technology, and environmentally friendly technologies in Songdo. There are services such as U-bike, U-Street, U-Foreigner Support Mobile as environmentally friendly services (Lee et al., 2016).

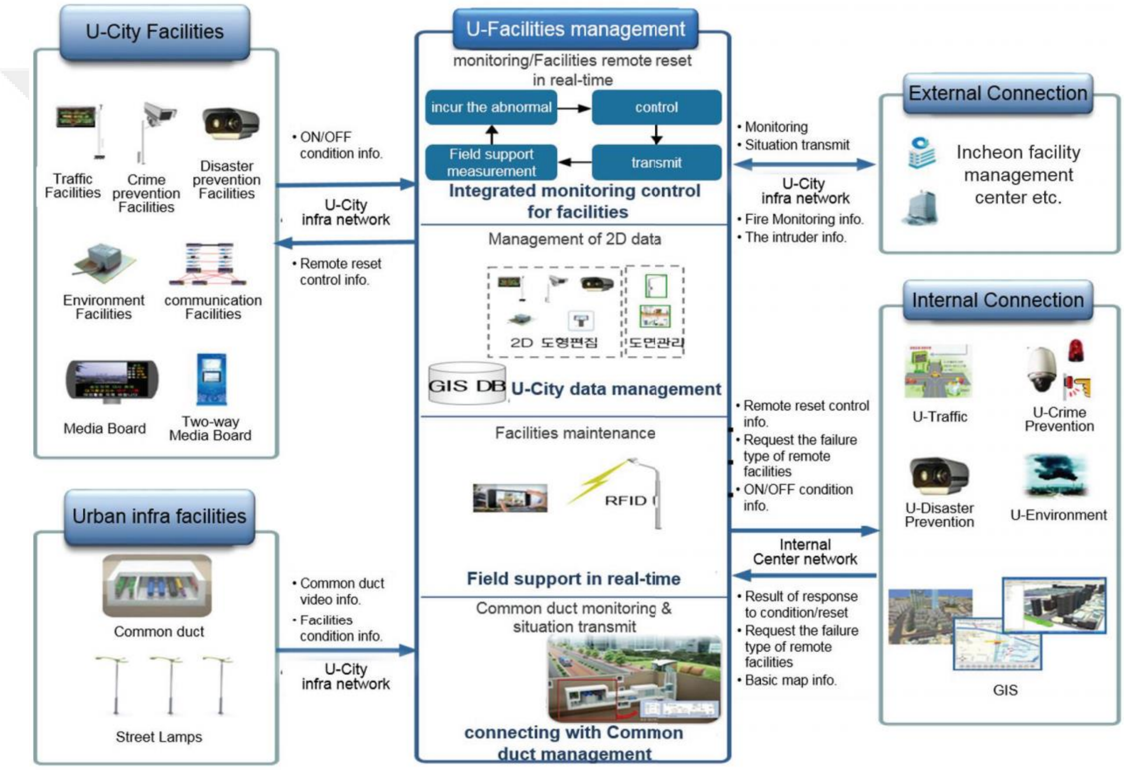


Figure 33. Block diagram of the U facility management system (Source: Lee et al., 2016).

The tasks of the IoT, sensors, and cameras used (Patel and Padhya, 2021);

(i) Detected sensors; because of its air and environment sensors, it measures weather conditions, wind speed, dust, oxygen, and ozone. It also measures fog and damaged surfaces when mounted on the road.

(ii) Abnormal Sound Monitoring: It is designed to put the operator on duty to help the citizen in an emergency.

(iii) Citizen interaction: It allows citizens to access the adapted system of the administration with their mobile devices.

(iv) Providing public transportation information; It shares the usage information of public busses. Automatically turns off lights to save energy when no person is present.

(v) Control illegal parking: If the vehicle is parked illegally, an announcement will direct the driver to another parking space.

(vi) Citizen safety: Besides monitoring images to ensure citizen safety through CCTV cameras, it also uses automatic number plate system to find vehicles with unpaid balance.

Figure 34. Lighting used in Central Park (1) and smart column (2) (Source: Choon, 2017).

Considering the product design, the column is equipped with many components. It looks like a pile of technology and does not appear to be a part of life. According to the smart lighting system used in Antwerp, it lacks design and has an aesthetic appearance. The presence of both lighting (number 1) and smart other (number 2) in the same environment makes one question how the functionality is implemented at some point. Songdo's attempt to become a high-tech smart city resulted in an underestimated scheme. Songdo's attempt to become a high-tech smart city resulted in an underestimated scheme. Smart city ideologies need to be linked to the environment and the user to see green energy as an activity. Antwerp is more prone to implement such an initiative because its smart city innovations have involved citizens for many years.

Figure 35. Çorlu Republic Park (Source: Harita Map, 2021).

Çorlu Cumhuriyet Park was opened in 2012 and was built on an area of 162,518.12 m2. In this area;

(i) *“Running and cycling path: 1477m long*
(ii) *Children's playgrounds: 2,455.41 m2*
(iii) *Flower beds: 1,843.44 m2*
(iv) *Grass area: 92,104.68 m2*
(v) *Pond: 882 m2*
(vi) *Six rectangular fountain pools, one circular pool*
(vii) *Concert area and backstage building*
(viii) *Three tennis courts and three grandstands*
(ix) *Two basketball courts*
(x) *Picnic area*
(xi) *Walkways*
(xii) *Summer cinema: 280 seats and*
(xiii) *There is a parking lot for 410 vehicles”* (Çorlu Belediyesi, 2012).

Equipment list;

(i) *“Bench with white, colored cast iron legs: 700 pcs*

(ii) *White, wooden cushioned camellia: 20 pcs*

(iii) *25 pcs of colored metal, wooden roofed pergolas*

(iv) *Disabled sports equipment (set of 11) 1 piece*

(v) *Children's sports equipment (set of 5) 2 pcs*

(vi) *Sports equipment (set of 11) 3 pieces*

(vii) *Trash Containers and receptacles”* (Çorlu Belediyesi, 2012).

Lighting: 318 pieces in total, 318 of which are LED and solar-powered charging station: 2 units

Figure 36. Solar charging station in Çorlu Republic Park.

Figure 37. Examples of lighting poles in Çorlu Republic Park.

Figure 38. Walking path and sitting groups in Çorlu Republic park.

- ∅ none
- improvable
- good
- very good

Smart Environment	SONGDO	ÇORLU	ANTWERP
Attractivity of natural resources conditions	improvable	improvable	very good
Environmenral pollution	none	improvable	none
Environmental protection	good	improvable	very good
Sustainable resource management	very good	improvable	very good
Contribution to renewable energy	improvable	improvable	improvable

Figure 39. Evaluation of Songdo, Çorlu, and Antwerp with the criteria determined under the title of the smart environment.

As a result of the triple city comparison, the evaluations were made under the title of smart environment as none, improvable, good, very good were determined as follows:

(i) None; does not have this criterion in either a positive or negative sense.

(ii) Improvable; In comparison to other cities has an average value and is open to improvement.

(iii) Good; The city has good value on a global scale.

(iv) Very good; the city has a very good value on a global scale and has a higher than average compared to other cities.

Songdo is ahead of Antwerp, a green area of 19.2% with its 30% (Choon, 2017) green area and greening value. Furthermore, unlike Songdo, Antwerp has different usage options for green areas for citizens to use for walking and meeting purposes and grow and collect their own vegetables and mingling (Focus on Belgium, 2018). Antwerp has a value of 34 and has “good” air quality values. Çorlu follows Songdo with a value of 63 with a lower value of 84. Unlike Antwerp, the other two cities are in the "moderate" group (Aqicn, 2021; Aqicn, 2021b; Aqicn, 2021c).

One of the most prominent sustainable resource managements for Antwerp is the urban water cycle. The reason for this orientation is the concerns about the following issues: Water scarcity, flood risk, water quality, air quality (all environmental concerns) and the unemployment rate. These issues are therefore a priority in the city planning and actions:

(i) “Basic water services,

(ii) Water quality,

(iii) Wastewater treatment,

(iv) Water infrastructure,

(v) Solid waste and

(vi) Climate adaptation” (Huyghe et al., 2021).

The second feature that stands out is the studies focused on green transportation because it is a port city. Supporting green actions and initiatives from the beginning to the end of the supply chain, creating a chain both within companies and international awareness (Notteboom et al., 2020).

Songdo recycles greywater and rainwater for irrigation and cooling purposes. It also uses energy management projects for energy-efficient buildings. However, the pneumatic waste system, which is shown as an extreme example of the infrastructure flexibility of Songdo and stands out in terms of sustainable resource management, is the pneumatic waste system. The fixed pneumatic waste system is transported to the collection center together with the waste collection points, which may be outside or inside the building, and a transportation network, usually consisting of pipes. Before reaching the municipal treatment system, for its final transportation out of the area, the wastes are collected, and the amount of air is reduced. The volume is reduced by being pressed with the mobile pneumatic method, the wastes are transported from the container to the truck and move to the suction point. With the pneumatic waste system, the aim is to eliminate the need for garbage collection trucks (Chàfer et al., 2019).

The order of importance in which technology is used and investments are made in urban development processes determines the dynamics of that city, as in the example of Songdo and Antwerp. While determining the features and requirements of smart city applications, it should also be evaluated in terms of social and economic sustainability contribution. State-sponsored initiatives in cities provide citizens' contributions to renewables. Waste collection systems or energy-efficient buildings are not sufficient to provide this interaction. Sustainability is a very wide spectrum, and it is not possible to deal with the typical bureaucracy of municipalities. Therefore, initiatives aimed at promoting the development of ecosystems in places such as Çorlu, which are candidates for smart cities, should be supported. For all cities, including Antwerp, Songdo, and Çorlu, for their initiatives to be successful in the long term, historical and real-time data must be in meaningful and actionable formats. When considered in terms of collecting environmental sustainability data; Niche topics such as green mobility, waste management, air pollution domain, energy consumption domain, urban biodiversity and water management should contribute to information sharing and problem identification by consumers (Angelidou et al., 2018).

For this reason, it is expected that cities will not abandon the use of ICT and integrate it into different areas of life. In a parallel sense, cities need to be shaped using social goals, human initiative, and technology (Bauman and Lyon, 2012). While the integration of technology into the environment makes the city more knowable and controllable than before, the human dimension relates to the ecosystem rather than economics, management, innovation, and entrepreneurship. Therefore, it is no coincidence that a city built from scratch, as in the Songdo example, is equipped with so much technology. The technological dimension and the human dimension - the two dimensions a city needs to be smart - are separated from each other throughout the process. This is because nurturing the human dimension ensures the emergence of concepts that glorify human potential and ensure efficiency in all areas, not the goal-oriented aspect of the city (Kitchin, 2013 ; Nam and Pardo, 2011). Therefore, Antwerp's emphasis on the human dimension and the environment-technology compatibility of the smart systems used in the city is higher than Songdo.

As a reflection of this information, Bilboria (2021) defines empathic cities as a

> *"Shift in ideology within both smart city and wellbeing thinking"*

and categorizes these types of change and the trends brought by initiatives

> *"The gradual shift from techno-centric to human-centric and from product. Based on context-based smart city wellbeing trends"* (Biloria, 2021).

Upon investigation, it was found that spatial empathy is an atmosphere created by considering users' emotional experiences when designing the interface of a place. Therefore, sense of place and use of space represent important social and cultural criteria of urban growth (Mattelmäki, Vaajakallio and Koskinen, 2014).

Establishing social norms and establishing trust are the factors that affect the citizen's participation in renewable energy. Environmental concern is cited as another reason for showing a willingness to participate. Therefore, it is necessary to ensure that the citizen is a part of this innovation in rural areas and in the city (Kalkbrenner and Roosen, 2016). The first three main spirals contributing to the innovation process in smart cities are; university, government, industry. These three spirals form the intertwined knowledge and innovation system model. Given the Triple Helix model, this triple helix advocates the creation of an evolving system overlapping with institutional partnerships (Etzkowitz and Leydesdorff, 2000). The triple helix model (state, university, and industry) partnerships trigger the mechanism for ensuring sustainable competitive advantage and increasing the quality of life. Because government, university, and industry partnerships are associated with the market through venture capital investments, technology transfer, and commercialization mechanisms.

With the involvement of citizens in the planning stage and benefiting from their skills and experience, civil society was added as the fourth spiral by Carayannis (2012), and the Quadruple Helix model emerged. The 4th spiral context of society highlights the need for greater public participation in the system for innovation development. Thus,

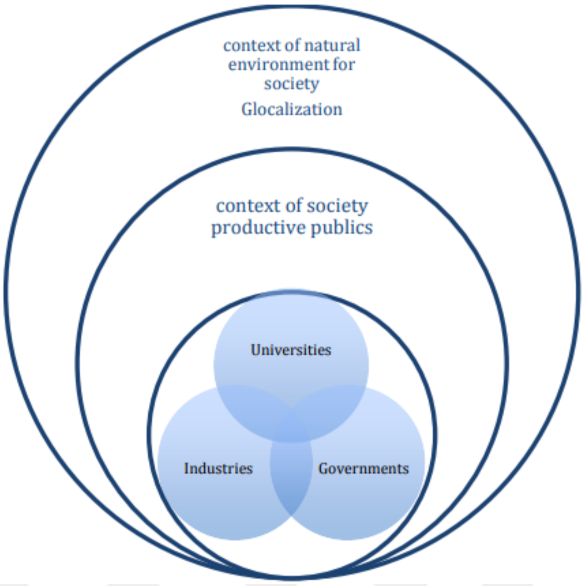


Figure 40. Detailing Carayannis' Helix model (Source: Cossetta and Palumbo, 2014).

it is aimed to spread knowledge production and innovation practice to a wider range. To rephrase it, the public uses and applies knowledge, so public users are also part of the innovation system. The public in the 4th spiral mentioned here is mostly civil society based on media, culture, and innovation. In the past years, context of natural environments for society was added to this model by Carayannis (2012) as the 5th helix. With the addition of the 5th helix, a system has been developed that promotes an expanded innovation ecosystem, that is, social natural systems and environments, balancing mode three knowledge production innovation systems and co-evolution.

Initiatives such as the context of natural environments for society and the interaction of citizens with the environment and creating creative information environments (living lab) correspond to the final ecological interaction of all pillars that make up the Helix model.

In this direction, present a proposal to the Helix model that includes all helixes in the research of the master's thesis. The local administration was contacted, and the investor was interviewed. Lighting is designed to be used in the common park areas, one of the most active parts of the city, and contribute to renewable energy. The main purpose of the design is smart lighting that provides its energy from human movement without being dependent on any other source; its functions have been increased with the developing technology, it saves energy and encourages citizens to act.

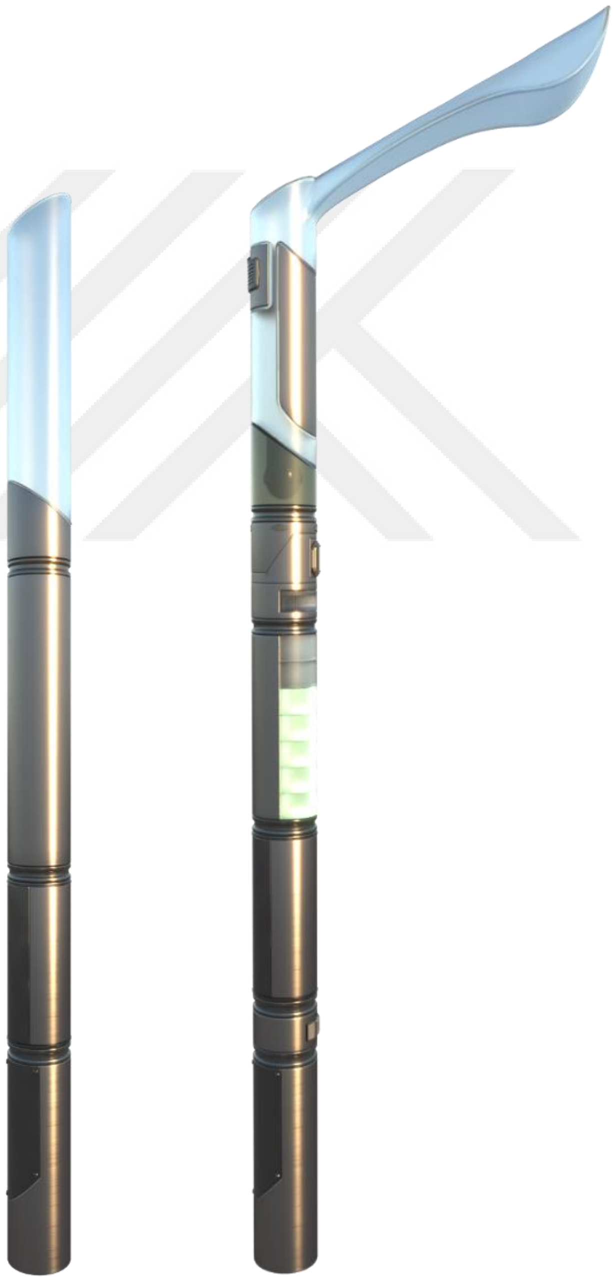


Figure 41. BAILIFF and BAILIFF 2.0.

For these purposes, the smart lighting system designed for Çorlu Republic Park was designed to be placed at 30m intervals on the approximately 1500m walking path. BAILIFF AND BAILIFF 2.0 are two different versions of smart lighting. BAILIFF 2.0 is powered by energy derived from human movement from piezoelectric floor tiles. According to the energy capacity of its battery, it transmits electrical energy to BAILIFF and other BAILIFF 2.0s. These two versions and kinetic tile are designed to increase people's environmental awareness and encourage action.

∅ none

✓ available

Equipmen List	BAILIFF	BAILIFF 2.0.
360 degree cold warm color LED	✓	✓
Air sensor	∅	✓
Camera	∅	✓
Speaker	∅	✓
Microphone	∅	✓
Motion sensor	∅	✓
Charge Indicator	∅	✓
Battery	✓	✓
USB charging port	∅	✓
IoT node	✓	✓

Figure 42. BAILIFF and BAILIFF 2.0. equipment list.

BAILIFF 2.0. It is a smart lighting system with all the equipment it has. Air quality measurement is made with the air sensor. The camera monitors 360-degree human movement. With the microphone and loudspeaker, communication is provided with the citizens in emergencies. With the motion sensor, energy savings are made in cases where the night citizen factor is low. The charge indicator shows the capacity of the electric energy obtained from the kinetic tile in the battery. The USB port is for charging. The IoT Node uses both versions of BAILIFF to analyze information gathered from energy use, savings, transmission, and all other sensor-oriented technologies.

BAILIFF is the semi-smart version of smart lighting. It is a supporting product for actual smart lighting. It is illuminated by the electrical energy obtained by BAILIFF 2.0. Since the equipment is modular, accessories such as camera and USB input can be added according to the place and purpose.

Figure 43. BAILIFF.

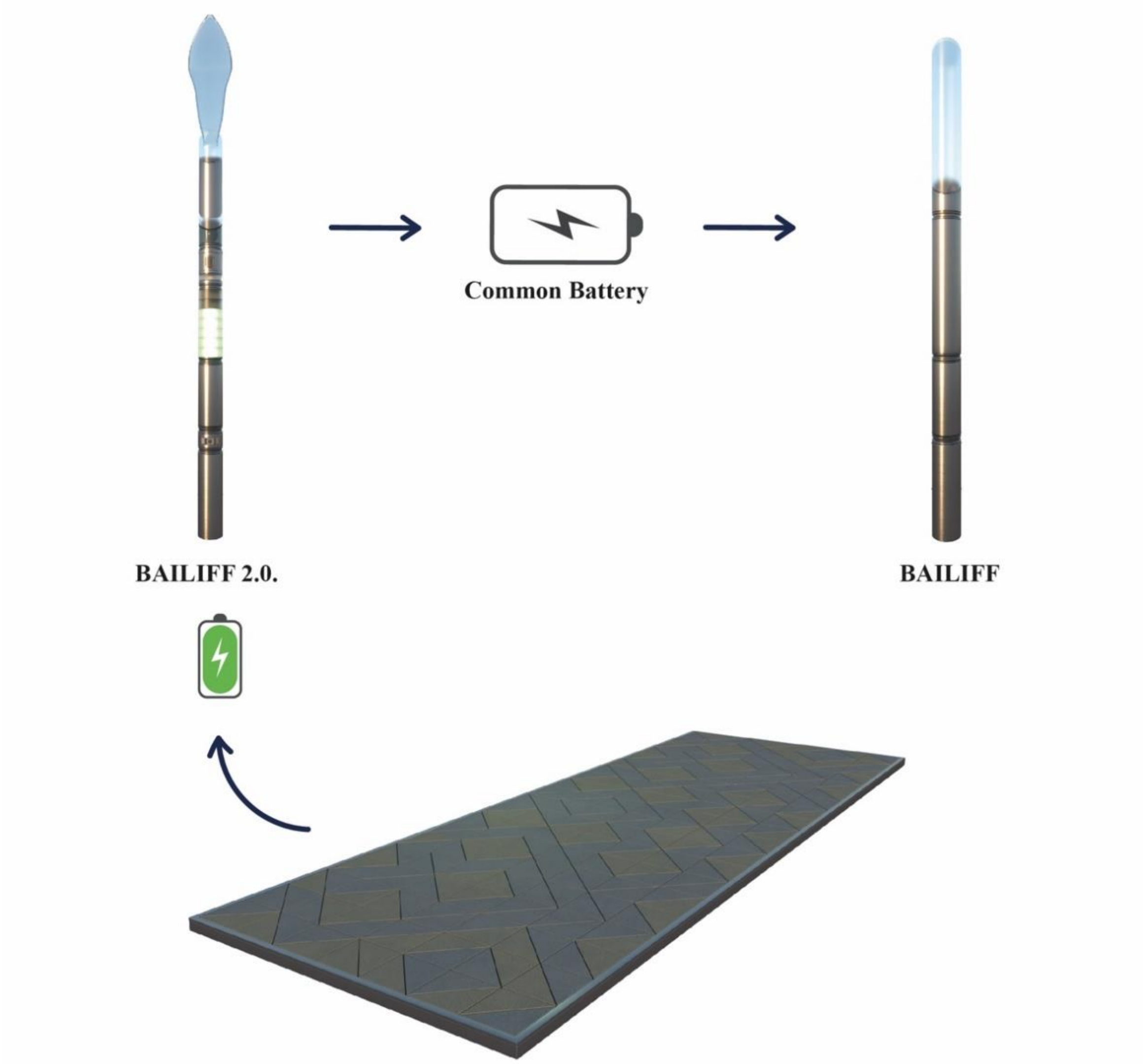


Figure 44. Demonstration of energy transfer from piezoelectric floor tile and battery.

Ten steps were averaged at 8m. One step corresponds to 5 watts of energy, the electrical energy that BAILIFF will use; 1 year is taken as an average of 300 days, and considering that it works 12 hours a day, 1 smart lighting will need 30 steps to work. In other words, it will provide illumination with a 10-watt LED, which is equivalent to a BAILIFF 60 normal bulb. Energy will be generated from human movement with a piezoelectric floor tile covering 2.80 by 8 m in front of each smart lighting. In other words, one person will provide the energy of lighting by taking three tours on the walking path alone. Piezoelectric floor tiles can also be used in the entrance/exit of the park or the children's playground. The reason why it is used the walking path is preferred; it ensures that the citizens who use the walking path create the enthusiasm to take the walking path second tour as they contribute energy.

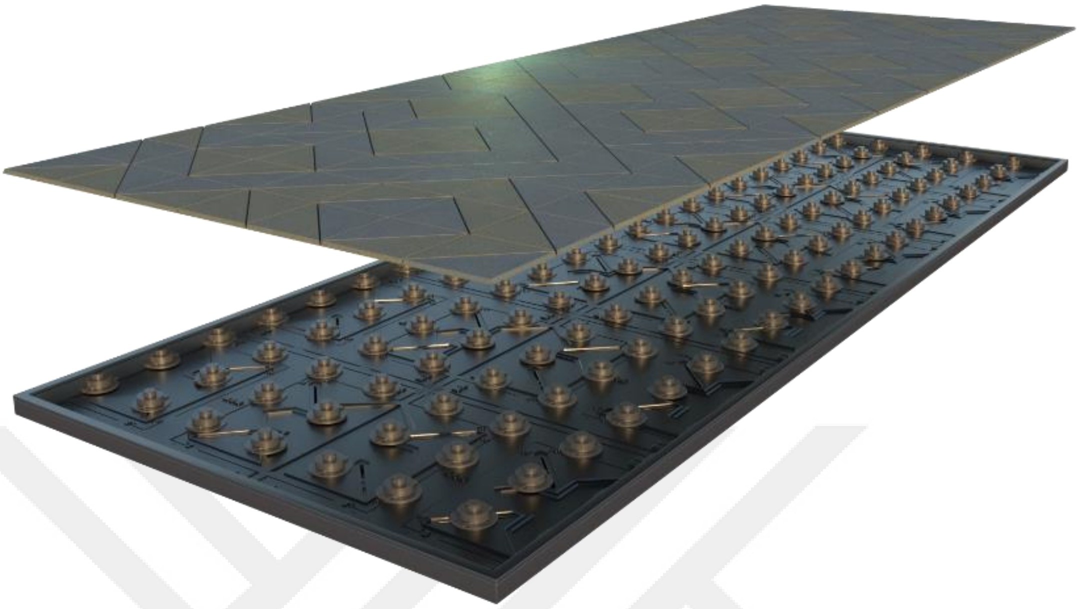


Figure 45. Demonstration of piezoelectric floor tile and interior suspensions.

To encourage citizens to act:

(i) Increase in charge indicator levels relative to the amount of energy the battery is filled with, and

(ii) The light of the kinetic tile under the step taken is on.

In total, these three methods will be a visual reflection in the design that people of all ages contribute by converting their activities such as walking, running, and jumping into electrical energy with kinetic tile. The embedded common battery will store the excess electrical energy obtained from the piezoelectric floor tiles coverings for the days when the human density is low. And the energy obtained will be accumulated in the batteries and distributed to other lightings when the capacity is full. Thus, the energy need will be met without being connected to the municipal grid or the need for a second renewable energy (solar, wind) system.


Figure 46. BAILIFF 2.0. and piezoelectric floor tile human product interaction.

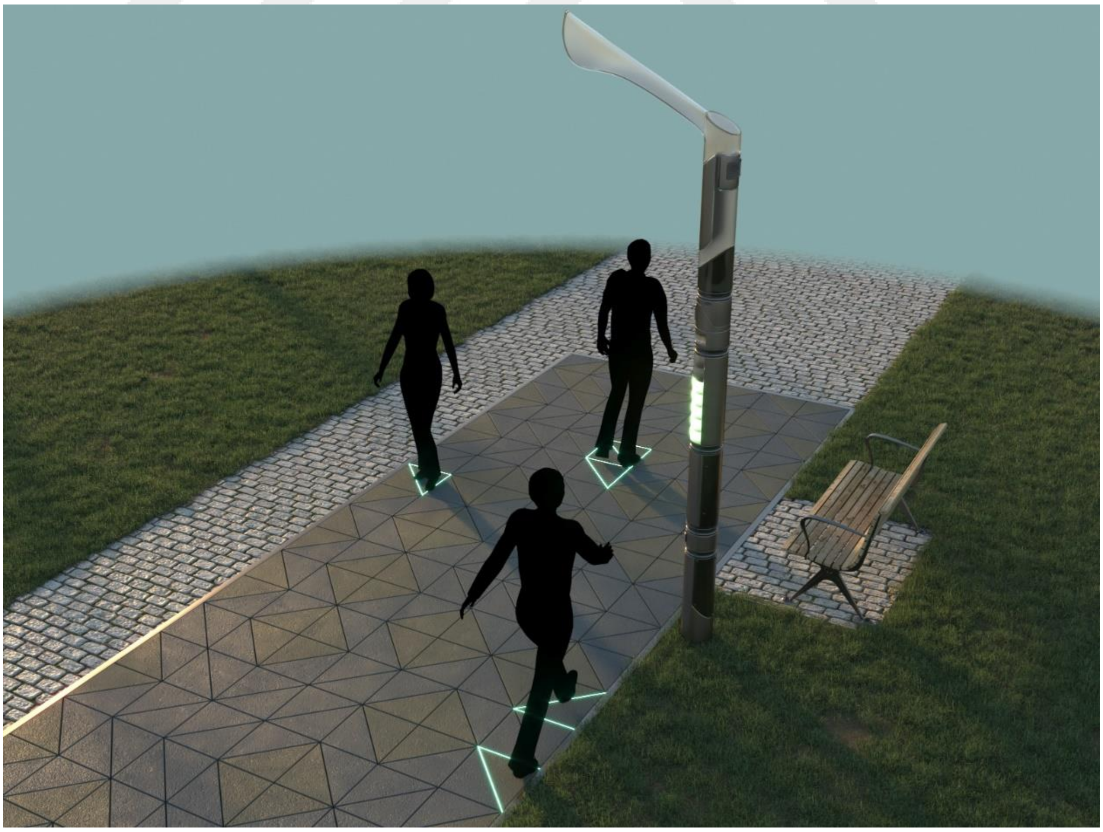


Figure 47. BAILIFF 2.0. and kinetic piezoelectric floor tile human product interaction perspective view.

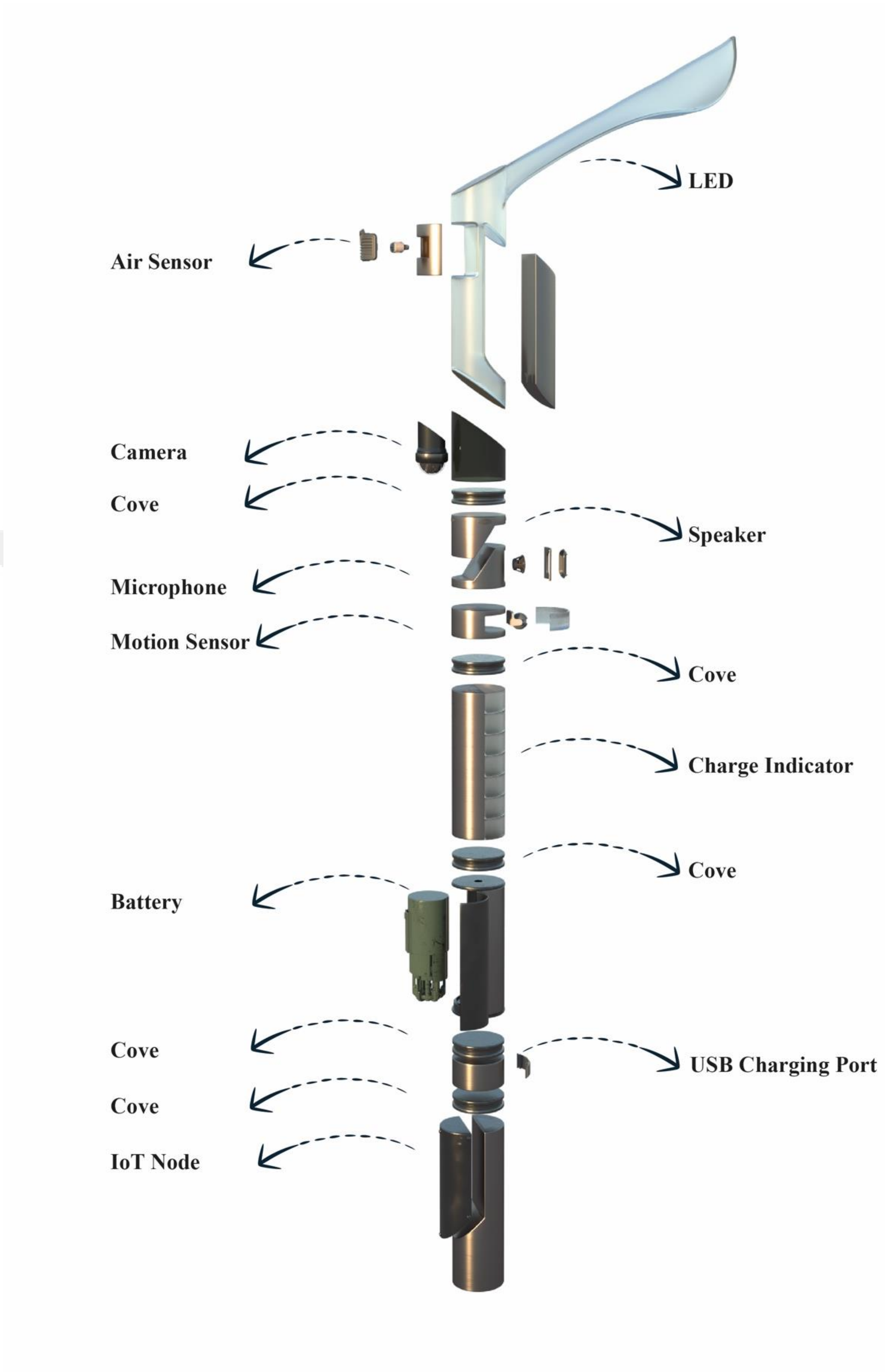


Figure 48. BAILIFF 2.0. exploded perspective view.

The pole of the lighting is galvanized for durability and longevity. LED and charging indicators are frosted glass, the motion sensor is milky glass. The glass is bottle dark green to avoid the feeling of being watched by the camera. The USB port is polyvinyl chloride (PVC), back covers are worn aluminum. Modular belts, speakers, and microphone brackets are metal.

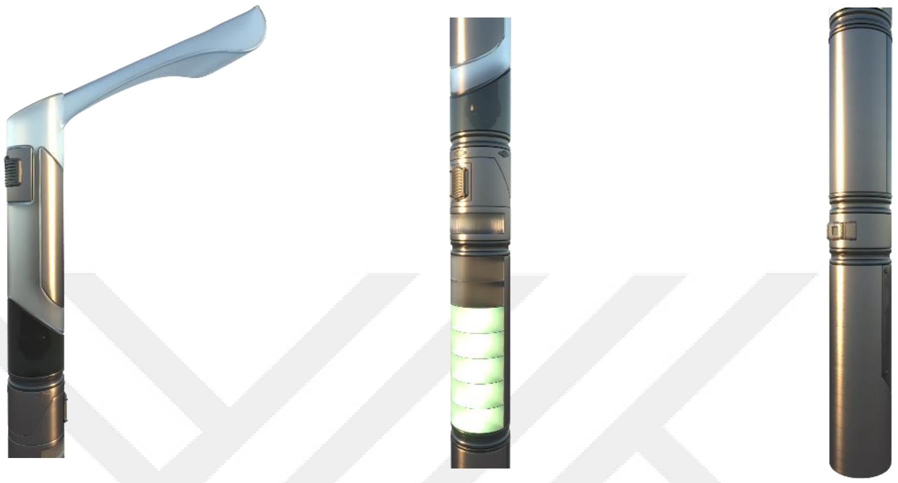


Figure 49. BAILIFF 2.0. detail.

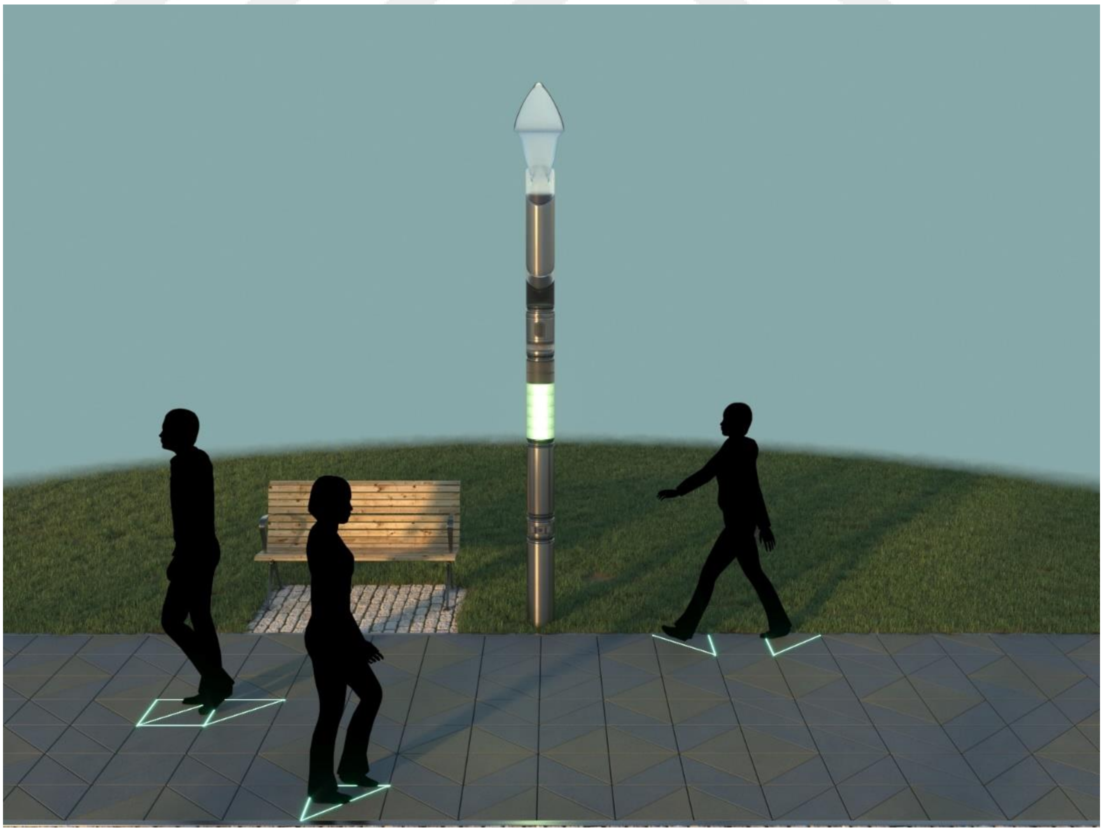


Figure 50. BAILIFF 2.0. and piezoelectric floor tiles opposite view.

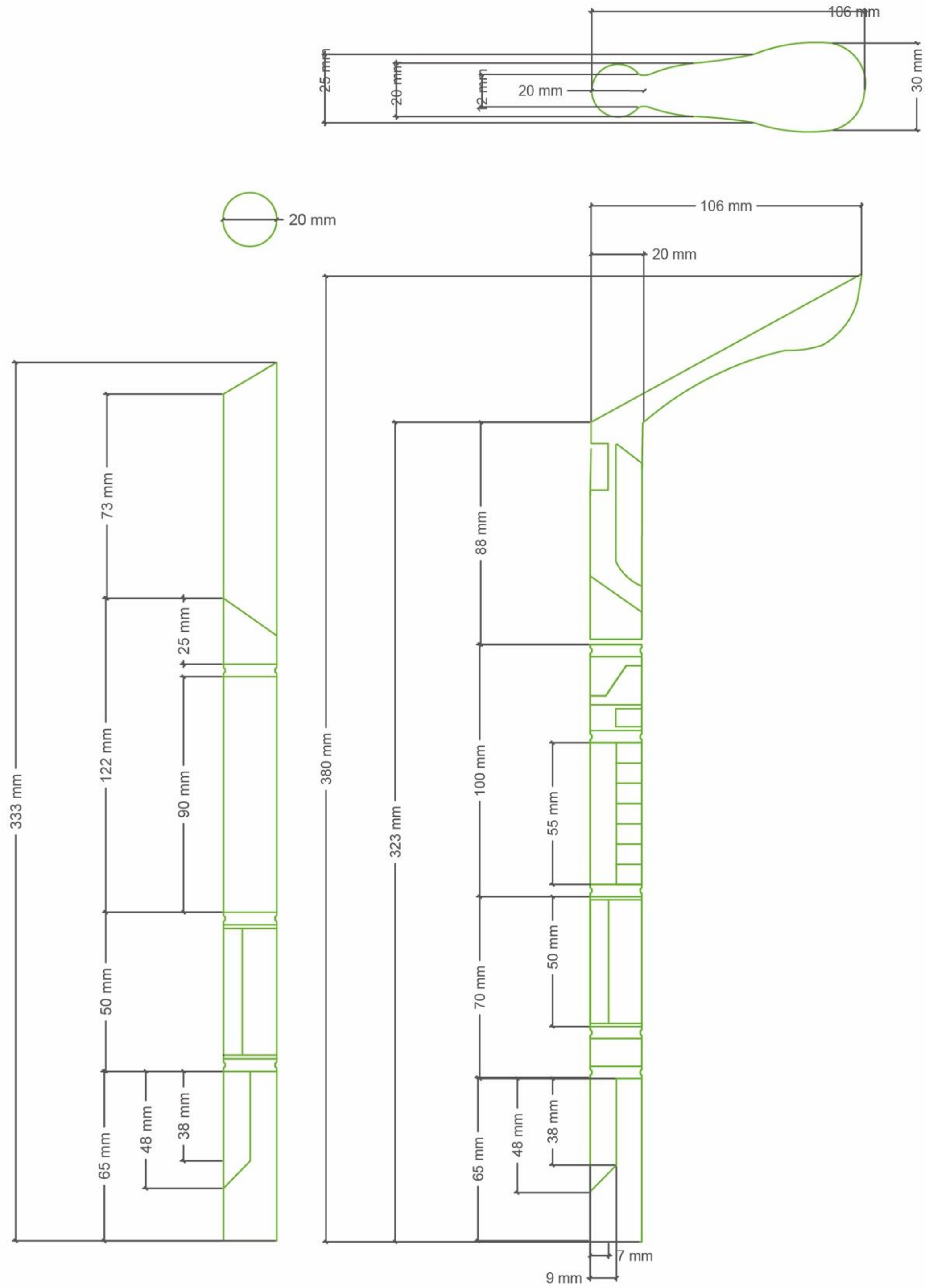


Figure 51. BAILIFF and BAILIFF 2.0. technical drawing.

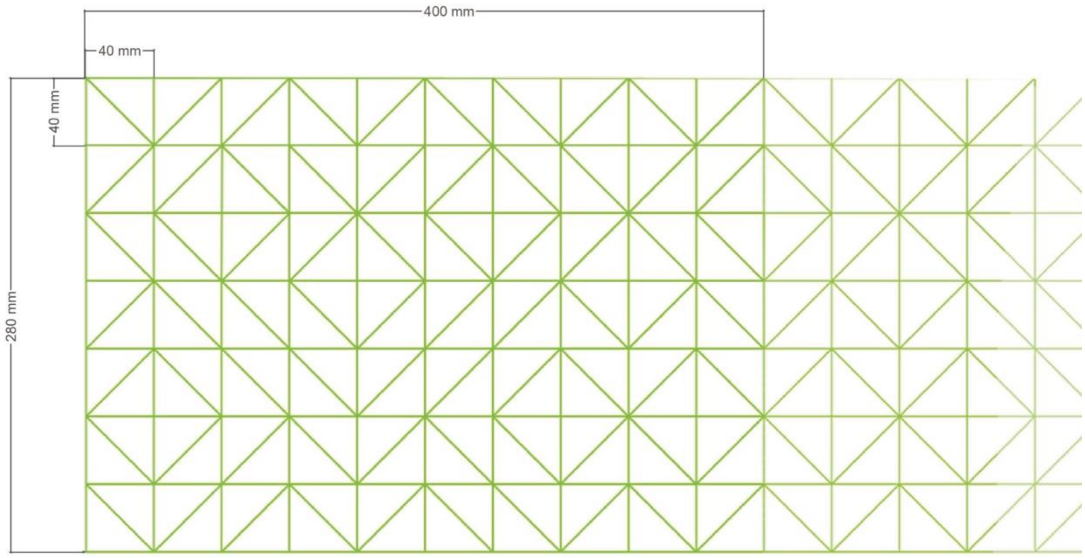


Figure 52. Piezoelectric floor tiles technical drawing dimensions.

Piezoelectric floor tiles are designed for Çorlu Cumhuriyet Park as 8m, twice the original 4m motif. The length of the flooring can be adjusted according to the place and location to be applied. Its material is polyvinylidene fluoride (PVDF). The average year of use of the conductive material that converts human movement into electricity is five years. The improved piezoelectric floor tiles support sustainable development by providing a cost-effective, green, and sustainable energy transformation.

4.4. Findings and Results

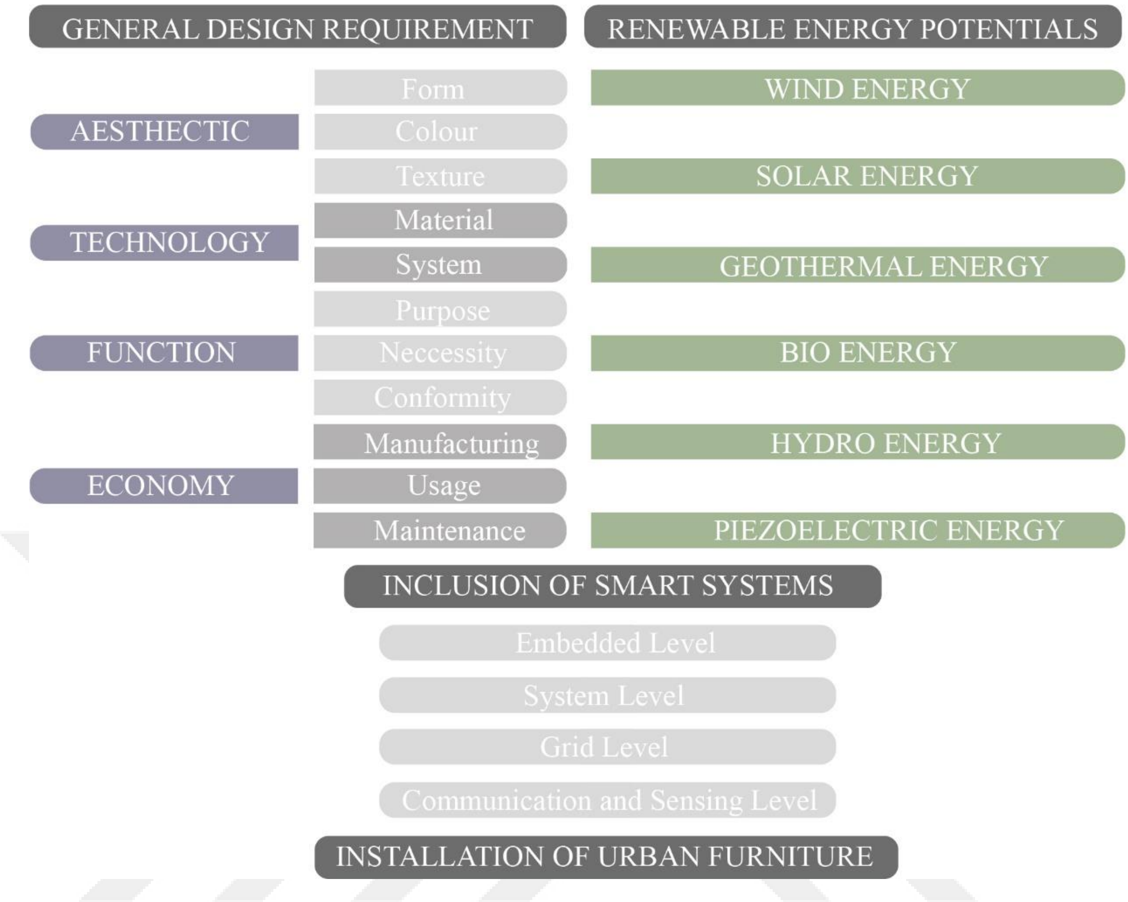


Figure 53. Stages of smart systems in the application of renewable energy sources in urban furniture.

One of the main purposes of smart lighting designed for Çorlu Cumhuriyet Park is to use the energy need arising from the city's density by converting citizens' movements such as walking, running, jumping, and cycling into the city electrical energy in the public green areas. Another aim is to increase the citizens' environmental awareness, contribute to renewables, and encourage action. Consciousness has been created to serve this purpose by the energy obtained by the piezoelectric floor tiles covering and the charging indicator on the lighting pole. The information collected by sensors and cameras is used for needs such as field analysis and information gathering. It is designed to determine the capacity of the IoT node and other smart lightings to provide energy efficiency and energy savings. BAILIFF is urban furniture that can be used as a support for common ones apart from being high-tech smart lighting. It is suitable for industrial cities with a high potential to become smart cities, such as Çorlu, and can be applied in different areas with its modular structure.

CHAPTER 5: CONCLUSION

This thesis analyzes the reflections of renewable energy and smart energy technologies on urban furniture in smart cities and presents a remedial proposal. As the most common feature of smart cities, it is necessary to have a networked infrastructure supporting social and cultural development. It is used as social capital for urban development in its citizens by encouraging urban development and creative activities. The natural environment, which plays a critical role in the planning of cities, is also used as a mask for countries' intentions to take their place in the technology market in the smart city strategy and participate in the competition in the world economy market. A country's energy policy and energy security do not only determine its economic power in the world. In countries aiming to be independent in energy imports or close to reaching energy supply, war, famine, and disease are more likely to occur.

The changing and shaping factors in the energy sector from past to present have been examined. According to this, technology development efforts in renewable energy have led to a significant increase in the world portfolio of renewable resources. It is also seen that energy-based problems are related to changing the flexibility of traditional energy, and complex energy systems are managed by blending energy demand among different sectors. The intelligence of energy is much broader than the concept of being renewable. Based on the principles of smart electricity grids, smart storage, and smart consumption, the Internet of Energy (IoE) model integrates any clean, green, sustainable, renewable, and conventional energy with ICT. It is foreseen that renewable high smart grids will provide two-way information energy flow to power all system users shortly, and renewable energy sources (RES) will form most future smart grids. The current state of technological development and the energy market should be considered to design the future's high renewable energy electricity system and implement the products that will contain the system. Electricity generation from renewable energy sources will provide direct or indirect economic benefits, apart from environmental contributions and future energy security. Energy demand and increasing population are directly proportional to economic growth, which creates the need for higher technology energy. When developing energy strategies, countries should know how to overcome local and global non-residential problems and position themselves in an international context through local communities. This goes through scenarios in which cities prepare themselves for the future. Smart cities all use different concepts and schemes for the transition of energy-based targets. The integration of renewable energies in urban areas prevents the depletion of resources and energy efficiency, and environmental degradation.

Public outdoor spaces, by their meaning and role, affect the identity and quality of the city. Considering this will vary depending on the level of detail and design, urban furniture should serve the region's spirit, serving the common language and not contradicting the aesthetic values of the place, rather than being a part of the system. Increasing the use of clean and renewable energy in urban open spaces will not only increase the quality of wisdom in a city. It will enable the citizen to take a step from not in my backyard to where I live. And the finding of smart urban furniture working with renewable energy in cities will also give the appearance of a sustainability fair for future generations.

The reason for considering the case study Çorlu is that it can handle such an investment in smart energy. For the infrastructure of the proposition to be made for Çorlu Cumhuriyet Park, the characteristics of Songdo and Antwerp, such as being a commercial region like Çorlu, strategic location, number of populations, and the use of different technological and human dimensions have been discussed. For this, a comparison was made for the smart environment by examining the following titles:

(i) Smart city vision energy use
(ii) Environmental objectives,
(iii) Green space use,
(iv) The citizen's contribution to renewables; and
(v) Evaluation of lightings used as urban equipment has been made.

Antwerp has seen that product or system designs implemented in the city by using the citizen factor in the decision-making and implementation of any innovation-based idea for the city are much more human-oriented. In the example of Songdo, even though large green areas are created, the equipment in the park gives the feeling of a technology stack. Even if it is surrounded by high technology, the feeling of being watched all the time makes the result of an artificial and soulless city unconditional. This seemingly useless product model is both an eye-catcher and an unaddressed recycling problem. As seen in Songdo and Antwerp comparison, social, cultural features, natural factors, and citizen factors are important for the dynamics of the city. Because when the idea is implemented, success depends on the user relationship and the product's sense of belonging to the place.

BAILIFF is an effective solution proposal for the Covenant of Mayors for Climate & Energy Europe agreement signed by Çorlu in 2019 and the role it will assume due to its potential. It will also inspire prominent energy-based projects for smart cities in Turkey by using kinetic energy and smart energy technologies. The use of renewable energy technologies in cities will be increased against possible power cuts and energy wars in the future. BAILIFF is designed to fit the keywords of industry 5.0: sustainability, people, green technologies, and digitalization. Therefore, it should be considered how high-tech products will be adapted to live, the green technology-human relationship, and most importantly, what will replace sustainability.

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APPENDIX

Appendix A: Covenant of Mayors for Climate & Energy Europe

Covenant of Mayors
for Climate & Energy
EUROPE

I, Ahmet SARIKURT, Mayor of Tekirdağ Çorlu Municipality have been mandated by the Çorlu Municipality Council on 10\06\2019 to sign up to the **Covenant of Mayors for Climate and Energy**, in full knowledge of the commitments set out in the official Commitment Document and summarised below.

Therefore, my local authority principally commits to:

- Reducing CO_2 (and possibly other greenhouse gas) emissions on its territory by at least 40% by 2030, namely through improved energy efficiency and greater use of renewable energy sources;
- Increasing its resilience by adapting to the impacts of climate change.

In order to translate these commitments into action, my local authority undertakes to fulfil the following step-by-step approach:

- Carry out a **Baseline Emissions Inventory** and a **Climate Change Risk and Vulnerability Assessment**;
- Submit a **Sustainable Energy and Climate Action Plan** within two years following the above date of the municipal council decision;
- **Report progress** at least every second year following the submission of the Sustainable Energy and Climate Action Plan for evaluation, monitoring and verification purposes.

I accept that my local authority shall be suspended from the initiative – subject to prior notice in writing by the Covenant of Mayors Office – in case of non-submission of the above-mentioned documents (i.e. Sustainable Energy and Climate Action Plan and Progress Reports) within the established deadlines.

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