ANALYSIS OF SMART CITY TECHNOLOGIES

AKILLI ŞEHİR TEKNOLOJİLERİNİN İNCELENMESİ

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ÖZET

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Önüne geçilemeyen ve bilimin ışığında akıl almaz noktalara erişen teknoloji, insanlara hayatlarında büyük kolaylıklar sunarak modern ve teknolojik bir çağ yaşatmaktadır. Çağımızın teknolojisi olan Nesnelerin İnterneti sayesinde hayatımıza giren Akıllı Sistemler, Uygulamalar, Çözümler ise bu noktada toplumsal yaşama yeni bir boyut getirmektedir. Son yıllarda hayatımıza giren Akıllı Şehir kavramı ise akıllı olarak adlandırılan sistemlerin bulunduğu büyük bir çerçeve olarak bu konudaki verilebilecek en önemli örneklerden birisidir.

Yapılan bu tez çalışması ile akıllı şehir konusundaki fikirlerin hayata geçirilmesinde bir yol gösterici rehber niteliği taşıması istenmiştir. Bu tez vasıtası ile akıllı şehir için geliştirilecek projelerde ne tür teknolojilerin kullanılması gerektiği, bu teknolojilerde hangi standartlara bağlı kalınması gerektiği gibi bilgilere erişimin kolaylığı sağlanmaktadır. Literatürde dağınık halde bulunan Akıllı Enerji, Akıllı Ulaşım, Akıllı Sağlık, Akıllı Atık ve Akıllı Bina çalışmalarının, bir araya getirilerek tek bir bütün halindeki sunumu gerçekleştirilmiştir. Bununla birlikte getirilerinin aksine Belirtilen alanlarda yaşanılan ve yaşanılacak olan sorunlar ele alınarak farklı bakış açısı da değerlendirilmektedir. Ülkemizde Konya Büyükşehir Belediyesi'nin akıllı şehir olarak örnek alındığı tez çalışmasında vaka analizi uygulanmakta, şehrin artı ve eksileri belirlenmektedir. Aynı zamanda hem kamu hem de özel işletmeler tarafından yapılması planlanan uygulama fikirleri için ilgili modellerin ortaya çıkışında bu tezin de göz önüne alınarak kullanılması hedeflenmektedir. Adı geçen başlıklar için ilgili kurumlar ile görüşmeler gerçekleştirilmiş, gerçek veriler üzerinden akıllı sistemlerin verimliliği konusunda çeşitli hesaplamalar yapılmıştır. Sonucunda ise farklı akıllı şehir bileşenlerindeki, akıllı çözümlerin tüm insanlığa ve yönetime olan olumlu etkileri ve sağladıkları yararlar bir bütün halinde sunulmaktadır.

Anahtar Kelimeler: Akıllı Şehir, Akıllı Enerji, Akıllı Ulaşım, Akıllı Sağlık, Akıllı Sistemler, Akıllı Atık Yönetimi

ABSTRACT

ANALYSIS OF SMART CITY TECHNOLOGIES

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Technology, that cannot be prevented and reaches unbelievable points in the light of science, maintains a modern and technological era by offering great convenience to people in their lives. Smart Systems, Applications, and Solutions, that entered our lives with the Internet of Things, which is the technology of our age, brings a new dimension to social life at this point. The concept of Smart City, which has entered into our lives in recent years, is one of the most important examples that can be given in this regard as a large framework containing so-called intelligent systems.

With this thesis, it was asked to be a guiding guide in the implementation of ideas about smart cities. Within the context of this study, it is provided to access information such as what kind of technologies should be used in the projects to be developed for smart cities and which standards should be adhered to in these technologies. Studies, researches that are related to Smart Energy, Smart Transportation, Smart Health, Smart Waste and Smart Building, which are disconnectedly and disorganizedly in the academical literature, have been brought together and presented as a single whole. Different points of view are evaluated by considering the challenges experienced and to be experienced in the specified smart city components. Case study is applied in this thesis in that Konya Metropolitan Municipality is handled as a smart city sample in our country and the pros and cons of the city are determined. At the same time, it is aimed to use this thesis in the emergence of relevant models for the implementation of ideas planned to be made by both public and private enterprises. For these topics, interviews were conducted with related companies and various calculations were made on the efficiency of smart systems based on real data. As a result, the positive effects of smart solutions in different smart city components to all humanity and management and their benefits are presented as a whole.

Keywords: Smart City, Smart Energy, Smart Transportation, Smart Health, Smart Systems, Smart Waste Management

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ABBREVIATIONS

AMI	Advanced Measurement Infrastructure
APS	Automatic Pass System
ATUS	Smart Mass Transportation System
DSRC	Dedicated Short Range Communication
EPRI	Electric Power Research Institute
FPS	Fast Pass System
ICT	Information and Communication Technologies
IOT	Internet of Things
KMM	Konya Metropolitan Municipality
NFC	Near Field Communication
RSU	Road Side Unit
STMS	Smart Traffic Management Systems
STS	Smart Transportation System
SVCS	Smart Vehicle Control Systems
V2I	Vehicle to Infrastructure
V2P	Vehicle to Pedestrian
V2V	Vehicle to Vehicle
V2X	Vehicle to Everything

1. INTRODUCTION

Internal migration from rural areas to cities seen often in developed and developing countries increases the urbanization rate in these countries, however at the same time cause many problems in local governments. Although traditional information technologies try to overcome these problems, more smart solutions are still needed for the public and the government. A globalized life is sustained in which studies in different fields are associated with each other and provide mutual benefits. This general perspective is also applicable to cities that contain different sectors from energy to transportation, from education to socialization. For this reason, smart solutions to be implemented should work with each other in an integrated way to increase the prosperity of the society and coordinate in a way that would not disrupt the environmental harmony. This where the concept of smart city emerges. With cyber physical systems that allow a city's all physical components to be transferred to a digital environment, cities are digitized and modernized. However, this leads to the creation of digital cities rather than smart cities. For a city to be called smart city requires the city to be equipped with sensors and cameras to obtain desired data from anywhere at anytime so that the external world becomes virtual. Additionally, an information exchange should be provided between smart devices so that all systems in the environment can work in an integrated way through communication. Lastly, the environment that becomes digital data is analyzed and processed with necessary algorithms in a digital environment so that people can live with maximum benefits due to artifical intelligence. For this reason, Harrison et al. [1] support that a smart city should have three main attributes. The first one is instrumented which refers to equipping the city with necessary equipment; the second attribute is being interconnected meaning that all living and non-living things should communicate; and the third attribute is being intelligent which refers to controlling all data obtained through equipments and communications in a digital environment and having mechanisms that can make decisions in their own.

The concept of "smart city" in the literature is defined differently by academicians and sectoral businessmen. The definitions and of smart cities from the academic literature are provided in Table 1.1.

Table 1.1. Smart City Definitions [2-8].

Definition 1	A new generation design plan in which all subunits in a city are in one mechanism.	***Gábor SZÖGI*** [2]
Definition 2	A way of thinking shaped by individuals with different perspectives in alignment with their benefits.	***Rob Kitchin*** [3]
Definition 3	A framework emerged through information and communication technologies that would make citizens' social lives easier and increase their quality of life.	***GILLES BETIS et. al.*** [4]
Definition 4	A design product as a result of multidisciplinary studies implemented through making technological developments a priority to use available resources efficiently and transferring to future generations.	***Paolo Neirotti et. al.*** [5]
Definition 5	Efforts that provide innovative solutions for problems that city management and citizens face, and that increase economic and social welfare. This includes every unit from the country's finances to transportation.	***Suha Alawadhi et. al.*** [6]
Definition 6	A big digital web created by using electronic hardware and softwares related to city management and a sustainable environment.	***Robert E. Hall et. al.*** [7]
Definition 7	An area that prioritizes healthy people and healthy social lives through using digital and flexible new generation systems rather than using dvices that have been and continue to be used.	***Saraju P. Mohanty et. al.*** [8]

Based on the definitions provided, smart cities can be defined as follows: Sustainable cities that are created through Web 2.0 technology and information and communication technologies (ICT) and that contain all infrastructures such as roads, bridges, airports, and tunnels, and resources such as water and energy in a center to monitor and control as well as using the data obtained to provide smart services for citizens to increase their quality of life in the areas of health, transportation, education, etc. and to transfer this structure to future generations.

1.1. Scope and Importance of The Thesis

Humans are social beings that are influenced by and shaped according to their environment. Cities, on the other hand, have factors that make up the interaction of human beings with other people, environment, and natural resources and determine their living standards. In all of these factors, the establishment of mechanisms that provide flexibility against the changes required by the age, and the use of technologies to facilitate the daily activities of the citizens make them consistent with digital life, including future generations. The concept of smart city is a large-scale project that gathers these ideas in a common center, where both public and individual interests are prioritized.

In this thesis, considering all of these, energy, transportation, health, waste and housing services, which are the primary requirements of the public sector, are evaluated with innovative smart solutions in technological context. It is aimed to investigate the standards, protocols determined worldwide for each component, and by examining different models in these components, to integrate them into a whole, and to gather the contents of the concept of smart city under a title. Afterwards, efficiency and economic gains are revealed by performing economics analysis as a result of related calculations. In addition, challenges and problems in smart city components are added as a different perspective and the thesis work is made comprehensive. In this way, it is shown in this thesis that this concept has both advantages and disadvantages.

Within the scope of this thesis, Konya Metropolitan Municipality is examined as a case analysis and application examples that are developed and to be developed for smart city components are presented. Konya is handled because of that it is an actively working municipality that creates a separate unit for smart city studies in our country.

When the literature is examined, it is seen that there is no study in which the majority of smart city components are evaluated in the technological context. It is seen that researchers should examine the studies separately for each concept. Regarding this deficiency, it is foreseen that the thesis study will make a large and extensive contribution to the literature and the importance of this subject is determined by the following articles.

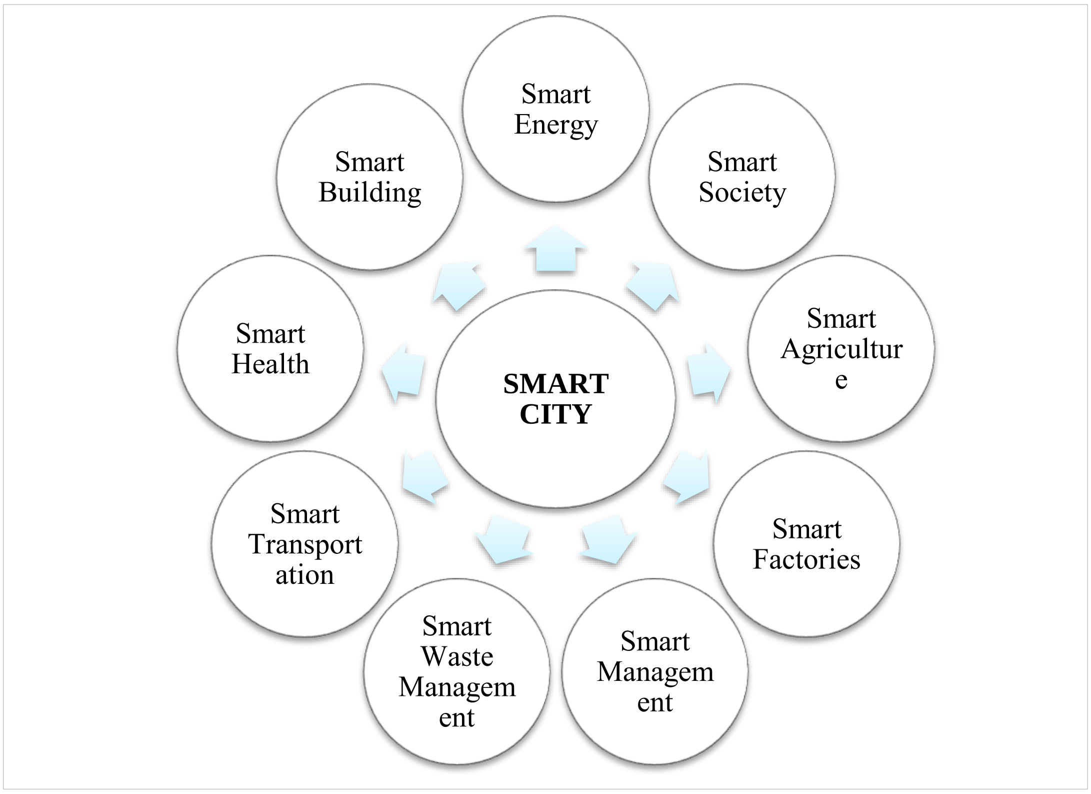
- The majority of the components of the smart city and their sub-factors are detailed and given in this thesis, which is carried out as a whole.
- The literature review for the identified smart city components is examined devotedly and in detail, and proposed models in the technological context are presented with images.
- All the standards required for the implementation and control of the factors that make up the smart city have been researched and these are included in the related titles.
- In order to evaluate the studies on smart energy in our country and to obtain an economic result in the thesis, interviews are conducted with many companies and numerical calculations are made thanks to the data obtained in real terms.
- This thesis is a guide for the public authorities, private enterprises and individuals on where and what technology to be used in order to catch up with the age and to apply welfare-enhancing practices.
- The applicability of smart city promises in real life is investigated through literature and relevant example city studies are available.
- Comparison of the innovative studies in the related smart city components with the traditional methods is carried out.
- Challenges for smart energy, smart transportation, smart health, smart waste and smart building management are addressed.
- Including difficulties and problems, there are two different points of view, both positive and negative.

- In Turkey, Konya applications that are most active city in this regard are being examined and evaluated.
- Konya's deficiencies and mistakes in terms of implementation are determined.

1.2. Smart City Components

Cities that provide and systematically sustainenergy, transportation, water, food, education, jobs, social opportunities that are needed for citizens through a certain government are insufficient for the public in certain aspects. Challenges in waste management along with not emphasizing environmental planning and lack of infrastructure for cleaning, noise pollution, not being able to meet the energy demands, road accidents, traffic jams are some inevitable problems that city managements face [9]. With the current technological developments, it is believed that smart cities will be created, a new digital management will be formed and solutions will be provided for all the problems that occur.

Figure 1.1. Smart City Components



The unstoppable development of technology does not influence the cities on its own. In addition to the technology, high level officers should help with systematizing and implementing through making necessary policies and documentation. Lastly, citizens are desired to be open to all these innovations, to be creative, and knowledgable. As Nam & Pardo report in their study that the fundamental actors in the creation of smart cities are technology, management, and public [10].

As described in the report issued by the ministry, smart cities are not a luxury, it is a necessity. For this, there are 4 main components [11]. They are; areas that are environment friendly and without pollution, infrastructure resources such as renewable energy sources and transportation to be built in these areas, satisfaction of end-users such as public, public institutions, and schools, and management that would provide control.

Management and technology should co-ordinate and collaborate in certain aspects to build a smart city for the society. These aspects include:

- Finding renewable energy sources for people, to make the available energy sustainable through efficient use, to increase productivity by meeting the city's energy demands at an optimum level.
- Eliminating the traffic problem due to increasing number of vehicles through providing smart solutions for citizens for transportation problems, and providing safety.
- Providing online services to citizens through mobile applications using ICT in education and health fields.
- Placing importance on the environment by taking carbon emissions into consideration.

In order for countries to reach a certain development level, the first step is to start with the city management which can be achieved through the points made in the previous paragraph. Based on these points, innovative approaches to issues including energy, transportation, health, housing, would not only increase the society's welfare but also respond to global issues such as environmental pollution, global warming, and disrupting the natural habitat and leave a more livable world for future.

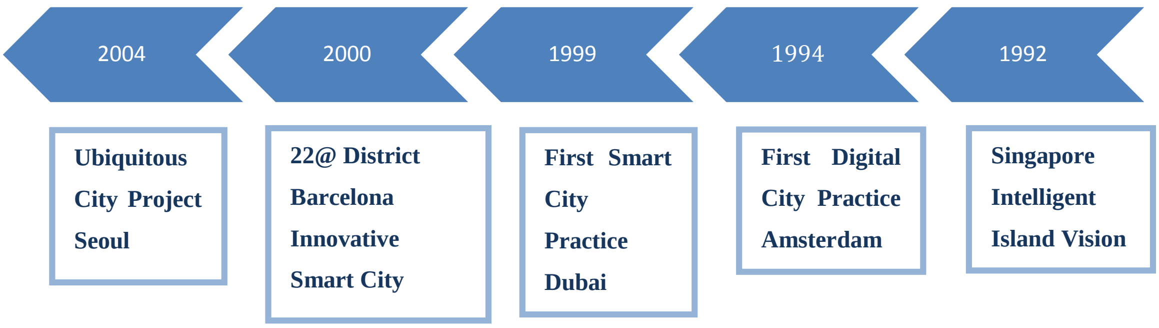
In the study conducted bu Mohanty et al., smart city components, its attributes, the target audience, and the necessary infrastructure are provided in a relational table [8]. They present the components of a smart city that is digitized and has artifical intelligence in 9 categories. The urgent and the most needed components among the nine are areas related to energy, transportation, housing, and health. However, Pardo et al. report in their literature review that the first component needed for a city to be called a smart city is public service [12]. In terms of services offered to public, they support that structuring of transportation, energy, solid waste, and housing as well as water management should be present.

1.3. Smart City Example

Based on the studies conducted by the United Nations, more than half of the world's population in 2018 reside in cities [13]. This situation varies in developed, developing or undeveloped countries. However, since the mid 20th century, it is observed that the city populations in these three different types of countries increased [14]. This brings out the importance of the urbanization concept and requires government administrators to follow the necessities of the era and meet the citizens' demands at an optimum level. Particularly developing countries need to take comprehensive measures as the study projecting on 2050 showed population increase in the city would change significantly [15].

The introduction of Web 2.0 into our lives created a digital life and the first examples of digital city creations emerged in 1992. During this period the foundation of smart cities were laid although they were initially described as digital or intelligent. Then, people started using this virtuality and digital lives emerged. The creation of smart cities was introduced to the world in 1999 in Dubai. Developments occurred in the field of smart cities are presented in Figure 1.2. In the next section, Singapore as the pioneer in this field with its big developments and innovative approaches in different areas are presented.

Figure 1.2. The Evolution of the Smart City Idea [16-20].



1.3.1. SINGAPORE

Singapore had proposed the `Intelligent Island` concept in the IT2000 report in 1992 and stated that they would combine information technologies with the city infrastructure and contribute to all units in the city. Thus, Singapore is considered the first with this idea in smart cities [20]. However, the background of this idea should not be forgotten. Singapore with its many environmental and geographical problems benefited from the spread of information technologies and communication over continents in 1980s [21]. Then, they used this for public service in higher offices with the purpose of increasing human power in this field and providing convenience for management. This process continued until 1985 and they described this process as information technologies developed for the public. After 1985, they wanted to use the current science and technology not only for high ranking offices but also for sectors that were believed to provide contributions and therefore placed an importance on information companies for development. They incentivized the industry to keep up with the modern day. Efforts were made in the country in relation to these areas until 1990 and this process was called the National IT Program. This process of gradual development is considered as infrastructure preparations for the `Intelligent Island` that is aimed to benefit citizens through establishing technology and the necessary infrastructure [22].

Singapore pledges for a smart city to bring everyone in the area in a virtual web in which they can interact in a virtual environment anytime and anywhere. The city placed an importance in information courses including technology and coding, and provides funding for students and teachers with the purpose of forming their own National Information Infrastructure. This would allow to increase the band capacity in the web and all structures in the city to have access to internet [23]. Also, public services provided by the government would reach citizens at a high efficiency level. With the national infrastructure, it is envisioned that information and communication technologies will provide solutions to meeting the energy demands of consumers and sustaining energy resources in cities with increasing population. The mobilization process following the Intelligent Island project, Singapore is ready in terms of infrastructure and society for the smart city with its Smart Nation project [24].

As a result of the above mentioned developments, Singapore is the city that started the process of developing a smart city and making significant process in the world. In 2017, the country's minister relevant to this matter announced that they would invest 2.5 billion dollars in all smart developments for the next 4 years. This makes the country the country that invests the most in digital and smart living matters [25, 26]. Due to investments and the amount of these investments, Singapore had won the best city award in Smart City Expo World Congress held in Barcelone in 2018 [27].

The investments along with smart solutions and services provided for issues such as increasing population of the capital Singapore which leads to traffic problems, lack of energy resources are presented in the following section.

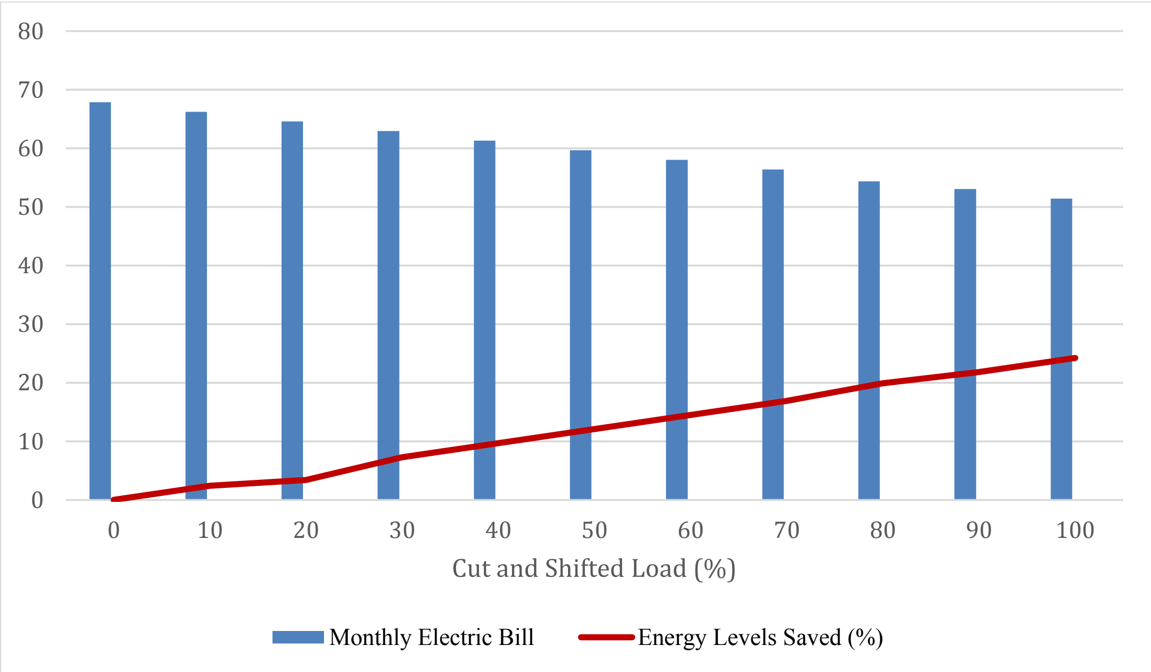
- Smart Transportation Systems

A platform called "ONE DIRECTION" in which all drivers, pedestrians, and units related to traffic in the country are connected, provides a one and only system to monitor traffic flow. This allows drivers to receive information and instant visuals about their routes regularly. Pricing of toll roads are automatically done by authorities [24]. The institution which is established under one umbrella in 1995 and operates under the Highway Transportation Ministry [28] provides convenience to citizens and commuters by using smart transportation system technologies. For example, with the Traffic.smart application they created, commuters are provided with information that is updated every few minutes about the traffic. In addition to services provided for commuters, the country also provides different services in the management such as using green wave for drivers and monitoring areas with high risk of accidents with relative units [29]. For mass transportation vehicles, a mobile application called MyTransport.SG was developed to provide current information to public on the wait time at stations and the bus routes [24]. Debnath et al. [30] state that all these developments have the characteristic of being sustainable.

- Smart Energy Systems

The first phase of a pilot project on energy saving for houses that constitute 20% of the total electric power consumption in Singapore was implemented in 2009. First, an internet based Consumer Energy Portal (CEP) was developed for consumers to be able to use individually and actively [31]. The portal allows for identification of illegal electricity, automatic pricing, and two-way comunication between consumers and distributors as well as individual energy management for consumers [32,31]. In the system established for energy management, different pricing is applied for customers at different times of the day and consumers can adjust their home devices to low pricing times with the Home Energy Management System (HEMS). The total energy consumption of devices occur during this period. This way, the energy supply for customers procedure does not occur at the same time on the distribution side and improvements are made at peak levels while at the same time low pricing is applied on the demand side [31]. In the first phase that used smart meters and necessary communication, and distribution protocols, the establishment of communication and energy units are completed. Also, a simulation was performed [33,31]. With relevant calculations, peak loads that energy is demanded the most are moved to low pricing phase and this provided customers with low cost energy. The changes in pricing and the efficiency of obtained energy in the simulation are provided in Figure 1.3.

Figure 1.3. Results of Singapore Smart Energy Simulation



During the second phase of the Smart Energy System pilot implemented in 2012, smart meters were placed in around 2000 houses in a certain area of Singapore. After that, the satisfaction of customers with the Smart Energy Systems is measured as well as including them in the whole system [33, 24].

2. SMART ENERGY

2.1. The Concept of Smart Energy

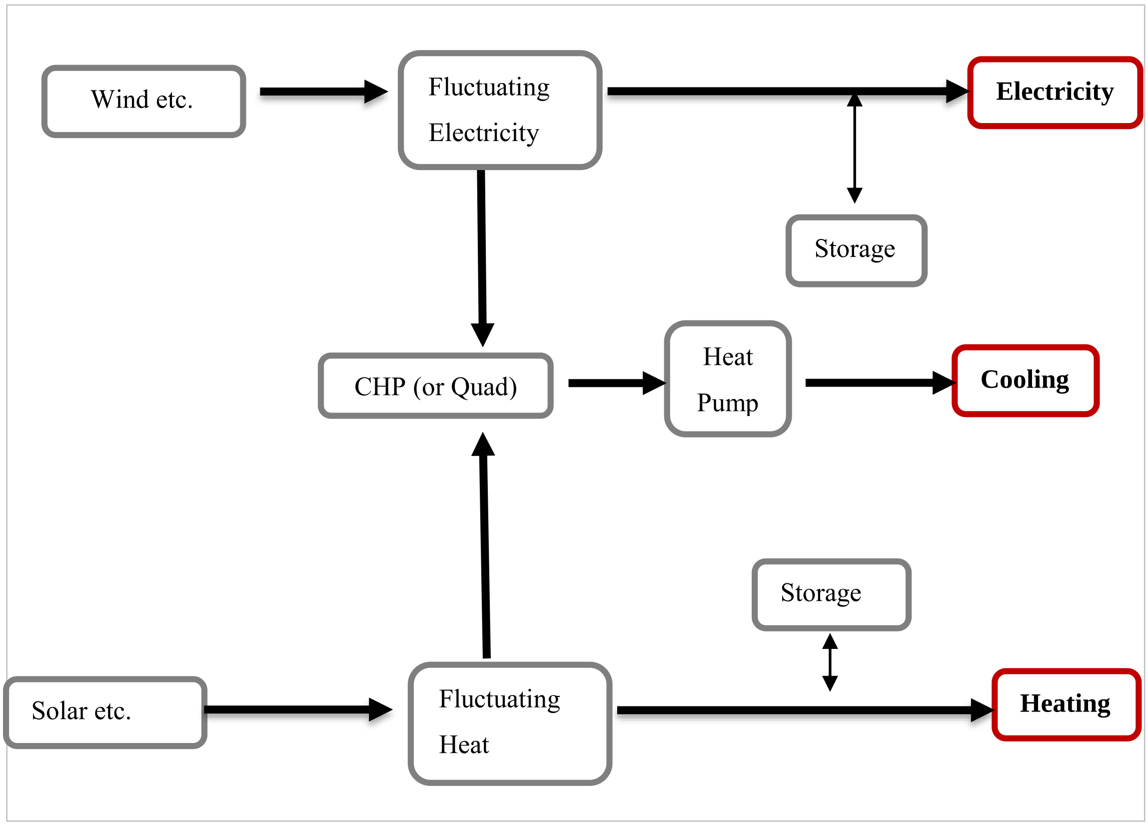
The energy, particularly electric energy that is needed for all living beings to sustain their lives have become an essential source for technological devices that have a wide presence in our lives. The fact that even a small technological device works with electric power is an indication of excessive use (consumption) of energy. This consumption creates significant global environmental problems and if no cautions are taken, a shortage in this matter will occur [34].

The environmental damages of rapidly improving technology within the scope of energy for the purpose of making human lives easier can not be overlooked and there are studies focusing on active resolutions in this area. The energy needed by smart technologies to provide different and innovative resolutions for problems in this area as sustainable and renewable energy which leads to the emergence of the concept of smart energy [35].

Smart energy aims to provide sustainable energy through integrating subjects including infrastructure for energy production, proliferation, and maintaining not only for today but also for future generations [36]. This subject matter which is very important for societies also bring up several expectations. According to Dinçer and Acar [37], smart energy with its environmental dimensions should be reliable, compatible with various systems for different purposes, and economically obtainable in order for people to adopt.

Smart Energy System (SES) is an energy system that can use solar and wind energy immediately or store and use the energy obtained from these resources. The process of smart energy is presented in Figure 2.1.

Figure 2.1. Smart Energy System Work Progress [38].



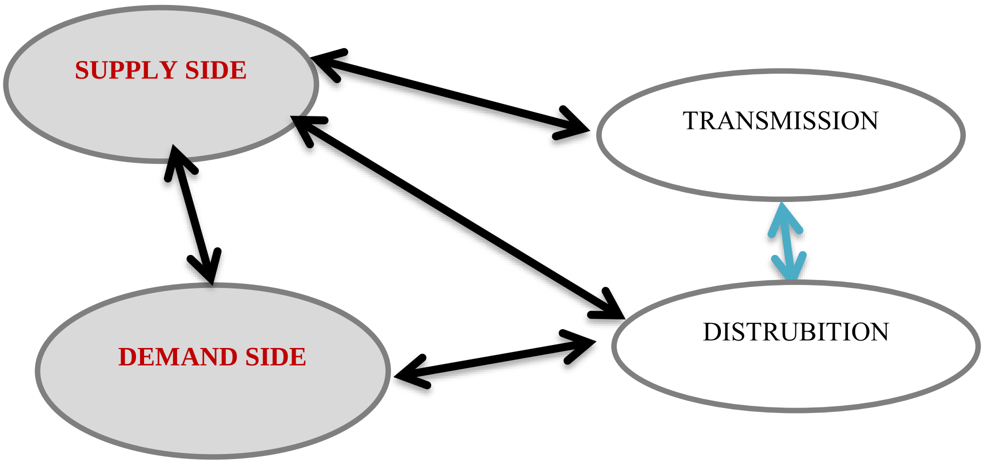
2.2. Smart Grid

The ever-growing energy need cause several problems as the uni-directional transfer of energy production from one source to consumers is not sufficient in terms of environmental and energy control aspects. With the new technologies developed in today's world, smart grids are used rather than grid circuits. Smart grids are easier to control, that provide bi-directional transfer both from and to producer to consumer, and that are more efficient through information and energy sharing [39]. With this new technology, renewable energy sources such as solar and wind will be used more actively and carbon emissions will decrease through increasing awareness on environment [40].

Due to the bi-directional transfer of smart grids, needs and demands between producer and consumer will be idetified, consumers will be able to place their requests whenever they want and producers will be able to meed those demands. There will be a control mechanism in the background which makes grids smart. Considering the system as a whole, it is a smart energy management system. In this system that can be controlled from one source, there are 3 main components consisting of Supply Side, Demand Side, and distribution and transmission of electric energy to consumers [41].

The responsibility of the supply side is to provide electric energy for consumers without interruptions, at low cost and in a reliable way. Consumers receiving energy can optimize the energy in their homes. Adjustment of meter in rates where pricing is high or being able to share the electric energy brought to the building themselves are example of efficient use of energy [42].

Figure 2.2. Main Components of Smart Grid Concept.



Sudden outages in electricity grids, issues with unidentifiable causes are eliminated by smart grids and the performance and safety are increased to higher levels. The reason for this depends on multiple different areas from bi-directional transfer to sensor technology, to information technology, to communication technology and control technology [43]. The safe implementation of smart grid that is a multidisciplinary effort, and its ability to renew itself when needed depend on the detailed infrastructure design [44].

When a problem occurs in a regular electricity grid, it can affect the whole system or it may take a while until the problem is solved which causes time and efficiency loss on the consumer side.

2.2.1. Smart Grid Standards

Identification of purposes of a device, concept, or system, the ability to work without problems, and to be acceptable by everyone are ensued by standards. As the concept of smart grid is a timely subject, it has various standards that would shed light to new initiatives in this area. Countries and energy institutions in different parts of the world that create their own standards are pioneers in this matter. According to the literature, standards developed for the new generation grids are presented in Table 2.1.

Table 2.1. The Standards of Smart Grid [45 – 48].

STANDARD NAME	FUNCTIONALITY OF STANDARD
IEC 62351	Providing Safety of the Digital Energy System
IEC 15118	Safety of Energy Charge
RFC 6272	Cluster of Communication over Internet Protocols
IEC 61850	Communication Webs and Systems for Power Applications
IEC 61870	Information transfer in the area that it's used actively
ANSI C12.19	Standardization of the Obtained Data from Meters
IEEE C37.118.1	Identification and Limitation of Measurement
IEEE C37.118.2	Grid Information Communication and Units

The standards presented in the table were developed by IEEE with the purposes of having monitored units be stable and identifying their limitations.

2.2.2. Supply Side

The first component of the smart grid is the institutions and entities that provide this service to customers. Additionally, units that manage and control all markets, and the whole grid including operators are considered within the scope of this component [49]. Technologies including current distributed generation, storing electric energy, and micro grids are explained in detail in the next section [50].

2.2.2.1. Distributed Generation

Distributed generation that takes place in the supply side and that is very important, is effective in managing carbon print by combining different alternative energy sources in addition to energy co-generation and provides significant contributions. Another important benefit of distributed generation is that it provides efficiency by increasing the quality of services in generation, distribution, and transmission points of electric energy [51].

Smart grids that also generates energy obtained by renewable energy sources including solar energy, wind energy, geothermal energy, integrate these resources and active resources to energy markets and necessary power systems with operators. The in-between power flow progresses in a multi-directional way [52] .

In the literature, new generation grids are described as smart and include a control mechanism. With this control mechanism, procedures needed for the energy flow in the web can be performed. Distributed generation, balancing, and adjusting of power in the energy that is sent to the consumer and the progression of the energy in an integrated way with the customer is monitored. This is how efficiency is achieved. The principle of “suitable and forget” in traditional grids are replaced with an active web management.

Due to an active control system, system performance improvements are performed to increase efficiency in smart grids [52]. Abovementioned distributed generation technologies provide significant benefits to meet the local energy needs, however, important challenges and problems need to be resolved prior to wide distribution is practiced [50].

2.2.2.2. Micro Grids

Micro grids are structures that contain renewable energy sources that are distributed and interact with each other, and consumers in a web. These structures allow this web to work synchronously with the central grid by integrating it to the central grid amd to work independently in the central grid [51]. The Energy Management System that is responsible for managing the power and electric energy between suppliers and consumers is placed within micro grids. Then, real power and energy generation is distributed between the components of Distributed Energy Resources [53].

Intelligent Distributed Autonomous Power System which has many internal functions and is considered as a micro grid can also work integrated to the central grid or work independently with the distributed energy resources and connected loads in itself [54, 55]

2.2.2.3. Electric Energy Storage Technologies

Energy storage is needed with the purposes of meeting demands including production, mobile systems, and renewable energy resources, and sudden power needs. Energy storage methods such as electrochemical cell can't meet the needs of energy storage in new generation grids. Thus, big scale systems that can work integrated into modern and smart grids are developed. The energy storage systems that are used and developed today are listed below [56].

- Flywheel storage technologies
- Battery storage technologies
- Supercapacitor storage technologies
- Hydrogen storage technologies
- Pneumatic storage technologies
- Liquid-piston technology
- Compressed air energy storage
- Pumped storage technology

The United Kingdom stated that the energy storage issue is an important one that needs to be resolved by the state and support the studies on smart grids by the Parliamentary Renewable and Sustainable Energy Group (PRASEG) [57]. The real power of an Energy Storage System (ESS) is limited to its capacity of installed storage [58].

Storage capacity and the ability of transferring energy determine an energy storage system's power. In smart grids, forming a balance by controlling all variables related to the dynamic load control provided by increased renewable energy resources is a challenge. This challenge can be overcome by the stored energy by the grid [59]. Meeting the demand without storing much energy in these storages indicates the presence of a smart energy storage system.

Studies conducted to reduce the costs of energy storage systems are effective in general designs and management of smart grids that contain these storage systems. For example, excessive load issues can be resolved, the issues on the transferred energy quality can be reduced. With the new developed storage devices, consumers in addition to suppliers will also be able to store their own energy [60] .

2.2.3. Demand Side

The Demand Side Management (DSM) is a system of softwares in smart grids that is used by authorized public service offices to control the energy used by consumers [61]. In the concept of smart grids, citizens in addition to public service units can monitor and control their energy use and make inferences. Thus, they can adjust their use of energy [62]. Control centers and the data gap issues that are present in all smart systems are also present in smart grids. In order to improve energy use of customers, there is a need for information sharing. There are many web-based attacks stemming from the excessive number of computerized meters and their interconnectedness with each other. This influences customers' selection of and approach to smart grids [62].

Despite being a personal safety issue, smart grids have significant contributions both at the state and individual level. Customers are aware of the energy that they use and determine when and how they will use the energy. Authorized public services in energy evaluate the supply and demand and encourage consumers to prefer low demand hours for their intense electric use so that they can manage their energy better and more efficiently [63].

The main factor in making big promises to citizens and public authorities is the ability to read meters measuring the energy consumption level of customers remotely. Automated Meter Reader (AMR) are used in identifying water, gas, electric leaks and even illegal use of energy. With this practice, there is no need for an government officer to visit houses to read meters in certain times which reduces the workload and this procedure can be done within seconds for every household [64]. In this uni-directional system, the expense information for households are collected in a shared databased. This way, shortages and problems are seen and necessary interventions can be done by the relative institutions [65].

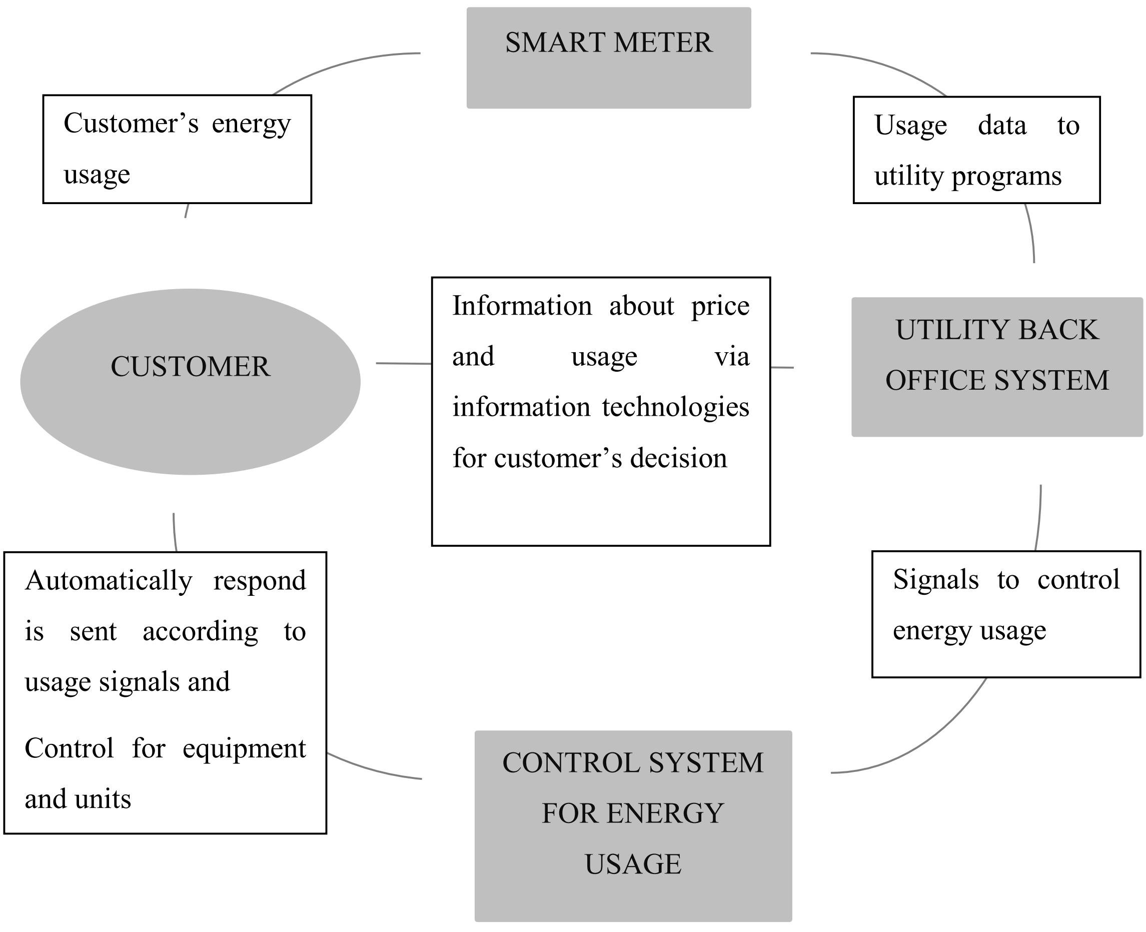
According to the information obtained through interviews conducted in Ankara with companies working on smart energy as part of this thesis study, individuals can share the information on their meter readers with information companies and obtain detailed information on consumption and take necessary cautions. Some companies work with big factories to identify and measure the amount of reactive energy in the factory and to reduce it.

2.2.3.1 Advanced Measurement Infrastructure

The latest point in digital energy systems is smart grids. Meter reading systems in water, electric, and gas energy consumption in households, factories, hospitals, and malls entered a new period and readings are performed automatically and remotely. Here, the transfer of data from the customer to the unit occurs uni-directionally. However, in smart grids this transfer is bi-directional. Advanced Measurement Infrastructure (AMI) systems constitute the majority in the creation of smart grids. Due to its bi-directionality, these sensors can monitor consumption instantly which is beneficial both for customers and suppliers, and public institutions [66, 67].

AMI plays a key role in the optimization of power management, in preventing any dangerous situtation due to a consumer's lack of attention, or in identifying pricing strategies occurring on the demand side. This system in which communication systems become highly important is presented in Figure 2.3. There is a bi-directional informing from general energy consumption and both sides take cautions in terms of environment and their own budgets and use [68].

Figure 2.3. The Concept of Advanced Measurement Infrastructure [69].



Smart Meter

As shown in Figure 2.3, the AMI consists of smart meters between the consumer and the control unit, systems that provide communication between them, and necessary software and hardwares to maintain the control and management of all these components. Mechanical meters used prior to smart meters did not provide accurate measurements done by authorized people. Later on, cable accessories were implemented to these mechanical meters and the monitoring of consumption amount is done by ultrasonic meters.

Following ultrasonic meters, smart meters are being used now. With smart meters in which functions can be planned and programmed, bi-directional communication and multiple other tasks can be achieved. These tasks are presented below [70 - 73]:

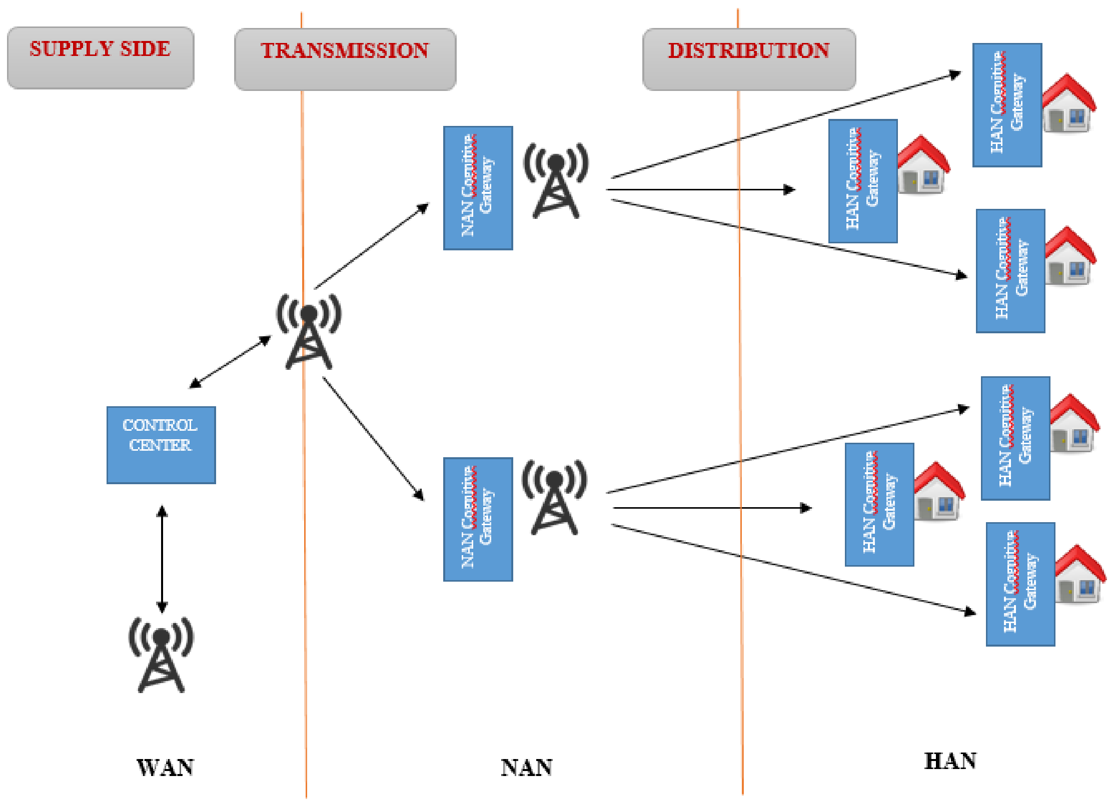
- Obtaining an accurate picture of the total energy consumption in the households they are connected,
- Learning about net consumption and consumption times, and planning environment and user-friendly pricing based on the information obtained,
- Monitoring problems that occur in energy supply and intervening in a timely manner,
- For example, in the case of a neglect by the consumer, identification of unnecessary energy consumption, shutting down, and prevention of dangerous situations at home when the consumer is away for a long time.

Smart meters provide the foundation for the application implemented by Weiss et al. [74]. This is a mobile device application that converts data obtained from meters into a readable format for consumers. It allows consumers to see their smart measurements, evaluate the data, and adjust their consumption times and amount accordingly.

Of first priority and primary layer for this system that includes this application and smart meters is home area network (HAN). Gateway and network nodes that devices in the house connect to through cable or wireless, smart meters and data collectors that provide external transformation of all information, and network operating and management systems that connect this network to neighborhood area networks (NAN) [75]. Security issues should be taken into account in HAN in terms of transfer of consumption information received from smart meters [76].

Information on consumption of all devices that connect to internet in a household are obtained and with this information pricing strategies geared towards consumer's expenditure are implemented. Household where advanced measurements would be performed constitute Neighborhood Area Networks through gateways. As shown in Figure 2.4, radio frequencies that have several advantages are used to collect information from houses without any cabling procedures [77]. This way the data of the consumer are sent to Wide Area Network (WAN) which has all other consumers' data. Smart grid having these levels eliminate all dangerous situations in the whole system while allowing it to work in a sustainable and effective way [78].

Figure 2.4. CR Based Smart Grid and Networks [78].



The first step of the smart grid systems is to obtain energy consumption of devices in a household, and to access all consumption information from each one of them through communication technologies. New generation devices connected to the internet communicate through wireless communication technologies including Wi-Fi ™, IEEE 802.11b [79]. As presented in the introduction section of this thesis study, based on an example implemented in Singapore, all devices in a household need to connect to a wireless network. When a popular technology such as ZigBee is used, smart meters obtain the data and the data coming out of HAN are transferred to other layers [80].

2.2.3.2. Energy Efficiency

Efficiency in energy use has gained a different dimension due to smart grids and continue to gain speed. Reducing demands in use, preventing constant renewal of infrastructure needs, reducing damaging effects to environment stemming from the reduction of demand, and maintaining efficiency in new generation grids are among the primary goals [50].

In achieving primary goals, necessary softwares for dynamic pricing and management and supply of received demands are developed. This not only increases efficiency but also reliability [81]. Control algorithms in grids can do certain optimizations for consumption in addition to electric generation, transmission and distribution. They can sense shortages ahead of time and thus reduce or prevent them, and provide supply and efficiency at an optimum level [82].

2.2.3.3. Demand Side Response Resources

In order for energy to be used efficiently, reducing energy use at times when customer demands are high or shift the time of use to times when demands are less. Demand response programs provide these services. Electric system designers and operators use these programs and other resource options in order to balance demand and supply. It is thought that this approach would reduce the electric costs.

The demand response refers to changes in customers' use of energy rather than normal consumption in order to respond to changes in electricity rates. As mentioned previously, they improve at times when use is high and at the same time reduce the use to ensure safety when a problem occurs in the system [83]. The demand response that helps with the smart grid system significantly removes the necessity of building new energy plants and thus, affects environment positively [84]. Due to these smart grids that reduce carbon emission, environmental sustainability is achieved.

Overall, an efficient demand response management system in smart grids have positive effects on production capacity, transfer lines, and distribution lines [85]. There are interconnected programs in this management system. In summary, these programs perform two main tasks. One of the tasks is load change which refers to spreading the peak point of the energy demand, and the second task is to create protection programs during the performance of the first task and maintain efficiency [86].

Customers and consumers should be encouraged and informed about information sharing to address their concerns with the purpose of being able to use demand respond programs. Financial savings, reduction in power outages, and adjustments that can be made based on energy needs should be communicated with them. Authorized public offices should inform and raise awareness in consumers and customers to increase the use of these programs [87].

Demand Respond Program Types

We need electric energy to run the machines in households or to use many objects in our daily lives in a sustainable way. In the case of a city, having excessive electric use in households would create significant increases both in the national energy consumption levels and in carbon emissions from an environmental aspect.

Uses that reach the quota in energy consumption and excessive energy demand in certain times can cause instant outages or problems. In order to prevent these problems, government officials and suppliers should focus on demand response programs.

Demand response programs that maintain efficient energy use without outages are categorized into two groups in the literature [87] that are; price-based and event-based planned programs. In our country, a system called time-of-use (TOU) is used which is presented in Table 2.2. In this system, a 24 hour period is divided into 3 hour-periods and different pricing is applied to these different time periods. The purpose of this practice is to reduce the hours with high demand and to decrease the peak points at those hours due to excessive load and to spread those points to other periods [88]. According to the information obtained from the literate, pricing program types are presented in Table 2.2.

Table 2.2. Demand Response Program Types [89,90].

Price – Based	**Event – Based (Dispatchable)**
Time-of-use pricing (TOU)	Direct Load Control
Real-time pricing (RTP)	Demand bidding/buyback programs
Variable-peak pricing (VPP)	Emergency demand response programs

Critical-peak pricing (CPP)	Capacity Market programs
Critical-peak rebates (CPR)	Interruptible/Curtailable
	Ancillary services market programs

The pricing programs presented in Table 2.2 can change momentarily and game theories are used for dynamic programs that can be programmed based on the use at the time. These theories are based on the Nash Equilibrium and widely used or planned to be used for smart grids [91, 92]. For all these strategies and programs, relevant public instutions, active energy companies in the market and customers that will be affected and benefit from these are needed for support [50]

2.2.4. Transmission and Distribution

Energy generation is achieved in generation grid systems similar to traditional grid systems that are being used today and then distributed to users. However, as shown in Figure 4, there are 3 different phases. When the energy leaves the center where high voltage is produced and arrives to the power distribution unit from the transfer level, the voltage would go down to lower levels. Following this, the distributed energy is lowered depending on the demand from the end user [93]. There are studies focusing on to provide an efficient power flow transfer at an optimum level. Lin & Chen developed an algorithm in this subject [94]. This algortihm develops a distributed and parallel algorithm for changeable energy flows in renewable energy sources to provide an energy flow at an optimum level.

Energy transfer and distribution in smart grids are the same, however, the control is maintained through visualization by using communication systems for applications implemented. With the increase in the energy demand, the amount of information and data shared in transfer and distribution also increases [95].

New technologies used in the transfer phase of new generation grid systems are listed below [96]:

- Flexible AC Transmission System (FACTS) Technology
- High Voltage Direct Current (HVDC) Technology
- Grid Shock Absorber Concept
- Dynamic Thermal Ratings Technology

- Reactive Power Management Concept
- Synchrophasor Technology

In the distribution phase of the energy in new generation grids, smart meters and relevant technologies play big roles to achieve communication both inside and outside the household.

Power distribution in smart gridsa re performed through HAN and NAN networks. Communication technologies needed for distribution in these networks are provided in Table 2.3.

Table 2.3. Communication Technologies in the Grid Distribution Phase [97].

HAN (Home Area Network)	***NAN (neighborhood area network)***
Wireless LAN - IEEE 802.11 Standard	WiMAX - IEEE 802.16 Standard
ZigBee - IEEE 802.15.4 Standard	Long Term Evolution (LTE)
Mobile Communications and Femtocells - Universal Mobile Telecommunications System (UMTS) and Long Term Evolution (LTE)	Broadband over Power Lines – Power Line Communications (PLC)

2.2.5. Smart Grid Communication Technologies

Overall, in smart cities all components of a city including energy, transportation, and health can be integrated to each other through communication systems. At the same time, the biggest factor in using these areas actively and in accordance with today's technology is the communication between sub-components that constitute these areas.

Communication technologies are also used between all the components that constitute smart grids in smart energy. In this thesis study, technologies that are used and planned to be used are identified based on the conversations with relevant institutions. These technologies are:

- GSM / GPRS

- PLC
- RF
- SigFox
- LORA
- NB-IOT

Due to the lack of infrastructure in Turkey, only GSM/GPRS technologies play an important role in smart grid applications. Moreover, it is stated that Lora and NB-IOT are the most suitable technologies for this area, however they are not used in Turkey.

As there is not a comparative study of communication networks used in smart grid systems, Lauridsen et al. [98, 99] compared the coverage areas of these technologies both in rural and central areas by using a local operator's different structures in a certain area. According to this comparison, NB-IOT has a wider coverage area. Additionally, considering a certain decibel decrease in peak points in indoor areas and devices, with a less than 10% loss, NB-IOT is more effective than others. A comparison of GPRS, Lora nad NB-IOT communication networks in select units is presented in Table 2.4.

Table 2.4. A Comparison of Smart Grid Communication Technologies [98 – 104].

	LORA	**GPRS**	**NB-IOT**
Spectrum (MHz)	169, 433, 868/915	700 – 900	700 – 900 LTE Band
Band	ISM Unlicensed	Cellular Licensed	Cellular Licensed
Bandwidth (kHz)	125 / 250 / 500	200	180
Range	22 km		35 km
Data Rate (Kbps)	0.3 – 37.5	56 – 114	226.7 - 250

2.2.6. Comparison of Traditional and Smart Grids

Grids that are used today are called electric grids as they contain a mechanical device that runs on electricity. On the other hand, smart grids are designed digitally and they provide communication between multiple devices and they can be controlled. Distributed generation system and bidirectional transfer in smart grids are not found in traditional electric grids. It is challenging to include the unidirectional power transfer in traditional grids and the alternative energy resources in the central generation system. The energy generation that is not one-centered and bi-directional power flow in smart grids eliminates problems such as power outage and transfer.

In electric grids, the shared energy through the center in electric grids can't be controlled and the energy providing companies do not have control over distribution. Sensors and receivers that allow devices to connect to the internet, interact with each other, and to be controlled externally are used in smart grids. These allow for monitoring the energy transfer and consumption.

The infrastructure of traditional electric grids is not equipped well to provide an option for customers in receiving power. Infrastructure can be shared by using smart technologies. This would allow more companies and alternative energy forms to come to the grid and allow customers to have more options in terms of receiving energy.

The system in which an active energy share is done and consumers are involved in management in smart grids can't be used in traditional systems. In these systems, consumers (customers) do not have sufficient information and opportunities. In digital, modern grids, consumers have information on how they will receive the energy and how they will use the energy received. A comparison of traditional and smart grids in certain areas is presented in Table 2.5.

Table 2.5. A Comparison of Electrical and Smart Grids [105-107].

TOPICS	TRADITIONAL GRID	SMART GRID
Characteristics	Electromechanical	Digital
Communication & Distribution	One – Way	Two – Way
Generation	Centralized	Distributed

Structure	Hierarchical	Network - Based
Restoration	Manual	Self - Healing
Control	Hard	Easy
Customer Involvement	Fewer	Many
Efficiency	Low	High

2.3 Smart Energy and Efficiency

2.3.1. Smart Grid Efficiency Application

As stated in the thesis study, the components constituting smart energy are presented in detail. Within this scope, interviews were held with relevant energy componies to get a better understanding of how smart grids are established, how they work and what the purposes are as well as to contribute to the body of knowledge in the literature. The headquarters of these companies are in Ankara and they provide services to other cities and countries with various innovations in energy systems. These companies that were contacted are listed below:

- Bimetri Smart Meter – Smart Grid Systems
- MANAS Smart Meter – Smart Grid Systems
- AKSES Smart Grid Systems

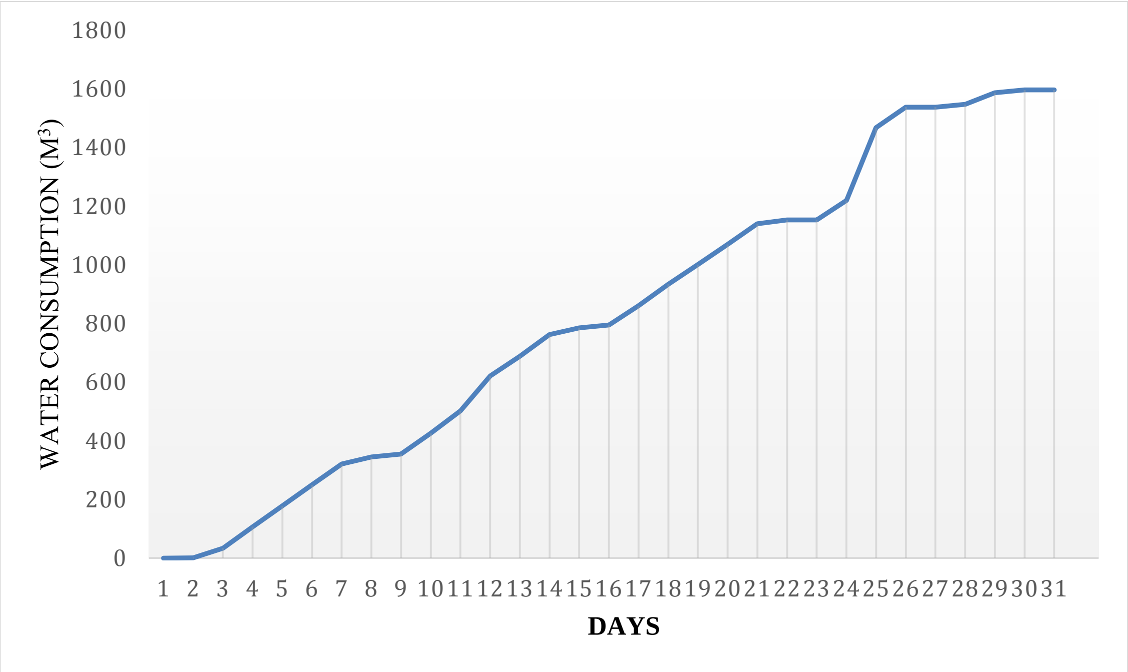
Interviews were conducted in companies that actively monitor and control the new generation grid systems and qualitative and quantitative data were collected. In light of the qualitative data obtained, studies conducted in our country in smart grids are presented below:

- Manufacturing smart meters that use RF and GPRS technologies,
- Providing customers with smart meters,
- Developing in-house softwares for monitoring and evaluating data obtained from smart meters,
- Visualizing instant energy consumption of customers that have smart meters due to GSM/GPRS based communication (according to the information received from the companies, Lora and NB-IOT technologies are used locally),

- Identifying and helping to reduce reactive energy of customers through application,
- Identifying leaks through smart water meters and monitoring systems,
- Reporting consumers' energy consumptions and present their consumption in terms of cash daily, monthly or annually; and presenting this information to customers in a clear and understandable way,
- Providing remote shut off when consumers are not home and left the devices running or when unnecessary consumption occurs.

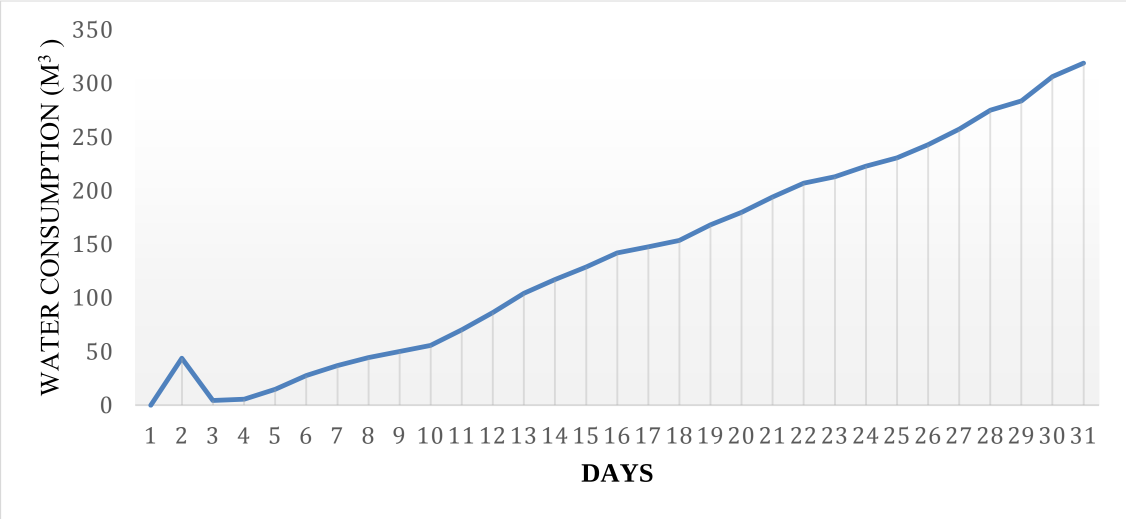
Another purpose of this thesis is to measure whether the use of smart meters are more efficient than mechanical meters in terms of consumption. In other words, the purpose is to measure whether the use of new generation meters have economical benefits for consumers. Within this context, quantitative data on monthly consumption of customers from two meters were obtained. In the study, data obtained from water meters are used. Thus, the monthly average of consumption in water energy use of customers are presented in Figure 2.5.

Figure 2.5. Consumers' Average of Water Use in 1 Month Using Mechanical Meter



The consumer whose consumption is presented in Figure 2.5 had installed a new generation meter that communicates through GPRS to capture consumption and take actions. Accordingly, the water consumption of the customer in one month received from the smart meter is presented in Figure 2.6.

Figure 2.6. Average Water Consumption of the Consumer in 1 Month Using Smart Meter with GPRS



Based on the data provided in Figure 2.5 and 2.6, the water index of consumption in one month using a mechanical meter is 1596,521 while the index is 319 when a smart meter is used. In calculating the water bill of this company in Ankara, the base pricing of 13,72 TL including taxes for 1 m3 identified by ASKI in 2019 for workplaces is used.

In light of this data, this company has an average of 21.904,26812 TL bill per month according to the readings in mechanical meter. On the other hand, when the bill is calculated based on smart meter data, the amount to be paid for one month is 4.376,68 TL.

The bills for the same company based on the readings from two meters are presented above. Thus, when the company uses the meter with GPRS technology and the consumption is monitored through a software, they save 17.527,58812 in one month. On the other hand, when the smart meter is used for consumption efficiency in water energy, it is seen that there is a huge efficiency.

2.3.2. Smart Energy and Efficiency in Literature

Establishing smart energy systems in which using renewable energy sources rather than non-renewable energy sources is incentivized, creating smart grids through new generation meters, and software support is costly for city managements. For example, according to the International Energy Agency (IEA), Europe has to invest € 2 trillion for this transition period [108]. There are cost benefit analyses done to investigate whether transitioning to these systems are economically beneficial or not, or whether it is necessary or not [112, 114, 115]. Reports prepared by Electric Power Research Institute (EPRI) are prominent in economic analyses. The Smart Grid conceptual model used in the 2009 report by EPRI is also used in the cost-benefit analysis report done for smart grid components by EPRI [52]. The sections Markets, Operations, Service Provider are presented in the Supply Side section of this thesis. Transmission & Distribution sections are evaluated under one section and customers are referred as the Demand Side. The cost analysis based on the examined report and this thesis study is presented in the table below. As exact numbers are not presented in the cost section of the report, only intervals are presented that are; low and high. Based on the data presented in the report, average costs are calculated and envisioned costs are presented in the table below [114].

Table 2.6. Smart Grid Investments of EPRI

Smart Grid Units	**Average Cost**
Supply Side	NONE
Transmission & Distribution	371,914 $
Demand Side	35,02 $
TOTAL	406,934 $

Although the investments to be made seem high, it is budget-friendly in terms of energy efficiency and customers. EPRI also provide a cost as unit based on the customer type. Thus, the costs for 1 household is an average of $ 1000 and for industrial factories is around $ 110,000 [114].

Smart energy systems that offer innovation and solutions to improve efficiency at every stage from energy generation to consumption provide benefits in practice through both using the available energy and appropriate use. When these systems that have examples in the literature are evaluated in general, it is seen that [109, 110];

- They reduce the energy use in the city by 30%
- They provide 20% savings due to controlled lighting in households,
- They reduce water use by 20% due to identification of leaks and unnecessary use.

Energy efficiency and savings in bills through using softwares and relevant new technologies, factories in diffierent industrial fields also benefit from these implementations. At the same time, cities where factories operate do not consume excessive energy and they save on energy. The company ENTES that conducts studies in energy efficiency point out necessary renewals by identifying issues in factories. In this thesis study, relevant factories, their problems with energy, necessary equipment to address these issues, smart solutions and outcomes are presented in Table 2.7.

Table 2.7. Factory Type, Issues in Energy, Smart Solutions and Outcomes [111].

FACTORY TYPE	ISSUE	SMART SOLUTION, NECESSARY EQUIPMENT	OUTCOME
PAINT FACTORY	High monthly bill	Monitoring of energy consumption – 40 energy analyzers, modems and 1Energy Monitoring Software	Reduction in the monthly bill, Energy use is more efficient by 30%.
TANK FILLING FACILITY	Not being able to price separately the consumption in different units of the factory	Separate Monitoring of energy consumption – 24 Energy and Power Meter, modems and 1 Energy Monitoring software	A reduction of 20.000 kWh wsa achieced in electric energy consumption. Each unit was separately monitored and priced. Unnecessary energy use was eliminated by using mobility sensors. Installment costs are refinanced in 4 months.
MARBLE FACTORY	Excessive enrgy consumption	Monitoring of energy consumption – 23 Energy analyzers, modems and 1 Energy monitoring software	As a result of monitoring, the current level of machines using excessive current was reduced to lower levels. Due to remote control, the number of employees

			decreased.
HOSPITAL 1	The constant malfunction the ultrasound device in the hospital is said to stem from the high voltage in the grid. High maintenance costs.	Measurement of energy values in regular intervals, 1 energy analyzer, 1 modem, and 1 energy monitoring software	It was shown that no high voltages occur in the grid through consistent monitoring. The cause of the problem was identified to be stemming from the device.
HOSPITAL 2	The need for monitoring consumption as a result of increasing the transformer power and renewing the hospital	Monitoring 1200 kVA transformer 2 energy analyzer, 1 reactive power control relay, modems and 1 energy monitoring software	Consumption was monitored clearly and calculated. It was identified that wrong pricing was used, energy efficiency was achieved.
TEXTILE FACTORY	Not being able to monitor the energy consumptions of loads that are connected to more than one transformer	Connecting and monitoring energy and power meters to the outlet of each transformer- 6 energy analyzers, 53 energy and power meters, 3 reactive power control relays, 1 ethernet modem, and 1 energy monitoring software	The use of reactive energy was identified. Energy saving was achieved by 13%. Devices that consume excessive energy were identified and replaced with devices that consume less energy.
WEAVING FACTORY	Not being able to calculate net consumption due to mechanical meter readings, excess expenses due to employee-based	Separate measurement of energy consumption of each machine, controlling the energy consumption from one center –	It was identified that machines were run needlessly and consumed energy unnecessarily. Reactive energy was reduced. With the control being maintained by a software and from one

	reasons	Energy and power meter for each machine in the factory, 15 energy analyzers for 15 distribution panels, 7 ethernet modems, and 1 energy monitoring software	center, no more human power was needed adn the costs in this unit were reduced.
WHITE APPLIANCES FACTORY 1	Request of calculating energy costs separately, not knowing the energy consumption per product	Monitoring of energy consumption of each production line - 50 energy analyzers and 1 energy monitoring software	Measured values were collected in one center. Production in each line was compared with the production output and product sales prices were identified again which resulted in increase in profits.
WHITE APPLIANCES FACTORY 2	Not being able to do cost analysis due to not knowing the net energy consumption	Monitoring consumption instantenously and clearly with the communication software and hardware – 47 energy analyzers and 1 energy monitoring software	It was identified that the machines continued to consume even when they were not working; that the machines were in the working process long before the manufacturing phase and consumed unnecessary energy. Based on these, precautions were taken and energy was used efficiently.
MOTOR FACTORY	Not identifying the affect of a particular unit in the factory to the energy cost.	Monitoring and control of the energy consumption in the particular unit. 130 energy analyzer and 1 energy monitoring software	The energy consumption of machines and their affects on the cost were measured by using GPRS based communication software. Energy savings were achieved in the

			machines.
LIQUOR FACTORY	Request of monitoring of total energy consumption in the factory and recording it in a digital environment.	Monitoring of energy consumption and transferring of records to the digital environment. 70 energy analyzers, 1 signal intensifier, and 1 energy monitoring software.	All the energy consumption in the factory was monitored and recorded. Unnecessary use of energy was reduced.
TELECOMMUNICATION	The need for measuring and monitoring the energy consumption in the regional power plants. The need for identification of reactive energy.	Monitoring and recording the energy consumption. 11 energy analyzers, 8 reactive power control relay, 1 ethernet modem and 1 energy monitoring software.	Compensation procedure was activated through the reactive power control relay. As each activity and consumption is recorded, customers could be provided with instant or conscious solutions. Reactive energy was reduced.

2.4 Smart Energy Systems Challenges

As stated in the previous sections of the thesis, creation and implementation of smart grids would bring many advantages. However, on the other hand, there are multiple challenges and different threats for users in creating the whole system. A literature search on studies focusing on this topic showed that the challenges and found threats that are faced are examined in 2 categories that are; first is energy big data management, and second is privacy and security.

In a study conducted by Zhou on big data management, general issues such as how data can be obtained from different locations in different forms, where the data would be stored and which algorithms can be used for analysis are discussed [112]. In another study from the field specialized these challenges [113]. In alignment with the findings of these studies, the challenges faced are are listed below.

- Smart energy system consists of multiple different factors and these factors continue to increase each day. Accordingly, the infrastructure of this system needs to be flexible and scalable in order to be able to work with these factors in a compatible way. At the same time, the primary need is the integration of these factors with each other to work in a coordinated way [113 - 115].
- Real time data processing is required to avoid any interruptions in the system, to respond to user demands real time, and for billing. In order to achieve this, new generation algorithms need to be designed.
- It is very challenging to interpret data and design user-friendly interfaces in smart energy systems with high data density levels.
- From a different perspective, in addition to the first item mentioned, there are multiple stakeholders in smart grids. Different data are obtained and each of these data sets are within the big data. Thus, this big data schema should be flexible [116].

Another challenge in creating smart grid systems is the geographical positions of the areas in which new generation grids will actively function [115, 117]. Cisco reports that the physical infrastructure is effective and creates challenges in these systems in which communication is the main factor. Zhong et al. categorized these challenges that are listed below [114].

1. Challenges of necessary communication for reliable smart measurement.
2. As mentioned in the previous sections of the thesis, different communication technologies such as Bluetooth, ZigBee, and Wi-Fi, and related standards are used for different functions in smart grid systems. Thus, it is difficult for all these different technologies and standards to function collaboratively and effectively without interruptions. This is one of the main challenges that are faced in smart grid systems.
3. Obtaining values read from thousands of meters instantly leads to traffic the created web. Prevention of traffic and having a web that is reliable and scalable for on-time transfers is a big challenge.
4. New applications based on the use and needs of users need to be developed for remote energy management. These applications are also expected to consider energy efficiency which creates another challenge. Additionally, it is possible to

encounter issues that may affect the whole system due to inclusion of users in energy management and in the big data schema [118].

2.4.1. Cyber-Physical Security

Smart Grid System is a broad web that transfers physical structures into digital environment. Thus, it is possible to have security issues and cyber attacks in the web due to the system's gaps. Each attack on smart energy web that constitutes the whole city's infrastructure creates a threat for the city's economy and infrastructure as well as the safety of the public [114]. The types of attacks listed in the literature are provided below [114, 119].

- Stuxnet Worm
- Denial of Service (DoS) Attacks
- Jamming Attacks
- Trojan Horse Virus

Based on the study conducted by Wang and Lu, it is seen that DoS attacks on smart grid systems occur at different layers. As Jamming Attacks can be applied to communication networks easily, it is very likely to encounter these types of attacks at the physical layer. Additionally, these attacks can be done at the MAC layer through changing the beraver MAC settings.

According to the TCP/IP protocol model, Network and transfer layers should provide security control for information transfer through multi-communication networks. DoS attacks in both layers can reduce the communication performance from one end to another just like distributed traffic overflow and worm attacks in the internet. Althought there are TCP/ IP reliable protocols due to distributed traffic flow created to prevent traffic in the network layer, it is inevitable to see attacks in these layers [119].

Privacy

Ensuring an effective energy efficiency and maximum benefit through Smart Grid Systems, it is necessary to keep the consumer and system privacy in the background. Establishing communication with customers, data sharing, and ensuring confidentiality through meters are provided by separate local communication institutions. This task in smart grid systtems that are distributed and open is a difficult one [113]. There are theoretical models by Sankar et al. for this dynamic structure to ensure network security and privacy through a sniffer [120].

According to the European Union Commission that presents other example models and perspectives to address issues encountered on privacy, consumer information and data obtained from smart meters can be separated with low and high frequency scores. In other words, the consumer data that has low informance can be found in high frequency and the other personal data can be securely stored [114].

Although the benefits of smart systems are highly promising, it is also necessary to believe in these systems in terms of their implementation and applicability. One of the important challenges is to find investments in this subject matter by city managers, city halls, and related institutions [121]. As stated in the thesis, Konya Metropolitan Municipality (KMM) is one of the leading cities that invests the most for a smart city in our country. However, there are challenges and issues that they face in smart energy systems which are listed below [122].

- Unequal distribution of costs and benefits
- The need for establishing a network to collect energy consumption data
- The need for developing economical storage systems
- Integration of distributed renewable energy resources into the grid
- Resolution of power quality issues
- Public perception and data protections
- Ensuring confidentiality
- Reliability of critical infrastructure, systems and work operations to make the energy demand stronger and more secure against physical and cyber attacks
- The cost of smart grid implementation.

2.5 Smart Energy System Applications in Konya

2.5.1. Management of Koski Water Wells with Solar Power

In smart energy systems in which the use of renewable energy resources is encouraged, KMM conducts an inspiring work. Koski, responsible for pumping the water wells, uses a photovoltaic system that transforms solar power to electric power to avoid using the available electric power and to increase power efficiency.

2.5.2. Lighting of Public Spaces with Solar Power

City lighting increases energy consumption significantly. Thus, KMM provides lighting for 960 bus stops in the city as well as many parks that require lighting from solar power. Through this practice, significant savings are achieved.

2.5.3. Meteorology Stations with Solar Power

Electric power is needed for temperature information, global insolation, wind speed and direction, 2 meteorology station for measuring the amount of rain (Tavusbaba and Gümüştepe). This energy demand is supplied through soalr power which allows for savings.

2.5.4. Purple Grid

In this project that aims to re-purpose waste water in Konya, waste water is re-used following lift pumps, prechlorination, coagulation, multimedia filter, ultraviolet disinfection, pre-post chlorination. Therefore, there is a water tower and a 24-km watering line to be used for green spaces. Konya is the only city in Turkey with a total 6 water networks inclufing re-purposing water, treated water facility, and Purple Grid.

2.5.5. Smart Water Networks

Konya Metropolitan Municipality generated the idea of smart water network with the purpose of controlling the water consumption of citizens in Konya and to prevent unnecessary expenses and leaks. First, water networks in 12 areas are isolated and the control valves and subscriber branch line pipes are identified, quantified, and associated with subscribers. With smart water networks which is still in the pilot phase, the purpose is to identify water loss and to take necessary precautions. Through instant identification of low pressure and increased flow rates to occur in 12 isolated areas, service interruptions will be able to be prevented. The Municipality plans to implement the smart water network for the whole city after the pilot program in the identified areas.

3. SMART TRANSPORTATION

3.1. The Concept of Smart Transportation

Expansion of citites makes mobilization without vehicles impossible. Thus, the number of vehicles in highways increase in an uncontrolled way. This increase create significant damages to the environment as well as causing an increase in wait-time in traffic and accidents to occur. There are studies aiming to eliminate these issues and increase the wellfare of the society. Due to various algorithms, current traffic can be monitored, instant interventions can be done in a timely manner when needed, and both driver and road safety are achieved through vehicles that have necessary equipment. These systems are called Smart Transportation Systems [123].

The duties and purposes of the new generation transportation systems in terms of current traffic problems are presented below [124 - 127]:

- Reducing arrival time for drivers, eliminating problems related to delays.
- Monitoring of every mobilization on the road and on the side of the road, and therefore maintain control of highways,
- Performing necessary optimizations in road use of drivers and pedestrians on the roads that are monitored,
- Resolving traffic congestion issues that occurs in certain areas at certain times through smart and new generation technologies,
- Establishing safety for drivers, pedestrians, and living and non-living things on the side of the roads,
- Providing sustainable and applicable help for management by drawing road maps on traffic and transportation for transportation offices of the city and the region,
- Providing safety of passengers in vehicles and make their trip efficient through communication and vehicle equipments,
- Providing instant data via mobiles when citizens use city mass transportation,
- Making mass transportation convenient for passengers and drivers through smart bus stops or mobile devices,

- Marking fastest routes for arrival in the case of an emergency for first responders such as ambulance or fire department,
- Providing a fast and smooth parking experience for drivers in smart garages,
- Making green transportation applicable and sustainable in an eco-friendly way while achieving the points listed above.

In terms of the foundation of smart transportation systems, the first lights used were 3-colored traffic lights that regulated the majority of traffic flow in Ohio [128]. Although traffic regulating systems following the traffic lights do not have technologies such as artificial intelligence or machine learning, they provide the foundation of traffic and transportation systems used today.

A few projects on transportation and traffic prior 1970 were realized in the United States of America and wireless communication was achieved between individuals maintaining the control of highways with the purpose of establishing road safety. However, due to high costs required, these projects were ended after a few years. Moreover, at the same time there were similar studies conducted in Germany and Japan [127].

In terms of technological studies conducted for vehicles, the Automated Route Control System [129] is an assistant system that helps drivers with arriving their destinations. The target destination is identified manually from the map and voice warnings are provided about deviations or turnabouts on the route. In the early 1980s in one of the states in America, the Automated Traffic Monitor and Control System was established for the first time for remote vehicle identification and monitoring [127]. The mention of smart systems in transportation and traffic and the applicability of these systems emerged in 1990s [130].

The standards of Intelligent Transportation Systems required for the reliable planning and execution of the applications under this heading are given below [131 – 136]:

- IEEE 802.11, IEEE 802.16, IEEE 1609.x,
- ISO 18092, ISO 14443, ISO 13157
- ETSI,
- 3GPP,
- WAP

• CALM

• SAE

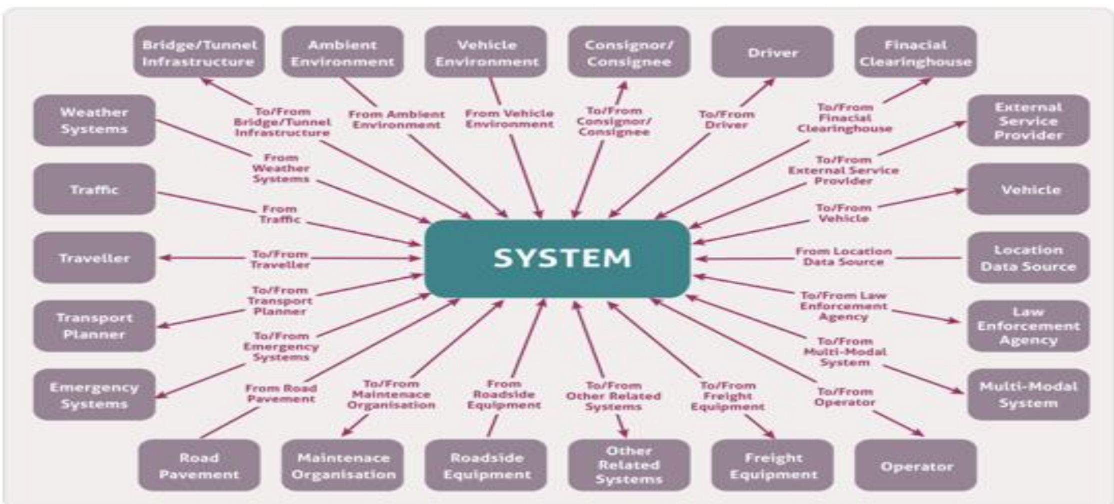
3.1.2. Smart Transportation System Models

3.1.2.1. Europe: FRAME

When the historical evaluation of smart transportation systems in the literature is examined, it is seen that technology-based solutions are provided for each member of highway transportation including vehicles, drivers, traffic signs, and pedestrians and that each of these members are considered as separate systems. However, it is necessary for these systems to function as integrated to each other, and that public managers and traffic regulators should be involved in the system as well.

The increase of motor vehicles that are registered makes traffic one of the biggest problems in cities. A centralized and modern transportation system in which active or passive actors in traffic including government officials coordinate and work with each other in a dynamic way in transportation is needed. In alignment with the identified need, a project name FRAME in the beginning of the 21st century was designed by the European Union which is a structure model covering all users that are aimed by smart transportation systems [137]. In this architecture, the purpose is to divide smart transportation systems into sub-systems based on its users, to identify the functions of these systems and to coordinate the information exchange between these functions. All the sub-factors and the communication ways and types of these sub-factors with the central system within the FRAME structure are provided in Figure 3.1.

Figure 3.1. The FRAME model of the European Union [138].



As stated in the previous section, smart transportation systems involve various duties and goals for any factor about transportation in a city. The system model proposed by the European Union coincides with multiple purposes of the STS. According to the website where these overlapping shared goals and the model are presented, the functions of FRAME are presented below:

- Providing online payment options in digital environment for mass transportation or taxis,
- Establishing an information flow between related units through equipments both in vehicles and road sides when problems occur in traffic,
- Maintaining all structures on highways and maintaining a controlled management of traffic,
- Performing optimizations in alignment with all procedures of mass transportation in the city including routes, fees, passenger and driver fleet management,
- Controlling certain in-vehicle systems for drivers during their trips,
- Planning trips in alignment with necessary information for transportation of tourists within the city,
- Helping with traffic laws and rules,
- Managing transportation vehicles including 18-wheelers on the roads,
- Providing transitions between areas of use and modes when needed,

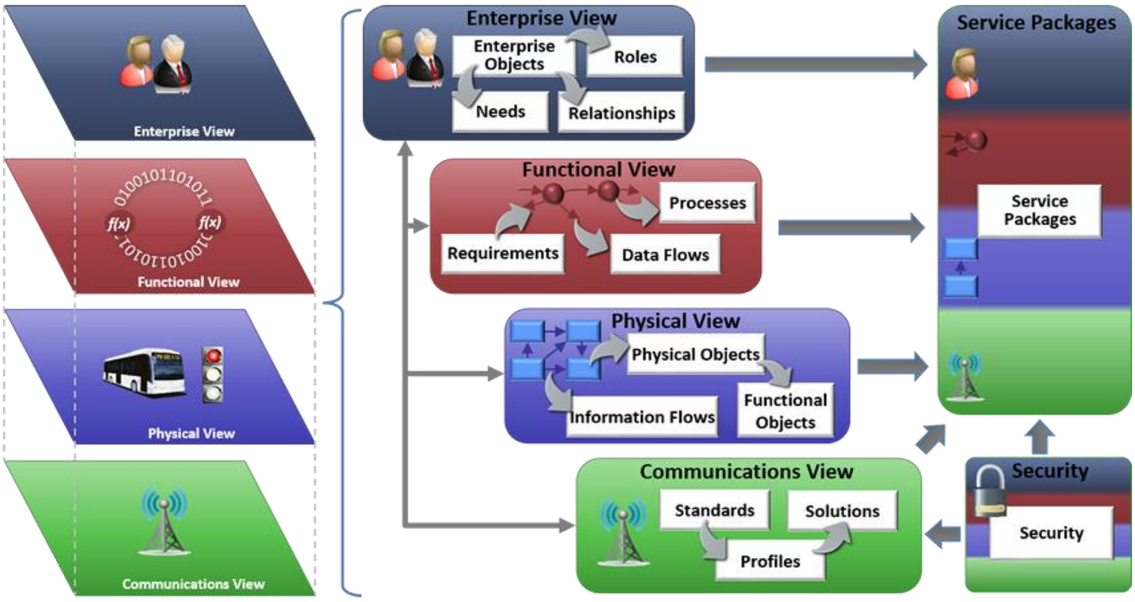
Government offices such as ministries of transportation play an important role in achieving all functions and purposes of the FRAME architecture as they can change policies in these matters for citizens [139]. Departing from this point, several countries that take FRAME in Europe as a base started to establish their own smart transportation system structures [140]. Some examples are as follows:

- France - ACTIF Architecture
- Italy – ARTIST Architecture
- Austria - TTS-A Architecture
- Czech Republic– TEAM Architecture

3.1.2.2. The U.S.A: ARC-IT

Both technological and public investments of the United States have contributed greatly to the transformation of smart transportation systems into their present form. However, the original initiatives, ideas and sketches of the architecture of their smart transportation systems were in the early 1990s [137] . All stakeholders and users were considered during the formation process of this architecture, function definition was made for each and then prototyping were started. As a result of successful prototyping applications, this architectural structure has been approved and it is seen that it has continued to develop by also getting support of the state. Architectural structure names ARC –IT, which is designed by urban and regional planners, architects, engineers and other professionals in this field, provides an interface to eliminate the concerns of all stakeholders on transportation and traffic, eliminate problems in these issues and provide ease of use for users.

Figure 3.2. ARC-IT Model of the USA [141].



This comprehensive and detailed project, which compiles all the Smart transportation systems in the USA within a framework, has 4 main components. As can be seen from Figure 3.2 taken from the website of US Department of Transportation [141], it is envisaged that different units and functions will work in integration with each other in order to provide a fast, easy and sustainable transportation service for different purposes. These 4 different components in ARC-IT are given and explained respectively below:

- **Stakeholder Layer:** Includes all persons and institutions in the city's transportation network. This also includes all other public transport drivers, taxi drivers, private vehicle drivers, passengers, including the authorized persons who make up this network. Furthermore, in this layer, the definitions of the duties and requirements of all these persons and institutions are made and the relations between them are given in detail.

- **Process, Motion Layer:** Covers all activities to meet all requirements on transportation. It helps to analyze and process all data from vehicles, roads and drivers in accordance with the identified needs and to optimize transportation for different people and institutions.
- **Physical Layer:** Includes all traffic signs and boards on roads, roadsides as well as all vehicles on roads. At the same time, by interacting with each other by means of the sensors in all these physical structures, the necessary functions along with data exchange are also determined in this layer. Separate small architectures are also designed in which information flows are provided for integrated links between these different objects. [142].
- **Communication Layer:** Identifies the communication between living and non-living beings in all Smart Transportation systems. It contains the standards and protocols necessary for the safety and ease of this communication.

Looking at the world in general, presentation of the new generation transportation systems in a body as a framework is found in 2 different ways in the literature, as European and US architectures. Bělinová et al. [143] have a study which compares these two structures in the literature. According to this;

- The financial investment made by US in the ARC-IT architecture is approximately 15 times of the investment made by Europe within FRAME.
- ARC-IT is designed for a single country, but since FRAME is a design that covers the members of the European Union, it is more flexible and can be used in different places.
- It is anticipated that users of the FRAME architecture will have difficulty in use.

3.2. Smart Transportation System Technologies

3.2.1. Sensor Technologies

Sensing devices such as sensors, transducers, actuators are the basis of the Internet of Things (IOT) technology where human abilities such as talking, controlling, taking decisions in case of any situation are transferred to non-living beings and interaction between them is provided. Thanks to the Cyber Physical Systems, where all the things happening in our physical environment are reflected in the virtual environment, all these non-living beings connected to the internet network can be controlled and communicate with each other. It is not possible to control and manage the roads and millions of drivers on these roads without sensors based on these technologies identified.

Thanks to the sensors in the required areas of traffic, in the traffic users, and networks created by these wireless sensors, by sensor nodes, by communication technologies such as RFID etc. instant traffic information flow on the related subject is transmitted to the authorized units. These sensors, which can be placed wireless or small, are easy to install and cost-effective. For this reason, smart transportation systems and smart traffic management systems are based on sensors [144 - 146].

Sensors on roads play a major role in the implementation of smart transportation systems. The main points targeted in applications by these sensors and the wireless networks created by these sensors are as follows [147,148];

- Firstly ensuring the safety of life, reducing accident and damage rates,
- Providing information about weather, road conditions, physical conditions to drivers and controllers,
- Guiding ambulances and firefighters by showing shortcuts for emergencies,
- Using the capacity of the road at the optimum level and thus, eliminating the problem of traffic congestion.

The sensors and wireless sensor networks on the roads are examined in 2 groups in the literature in order to realize the above mentioned purposes. The first is the sensors located on traffic lanes, roads. The second group is the sensors placed as embedded to traffic lanes and roads. In the continuation of this thesis study, these sensors are mentioned in sub-titles.

3.2.1.1. Traffic Lane Sensor Technologies

Sensor Technologies Over the Traffic Lane

These sensors, which can be located on the roadsides, on the road, in the middle of the road, do not require any infrastructure and installation. These sensors, which are generally active at the point of image acquisition and processing, enable to reach certain provisions about traffic and take action on them thanks to algorithms. These sensors are positioned in different places according to their intended use. For example, microwave and radar sensors are placed adjacent to or on the road, while camera sensors are placed on traffic signs, lights. It is also said that sensors are installed in tall buildings on the side of the road for a wide area control, and radio towers are constructed for them. [149].

As mentioned above, there are many types of on-road sensors placed in different parts and areas of the road for different intended use. Towelde's research and Mimbela et al.'s project on this subject are examined and the on-road sensors and their functions are brought together in Table 3.1 below.

Table 3.1. Sensors Over The Traffic Lane and Their Functionalities [149, 150].

SENSOR NAME	FUNCTIONALITY OF THE SENSOR
Camera	It is used to digitalize the images on the traffic lanes and to interpret them after processing them.
Microwave Radar Sensor	It is used to detect vehicles on the traffic lane and to determine the speed of vehicles and the distance between them.
Infrared Sensor	It is used for tracking traffic flow.
Ultrasonic Sensor	It is used in determining the number of vehicles in traffic, analyzing the current situation and calculating the occupancy rate of the traffic lane.
Passive Acoustic Array Sensor	It is used to determine the noise level by calcu-lating the acoustic energy in traffic, and to de-termine the occupancy rate of the road.

Embedded Sensor Technologies to The Traffic Lane

They are the sensors embedded in or attached to the foundation of the road and adjacent to roads [149]. They provide more detailed and sound information about vehicles and traffic, but they also have many disadvantages. These are the high cost of maintenance and installation of the sensors, the fact that these processes take a long time, and that cause traffic congestion, disrupting the layout of the road [151].

There are different types of sensors used for vehicle conditions, traffic leveling. Table 3.2 shows the types of sensors embedded in the road and their intended use.

Table 3.2. Embedded Sensor Technologies to The Traffic Lane and Their Functionalities [149 – 151].

SENSOR NAME	FUNCTIONALITY OF THE SENSOR
Pneumatic Road Tube Sensor	It is used in the classification of traffic density levels by performing the existing traffic analysis.
Inductive Loop Detector - ILD	It is used to determine vehicle crossings, number of vehi-cles and accordingly road occupancy rate.
Magnetic Sensor	It is used to detect moving or not moving vehicles on the highway. It is also preferred for measuring traffic density.
Piezoelectric Sensor	By learning the number of axles, axle spacing and weight of vehicles on the traffic lane, it is used in vehicle classification, as well as in determining the speed of the vehicle.

As indicated in the table, magnetic sensors and inductive loop detector are used to measure the traffic density of the road in which they are located. However, it is reported that the networks formed by magnetic sensors are less costly than the other, and that it enables faster data transmission due to the presence of many sensor nodes and an access point in the network [152].

3.2.1.2. Sensor Technologies Inside of The Vehicle

Due to the development of the automotive sector and accessibility for all segments, billions of vehicles in traffic are used. According to 2018 TURKSTAT data, there are approximately 23 million vehicles such as automobiles, vans and motorcycle registered in Istanbul [153]. In addition to this, millions of major and minor damaged accidents caused by drivers or vehicles occur in our cities. In order to avoid such misfortunes, equipping the vehicles designed in the STS concept with high level technologies ensures that the vehicle driver and other drivers to have a safe journey.

In vehicles designed behind today's information age, information and communication technologies are not as common as today and only the power, speed and robustness of the vehicle on the road are given priority. But now, it appears that vehicles do not depend on the capabilities of the drivers, but on the basis of design and their own artificial intelligence. Many sensors in the vehicle take part in the creation of the specified artificial intelligence and in the interaction of the vehicle with other vehicles and any signs or symbols on the line that it goes. In this way, by creating a wireless sensor network, fast and efficient data exchange is provided from the sensors [154].

For example, before information and communication technologies reached the current level, drivers were often troubled at their destination and got lost frequently. Now, with the applications available on mobile smart devices, the most suitable, fast roads to the destination are brought to us and different options are also offered along this path. The subject of how this works is as follows; our vehicles use the automatic vehicle identification (AVI) system GPS and RFID tags as sensors to provide vehicle tracking. The flow of data in the vehicle is provided via the Controller Area Network (CAN) bus. Thanks to GPS technology, which has a total of 24 satellites, the coordinates of the desired location information can be determined and displayed horizontally or vertically in applications. [155]. Real-time location information from the vehicle and the specified coordinate provide online information for the driver and the vehicle and all other necessary services via the Internet [124].

Traffic accidents in the world and in our country occur for many reasons, but it is found that sleep is one of the main factors. [156]. It is said that half of the drivers who are actively driving in traffic fall asleep at the wheel [157]. It is reported that the age, sex, physiological and mental states of the person are effective in the occurrence of this situation. [158]. Sensors placed inside the vehicle, which is within the smart transportation systems and which is of great importance, also make the necessary determinations and give warnings about sleep. For example, thanks to the simple webcams in the daytime and IR cameras at night which are placed in vehicles, changes in the face of the driver and the response to certain actions are monitored, and thanks to image processing algorithms. All these movements are named, and warning signals are sent to the vehicle drivers. [159, 160]. At the same time, the driver is also controlled by monitoring the movement, direction of the vehicle on the road and the wheel rotation speed and angles [160]. Another method for the detection of sleep is to follow the frequency of opening and closing the eyelids of the driver, ISCAN eye tracking systems are used in addition to the baseball cap in order to obtain high resolution images of the eye and to reach certain provisions [161]. This issue attracts the attention of the automotive sectors and they produce the related accessories. For example, Ford has considered the use of this cap appropriate for long-distance drivers and has made an innovative production in this regard [162].

In-vehicle sensors with the areas of use such as GPS use, drowsy driver detection also have other areas of use. Generally, these types of usage are classified under the following 6 main titles.

- Routing / Location Assistance System
- Lane Change and Tracking System
- Drowsy Driver Warning System
- Blind Spot Monitoring System
- Adaptive Cruise Control System
- Object Detection and Collision Prevention System

In this thesis, for the detection of sensor types which are evaluated in accordance with the above-mentioned fields, the related studies in the literature are examined and collected and tabulated and presented in Table 3.3.

Table 3.3. Usage Areas of Sensors Inside Of Vehicle and Related Sensors [150, 163, 147, 123].

Functional Areas	Sensors Used
Routing / Location Assistance System	Gyro Sensor Accelerometer Sensor
Lane Change and Tracking System	Radar Sensor Speed Sensor Camera

Drowsy Driver Warning System	Camera
Blind Spot Monitoring System	Camera Radar Sensor
Adaptive Cruise Control System	LIDAR Laser Scanner Radar Sensor
Object Detection and Collision Prevention System	Proximity Sensor Ultrasonic Sensor Electromagnetic Sensor RAdio Detection and Ranging (RADAR) Sensor Laser Sensors Camera

3.2.2. Communication Technologies

It is stated that one of the biggest problems of our time, the traffic issue is to solve via the smart transportation systems with the technologies such as internet of things, artificial intelligence, data mining, machine learning, and with the related algorithms, and with other factors, and that any problem can be overcome by taking into account the citizens and management in the city. Sensors are the greatest technology in traffic systems with these digital and their own decision-making mechanisms. Then, thanks to these sensors, the communication of the vehicles with each other or with any object on the road, roadside is realized by means of communication technologies. [164]. In this way, sudden accidents for drivers, vehicles, pedestrians, and all kinds of living and non-living beings on the roads are prevented and opening of the traffic is provided in necessary cases and emergencies. Table 3.4, which follows the text, provides the communication technologies required for smart transportation, the features and the related standards of these technologies. In Table 3.4, technologies are compared under certain criteria according to their duties in STS. Subsequent subtitles give their relations with STS and their specific characteristics that are related to STS.

Table 3.4. Vehicular Communication Technologies, Features and Standards [131 – 134].

STS Communication Technologies					
	Traditional Communication Technologies		**Vehicular Communication Technologies**		
	Wifi/ WiMAX	**Mobile Comm. (GSM/GPRS)**	**Infrared**	**DSRC/WAVE**	**NFC**
Range	15 km	10 km	~100 m	~1 km	~5 cm
Operating Spectrum	2.3 GHz, 5.8 GHz	0.8 GHz, 1.9 GHz	~1000 nm	5.86 GHz, 5.92 GHz	13.56 GHz
Suitably for Mobility	Yes / Low	Yes / High	Yes / Medium	Yes / High	Yes / High
Standards	IEEE 802.16 IEEE 802.11	ETSI, 3GPP, WAP	ISO	IEEE 802.11, IEEE 1609.x, ISO, ETSI	ISO 18092, ISO 14443 ISO 13157

Wifi/ WiMAX

It aims to establish a rapid communication with the signaling signs, infrastructure sensors, or other vehicles around the vehicle in traffic. The aforementioned communication technology, which is based on the IEEE 802.16 standard, is also suitable for use in systems such as Vehicle to Infrastructure (V2I) or Infrastructure to Infrastructure (I2I) [131, 133] .

Mobile Communication (GSM/GPRS)

When it comes to communication systems, the first things that comes to mind are GSM / GPRS technologies. These systems, which are widely used and based on the IEEE 802.11 standard and various sub-versions, have a large scale and are preferred for long distance communications [131, 132]. Delays in the exchange of information on Vehicle to Vehicle (V2V) and V2I systems increase due to communication via base stations. However, necessary efforts are being made to eliminate this disadvantage of GSM / GPRS, and it is promised that data can be shared faster and more reliably in driverless vehicles and other systems with the new generation such as 5G [165].

Italy, which does not ignore the developments in GPRS, aims to integrate the transportation systems with the mentioned technology and has a project called GITS (GPRS for Smart Transportation Systems) [166]. The promised solutions in transportation thanks to GSM/GPRS are given below:

- Guiding services for drivers and passengers,
- Providing information to drivers about weather and traffic conditions in their own direction,
- Improving safety for drivers and pedestrians on the roads,
- Transmitting information about any problem on the road, dangerous situations to drivers who will use that road.

Infrared

Intelligent transportation systems, which provide the ease of payments in public transportation systems and enable them to be realized in digital environment thanks to magnetic cards, realize most of these promises with the infrared communication technology. It is possible to see examples of these practices in many countries from Europe to the Far East [167]. In addition, in the communication between the relevant units on the side of the road and the vehicle, they measure temperature from non-close distances and are active in predicting weather conditions, as well as in real-time data transmission, especially during long journeys [131, 133].

DSRC/WAVE

During the testing phase of communication of driverless vehicles with other vehicles, infrastructure on the road or with all other objects on the road, the wireless local area networks (LANs) based on IEEE 802.11 standard are used. In this network, Dedicated

Short Range Communication-DSRC / WAVE communication technologies that enable fast communication, minimize delays and operate at 5.86 and 5.96 GHz bandwidth are preferred [131, 168]. Another reason of being preferred is that it can sort the works to be done with IPv6 and WSMP protocols according to process priority. [169]. The actions taken by this system are listed below [133]:

- Two-way information exchange of the vehicles is provided with the relevant caution, warning devices and signs on the traffic lane.
- Used in the design of traffic signaling systems,
- In the control of traffic congestion problems,
- In electronic exchange of money.

NFC

Data exchange in the Near Field Communication technology, which is less known than all other technologies and is being used recently, is done by two devices at very close distances generating their own energy and forming a radio frequency field network. [170]. However, in the statement published by Kim et al. this communication is examined in two types. This varies according to the energy of the initiator of the devices and the process that the other device will or will not do. [171]. In terms of transportation, the mentioned technology is used in areas such as APS, FPS and has a supporting effect for green environment [133] .

3.3. Smart Transportation System Application Areas

Transportation, which concerns the entire population of the city from young to old people, is becoming an important issue, especially in large metropolitan cities. With the developing sensor and communication technologies, smart transportation systems are available in many different areas of transportation. Systems in line with today's technology age, both in traffic and in systems that facilitate the use of public transportation vehicles by citizens and by public institutions are used in various fields as indicated. Support from the public and a number of long-term strategies created by the competent authorities are extremely important in order to be sustainable and more applicable.

There are many areas where the new generation of urban or local transportation structures function. In this thesis, the functional areas where smart transportation systems are actively used are listed below:

- Smart Traffic Management Systems (STMS)
- Smart Vehicle Control Systems (SVCS)
- Smart Car Park and Smart Parking
- Smart Bus Stop

3.3.1. Smart Traffic Management Systems

When it is considered at smart transportation technologies, it is seen that these are sensors and communication technologies. Smart Traffic management is all of the systems that improves traffic signaling systems and optimizes the road usage rates of vehicles and predicts efficiency in transportation with these technologies. For this, especially by means of equipment located on roads, junctions, they need to obtain traffic, vehicle, and driver data, make instant traffic control, manage events and, where necessary, have certain powers and transmit these powers to the relevant units [172] .

Processes expected to be carried out by STMS are given below [173]:

- Monitoring, tracking the flow of traffic flow (access to information about the road and the occupancy and usage rate on the road)
- Making predictive modeling according to the traffic flow displayed,
- Detecting the status of vehicles in traffic (detection of vehicles standing or moving, vehicle speed, evaluation of the distance between vehicles),
- Monitoring and controlling traffic flow (ensuring the safety of drivers, pedestrians and other related objects on the road),
- Providing optimization of the relevant signaling systems by predicting or detecting traffic congestions at junctions,
- Pre-detection of emergency or dangerous situations in traffic and interacting with relevant units,
- Accelerating the process of charging at highway ramps,
- Transmitting the traffic regulations, cautions and warnings to drivers more quickly and reliably in a digital environment,
- Managing demands on traffic.

As mentioned above, smart traffic management systems have many functions. The algorithms designed for this purpose, the methods and the information on where and why these methods to be used are given in Table 3.5 SCOOT, which is used in the modeling of traffic flow, also aims to shorten the vehicle queues in traffic with the TRANSYT method. It has also been seen in the literature that SIEMENS, one of the manufacturing sectors, aims to find low-budget solutions for traffic by using these methods [174].

Apart from the algorithms and methods required for STMS, various traffic lights, devices, signs and equipment are required to monitor, control and further regulate the flow of city traffic. It is possible to see these in detail in Traffic Systems, Inc.'s website, which works on this subject and brings together the related solutions [175].

Table 3.5. Methods and Algorithms Used in STMS

ATYS'de Kullanılan Yöntemler	Yöntemler için İlgili Bilgiler
SCAT (Sydney Coordinated Adaptive Traffic)	The SCAT, which divides the traffic flow into sections, collects data from sensors, detectors on the roads, calculates the intensity of traffic on that road and the lane flow that should be [176,177].
SCOOT (Split Cycle Offset Optimization Technique)	SCOOT, which measures the traffic density at the relevant junction dynamically and instantaneously (measurement takes place every 2 minutes) by dividing the traffic into sections like the SCAT method, is used to determine delay times and stop numbers at the junction. Traffic signaling at the junction is checked and re-arranged according to the set times [177,178].
TRANSYT	The TRANSYT method determines a performance index for that junction based on delays and pauses of vehicles at junctions. This index shows the traffic behavior of the junction over a fixed period of time, not instantaneously. This method also evaluates the effectiveness of different methods used at that junction [179,180].
UTOPIA (Urban Traffic OPtimization by Integrated Automation)	This specified method constitutes a level management and control mechanism from lower level to upper level. Accordingly, first of all each junction is defined as a sub-problem and evaluated within itself. Afterwards, all other junctions are controlled and integrated with each other and their signaling is determined accordingly [181]. The aim is to reduce the driver's waiting time at junctions, thus to reduce

	their travel time. Its special purpose is to ensure emergency vehicles and public vehicles not to wait at junctions [180].
PRODYN	Thanks to this algorithm by which the traffic signaling system is controlled instantly, traffic network is subdivided by dynamic programming [180, 182]. It calculates signal settings in real time based on delays at the junction.

3.3.2. Smart Vehicle Control Systems

It is seen that one of the main purpose of the smart transportation systems and all of their sub-units is to ensure the safety of all people using traffic or who are currently in traffic, and to promise safer and more efficient journeys for them. Smart Vehicle Control System (SVCS), which was founded as an idea before the 1990s, also helps the drivers in traffic to make their travels smooth and faster by monitoring their driving behavior. In addition to that Europe is the pioneer in this field, it also presented projects such as PROMOTHEUS, EUREKA [183]. SVCS Systems that include automatic controls in addition to human control in vehicles plan to prevent many possible situations in traffic [184].

In his study, Shladover [185] examines advanced vehicle control systems in three levels according to their level of development and the control left to the driver. According to this;

At level 1: The obstacles which are beyond visual range of the driver and outside the vehicle that create any problem and may cause an accident are identified, actions beyond the self-control of the driver are controlled and possible accidents can be prevented by pre-measures.

At level 2: At this level, a control mechanism is implemented, especially for vehicles on highways, including the controls at level 1. The relationship of the vehicle on the highway with the other vehicles in the vicinity, distance and its speed conditions are detected and possible large collisions of the vehicles traveling very fast are prevented.

At level 3; Thanks to advanced sensors, detectors and communication devices in the vehicle, all the control, handling on the road is handled by the vehicle, except the driver.

Providing vehicle-related data, even on roads which the driver is not familiar with, it determines its own roadmap by taking all measures into consideration.

The final point that came with the level 3 defined by Shladover and with a multidisciplinary study of the IT sector with the automotive sector, is examined under the titles of Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Everything (V2X). These titles are examined in the following titles. What equipment the vehicles have, and the functions they perform under these technologies are given in detail. As a result, all these technologies developed under the concept of SVCS are designed to ensure the safety of drivers in traffic and to ensure efficient travel.

3.3.2.1. Vehicle-to-Vehicle (V2V) Communication

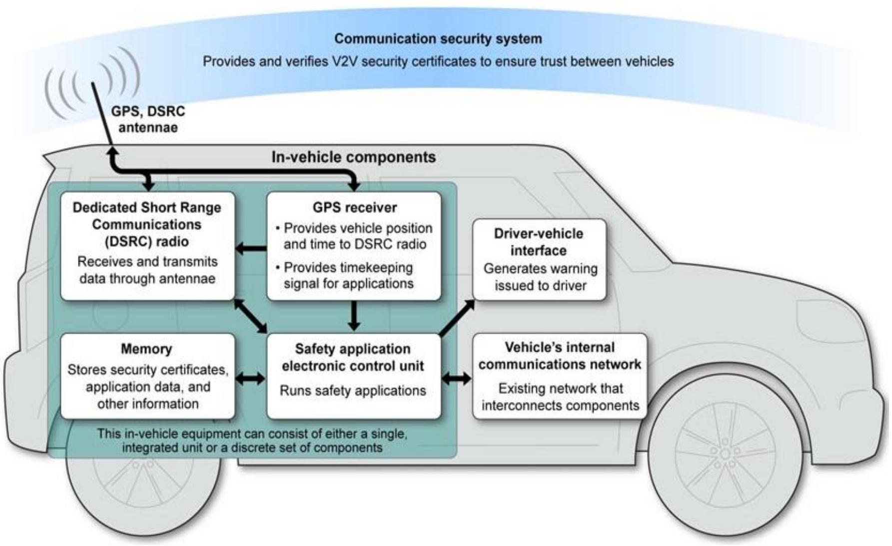
Generally speaking, this system, which was called at a congress in America in 1999, is a communication system based on a wireless network where the vehicles send directions, locations and speed information to each other on the road [186 - 188]. The reason for its emergence is to find a solution to the traffic problem in developed societies and to create a sustainable environment where there is no human ego, traffic rules are strictly followed and thus accidents and traffic problems do not exist.

In the V2V, which is generally seen as a complex communication network, a variety of communication technologies based on IEEE 802.11, a wireless network standard are used [188]. The communication technologies and their main features are given in Table 3.4 in the STS Communication section of this thesis.

Using the IEEE 802.11 standard, the United States allocates the “Dedicated Short Range Communication (DSRC)” wireless communication band for use. In accordance with regulations in the United States, these devices operate in the 5.9GHz band with a bandwidth of 75MHz allocated individually for vehicle communication, and the distance between these vehicles can be up to 1 km. DSRC devices communicate not only with other vehicles but also with the road infrastructure. It contains road signals or informative nodes established by the roadside [189, 190].

The following Figure 3.3 shows what equipment a transportation vehicle must have for reliable communication between vehicles, as stated in the 2013 report of the US Government Accountability Office.

Figure 3.3. In-Vehicle Units Required for V2V Communication [191].



The first implementation of V2V communication technologies is supported by General Motors in 2006 and is introduced in Cadillac vehicles [192]. V2V solution of Cadillac uses Dedicated Short-Range Communications (DSRC) and GPS technologies that are permitted by the US and can receive 1,000 messages per second from vehicles up to a distance of about 1000 feet [193].

Afterwards, in addition to large scale car manufacturer companies such as Toyota, Audi, Volkswagen, Volvo, Tesla, Suzuki, and Ford Motor Company, Aselsan Defense Industry from our country is also working on this issue [194]. Aselsan is conducting a project named "94 GHz Transceiver Integrated Circuits Development" with IBM company within the scope of 5G technologies and it is stated that the outputs of this project and the technology to be acquired will have an important place in 5G, especially in the communication of vehicles (V2V) and data communication with other structures (Internet of vehicles-IOV) [195].

In addition to the automotive industry, leading IT companies such as Bosch, Daimler, Google, Uber, and Visteon also develop autonomous driving technology for vehicles and are referred to as V2V suppliers [196].

In general, the innovative driving behavior of vehicles with V2V technology in transportation and traffic and the studies conducted on this subject are summarized in Table 3.6 by gathering them under the main titles.

Table 3.6. Types of Applications Involving V2V Communication [197].

APPLICATION MAIN TITLES	RELATED APPLICATIONS
SAFE DRIVING	• Switching on the brake lights for emergency response when necessary, • Warning of obstacle beyond visual range of driver, • Possible accident warning based on tracking distance and speed, • Speed warning by getting road condition and congestion data,
EXTRAVEHICULAR CONTROL, ENVIRONMENTAL AWARENESS	• Parking the vehicle in accordance with the pavement and lanes, • Choosing the road by being sensitive about green environment, • Use of junctions with vehicles in communication with each other, • Tracking traffic flow • Transmitting the edited route information to the driver
NEW GENERATION TRAFFIC LANES / MOVING VEHICLE	• Instant communication and guidance for dangerous situations and emergencies • Signaling systems at junctions • Vehicle detection without any external intervention • Connection of the vehicle with the relevant traffic signs

3.3.2.2. Vehicle to Infrastructure Communication (V2I)

Due to the increasing number of vehicles, insufficiency of roads in cities, problems arising from traffic accidents or traffic congestion, health problems reveal that infrastructural studies should be conducted on this issue. The relevant public institutions, urban and regional planners, authorized personnel in the field of system, and IT establish the necessary mechanisms on the roads. However, the infrastructure laid out on the roads, regulated traffic systems and traffic devices do not provide a one-way solution. This should include all the users who use the roads. Both road side units (RSU) and all on-board units (OBU), which are active or passive on the road, must work in an integrated way by communicating with each other, to ensure the order and efficient flow on the roads. In this regard, Vehicle to Infrastructure (V2I) systems come into play. Vehicles that communicate with the signs regulating the relevant traffic receive data for the road, and thus accidents and congestion are prevented [198, 199]. The processes that are expected to be realized and the applications providing safe transportation thanks to the new V2I technology in our lives are given respectively below [200]:

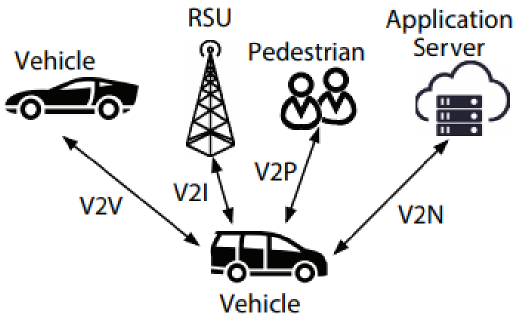
- Predicting future Stop warnings (such as Red Light) for drivers,
- Speed adjustment of the driver on winding roads, ensuring to slow down by giving the related warnings in advance,
- Checking crossings at junction use, and at current lane changes,
- Analyzing the roads on the roadmap and giving warning of maximum and minimum speeds to drivers,
- Taking weather forecasts from the meteorology for the destination and warning the driver,
- Warning the driver by providing information on future road congestion,
- Warnings for the safety of the driver in crossings such as railroads and bridges on the roads,
- Detecting the lengths of structures such as overpasses and tunnels on their routes for drivers who drive vehicles of a certain length, and warning the drivers and routing them in different roads,
- Changing signaling for the priority of transit of emergency vehicles,
- Digital recording of data for exchange of money at highway ramps, stops and warning the driver.

To implement several of the applications listed above, Japan, using the relevant communication technologies, is engaged in a number of different activities on behalf of the smart transportation systems that can be found anywhere, anytime with the project called Driving Safety Support Systems (DSSS) [201].

3.3.2.3. Vehicle to Everything Communication (V2X)

As seen in the previous titles, the vehicles communicate with each other and also with the related infrastructure located on and under the road and on the roadside. In the Vehicle to Everything system, as the name implies, the vehicles can exchange data with all other objects and creatures on the road. For this reason, V2X has been described as an umbrella in the literature as these systems cover all the vehicular communication systems [202, 203]. V2X technology, which includes communication of vehicles with relevant RSUs (V2I), communication of vehicles with other vehicles (V2V), communication of vehicles with pedestrians on the road (V2P), can also communicate with central traffic management systems of vehicles. In this way, the drivers have all the information about that road and can travel more efficiently and safely. V2X technology described as an umbrella is illustrated in Figure 3.4.

Figure 3.4. Other Communication Types Under V2X Communication [204].



It is seen that V2X technology is mostly connected to DSRC and LTE communication technologies in order to provide all of the communications specified in Figure 3.4. However, there are studies that many standard organizations plan to implement in this area. Generally speaking, the relevant organizations and current standards on this subject are listed below [136, 205]:

- Car 2 Car Communication Consortium (C2C Consortium): This group, which gathers all the units in the automotive and transportation sectors under one roof, aims to set a standard for Europe which aims to have a FRAME structure.
- 5G Automotive Association: This group, which aims to set standards for the safety of vehicle-to-vehicle communication, includes communication

operators, suppliers in the automotive sector and related information companies [206].

- 3GPP: LTE, the first cellular standard used in V2X trials, is defined by 3GPP. This standard cellular V2X includes the cellular assisted V2V and the cellular unassisted V2V paradigms [202].
- IEEE: IEEE, which has set many standards for smart systems, is actively involved in V2V, V2I and V2X technologies with the wireless communication standards.

3.3.3. Smart Car Park and Smart Parking

In the smart transportation systems, which examine the behavior of the vehicles on roads and bring solutions for this, problems in parking of vehicles are also examined. Thanks to smart parking and related applications, it is aimed to respond to problems such as finding suitable parking spaces, parking in wrong locations, wrong or unregulated parking for vehicles [207, 208]. On the other hand, it is aimed to digitally record the price determination in the paid car parks, and to pay electronically during the exits of the vehicles, thus to gain efficiency from time.

The applications that are targeted to be realized through smart parking are given below with their explanations [209 - 211]:

Providing appropriate location-based parking for drivers

- Thanks to this informative system, drivers can display appropriate parking spaces to stop their vehicles at their destination. Drivers are informed for this system through an application installed on their mobile devices. The technologies and methods used in this application are; Vehicle Detection Sensors and FPGA.

Displaying Parking Layout, Detecting Appropriate Spaces

- Drivers receive the layout and current usage information of a shopping center, museum or a car park in advance. It is aimed to shorten the time spent in parking, to reduce the amount of fuel used in this period and thus to reduce the carbon footprint for the vehicle moving according to this information.

Facilitating the time and price determination, and money exchange in the Paid Parking Lots

- Thanks to license plate reading systems provided by the use of image processing technologies, vehicle entries can be recorded digitally, the fee will be calculated during the elapsed time. At the same time, fee collections will not be made from a single place, by an employee, but can be carried out digitally on the automated system.
- On the other hand, it is planned to determine the prices in the parking lots by comparing the current usage rates. In this way, with elimination of the roadside parking problem, the formation of traffic on the lanes can be prevented.

Keeping Parking Place

- Drivers will be able to request space for their vehicles from the parking management system, which they can access from their mobile devices, without going there. This transaction made via SMS or internet will not only save time, but will also bring money if it is in certain times.

Making certain markings and distinctions for Emergency Vehicles and Disabled Vehicles,

- Parking can be a big problem for disabled citizens. In order to overcome this, there will be parking spaces reserved for them, which will be notified to the relevant drivers in advance. They will be easily distinguished by special markings. At the same time, other emergency vehicles will be identified and it will be ensured not to be problems at their entrances and exits.

Connecting parking to an automated system,

- In parking lots that will use an automatic system, parking will be carried out by the system, not by the drivers, according to the layout. The aim is to make efficient use of the parking space and prevent the driver from parking incorrectly or vainly occupying space.

Placing PV panels as roofs on open parking lots,

- PV panels are placed on the open parking lots in the form of roof to provide solar energy. Considering a sample project developed for this purpose;

When 20 pieces of 4.8 kw panels are used in an area of 35 m2, it is seen that monthly average 850 kWh energy production is realized.

3.3.3.1. Technologies Required for Smart Parking and Smart Car Park Applications

Ignoring the parking ability of the drivers, in the smart parking systems that aim to make this process more systematic and efficient, and also provide to eliminate the problem of finding suitable parking spaces and pricing problems in public parking, many technological hardware, methods and software are used. Smart Car Park working principle with determined hardware also is shown in the following. When the literature is examined, it is seen that these solutions are based on 2 foundations [207]:

- Sensor Based Solutions
- Image Processing Based Solutions

Sensor types in sensor-based solutions are given below [211, 213]:

- Passive Infrared Sensor
- Ultrasonic reverse parking sensor
- Electromagnetic parking sensor
- Active infrared sensor
- Inductive loop detectors
- Magnetometer
- Acoustic Sensors
- Anistropic Magnetoresistance sensors
- Piezoelectric sensor
- Pneumatic road tube
- Weight-in-motion sensor
- Microwave radar
- Ultrasonic sensor

The hardware and software required for image processing based works are as follows [214, 215]:

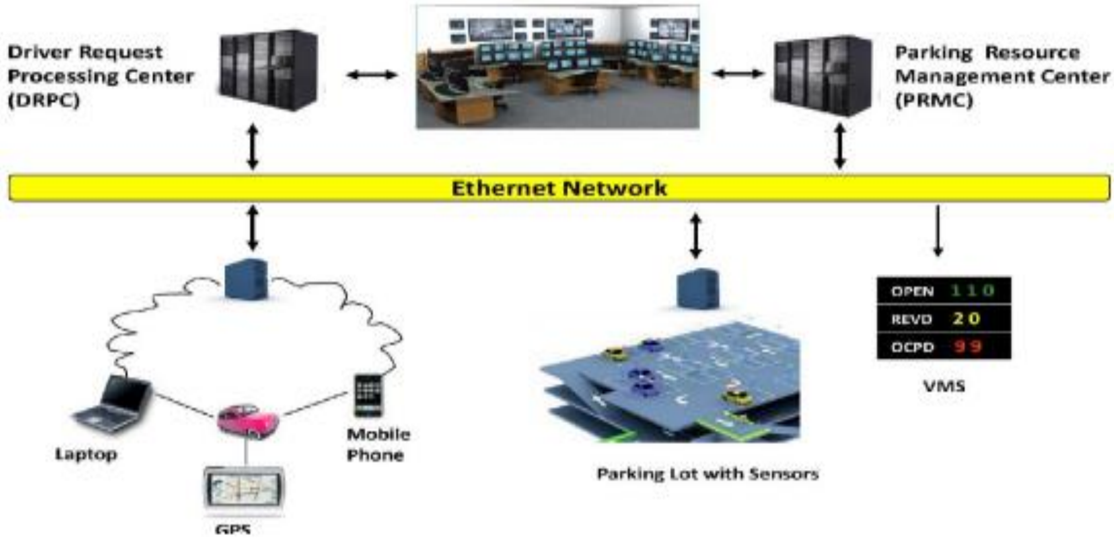
- CMOS Camera
- Camera
- Pi camera
- RabbitCore® Microcontroller
- The Close Circuit Televisions (CCTV)
- Energy-efficient LED edge lighting

For communication [214, 215]:

- Zigbee Wireless Sensor Network (WSN)

- Bluetooth
- GSM
- WiFi-3G
- SPARK (for vehicle to vehicle communication)
- GPS (location information)
- RFID

Figure 3.5. Smart Car Park Working Principle [201].



3.3.4. Smart Bus Stop

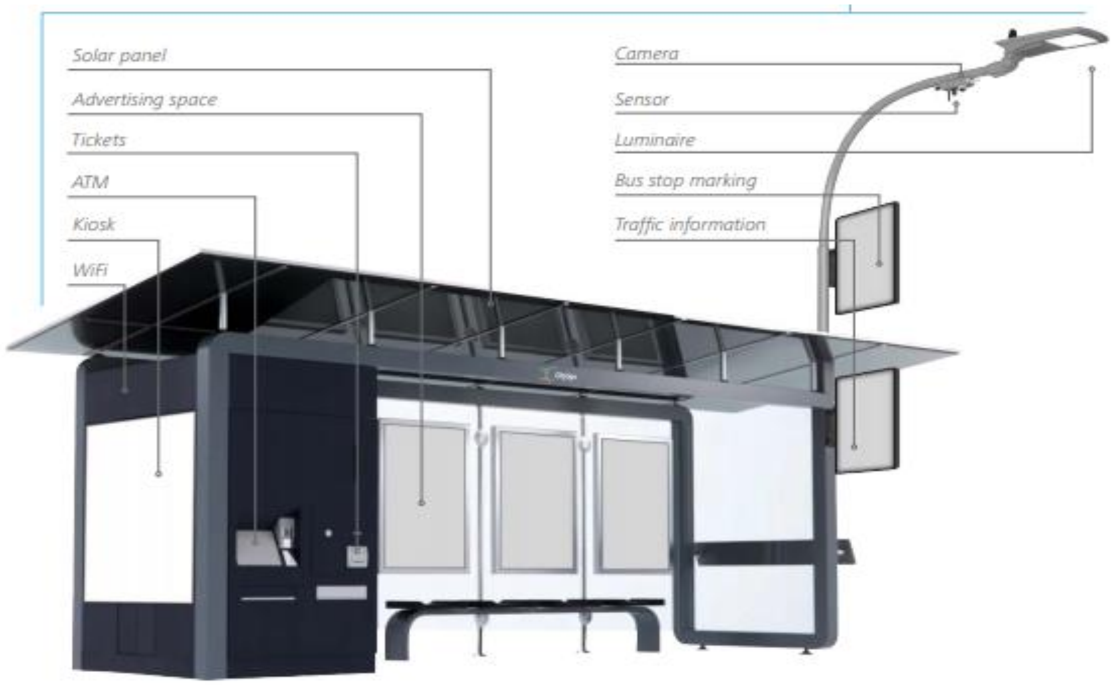
For a green and sustainable environment, people are asked to prefer public transport instead of private transport. However, for people, this choice causes them to lose more time, delays, and unnecessarily waiting at stops on their travels. It is handled that within this framework, the new generation stops designed by the smart transportation systems will play a major role in;

- Solving the traffic problem by encouraging people to use public transportation,
- Reducing carbon footprints of vehicles in the atmosphere layer where we live by the use of public transportation vehicles.

It is stated that many functions will be present in the new generations as opposed to traditional stops indicating only where the bus stops. The functions to be performed in these stops where artificial intelligence and data mining are largely active are listed below [216 - 219]:

- Real-time location information will be provided from buses via GPS, and will be displayed on the digital screens at the stops.
- Notifications will also be made by voice including disabled citizens.
- With the mobile applications of the city, people will get information about the stop and bus arrival time and route they will use via their mobile devices before they reach the stop.
- There will be information screens at the stops for new arrivals to the city and those who will use public transport and people will have access to information such as which buses they should use and which routes to follow.
- Bus stops will have Wi-Fi networks and passengers will be able to access the internet while waiting.
- The current status of the bus station will be monitored by the actuators, sensors that enable the transfer of physical data such as temperature, humidity, air and sound to the digital environment, and the micro-controllers to which they are connected at stops.
- Information on the air pollution rate, noise and temperature in the stop will be displayed on the mobile devices of the passengers.
- Thanks to the sensors in the bus station and the software that can process, analyze and monitor the data from these, remote monitoring and intervening when necessary will be ensured.
- The tickets for the bus can be sold in cash or electronically thanks to kiosks at the stop.
- In case of emergency or when people are in need, there will be lines to communicate and they can make the necessary calls from there.
- An uninterrupted monitoring with cameras will be provided for the safety of passengers waiting at the stop.
- Stops will be able to charge people's electronic devices such as telephones, tablets and laptops from the free USB charging points, and there will also be a charging point for the electric wheelchairs of disabled citizens.
- Thanks to the sensors in the station, the number of people waiting at the stop will be determined, if this number is 0, the lighting will be turned off and thus, the energy will be used efficiently.
- The bus stops will be covered with PV panels and electricity will be generated from solar energy.

Figure 3.6. Smart Bus Stop Sample Prototype Model [218].



There are many companies that started the production of smart stop prototypes in Figure 3.6. At the same time, Singapore and Barcelona, which are using these and have smart bus stops with different functions, are regarded as pioneers [220].

3.3.4.1. Technologies, Hardware and Software Required for Smart Bus Stops

Bus stops, which are considered traditionally and as useless for passengers, are now connected to a certain internet network and thus become an equipment for remote control as well as many possibilities for passengers. In these equipment where cyber physical systems are effective, the necessary technologies to take the adjective “smart” which they get thanks to the artificial intelligence behind them are presented below:

- GPS for instant location information
- Artificial Intelligence and Real Time Data Processing Algorithms to process data from the stop and instant location
- MQTT (Message Queuing Telemetry Transport) Protocol that provides location information to both the stop and the passenger
- GSM/GPRS for communication of the passenger and the stop
- RFID for bus tracking
- Wi-Fi, WiMax, Bluetooth for contact and communication in the stop
- NFC, RFID for digital balance filling in the stop

- Sensors measuring temperature, humidity, light and air pollution, sensors detecting motion, and microcontrollers with I2C (inter-integrated circuit communication) protocol to which these sensors are connected to obtain bus data
- LCD screens for displaying buses and routes.
- PV Panels for solar energy use.

3.4. Smart Transportation and Efficiency

In the thesis, all sub-elements are given under the title of Smart Transportation. Information about the benefits of the new transportation architecture of these components and the purposes for which and where these components are used are listed under the previous titles. In the light of all these technologies, there are many applications available in the literature. For example, in India, which ranks 2nd among the most populated countries in the world, there is an intense traffic parallel to this. Smart traffic regulation systems are installed by Schneider Electric in one of the busiest cities in India. Accordingly, it is seen that the total traffic time on a day in the city is reduced by around 10%. At the same time, thanks to the intelligent intersection signaling systems installed, the energy used by the traffic signs is saved in approximately 80% [112]. From the general framework, as it is stated that 28% of the city's energy is consumed by transportation systems, the fact that the energy decrease is so high has a big impact on the city's energy supply [214].

On the other hand, it is stated that approximately 90% decrease in traffic accident rates caused by both drivers and traffic signs due to the 20% reduction of traffic flow in the city by these developed systems [213].

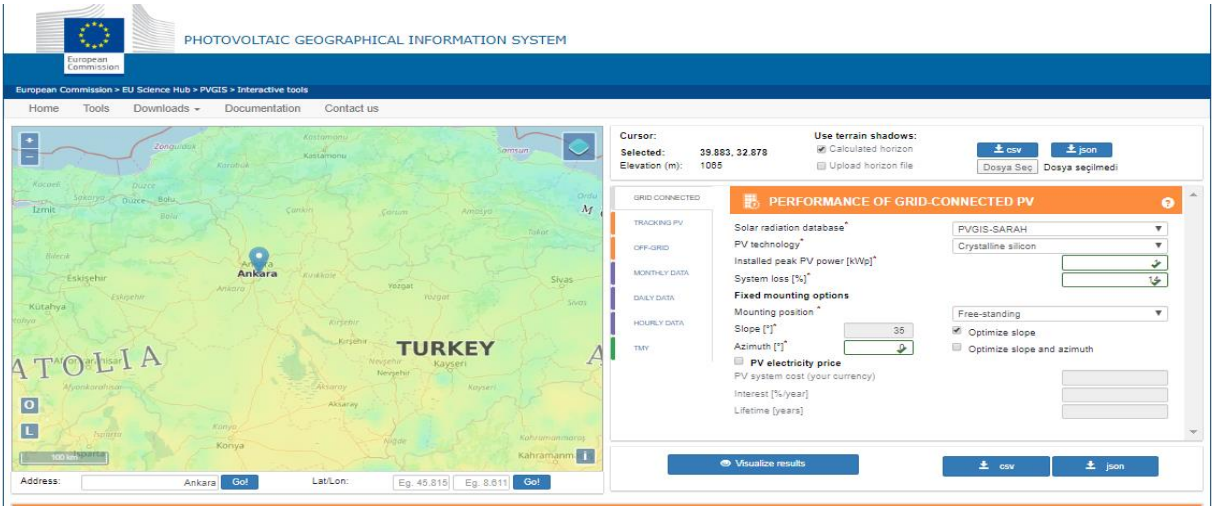
3.4.1. Smart Transportation Efficiency Application

Collecting the required information from highways and managing them in a single center, systems that perform safety and time optimization for all the beings on the roads are a general definition of smart transportation system. In this thesis, the findings obtained as a result of sanctions are given under the title of Smart Transportation Efficiency.

Under this title, which is determined as an application, Smart Stop, which is one of the sub-units of STS, is examined and as it promises there, the energy production with solar panels and its conversion into money are calculated. For this calculation, Ankara is taken as an example and the total number of bus stops in this province is detected. For this, the Ego Application of Ankara Metropolitan Municipality, which also provides passenger information services within the scope of STS, is used [221]. Accordingly, there are a total of 12689 bus stops used by public transport [222]. Here is the application to be made, the calculation question is as follows: "If one 270 Watt PV solar panel is used for each of the 12689 bus stops in Ankara, how much energy is generated annually from here? When we turn this into material gain, how much is the total income calculated?"

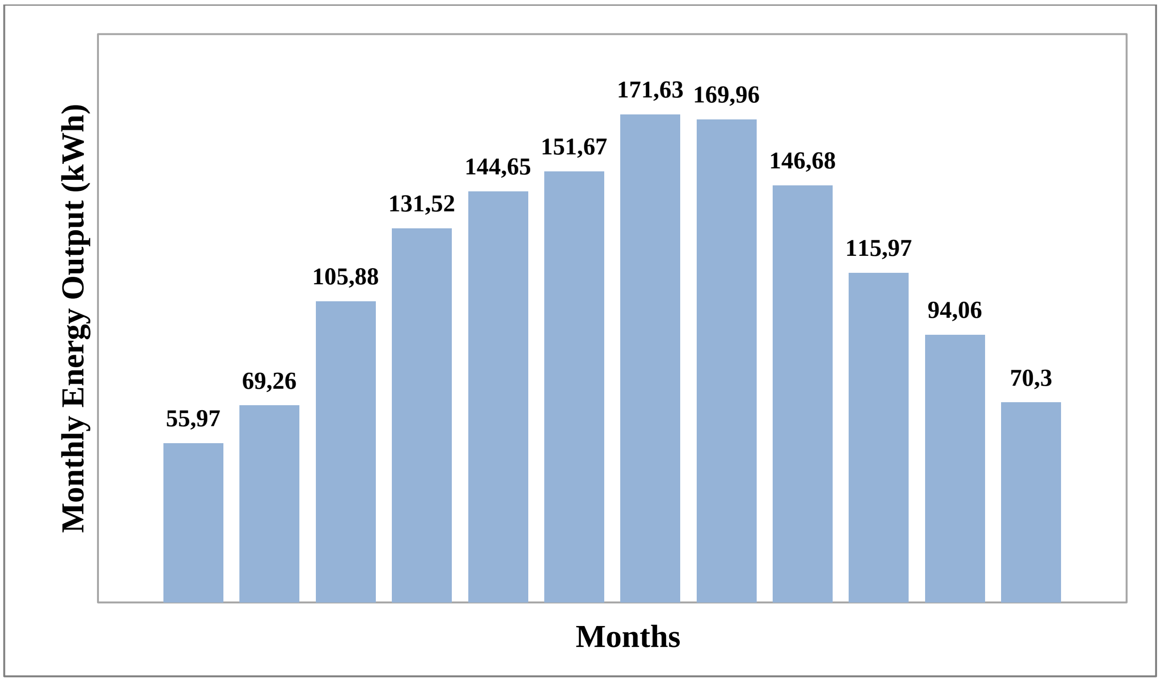
In order to perform the calculations, it is necessary to determine the average daily sunshine duration for Ankara. In order to achieve this, the site prepared by the European Union is used and information is obtained from the site, such as annual sunlight reception duration, energy production and arrival angles for the province determined [223]. It is requested to obtain results by filling the relevant information on the site specified in Figure 3.7.

Figure 3.7. Obtaining Annual Sunshine Duration Information for Ankara Province [223].



According to the information obtained from the site, the monthly distribution and amount of energy supply of the city in a year is given in Figure 3.8.

Figure 3.8. Energy Output in Monthly PV System in Ankara Province [223].



The following equation is applied to find out how many hours of solar energy originate in Ankara for 1 day [224].

Daily average sunshine duration = Total Energy Output in All Months / Total Days

Accordingly, the average sunshine duration of 1 day for Ankara is calculated as 4 hours.

Assuming the use of one 270 Watt PV solar panel per bus stop,

the total power obtained = 3,426,030 Watts, in other words, 3426,03 kWatt.

Accordingly, the total energy generation to be realized in 1 day is calculated as;

1-day Total Energy Production = 4 x 3426,03 => 13,704,12 kWh.

On a city basis, the total energy production from the stops without any additional effort is 5.002.003.8 kWh annually.

In the determination of value for money of these figures, the figures and calculations in [225] are considered as guideway. As 0,133 $ is granted per kWh, it is calculated as

1-day total revenue = 1.822,64796 $

1-year total revenue = 665.266,5054 $.

As can be seen from the calculations, the bus stops, which are seen as worthless today, bring millions of dollars to a city thanks to smart ideas and technologies and become a new energy production place. As it is noticed, smart transportation also works together with many other sciences like many other studies today and provides two-way benefit for both itself and other sciences.

3.5. Smart Transportation Systems Challenges

3.5.1. Data Management

The components, related technologies and standards of Smart Transportation Systems are provided in the thesis. As seen, vehicle users, traffic infrastructure, and all living and non-living organisms are included in this system. One of the main problems in this system where different components are connected to is the complexity and the massive amount of data obtained from these components [226]. In addition to processing and interpretation of this data, it is also difficult to provide life and data safety. Although the standardized use of communication protocols make things easier, it is very challenging to control a dynamic structure that is constantly on the move. Along with lack of resource and knowledge, the difficulty of finding qualified employees adds to the challenges [227].

Driverless cars or cars with cruise control require a remote controller and establishing communication of these vehicles with other objects. In a study conducted by Camacho et al. accidents due to issues in communication of vehicles in this system, and potential challenges of these vehicle networks to avoid delays are presented [228] that are listed below;

- Addressing vehicle location information coordinates,
- Risk analysis and management: Planning the obstacles that vehicles may encounter and solving potential situations in an optimum timeframe,
- Ensuring the reliability and accuracy of all the data on traffic,
- Establishing data categorization and providing data confidentialtiy of related components,
- Securely positioning traffic control signs and devices,
- Developing algorithms for smooth direction of vehicles throughout the route,
- Listing priority data in communication and organizing data packaging.

Besides communication, researchers should also plan the use of environment-friendly fuel for the aforementioned vehicles [229]. When considered in general, smart transportation systems which is a multi-disciplinary field, the traffic problem seems to be addressed. Additionally, a green and sustainable environment is also taken into consideration. As discussed in the thesis, based on the ARC-IT and FRAME models, this system schema is desired to be implemented and supported by many institutions [230]. This brings another challenge which is the difficulty of agreement and working in an integrated way between institutions. In this system which requires a work principle within a broad range from public offices to automative industry, from weather bureaus to drivers and pedestrians, interoperability is one of the biggest problems [231, 232]. Another challenge is to plan the tasks of all these components and the communication process between these components, and create a general design by establishing a whole-system schema [233].

3.5.2. Security

As the speed of vehicles of smart transportation systems depends on variables that can change instantly such as position of vehicles, they have a dynamic infrastructure. These systems do not have a fixed topology due to Ad-Hoc network [234]. There are multiple challenges stemming from this and on providing safety in traffic. Firstly, different scenarios need to be considered to manage incidents which leads to 2 different scenarios depending on the number of vehicles in traffic. There are delays due to problems stemming from the limitation of bandwidth in scenarios with high vehicle density and security issues are encountered due to lack of communication. There is a need for algorithms to prevent this problem [234].

Cyber Security

In addition to providing safety on roads, Smart Transportation Systems encounter another big challenge which is to provide security in the cyberspace as they have a big communication network. The attacks against the system are categorized into 3 groups that are; physical, network, and wireless attacks. Wireless attacks include attacks that can affect concepts such as V2V, V2I, V2P, V2X that are within the Aus. The attack types and threats are provided below [235].

Physical attacks;

- Access to open connection points such as USB, PS2, series etc,
- Accessing, stealing, and exploiting personal information,
- Auditing a network traffic between a device connected to STS and the end point,

- Man-In-the-Middle attacks that use open wires/wires to interrupt data – Using MitM for open wires that communicate data and thus, sending wrong data to back end servers,
- Placing an STS device to a network which it does not belong to as a safe entry point,
- Manipulating the system through using the gaps in the system's processing system, hardware, and protocols.

Network attacks;

- Installing malwares to be used in the network,
- Identification and maluse of device misstructures,
- Identification and maluse of errors in structures of devices in the network,
- Creating threats and network-focused attacks supported by big governments,
- Creating DDoS attacks on the STS infrastructure and backend servers in the web,
- SQL injection attacks
- Cross-site scripting (XSS) attacks
- Deceiving and stealing information through DNS,
- Watering hole attacks
- Pass the Hash attacks
- Pass the Ticket attacks (Kerberos)

Wireless attacks;

- Performing Man-In-The-Middle attacks that interrupt data transfer and thus, sending fake messages to devices and drivers in traffic,
- Tapping into Wi-Fi technologies that devices have,
- Identifying the vehicle Wi-Fi as the entry point for CAN, OBD, TCU units and thus, control vehicles independently,
- Installing malware to a mobile device that connects to the vehicle Wi-Fi,
- Jamming in-vehicle sensors electronically and eliminating safety.

As seen, attacks that can happen in cyberspace for STS can be performed for multiple purposes. According to the European Union Agency for Network and Information Security, it is possible to prevent these attacks through 3 main categories and sub-categories [236]. They are; having applications that are technically good such as encrypting, establishing policies and standards that are accepted by the large public, associating with laws legally [237], and including institutions and individuals in the process and informing them.

As handled in the thesis, Konya Metropolitan Municipality have multiple applications in real life in terms of smart transportation systems. However, there are several issues and challenges that Konya has and continues to face. These issues are listed in order below [238]:

- Lack of policy regulations,
- Rapid technology development,
- High investment costs,
- Challenges faced in compatibility, integration and collaboration issues,
- Challenging nature of physical conditions,
- Limitations in infrastructure.

3.6. Smart Transportation System Applications in Konya

3.6.1. Smart Mass Transportation System

The systematization of mass transportation in smart transportation system which is a big component for smart city is significantly important for both customer satisfaction and the management. In alignment with making the transportation network control easier and meeting the transportation demands of citizents, KMM is developing Smart Mass Transportation System that is called ATUS. It is possible to access this system via multiple channels such as the website, mobile apps, SMS and phone lines. Therefore, people with disabilities are also included in this implementation. This application that contributes to smart transportation, smart energy, smart environment, and smart health serves as a city guide for citizens.

3.6.2. Smart Intersections

Examples of smart transportation systems aiming to optimize signalization systems at intersections and to reduce wait-times can be seen in Smart Intersections application implemented by KMM. Due to smart traffic management system used in 86 intersections in downtown, the working principles of traffic lights are managed. With the visualization of density in roads through cameras, the time of green lights in jammed lanes is extended. In lanes that are not jammed, the time for green lights is shortened.

The wait times of drivers and the carbon emissions transmitted to the environment are reduced and the satisfaction levels with driving are increased due to smart intersections.

3.6.3. Central Traffic Management System

This system provides monitorization 24/7, reception of data and control through the statistics based on the data for smart intersections in Konya. At the same time, it allows for instant interference through live connections.

3.6.4. Mass Transportation through Contactless Banking

Konya Metropolitan Municipality provides the option to pay with credit cards and debit cards in addition to the magnetic cards used in mass transportation. As this service is offered in all vehicles of mass transportation, Konya is the first city in the world in this matter. Citizens can also make payments through NFC communication technology in their smart devices from their mobile banking apps.

3.6.5. Bike Lanes and and Smart Bicycle System

The public is encouraged to prefer bicycle in their daily transportation to reduce the damage to the environment and for a healthier community. Due to Konya's geogpraphical suitability, it is among the top cities in comparison with other cities with its 550 km-long bike lane. With technological developments, smart solutions are being created in this matter. Smart bicycles that are open for everyone can be rented from identified areas through debit cards at any time. The location, status, and availability information of bicycles are obtained through ATUS app which is a Konya city guide.

3.6.6. Icing Monitoring System

It is stated that weather information is provided instantly for drivers and related units in management in the smart traffic management. Konya Metropolitan Municipality uses this system as a mechanism for forecasting during frost when accidents happen frequently. The purpose with the icing monitoring system which provides the place and time of potential frosting is to prevent traffic accidents, and to provide safety in traffic.

3.6.7. Heated Bridge Crossing and Pedestrian Overpasses

Konya Metropolitan Municipality can intervene instantly due to icing monitoring system and additionally, similar studies continue to be conducted. Road status is evaluated through temperature and humidity sensors on the roads, and heating systems on bridge crossing and pedestrian overpasses are used in downtown.

3.6.8. Electronic Surveillance System

Speed control of vehicles are performed through speed corridors built on highways to reduce traffic accidents due to drivers. Konya Metropolitan Municipality conducts electronic surveillance 24/7 through cameras set up above lanes. A city-wide evaluation in 2013 following the set-up showed a 54% decrease in accidents with injury and 63% decrease in accidents with deaths.

3.6.9. Find Parking

Citizens in Konya receive services from ATUS which is a mobile app. One contribution of this system to transportation is the services for finding parking. Citizens can find parking close to their location obtained through GPS and receive information on the availability of parking garages or work hours. Through this app, directions for parking spaces nearby or for parking spaces identified by drivers are provided.

3.6.10. Electeronic Clearance Monitoring System

Electronic Clearance Monitoring System is used for clearance measurement and control procedures defined by the Highway Traffic Regulations. In this system monitored via electronic surveillance system, images are sent to drivers who do not obey traffic rules and the Traffic Control Center as evidence. At the same time, drivers are informed through digital screens above lanes. When the driver continues to breach the rules, SMS are sent to the driver through mobile devices and the driver is stopped at a control point. Konya is the first city in Turkey to have this system with the explained working principle. The city management aims to prevent endangering of traffic flow by vehicles that have higher clearance, and to maintain safety of roads and pedestrian overpasses.

4. SMART HEALTH

There is a great and constant connection between the people living in the cities and the hospital and the doctor due to the increase in environmental pollution, work stress, future worries and chronic diseases. At this point, smart health systems appear with the aims of accelerating the treatment of citizens, following their diseases and intervening immediately in case of emergency or by determining that emergency in advance. Many different versions of the concept of smart health, which show a multidisciplinary approach by working in an integrated way of informatics, communication and medical science, are included in the literature based on the technological developments. In this thesis conducted, these stages are examined as e-health, m-health and ultimately s-health and its sub-branches.

4.1. e-Health & m-Health

It is seen that with the deep integration of technology into the production sector, it started to realize the 4th Industrial Revolution with the name of Industry 4.0. The same situation also applies to health. Today, when we look at the developments of the integration of the information sector and the communication sector into health care, it is observed that people no longer wait in the hospital queues, do not need to go to the hospital in advance to make an appointment, and do not wait for the test results for days. This concept, referred to as e-Health in the literature, is an innovation concept providing these conveniences that is used not only for the communication between the patient and the hospital but also for other services and administrative tasks in the hospital [239, 240]. All in all, the services available in e-Health are listed below [241]:

- Digitalization of patients' hospital entrances, keeping their information in a virtual environment,
- Management of hospital analysis, test results and analysis procedures in the digital environment,
- Giving the patients' prescriptions not by hand by the doctor, via virtual portals, and transferring to pharmacies,
- Creating the planning of patient appointments in digital environment, and ensuring their controls,
- Keeping the results of the patients in a digital environment so that they can be accessed and monitored by the doctor at any time.

E-Health, which enables patients to establish close relationships with hospitals and doctors without going to health institutions very often, also makes them conscious by providing them access to detailed information about their diseases and results. [242]. There are various applications in this regard in our country. Thanks to the MHRS system, all citizens can make appointments online by selecting hospital, doctor and time according to their own preferences through the virtual portal [243]. At the same time, patients can access all the information about their illnesses or any health problems at anytime and anywhere via e-Pulse portal and share them with other people or doctors. There are worldwide required standards for e-Health services which are used in different parts of the world outside our country. Different organizations set certain standards to meet the requirements of both health and information as the system requires.

Standards Required for E-Health Applications [244, 245] :

- CEN/TC 251: Health Informatics
- Continua Health Alliance
- EpSOS: European Patients Smart Open Services
- GS1 Healthcare
- DICOM: Digital Imaging and Communications in Medicine
- HL7: Electronic Health Information Systems
- ISO / TC 215: Health Informatics
- ISO / IEEE 11073: Medical / Health Device Communication Standards
- ITU-T Q28 / 16: Multimedia Framework for e-health Applications
- ITU-T FG M2M: Machine-to-Machine Service Layer
- ITU-T IoT-GSI: Internet of Things Global Standards Initiative
- E-health Standardization and Coordination Group
- WHO Global Observatory for e-Health

Another branch of e-Health where remote access is possible by transferring patient records and results to digital environment is m-Health [248]. In this concept referred to as Mobile Health, doctors can follow up patients remotely with the mobile devices in the patient, and patient-doctor communication is provided with more cash and time efficiency via wireless communication tools [245, 246] . Thanks to m-Health, it is possible to provide assistance in emergency situations by monitoring the patients in need including care of elderly citizens remotely with their personal wireless devices. By this way, public health is protected and remotely controlled [247]. In the continuation of the thesis, the applications, related technological equipment and working principles which are realized under the title of Smart Health Monitoring Systems are given.

M-Health applications are examined in two groups in the literature. The first is the sum of the interventions aimed at encouraging people by thinking about the disease and the patient. These are called bedside activities. In the second group, the applications covering the communication between the patient and the hospital are included. These are called applications not related to the health unit. The applications in these two groups are summarized in Table 4.1 below.

Table 4.1. M-Health Practices Examined in 2 Groups [246,247].

Applications related to Health Unit	**Applications not related to Health Unit**
Informing patients and suspicious patients via mobile devices	Ensuring efficiency in communication between health unit and patient
Reminder of the patient's disease solutions such as medication, physical therapy or by SMS or phone call	Optimum ease of use for equipment to be used for patients in the hospital and efficient management on patients
Informing patient's test results, drug prescriptions via SMS	Ensuring the safety of employees through mobile devices through advanced technologies
Recording patient information in the hospital database and displaying this data on the web	Appointment system and informing the necessary units
Intervention in unexpected situations	

The World Health Organization examines the initiatives they have made and developed in 112 countries for m-Health and quantitatively graphs them quantitatively graphs them. Based on these graphs, the categories in the questionnaire are classified under 2 headings by adhering to the literature as indicated in this thesis.

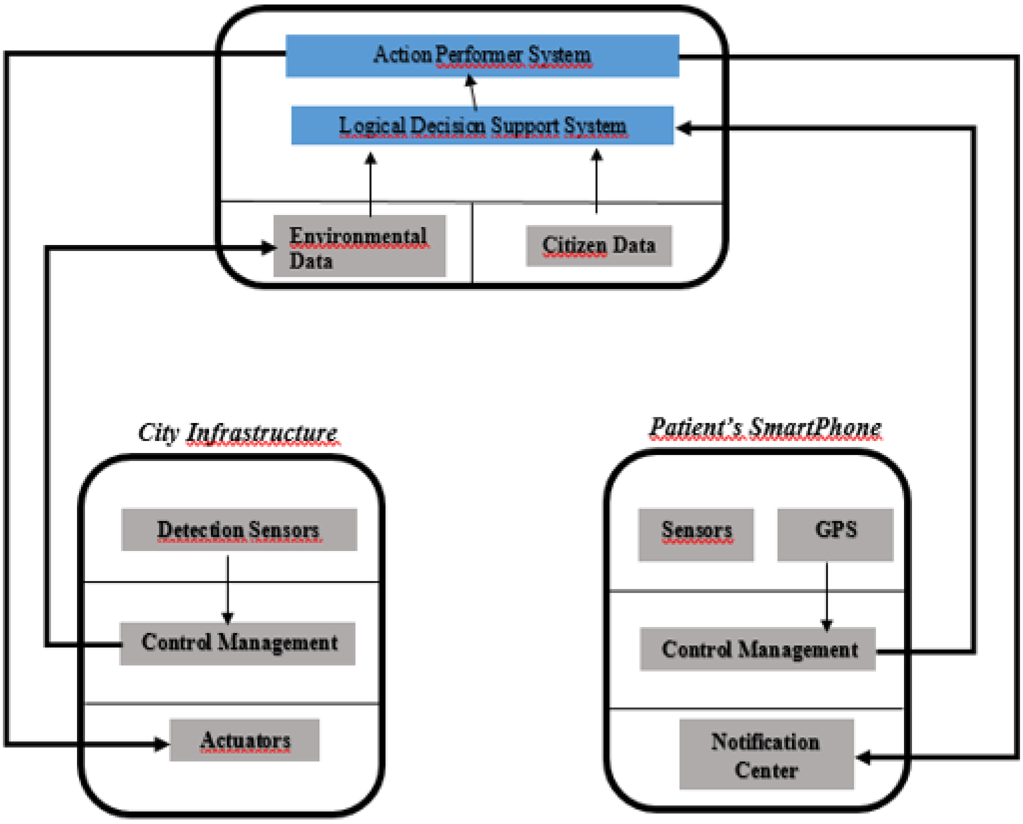
m-Health offers many new opportunities and facilities for the health sector and related departments. As stated in the report published by McKinsey & Company in 2010, by means of these systems, treatment systems can be collected in a single system and be based on a standard. At this stage, different points of view can be created through the exchange of information of all relevant units and quick and practical solutions can be offered [248].

4.2. s-Health

Monitoring of the patients and where necessary, intervention of the doctor or any health unit, its employee are under the concept of m-Health. In the term Smart health s-Health, there is now an artificial intelligence lying in the background. Thanks to the sensors in the patients and which are used to get their health information, data are obtained, and these data are analyzed and processed and a number of notifications are made for the patient to heal or avoid bad conditions [249, 250]. Thanks to programs compatible with different operating systems, public health is monitored, they are kept away from dangerous and harmful situations, and it is ensured them to live under even better conditions [251]. s- Health does not cover the period until the end of the patient's disease, and does not depend on any outcome. Here the patient can improve the quality of life through programs designed to his advantage during all his/her life. In this way, a healthy and conscious society is observed in the city. For example, a person suffering from obesity receives the necessary instructions by means of sensors and a wireless mobile device, and it is possible to check whether his/her diet is regularly administered daily. Subsequently, the patient achieving the appropriate weight, can use this application for a controlled and balanced diet, and the application decides whether the food can be consumed in terms of calories.

Ding et al. describe s-Health as the systems developed for the protection of public health and the application of medical treatments through the integrated use of various disciplines that constitute city infrastructure [252]. Also in this declaration, they foresee that the pollution due to traffic in the air can be measured by using the signs in the transportation infrastructure and the sensors embedded in traffic lights. Thanks to this model they planned, based on pollution, pollen information from the environment, citizens are provided with notifications that show green alternative ways, especially to sensitive people via their mobile devices. The model they developed is presented in Figure 4.1 below.

Figure 4.1. Proposed Model for s-Health Practice [252].



As can be seen in Figure 4.1, public health can be protected with the infrastructure provided in the city. The terms health and smart city come together under the principle of "Creating a healthy society". With the s-Health applications that occur in line with this principle, health solutions are no longer limited to hospitals, they can be available at anytime and anywhere. [253].

4.3. m-Health & s-Health Combination: Smart Health Monitoring Systems

First, Smart Health Monitoring Systems aiming to provide solutions to patients who cannot go to the hospital continuously or to be treated with monitoring of their daily lives, programs and personal assistants are developed to improve the quality of life of all people in terms of health. With these systems using GPS and RFID communication technologies, citizens can be monitored from anywhere at any time [254].

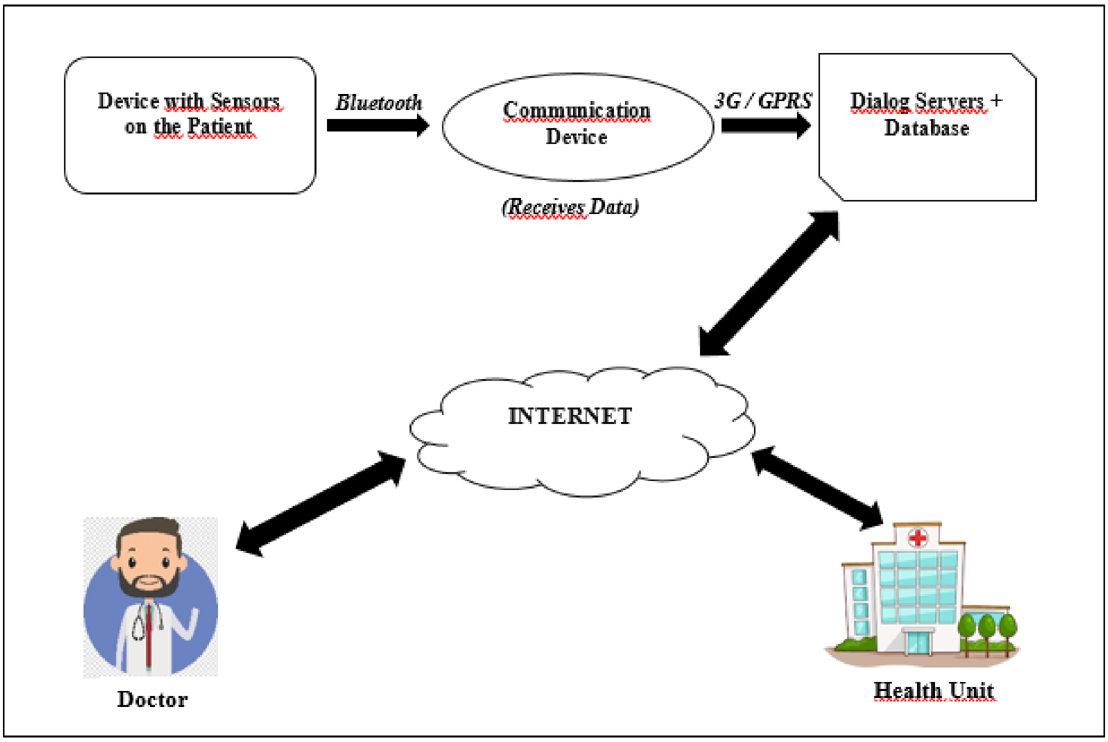
The follow-up of the people, especially the chronic patients and the elderly, is carried out in different ways thanks to the convenience of technology. Smart monitoring systems, which are formed by the combination of mobile health and smart health, are examined under two titles in this thesis prepared. Although the working logic and objectives of these technologies are similar, they differ in terms of their ways of implementation and the infrastructure they include.

4.3.1. Remote and Mobile Monitoring Technologies

These systems are used to obtain results about the patient and the disease by evaluating the acquired data through the use of the electronic devices that are emerged and established by the use of communication technologies in the field of health. As noted in the patent taken by LeDain et al. in these systems, the patient and the relevant health unit includes a remote monitoring unit for monitoring the patient and the disease, and means of communication between these units [255]. It is seen that there are also different patent studies taken in this field in the literature [256, 257].

In the industrial field, thanks to the device developed by Bosch for Asthma patients, the patients are monitored in their daily lives and this information is transmitted to the relevant doctor via GSM technology instantly. In this way, the patient can be intervened when needed and the patient's hospital stay is shortened. At the same time, during the examination, the doctor gives the necessary medication to meet the exact needs. Because the results are not handled in an instant, they spread to daily life, the treatment is administered neither more nor less [258, 259]. On the other hand, the portable, remote health device introduced by Ericsson in 2012 is also shown as an example of the innovations developed in this field [260]. Various applications made with this device are available in the literature as articles or communique [261, 262]. Ericsson has a pilot application for the cardiac patients of a hospital in Sri Lanka, by cooperating with different companies [262]. The study has mutual interests for both sides separated as patients and health care team. It is based on improving individual lives by giving importance to individuality for patients. Accordingly, the proposed architecture is given in Figure 4.2 below. From here, it can be concluded what should be included in a technical infrastructure architecture for remote sensing systems, which is the subtitle of patient monitoring systems in smart health.

Figure 4.2. Remote Health Monitoring System Proposed Model [262].



As it can be understood from the proposed architecture, in order to transmit the data in the device placed to monitor and measure the patient's blood pressure, heart rate, firstly Bluetooth or other close distance communication technology is used; but in order to be transmitted to the doctor, one of the end users in the system, to be transferred to the cloud environment, technologies like 3G, GPRS are required. In this way, the relevant health consultant can monitor the patient's state at any time. However, since the remote sensing systems are positioned on the patient, they can be confused with wearable health technologies. The devices are used in case of any danger, or when the patient feels necessary.

The relevant medical devices in remote sensing health systems need to have certain standards. Certain standards are also applied for communication protocols and systems. In general, these standards are medical device standards based on IEEE 11073-10207-2017 [263].

Under the specified title, the remote sensing and mobile tracking systems is found. Although these two systems proceed similarly, there are differences between them. For example, in remote monitoring systems, the patient uses the relevant wireless device where necessary, so that measurements are performed and this information is transmitted to his/her doctor. From the medical data provided, the doctor reaches a conclusion and returns the patient by call or message on the mobile device. Another aspect of use is that the patient's data is transmitted to the doctor and stored in the patient database, when the patient comes to the examination, the doctor performs the checks according to the available data. In mobile tracking systems, patient data is obtained by mobile devices such as smart phones and these data can be displayed online by the patient as well as being forwarded to and displayed by any medical team. The exemplary architecture of the system for monitoring the health status of the patient over mobile, which is formed by using the studies in the literature, is given in Figure 4.3.

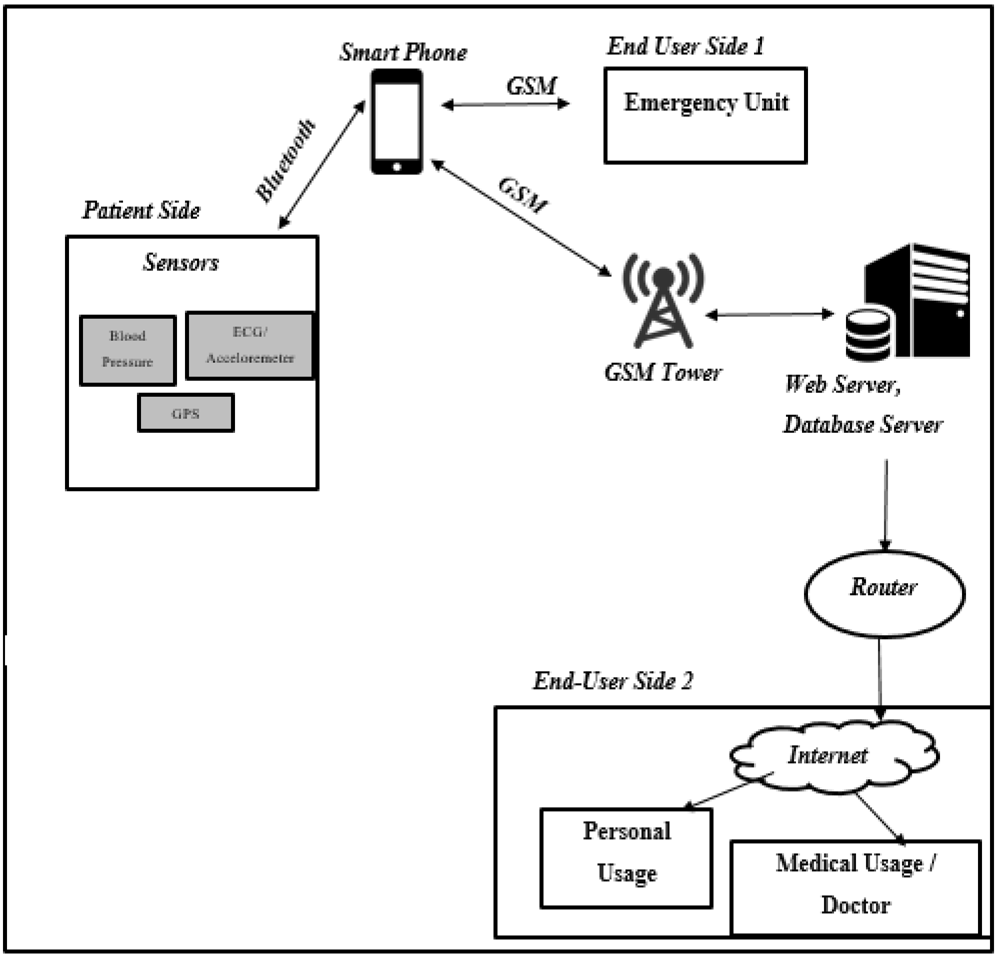


Figure 4.3. Mobile Health Monitoring System Proposed Model [264 – 266]

4.3.2. Wearable Technologies

When the world is considered, the increasing number of elderly population, diseases and related deaths in the early ages reveal that it is required to be a follow-up, monitoring system under smart health title for the regular follow-up and treatment of chronic diseases experienced, for the immediate intervention and for the health of the patients. In a statement issued by Poon et al., they gather the functions of these systems under the title 6-P [267]. Accordingly, there are sub-elements as (Participation) for the participation of all people, (Prediction) for prediction of diseases, (Prevention) for preventing them, (Pre-Emptive) for identifying and applying primary treatments, (Personalized) for handling the applications to be performed individually, and (Pervasive) for becoming widespread. For these needs, it is considered appropriate to use wearable technology to ensure the sustainable surveillance of patients and their treatment by providing continuous data [268].

Thanks to wearable technologies, relevant healthcare units also obtain a number of benefits. For example, working times are shortened and allocated workloads are reduced. At the same time, thanks to the fact that the applications that endanger the lives of many healthcare workers in the places where they are working are made automatically by means of machines, their quality of life is increasing l [269].

Sensors play an active role in the evaluation of the energy system, transportation system of a city as a “smart” in general. For health, the cases that the doctor establish a patient follow-up, the data is taken for the observation of the disease, they are analyzed and reached a conclusion are also realized through the sensors. Many sensors with different functions are used at the basis of wearable tracking devices. The sensors used in this stage are listed in Table 4.2 below according to the classifications indicated.

Table 4.2. Sensor Types for Wearable Technologies [270].

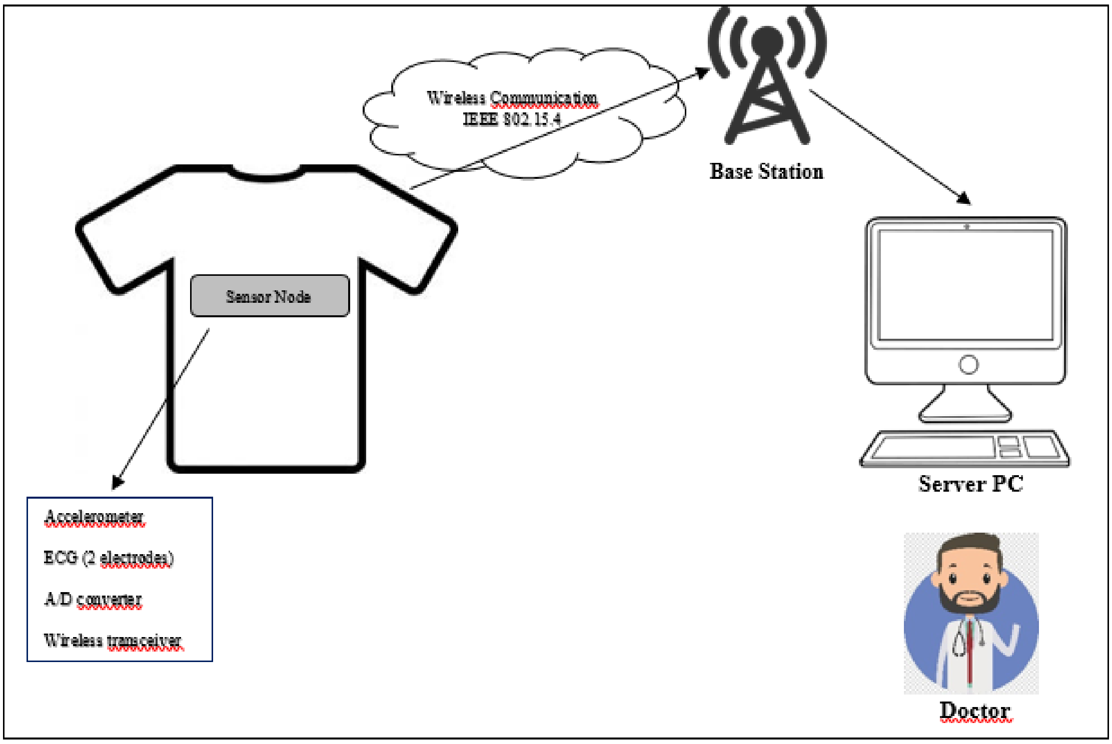
Place of use	**Sensor Types**
Image Acquisition	Light dependent resistor (LDR), Photodiode, CMOS (e.g. camera phone), CCD (e.g. video camera), Laser range-finder, Infrared camera, Passive Infrared (PIR), Image recognition/gestures
Sound Acquisition	Microphone, Speech recognition, Audio recording Ultrasonic detector, Barometer/altimeter
Motion Detection	Tilt-switch, Vibration sensor, Accelerometer (2D and 3D), Potentiometer, Electronic induction, Piezoresistive fabrics, Pedometer

Contact Detection	Mechanical switches, Textile switch (i.e. Elektex), Fabric keyboard, Polymer switch (i.e. softswitch) Laser keyboard, Capacitive touch screen
Temperature Detection	Thermistor, Resistance temperature, detectors (RTD)
Measurement of Biological Conditions	Electrocardiogram (ECG), Heart-rate (e.g. polar sports), Galvanic skin response (GSR), Electroencephalografiky (EEG)
Obtaining Location Information	Global positioning system (GPS), Ultra wideband (UWB) radio WIFI, Bluetooth and Cell ID, Ultrasonic, Infrared beacons, Visual markers (barcodes), Radio frequency identification (RFID)

By integrating the sensors in Table 4.2 into various textile products, it is provided to receive data from people and thus, the developments in the field of medicine are handled by many academicians in the literature. While applications of wearable technologies mentioned in the Bonato's statement presented in a conference in 2010 are explained to be used in the field of health for Parkinson's patients and people suffering from heart disease [271], thanks to the washable technological vest created by Pandian et al. with microprocessors, wireless communication tools and location providers, it took place in the academic literature that people can obtain and interpret physical parameters such as heartbeat rates, body temperatures etc. [272].

A shirt formed by the sensor node consisting of sensors in the wireless state monitors the heartbeat depending on the acceleration of the wearer [273]. The heartbeat rate and other data, which are converted into electronic signals, are transmitted to the relevant health consultant along with the specific communication standard. The architecture for this realized system is given in Figure 4.4 below.

Figure 4.4. ProposedModel for Wearable Technologies in Health Sector [273].



As a result, these technologies, which are produced and developed in order to conform to the human body and medical field, have to have accepted standards by passing through certain test stages and varieties. For this purpose, TÜV SÜD has different tests and the standard P360, currently used by IEEE, is developed under the leadership of Soo Kim [274, 275].

4.4. Smart Health and Efficiency

The concept of smart health, which includes issues such as protection of public health, follow-up and timely treatment, is a subject that can be encountered anywhere, anytime of life. In order for each citizen to benefit from these innovations and to become a healthy individual, the top managers in cities have big duties in this regard. They have to integrate all these technological hardware and software with the city infrastructure.

With the renewal of the health infrastructure, there are positive effects both on individual and country basis. The benefits provided by the establishment of these systems in different countries are researched from the literature and given in the following articles [109, 241, 276]:

- Thanks to the wireless and fast communication systems and smart transportation mechanisms established, intervention times for heart attack patients are shortened. Due to the decrease in the duration of approximately 15 minutes to 5 minutes, the chance of survival of citizens in such cases is greatly increased.

- Monitoring of patients and transmission of data to a doctor via remote and mobile devices reduces the number of patients going to hospital and the time spent there. Based on this, it is seen in the literature that these visits decreased by about 10%.
- Work efficiency of health workers is increased by approximately 20% thanks to the profit given in second article above.
- Due to the availability of hospital appointment systems and working according to the appointment hours, this decreases the examination delay times by approximately 17%, and consequently increases patient satisfaction by approximately 22%.

4.5. Smart Health Systems Challenges

4.5.1. Data Management

Solanas et al. describe the challenges in the process in smart health from data collection to interpretation and transferring to related individuals [277]. Accordingly, these phases and their own challenges are listed below [277 – 280]:

Data Gathering;

- Designing sensitive sensors based on the purpose of use,
- Adjustment of magnetic fields that would be affected by the sensors on patients according to different scenarios, and ensuring patient safety [280],
- Integrated function of medical devices connected to the internet.

Data Storage;

- Organizing the big data real time,
- Making data management more efficient by integrating heterogenous data.

Knowledge Acquisition;

- Early identification of conditions in disorders,
- Categorization of disorders and patients,
- Analysis of the process between a doctor and a patient.
- Achieving process mining.

4.5.2. Privacy and Security

The operation of smart health systems relies on the security of data obtained from patients, hospitals, and doctors. Otherwise, it would affect human lives significantly. Wireless devices or wearable technologies that patients have can receive both cyber and physical attacks [280].

Ballesté et al. [281] identified and evaluated according to certain parameters on smart city privacy. In [282] which constitutes the basis of this study, these parameters are specialized for health. For example, anonymity of patient Ids and protection of their data is difficult. Thus, they overcome this obstacle by using pseudonyms based on patients' locations. They plan to increase security by changing these pseudonyms frequently. Another challenge is to establish confidentiality of questions sent to the system by patients. One other challenge related to security and confidentiality is the attacks against s-Health applications. For example, instead of providing accurate information, misinforming of patients can be done [282].

s-Health applications due to Internet of Things may have several damaging effects for citizens as personal data can be exploited which creates a big challenge for new systems. Farahani et al. evaluate these challenges encountered from the dimension of the components that are in Internet of Things. Accordingly, the first layer is the device layer which includes sensors to obtain data from patients. Here, cloud testing is done for copying data for other use, tapping into communication, jamming radio frequencies, and damaging the network with harmful commands installed to the device. The challenges in the network layer in which communication is provided during the period between obtaining data from patients and uploading them to the cloud make the network stronger against attacks including Eavesdropping, Sybil, Sinkhole, and Man-in-the-Middle. In addition to DoS attacks that exploit system gaps in databases in cloud where data are stored, attacks such as interferance with inquiry processes, remote control of code compilation process, cross site scripting (XSS), and Trojan horses. Besides these, it is also necessary to inform patients about physical attacks with malevolant purposes such as obtaining user passwords [283].

There are several striking initiatives to store citizens' personal information securely and and increase their safety. For example, Trust-worthy Health and Wellness (ThaW) project aims to ensure data security in informatics services provided for a healthy life.

Additionally, the Strategic Healthcare IT Advanced Research Projects on Security (SHARPS) project conduct studies particularly on protection of data used in m-health applications [284].

In addition to security, another challenge in smart health systems is related to the operation of electronic devices placed on patients [285]. These devices should be ready to use anytime when the patient needs them. Thus, their designs are expected to be improved in order to avoid battery life and electronic issues.

The challenges reported by the Konya Metropolitan Municipality for smart health systems are as follows [286]:

- High investment costs,
- Lack of a co-operation approach,
- Challenges of providing security for personal information,
- Safety of health systems – Cyber security threats.

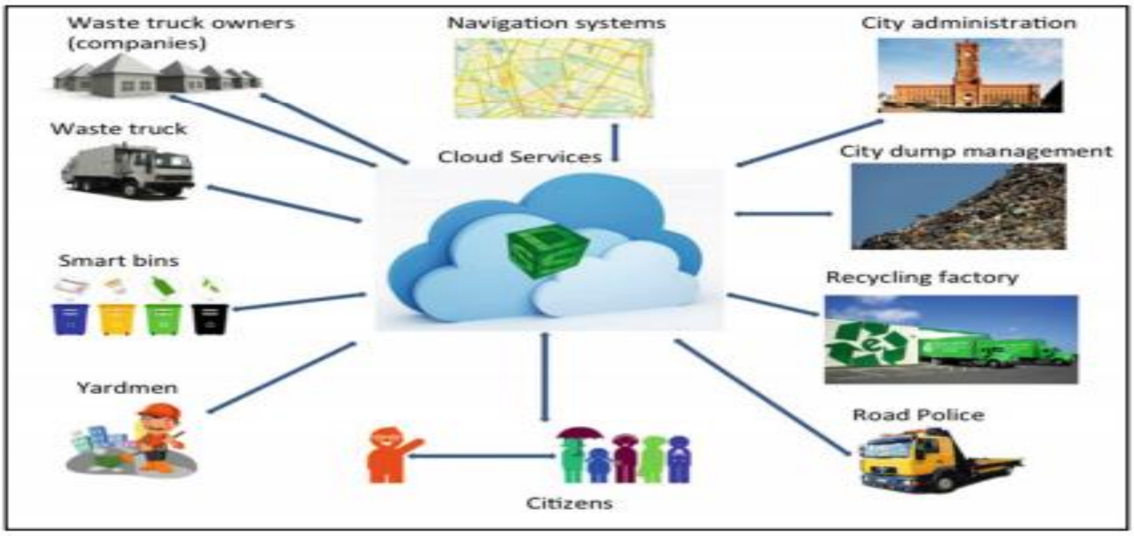
5. SMART WASTE MANAGEMENT

5.1. Smart Waste Management Definition and Its Applications

Human or any living being does not occupy as much space as its own in the world, but it also leaves traces on the earth with the waste it leaves behind. The transfer of the idea and formation of the 8th Continent, which was put forward in 2019, to all mankind, places a great emphasis on environmental pollution. These wastes, garbage around us are a major threat to the environment and human health. Lack of regular, on-site and timely waste collection in cities results in many diseases. In order to collect and manage these wastes positively, smart waste systems are needed. Thanks to these systems, not only the municipalities but also the people living in that city are included in this issue. It is aimed to protect the health of all living beings by intervening in the relevant area on time and cleaning the environment, doing waste tracking with the help of the relevant sensors and GPS [287, 288] . At the same time, thanks to the Smart Waste Management System, the extra expenditures that the government has made on this issue are determined and it is aimed to provide economic benefit in this item [289] .

Traditionally, it is observed that the collection, disposal and evaluation of waste is carried out only through municipalities. However, thanks to the newly introduced systems, it is determined that all relevant public units from garbage bins to citizens and garbage collection vehicles are connected to a common network and their communication is realized through this virtual network [287, 288]. Control is provided from the formation process of the waste accumulation to the disposal or evaluation process, and there is complete management through communication with the figures in each step [289]. Figure 5.1 shows the elements that are actively involved in the virtual network for waste management.

Figure 5.1. Smart Waste Management System Components [287].



The objectives and applications of Smart Waste Management are listed below [287, 290, 291]:

- Full control of stages such as collection, evaluation and disposal of wastes accumulated in cities,
- Monitoring waste filling levels and intervening when necessary,
- Eliminating the visual and physical pollution given to the environment through timely waste disposal,
- Getting rid of unnecessary expenses and labor by accessing only the needed areas,
- Reducing fuel, maintenance costs through prudent use of municipal waste collection vehicles,
- Controlling the work of the staff working in this area in the municipality, and encouraging them for better service to the public,
- Raising awareness and inclusion of all citizens living in the city on waste collection,
- Providing separation of the waste to be recycled both by the public at the beginning and later stages,
- Making improvement of the route for municipal waste collection vehicles to accelerate their arrival to the relevant region,
- Electronic recording, tracking the waste bins on the streets, and preventing the possible losses.

5.2. Smart Waste Management Technologies

Smart waste management systems, in which the existing pollution in our world does not increase or increase in a controlled manner, is based on many different technologies. However, when the literature is examined, it is seen that RFID and IOT and sub-technologies are mostly used in the applications on this subject. These technologies specified and applications realized are given in Table 5.1 of this thesis.

One of the important communication technologies, RFID and IOT where every object has its identity in a virtual environment and thus communicates with other objects, has a high return on waste collection for municipalities and citizens. It is possible to see its examples in Dubai, Singapore and Australia.

Table 5.1. Smart Waste Management Technologies and Applications [258 – 264].

BASIC TECHNOLOGIES USED	RELATED STUDIES	IMPLEMENTED APPLICATIONS
RFID (NFC Sensors, Geographical Information Systems, GSM)	***Chowdhury et.al.*** [292] ***Glouche et.al.*** [293]	• Waste bins are identified and saved electronically. • The weight of the waste bins is calculated by means of their RFID tags, waste containers are classified according to the types of waste bearing RFID tags. • Regional separation of waste collection bins is made, and it is placed in missing areas. • Stolen or damaged waste containers are detected via the system. • Citizens scan the RFID tags on their garbage and decide which garbage they should use for recycling through the application on their mobile devices. • Finding the right waste in the right garbage makes recycling faster and easier.

IOT (GPS, Geographical Information Systems, IR Sensors, GSM, ZigBee, LabVIEW)	***Shyam et.al.*** [294] ***Lata et.al.*** [295] ***Navghane et.al.*** [296] ***Medvedev et.al.*** [287] ***Meghana et.al.*** [297] ***Khedikar et.al***. [298]	• Garbage containers and related information transferred to a cloud environment. • Waste bins are detected when they are about to fill. This reduces pollution to the environment. • Information such as waste bins are full, damaged, lost can be transmitted by the citizens to the relevant units. • Short-time routes are set for garbage collection vehicles to go to the target area. • Since containers that are considered smart are expensive in terms of cost, relevant sensors are installed and digitization of the currently used containers is provided. • Whether waste is disposed or not, environmental cleanliness is monitored and controlled. • Effective decision-making mechanisms are established by means of artificial intelligence, which is designed by considering the existing garbage collection routes and operations.

There are different companies around the world which make the waste collection to progress systematically and to be remotely monitored and controlled through the new generation technologies. Some of these companies seem to have made their targets in this field feasible in real life, while some firms are still in the testing phase [299]. The companies that will carry out studies for both public units and citizens based on IEEE 2413-2019 standard on waste management [300] are listed below [299, 301- 302]:

- Bigbelly
- Compology
- Ecube Labs
- Enevo
- Nordsense
- CitiBrain
- Nebulae
- Sensoneo
- AcoRecycling
- Top-k
- Robust
- Tracking

- Smart Waste
- Priority

5.3. Smart Waste Management Systems Challenges

Insufficient measures on environmental pollution in cities endanger the lives of organisms in that city. In this thesis, the information sector, supportive applications and smart solutions for municiplaities are discussed. Although the benefits are envisioned to be many, both managers and the information sector face challenges in reaching the desired level.

The main challenge faced in smart waste management is first phase, which is the design and planning phase based on the priorities of the system. In this system that is expected to work real-time, shortening the arrival time of waste collection vehicles and selecting appropriate routes are a challenging process [303]. Following such calculations, placement of trash containers around the whole city and establishing a communication network require an expensive infrastructure [304] [305]. Hannan et al. report that although expensive infrastructure is among the challenges, another challenge is experienced at the separation phase. In the article, it is stated that the process should be monitored from the beginning for separation. Here, producers categorize different products and label them for recycling, developing softwares that can make the separation precisely, and making it at a universal level are among the challenges faced in the smart waste system [304]. The article published in [306] reports that when solid waste separation procedure is not performed in smart waste management, then only the fifty percent of success is achieved, which supports the argument in [304].

Another challenge in the smart waste management system built on sensors is the placement of sensors on trash containers to get the most efficiency and to interpret the data that will be received through them [305, 307]. Whether the containers are full or not is determined through the distance between the trash inside and the lid of the container. However, if the trash is not distributed equally and accumulated on one side, this does not mean it is full but if the sensors sense this, then they would send wrong notifications. Vehicles that start to move for containers that are not filled yet would cost unnecessary gas expenses and thus, hurt the economy and damage the environment due to the carbon they will be transmitting [307]. Therefore, sensor settings and positionings should be performed well.

Bringing new approaches to existing systems requires raising awareness not only in employees who will work in this field, but also in higher officials. One of the challenges that Smart Waste Management encounters is to increase the awareness levels of public offices and high officials through enforcement [305]. While Konya Metropolitan Municipality has this awareness, they continue conducting studies on waste management within the municipality. However, they have to face and overcome many problems and challenges while achieving these. The issues encountered by the municipality are listed below [308].

- High first investment costs,
- High unit pricing of technology products that will be used,
- High management and maintenance costs,
- Lack of qualified human resources
- The need to improve hardware to make the current infrastructure smart,
- The current infrastructure being old and in use,
- Lack of regulations,
- Lack of guiding policies at the city level,
- Technical restrictions,
- Low level of interoperability in environments with multiple supplier,
- Low level of interoperability of systems.

5.4. Smart Waste Management System Applications in Konya

5.4.1. Electric Power Production in Solid Waste Facilities

Konya Metropolitan Municipality stores solid waste in Aslım Solid Waste Storage Field which causes methane gas production. The municipality desires to re-purpose the methane gas produced positively and aims to produce electric power. In Konya Integrated Waste Disposal and Energy Production Facilities established in 2011, 9.39 MW/Hour electric production is done at full capacity. With this production, the electric demand of an average of 40.000 households are met. This practice of the municipality is not only a part of the Smart Energy Systems, but also constitutes an example of smart waste management.

5.4.2. Environment Management Information System Center

Konya Metropolitan Municipality monitors the sub-dimensions of environment managemet from waste management to landscaping, to noise and air pollution and tracking of service vehicles through a centralized system. In addition to obtaining instant images, the data obtained can be inquired and analyzed through associating them to each other.

On the other hand, service vehicles for landscaping and cleaning are tracked and controlled through Vehicle Tracking System. In services to be offered to citizens, the goal is to optimize vehicle redirections and shorten the time.

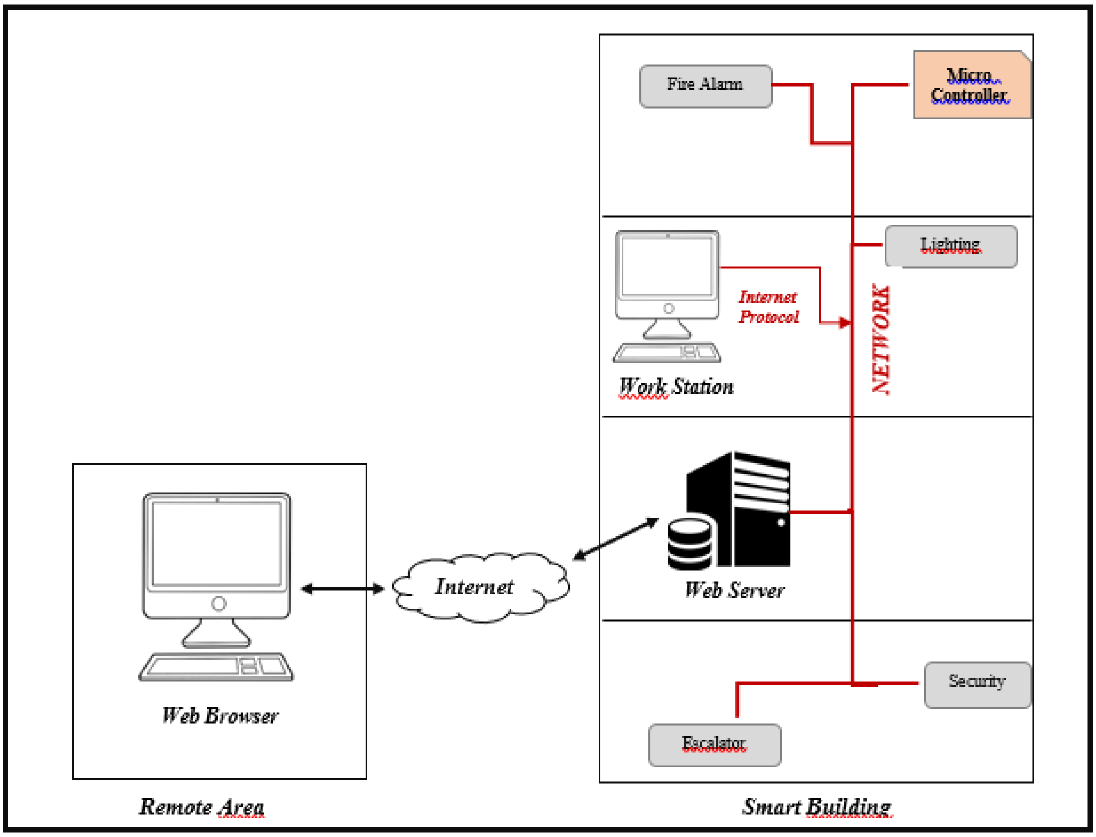
6. SMART BUILDINGS / HOUSES

When it comes to a smart life, the term "Smart Building, House" of which applications are often mentioned, comes to mind. Thanks to the single-center control management that comes with the Internet of Things, these houses are monitored and offer smart applications and solutions to their owners. Based on these services, it is said that smart houses respond to real-time demands and interact with the smart control center while focusing on a larger dimension of controls, being self-aware and informing the center of their situation [309]. Based on all this information, 'Smart Building' is defined as structures that provide user satisfaction, energy efficiency, sustainability, and which explain and combine communication, management, control and hardware with construction as a whole building system [310]. Many different technologies are used under this structure, which requires a multidisciplinary approach.

The most important control mechanism that is required in a smart structure is realized on the platform named LonWORKS (Local Operating Network) developed by Echelon Corporation and adhered to ISO / IEC 14908 control network standards. The SmartServer structure controller of this organization, which carries out extensive studies on smart structure, can be operated in a compatible manner by combining with SOAP / XML Web services or network and enterprise applications via BACnet / IP and LONWORKS, Modbus and other device level protocols [311].

RFID (Radio Frequency Identification), which is the most important data source of Internet of Things technology, is also used in smart houses for data monitoring and control of heating, cooling systems called HVAC systems [312]. Similarly, a system called iDorm is developed by using embedded systems, sensors and a multi-structured architecture to adjust the air of the home environment and they provide solutions to the demands of the users [313]. In the infrastructure of all these technologies, wireless local networks subject to IEEE 802.11 standards as well as personal networks using IEEE 802.15.4 standard are used [314].

Figure 6.1. Proposed Model of Smart Building [315].



6.1. Smart Building / House Applications

The new generation houses displayed thanks to the software designed in smart grids help the users to use electricity, water and gas energy more efficiently. The householder can control the heating and cooling system of the house and these systems can also be managed by a remote controller.

The occupancy detection sensors determine the condition of the house and the heating and cooling systems are operated accordingly. At the same time, the user can also monitor the condition of the house thanks to the application on his/her mobile device. The relevant units in the smart buildings whose model is shown in Figure 6.1 are connected to a network via Ethernet or Wi-Fi and this network is controlled by a remote connected system.

Huang et al. examine the smart applications in the houses with the mentioned innovative studies in two groups in their study [316]. As already mentioned, installations where home energy systems are controlled and which provide economic benefit to the user and provide great benefits in city energy use constitute the first application class in smart houses. In the second class, the location of the householders is determined by the sensors placed in the house and the ones in need are presented to them according to their area [317]. For this reason, these applications are called in-house location services. For example, the system, which starts to operate while the user arrives at the building, provides the user's location information with GPS and allows to go to the designated location for parking the vehicle. Since it is also a voice and image recognition systems, it is aimed to solve the security problem in these smart buildings.

It is stated that energy production should be provided in smart houses as in smart stops and that electricity and water need in the house should be provided by this energy. By maximum use of PV Solar panels and natural lighting, it is aimed to reduce energy consumption costs for the householder.

6.2. Smart Building / House Systems Technologies

It is said that the use of unnecessary lighting affects all other objects on the planet as well as creating environmental pollution. In addition to this, increasing energy use billing charges reveals to take measures on lighting and to apply them.

There are lighting, heating, and cooling systems on the basis of smart buildings. It is desirable to use LED light to provide ease of remote digital control and ease of installation and maintenance for the subject of lighting. In this way, there is no need for an inverter, and it is easily adapted to operate with solar panels. Insulation systems ensure the protection of the heat in the house, and thanks to the new generation of windows, lighting is provided at maximum level and heating and cooling systems are benefited by minimizing the heat transfer [318].

Thanks to the location information and occupancy sensors from GPS, the efficiency in household use of the householders can be increased. In addition, saving is achieved by determining the energy consumption level by means of sensors. On the other hand, communication between devices connected to Ethernet or Wi-Fi in the house and data exchange from house for remote controller is realized through 6LoWPAN, 6LoWPAN-ND, RPL, IP, UDP protocols [319].

There are many companies from different countries that bring together the necessary hardware in buildings and by digitizing them, contribute to the operation as integrated with both consumer and city infrastructure. The most important ones are listed below [320]:

- Honeywell (US),
- Cisco (US),
- Siemens (Germany),
- IBM (US),
- Schneider Electric (Germany),
- Huawei (China)

6.3. Smart Building / House Systems and Efficiency

In the literature, the use of LED lighting in smart houses not only reduces consumer spending but also brings together management in one center and ease of control. In this thesis study, when LED bulbs are preferred, an example comparison study is made about the economic gains for the benefit of the consumers. For this comparison; 2 different types of lighting devices (Incandescent Lamp and LED Lamp) are used, for example, a 3 + 1 apartment is used as base and accordingly 8 bulbs are needed. The lamps are assumed to remain on for 6 hours per day.

Incandescent Lamp operates at 75 Watt and consumes 0.45 kwh of energy per day.

On the other hand, there are 12 Watt LED bulbs, which use less power, which is equivalent to that, but provides the same amount of lighting as the other bulb. The amount of energy spent with this bulb is 0.072 kwh per day.

When looking at the billing for the consumer,

Considering that the average billing unit fee in our country is 0.54 TL kw / s [321],

This consumer;

When used 1 incandescent lamp, daily cost = 0.45 x 0.54 => 0,243 TL.

When the monthly (30 days) invoice is calculated, it is reflected as 58,32 TL for a total of 8 same type lamps.

The same consumer;

When used 1 LED Lamp, daily cost = 0.072 x 0.54 => 0.039 TL.

When the monthly (30 days) invoice is calculated, it is reflected as 9,33 TL for a total of 8 same type lamps. These calculations are given as a whole in Table 6.1.

Table 6.1. Consumer Lighting Devices Price Comparison

	Incandescent Lamp	**LED Lamp**
Energy spent for 1 day (8 pcs bulb)	3,6 kwh	0,576 kwh
Pricing for 1 day (unit price, 0,54 TL)	1,944 TL	0,311 TL
Monthly Invoice Amount (30 days)	58,32 TL	9,33 TL

As it can be seen in Table 6.1, LED lamps provide a great gain in consumer's monthly bills as economic gain. According to the sales prices, LED lamps are 8 times more expensive than other lamp prices. However, it can be predicted that the use of LED lamp pays for itself in the first 3 months.

It is said that glass and doors that do not transmit heat for heating and cooling systems but that will reflect the maximum daylight outside have a big role in smart houses. Thus, based on the literature, it is reported that the expenditures in this item within the household are over 40% [318].

6.4. Smart Building / House Systems Challenges

Human needs and desires that increase each day are a challenge in technology as well. Each new technology brings other needs for users and contribute to the emergence of unavoidable desires. As discussed in smart home/building literature, one of the main issues is the development of applications that are appropriate with the user’s daily life and requests [322 - 324]. Chan et al. [322], who focus particularly on the integration of health with home management and smart homes established through this integration, emphasize the importance of developing user-friendly technologies and integrating these technologies into their lives.

On the other hand, Komminos et al. who study the challenges of building a smart home, categorize the challenges in 2 groups. In the first group addressing the process of necessary standardization by higher officials, they list the challenges of auditing of procedures, examining cyber security systems, and adding new protocols. In the second group, the challenges are evaluated at a technical dimension and include the control of integration processes of electrical devices into smart homes. And creating encryption systems for users in automated measurement infrastructure and broad band measurements, and to develop new attack detection systems for jamming attacks that may occur in the home network [325].

There are many security gaps in smart homes where wireless networks are used and thus, they are exposed to different cyber attack types [326]. In a study conducted by Saxena et al., the types and functions of these attacks are presented [327]. These attacks and the damages they can cause are listed below [327].

- Eavesdropping: In this attack which eavesdrop the conversation between two ends in the home network, the data schemas are obtained under disguise as a user that is registered in the system but who doesn not have information.
- Masquerading: The purpose of this attack is to obtain data from the system and access to original services by using a fake ID besides the main user.
- Replay Attack: The data exchange between two points in the home network is repearted with a malevolent purpose. The aim is to replace the original point and eavesdrop to the data easily.
- Message Modification: In addition to capturing data between two nodes and the origional messahes, messages that are malevolent to the system are conveyed.
- Denial of Service: Smart home user makes multiple requests from the server in the home network through mobile applications. In this case, DoS attacks send continuoues messages to the server with the purpose of keeping the server busy and prevent requests to be responded.
- Man – In – The – Middle Attack: Following the disruption of connection between two nodes, a node is placed in between and the communication is achieved through this node. The original two nodes in the system continue the data exchange without knowing that there is a harmful and fake node. This way, both the data communication is captured and interference can be achived.

Besides the attacks listed above, there are other multiple cyber attack types. As a result of these attacks, several issues are encountered such as misinformation of users, not being able to provide planned services, access to confidential data, and data theft [328].

One of the main challenges seen in smart home systems is the design of reliabile systems to eliminate such issues and to take necessary precautions for these systems.

In addition to the protection of security and confidentiality, smart home systems should also consider energy efficiency. The fact that all the objects in the house increase the need for energy as they are digital and smart objects. Accordingly, optimization of energy use and planing device work principles accordingly constitute another challenge [326, 329].

Konya Metropolitan Municipality, which was the focus of the thesis as a case study, create smart structures and conduct studies on smart home/buildings. However, there are multiple challenges to overcome. The challenges below are among those listed by the municipality [330];

- High cost of investment and maintenance,
- Lack of an interoperability approach,
- Lack of regulations,
- Increase in pressure on building management system including increase in population, increase in water pollution, and increase in waste,
- Concern over building infrastructure that is getting old,
- High unit price of technological products to be used.

6.5. Smart Building / House System Applications in Konya

6.5.1. Konya Metropolitan Stadium

The stadium built in 2014 by the Konya Metropolitan Municipality is a sustainable structure with smart lighting systems and a Leed certificate. In the structure where LED lighting is used, all the electricity and electronic systems are controlled through a connected automation, and represent examples of smart lighting and energy use. 96 speakers are used in the sound system of the stadium and the volume is adjusted automatically based on the crowd in the environment. In this stadium that was built with a wireless infrastructure, the grass is constantly maintained at a fixed temperature and humidity level due to the automated heating and cooling systems.

6.5.2. Konya Science Center

Konya Science Center which is the first and only Leed-certified science center in Turkey is an exemplary structure for smart energy and smart building. Additionally, in building this structure, environment was taken into consideration and thus, the 50% of the construction materials used are recyclable. The benefits of having these systems from security to cooling are listed below.

- Due to the smart energy system, there is 39% of energy savings in comparison to other similar systems,
- 53% less consumption is seen in water consumption,
- 30% more quality air due to smart solutions used inside the buildings for ventilation,
- Does not contribute to global warming due to not using cooling systems that would damage the ozone layer,
- 39% less greenhouse gas emission of the building.

4. CONCLUSION, EVALUATION AND RECOMMENDATIONS

The standard of living and quality of each person is determined by themselves, as well as by the conditions, requirements and higher-level managers of the environment in which they live. Opportunities, constraints and technological development in a city have a major impact on the lives of those living in that city. In this thesis, the sub-factors that are defined as the last situation in cities and their introduction as smart are investigated. The subject of how the main components of the city have developed with artificial intelligence, sensors and related technological equipment, which are not always followed and are encountered at every point, and where and by whom, in which technological context they are realized are given by this thesis prepared. In this study, which is completed in the light of the information obtained from the academic literature, current and present applications and related institutions and individuals, smart energy, smart transportation, smart health, smart waste and smart building subjects and their sub-factors, standards, related software, programs, hardware and models are formed. In general, conceptual analysis method is also included in this thesis which is prepared as a compilation.

Also, by this thesis, a few of the promises of smart solutions are compared with other traditional devices and programs in the light of the data obtained, findings on why an intelligent system is needed and how much efficiency is achieved in this regard are gained, and it is expressed academically in a way that readers from all walks of life can understand. Information on the economic gain on the side where the citizens living in the city are located as individual users is obtained from the calculations. On the other hand, the problems in the identified enterprises are observed and stated with this study with their solutions by innovative approaches. In the following section, the results obtained for the smart city components examined and detailed are given.

On the subject of Smart Energy, besides the literature review, companies actively involved in related smart energy systems in Ankara were interviewed. The result of the interviews is that there are many projects in our country where large investments are made for smart grid systems. The implemented projects serve large organizations such as shopping malls and production factories. The number of systems reaching individual households is very small. The reason for this, it is insufficient in smart grid systems in terms of communication technologies, and only GSM / GPRS technologies are adhered to. At the same time, a comparison of mechanical and smart systems has been carried out in the light of the data received from the companies, and it has been concluded that smart systems provide a financial gain on the user side.

Smart transportation, which provides solutions with innovative approaches to the increasing traffic problem in this period when vehicles are no longer a luxury but a necessity, is given a wide coverage in this thesis. Under the name of smart transportation systems, it has been learned that everything from the protection of the safety of every object on the road from the driver, to pedestrian, to parking of vehicles, and clearing congestion at junctions can be controlled remotely via sensors. Using the literature, it is determined that there is a 90% decrease in traffic accident rates. At the same time, the effect of transportation and energy on each other is observed, in this regard, as a result of the application made during the thesis process, it is determined that a solution within smart transportation generates millions of kWh of electricity in the city.

In the smart health, it is seen that the multitude of the state's function in making the patient-doctor relationship remote and sustainable, however, it has been found out that large IT companies also play an active role. The fact that patients can be monitored remotely by means of personal belongings such as watches, clothing, especially of elderly citizens is effective in increasing their social standards of living. In addition, it is concluded that the appointment system in the e-Health concept implemented by the government increases patient satisfaction by more than 20%. It is seen that smart transportation systems have an impact on health as well, and it is concluded that emergency vehicles communicate with other vehicles on the highways and gain priority of transit and thus increase the survival rate of patients.

If the wastes around us are uncontrollable, this brings many harm both for the environment and for people. It is concluded that the sensors on the wastes promise to provide the cleanliness of the city and to provide financial gain in most of the municipal expenditure items in cities. However, it is seen that there are a lot of private institutions for smart waste, but the transition to implementation by public institutions is slow.

Innovation, smart solution for houses, a miniature model of a city, basically affects the entire city. In the concept of smart house, it is seen that the management is in both the householder and a remote controller. This controller is active in everything from lighting to safety. In this thesis study, it is concluded that the use of LEDs in home lighting facilitates the remote control and, as a result of calculations, it will provide financial savings to users in monthly invoices.

As a result of the researches and calculations carried out, it is seen that smart solutions and systems in the components of smart cities not only increase the social welfare of those living in the city, but also make them gain economically. Developments in the IT sector provide a wider and sustainable benefit for citizens when evaluated and used by the public.

In addition to the positive effects of smart systems, there are many factors that will be against the users and the system during the design and usage phase. With this study, two different perspectives are evaluated for smart city components. In terms of the challenges encountered, although each component has different challenges according to its intended use, there are two main challenges. The first is data management, and the other is a security issue. Increasing system resistance against malicious attacks and processing and making all kinds of data are meaningful issues to be resolved.

Extending the battery life of electronic and digital objects and maintaining energy efficiency are other challenges. At the same time, people have to use devices that are connected to their bodies, especially in smart health. It is very difficult to design these devices so as not to harm the human body. It is seen that these multidisciplinary studies that are smart energy, transportation, health, waste management, building require interoperability. It is anticipated that it can spread to a wider audience if certain standards and regulations are determined.

Smart city is not a single entity with an idea light, but it is a large-scale system that arises as a result of the main factors in that city going through certain stages and being integrated with each other. The biggest role in the integrated operation is the developments in communication technologies. As a result of the thesis, it is seen that detailed communication technologies given in tables in the thesis are the basis for the formation of a smart city.

Another study in the thesis study is to examine Konya Metropolitan Municipality smart city approaches as an example in case study. According to the reviews and interviews with authorized person who works in Smart City Organization of KMM, it is seen that the municipality deals with intelligent transportation sub-components in a comprehensive manner. Regarding smart energy systems, it makes use of the geographical location of Konya and converts the majority of sunbathing time into electrical energy and uses it in the relevant public institutions and open spaces. However, there is no sanction on smart health.

Smart grid systems are realized as pilot applications in Konya. In the light of the data received from 12 pilot regions, an intelligent network system is expected to be established for the whole city. As for the smart building, Konya chooses the buildings that will be used collectively by the public as the first example and does not yet make user-oriented studies for individual households. With green smart buildings, Konya shows that it can save energy and does not damage the environment. When the smart approaches of the municipality are evaluated, generally regional studies are available. The necessary legislation and communication infrastructure must be established for its reflection in the entire city.

With this thesis, it is aimed to be a guideway in the implementation of ideas about smart city. With this thesis, it is provided to access to information such as what kind of technologies should be used in the projects to be developed for smart city and which standards should be adhered to in these technologies. Smart Energy, Smart Transportation, Smart Health, Smart Waste and Smart Building works which are scattered in the literature have been brought together and presented as a whole. It is aimed to evaluate the smart city formation from different perspectives by investigating the challenges as well as the returns. At the same time, the studies of Konya Metropolitan Municipality are examined and they are requested to set an example for other cities. In this way, this thesis is aimed to be used in the emergence of relevant models for the implementation ideas planned to be made by both public and private enterprises.

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