Smart street lighting is a cost-effective way to prepare today's cities for the future. Savings of up to 70% in street lighting consumption were achieved in Oslo, the world's first city to implement smart street lighting.

Smart Energy

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT,
URBANIZATION AND CLIMATE CHANGE

DIRECTORATE GENERAL OF GEOGRAPHIC INFORMATION SYSTEMS

Smart Cities Capacity Building and Guidance Project

Training Manual

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT,
URBANIZATION AND CLIMATE CHANGE

SMART **ENERGY**

Smart Cities Capacity Building and Guidance Project

www.**akillisehirler**.gov.tr

DECEMBER **2020**

"We will broaden new horizons in urbanism with smart cities. We will support all Smart City applications that will expedite the daily life of our people, from access to municipal services to the management of transportation, energy, buildings and devices."

"We are pursuing for constructing smart cities."
"We are setting out the principles to meet the future needs of our cities, not the past or present needs."

"We will leave cities which have identities, to be proud of, to find traces of our civilization for our future generations."

"What is the main thing? The main thing is the human. We will provide opportunities for the human."

Recep Tayyip ERDOĞAN

President of the Republic of Turkey

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT,
URBANIZATION AND CLIMATE CHANGE

"The yields of technological developments are reflected in urban life with the concept of smart cities. One of the elements that makes up the city is culture and the other is happiness of the human. What needs to be considered is to build cities that preserve the cultural fabric and reflect their own identity. I believe that both history and culture should be strictly preserved while making cities smart."

Murat KURUM

Minister of Environment, Urbanization and Climate Change of the Republic of Turkey

SMART ENERGY
Smart Cities Capacity Building and Guidance Project

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Preface

Urban populations are increasing day by day in our country and in the world, and as a result of this mobility, cities have to cope with new needs in many areas such as infrastructure, affordable housing, water, environmental cleaning, health services, transportation and security.

The concept of "smart city" comes to the fore in responding to these needs and even creating opportunities for urban development.

With its ability to transform the information it offers into social benefit, the smart city will create gains in the titles of sustainable development, competitiveness and environmental sustainability, increase the quality of life, contribute to economic development, and serve to prepare our cities in a way that reflects the perspective of history and civilization. However, the implementation of smart cities will contribute to the realization of many goals such as "Sustainable Cities and Communities", "Accessible and Clean Energy", "Industry, Innovation and Infrastructure" and "Climate Action" specified in the United Nations Sustainable Development Goals.

In our country, parallel to the whole world, smart city applications are becoming widespread day by day. Therefore, it is important that all public institutions, local administrations, universities, the private sector and non-governmental organizations act in a collective action in order to plan and direct smart city studies on a national scale.

With this motivation, it is to gain the ability to work together by bringing a holistic view at the national level to smart city policies in our country. At the same time, it is necessary to ensure that the investments are implemented with the right projects and activities by prioritizing the investments that are compatible with the determined policies. For this purpose, the 2020-2023 National Smart Cities Strategy and Action Plan, which was built with the common mind of ecosystem stakeholders, which considers national needs and priorities holistically, has been prepared. With the 2020-2023 National Smart Cities Strategy and Action Plan Circular No. 2019/29, it was published in the Official Gazette dated 24 December 2019 and numbered 30988 and entered into force.

The "Smart Cities Capacity Building and Guidance Project" was implemented by our Ministry in order to contribute to the realization of the actions, duties and responsibilities defined within the scope of the 2020-2023 National Smart Cities Strategy and Action Plan on a national scale and to increase the capacity of all stakeholders, especially our local governments.

This document you are reading is one of the guidance documents prepared within the scope of the aforementioned project, and all guidance documents can be accessed at www.akillisehirler.gov.tr.

Contents

1

INTRODUCTION

A smart city is a city that makes efficient use of its resources, which can provide quality of life and comfort as part of sustainable development, and can provide competitive, uninterrupted urban services at affordable prices. In that context, it is clear that the systems that power all of those services should also be smart systems. Smart energy systems are rapidly developing systems that can provide all of these. These systems, which reduce the dependence of cities on foreign sources by using local energy resources, and provide efficiency and efficiency by using different types of energy together, do not only create cost advantages in terms of management, but also increase strategic options.

The Smart Energy Component, one of the Smart City components, is concerned with the development of different energy production, distribution and storage systems by creating synergies to improve urban metabolic flows. Arrangements made on issues related to the Smart Energy Component, which should be considered integrated with components such as smart economy, smart transportation, smart space, smart infrastructure, and the implementation goals included in the national strategy and action plans have started a rapid change process in this regard in Turkey.

In this guide, first of all, the smart energy component and smart energy systems are examined in terms of national and international literature, the definitions and goals within the scope of the 2020-2023 National Smart Cities Strategy and Action Plan are presented, and the relevant systems are evaluated within the framework of urban metabolism.

In the next section, the sub-components of the Smart Energy component are discussed. However, due to rapidly developing technology and technological convergence, it is not possible for the information presented in this section to cover all topics. Then, in the fourth chapter, developments in the management of smart energy are presented.

In Chapter Five, there are various examples of smart energy applications. After presenting this general information, energy trends in the world and in Turkey and policies and programs on smart energy are briefly mentioned in the sixth chapter. This dynamic and broad subject area is summarized in this guide. In Turkey, legal and administrative provisions concerning national development plans and national strategy papers are mentioned.

In the sixth chapter, the goals defined within the framework of the 2020-2023 National Smart Cities Strategy and Action Plan regarding smart energy and international cooperation opportunities for these goals were evaluated.

Finally, a comprehensive evaluation is provided.

2

SMART ENERGY

In this section, first of all, the transformation of conventional infrastructures into smart infrastructures is examined in a general way. Next, the concepts of "smart energy systems" and "smart energy component" are presented in the international literature and in the 2020-2023 National Smart Cities Strategy and Action Plan. Finally, in order to provide an intellectual basis that will contribute to the development of strategies related to the Smart Energy Component, the main characteristics of the urban metabolism framework, material and energy flows are presented.

2.1. TRANSFORMATION FROM CLASSICAL INFRASTRUCTURES TO SMART INFRASTRUCTURES AND ENERGY INFRASTRUCTURE

In general, infrastructure is defined as follows:

- A “market” that consumes matter or energy,
- Processing unit where matter or energy is converted from one state to the next.
- The place where the processing unit is located with a physical distribution structure that takes the matter or energy from the place where the processing unit is located and brings it together with the consumer.
- The environment which supplies inputs to the infrastructure system and its outputs (Nielsen and Elle, 2000).
- Additionally, when considering infrastructure systems,
- Building, using and operating-executive knowledge (know-how),
- The actors involved and their duties and responsibilities.
- The service provided by the infrastructure should also be taken into account.

- From another perspective, the energy sector as an economic sector currently operates in the following sub-sectors:
- Extractive industries
- Transformative industries
- Distributive industries (Singelmann, 1978).

The extractive sectors can be regarded as sectors such as agriculture, oil, mining (including coal, uranium, etc.). They directly extract natural resources and make them available to other industries with little processing. Transforming sectors, on the other hand, change the form of matter or the type of energy. For example, electricity can be produced with natural gas. Considering renewable energy systems, it is possible to consider them as both extractive and transformative sectors. Distributive sectors, on the other hand, are infrastructure, transportation, etc. It covers sectors and includes activities that ensure the delivery of a good, energy or service to consumers. For example, companies with power distribution networks or state-owned enterprises, natural gas distribution companies and cylinder gas distributors.

Since the definitions or functions related to energy are traditionally handled in a narrow single-sector framework, classical definitions are insufficient to explain the smart energy component that has emerged with today's technological developments and managerial changes (Lund, et al. 2017). To that end, it would first be necessary to examine the differences between conventional and smart infrastructure concepts in general.

In conventional infrastructure systems, physical elements like pumps, pipes, etc. they do not communicate with each other or communication is restricted (O'Reilly et al. 2001). For this reason, monitoring and management functions of operations are very limited. While the situation is slightly different in systems related to electric power, the situation is almost the same until smart grids, which are examined below, emerge.

In simple terms, the differences between smart and conventional infrastructure can be summed up as follows:

- Classic Infrastructure consists of a physical layer (infrastructure) and a service layer.
- In Smart Infrastructure systems, a digital layer emerges between these two layers, representing the physical infrastructure and the features of the users.

Within this digital layer, a lot of old and new information systems become interoperable.

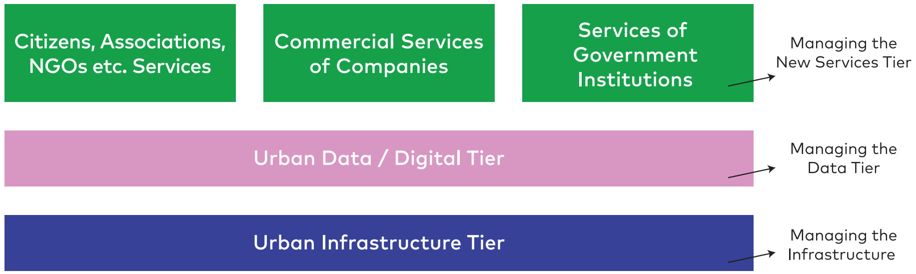


Figure 1: Classic and Smart Infrastructure Layers

Since the 1990s, innovations in information technologies have started to offer important opportunities in order to associate the components of old infrastructures with each other and to operate them as a whole. As mentioned above, developments in communication networks and developments in sensors have played an important role in this respect. Enterprise resource planning (ERP) approaches have created the opportunity to transform disjointed systems into a single and richly functional system, applications and products (SAP) and to provide uninterrupted services for operators.

With these applications, all possible business models and transactions can be standardised on one Geographic Information System (Smart/GIS) platform. The fact that construction, maintenance-repair and accidents in a wide geography can be followed simultaneously by many managers from a single source creates significant economic gains (Al-Hader and Rodzi, 2009).

Weiss (2009) argues that all cyber-physical infrastructure systems that make cities "smart" are smart infrastructures. Guizani and Anan (2014), define smart infrastructure as the combination of an smart subsystem (such as energy or water), an smart information subsystem, and an smart communication subsystem that works holistically. This means that more adaptive, longer-lasting and more efficient services can be offered to consumers and businesses. We need to take into account that they enhance the resilience of cities to disasters and economic crises.

Smart infrastructures are systems that communicate with other systems, adapt to demand conditions from users or connected devices, and connect to larger systems (Royal Academy of Engineering, 2012; Weiss, 2009: accessed in Ogie et al. 2017).

In this context, smart energy systems are considered to be systems that integrate various infrastructures.

2.2. SMART ENERGY COMPONENT AND SMART ENERGY DEFINITIONS

The Smart Energy component, a key component of the smart city concept, can be viewed as an application and management area covering smart energy systems and smart energy management.

From an infrastructure perspective, key smart infrastructure technologies include:

- Building information modeling
- Geographic information systems
- Artificial intelligence and machine learning (artificial intelligence-AI-including machine learning)
- Enabling technologies (fiber optic or wireless sensor networks, low energy microelectromechanical systems (Memss)) that provide real-time data access and processing (Liu and Tomizuka, 2003).

Another feature unique to Smart Infrastructure systems is the continuous collection, analysis and use of large amounts of information (processed and shaped data) to improve performance in the operation of the system (Engineers Australia, 2015: Ogie et al., 2017).

In simple terms, a smart infrastructure is an infrastructure in which interconnected sensor networks provide real-time digital information on the state of the system (Morimoto, 2010). According to this definition, the system has the ability to monitor itself through physical assets and digital technologies (Balakrishna, 2012).

2.2.1. Smart Energy Systems

In recent years, the terms "Smart Energy" and "Smart Energy Systems" have become more and more prevalent. The smart grid is a concept only related to electrical networks. However, today, integrated energy systems, including electricity, building heating and cooling, industry and transportation systems in smart cities, have reached quite advanced levels (Lund et al. 2017). Technological progress and convergence rates are also quite high in these matters.

Apart from being integrated systems, smart energy systems have gained great importance as they are systems that facilitate the achievement of sustainable development goals and allow the use of renewable energy resources by considering market conditions, technological limits and user needs.

The concept of smart energy systems was used for the first time in 2012 as a scientific concept to express integrated systems that cannot be expressed with the definitions of individual sectors (Lund et al. 2012). However, some professions (such as control engineering) can use the smart energy system in a much narrower sense instead of smart grids. Sometimes, rather than this concept, we use the concepts of "integrated energy systems" or "integrated district energy systems". In addition, it is seen in the literature that renewable energy systems are used by articulating existing energy systems (Lund et al., 2017).

In summary, smart energy systems, information technologies, energy technologies and developments in renewable energy technologies; It is defined as systems that emerge in a market-oriented economic structure depending on the convergence of technology, are affected by globalization and localization processes, and whose importance increases in agendas such as sustainability and urban/regional resilience. The most important aspects of recent years have been the integration between sectors and the integration of renewable energy systems with existing systems (Lund et al. 2017).

2.2.1.1. Benefit and Synergy Created by Smart Energy Systems

Lund H. (2014) and Connolly et al. (2013) "Smart Energy System" smart electricity, thermal, gas, etc. It defines it as a system where optimal solutions are produced for the entire energy system as well as for the sectors coordinated with the synergies created between and associated with the energy storage technologies of the grids. The situations in which smart energy systems generate benefits and synergies can be summarised as follows:

- The use of waste heat from industry and electricity generation for district heating and space heating.
- In cases where electricity will be used for heating purposes, heat can be stored instead of electricity as it is cheaper, economical and efficient.
- It is possible to use heat pumps for heating in district cooling systems and vice versa
- The electricity used for heating can be used to balance power and electricity networks (taking into account power markets).
- The steam needed to convert biomass to gas or liquid fuels can be produced at integrated heat and power (CHP) stations, while the low-temperature heat generated can be used in district heating and cooling systems.
- The low-temperature heat required by biogas production can be produced more efficiently by the district heating system compared to a terminal.
- By using electricity in gas production techniques such as hydrogenation, gas can be stored easily and cheaply instead of electricity.
- Energy savings in heating buildings are actually the use of a low-temperature district heating system, thereby optimizing industrial thermal surpluses and thermal resources such as power and heat terminals.
- Electricity used in vehicles replaces liquid fuels and can be used to balance the electrical network.

In addition, Dinçer and Acar (2017) identify key expectations for smart energy systems as follows.

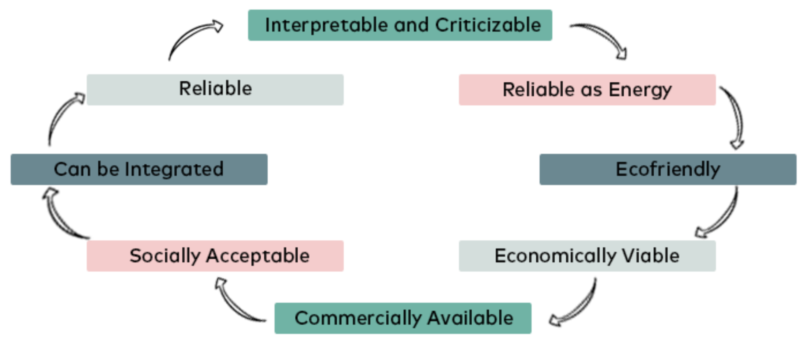


Figure 2: Prospects for Smart Energy Systems Source: Dinçer and Acar, 2017

The economic benefits of smart energy systems include balancing electricity and heat supply in the city in real time, reducing heat and electricity waste, taking advantage of the economic benefits of smarter energy for the city, electricity leakage and theft using smart meters.

The environmental benefits of smart energy systems are; To support the changing generation and consumption patterns of renewable and sustainable electricity systems, to reduce total greenhouse gas emissions by providing demand management, to increase energy resilience by integrating distributed energy sources, and to integrate renewable energy at scale to meet the clean energy demand in the future.

Smart energy systems reduce the need for additional energy generation by using all energy sources from small and large suppliers (ÇŞB, 2019).

2.2.1.2. Spread of Smart Energy Systems

As the share of renewable energy sources in the energy mix of countries increases, it becomes more important to integrate renewable energy sources efficiently into grid systems to balance supply fluctuations. Today's energy systems and smart energy systems are quite different from one another. However, the establishment of smart energy systems and the spread of related technology face many obstacles. In this framework, the transformation of energy systems over time can progress at different speeds depending on technological developments. These technical challenges and possibilities are presented below (Figures 3 and 4).

Smart energy systems are all cost-effective and sustainable energy systems that stem from efforts to provide a greener future for future generations. In this system, renewable energy production,

infrastructure support and energy consumption are intertwined; at the same time, energy services are coordinated with active users and up-to-date technologies. With the motivation to be created by raising awareness of energy service providers and consumers on this issue, it will be possible to obtain more effective, reliable and clean energy with smart energy systems that work with the logic of remote monitoring and control of the entire network from the production stage to the end consumer (ÇŞB, 2019).

The idea of smart energy is based on the establishment of new generation communication networks and the creation of a versatile, sustainable, self-healing energy network to collect the rich data necessary for the realization of operational activities, with a smart electricity system that connects all supply, grid and supply elements through the smart communication system. It is based on the principle of smart grid that is reliable, sustainable, secure, manageable and works according to standards (Batal 2017).

There are many smart energy systems technologies and initiatives available to take advantage of. Computer-based remote control and automation applications, energy storage, plug-in hybrid vehicles, wireless street lamp control and smart lighting systems are among these technologies.

Today's energy system characterized by linear paths from fuel to energy demand

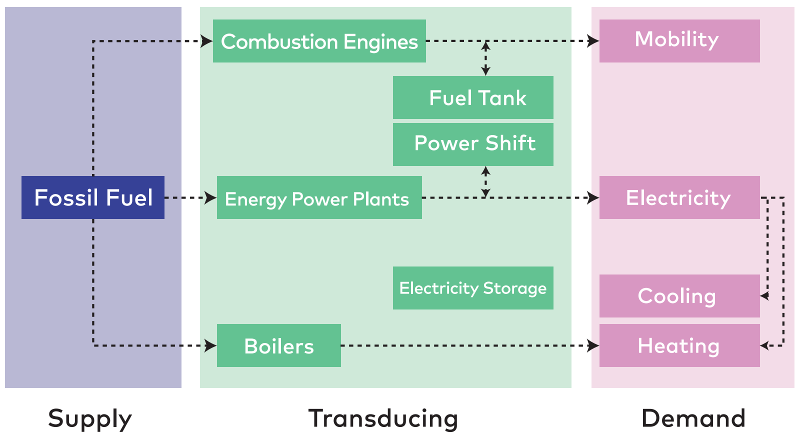


Figure 3: Today's Energy Systems

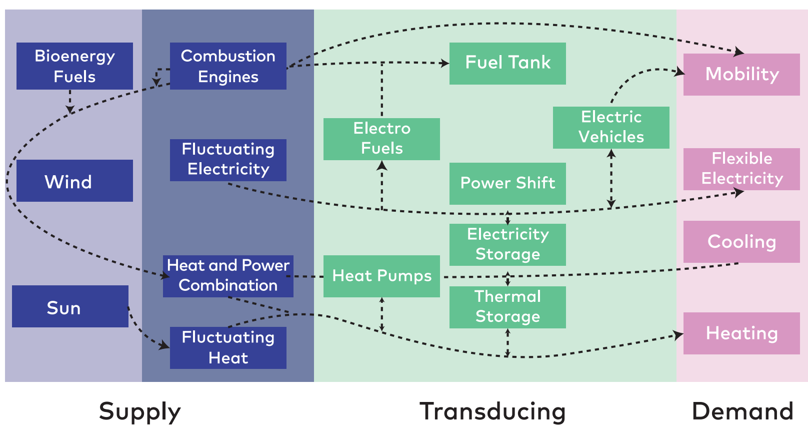


Figure 4: Smart Energy Systems

2.2.3 Smart Cities and Smart Energy Component in International Literature

In order to understand the place of Smart Energy Systems in the smart city agenda, when the applications related to smart cities and the literature are examined, it is understood that the following phenomena are observed in smart cities. (Anthopoulos, 2015; Fernandez-Anez, Fernández-Güell & Giffinger, 2018; Nam & Pardo, 2011; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014; Paskaleva, 2011):

- High educational density, knowledge-intensive employment and types of work, knowledge-based sectors
- Evidence-based planning systems exist
- Sustainability-oriented initiatives,
- Creative - innovative actions,
- Higher quality of life,
- Smart management of resources,
- Existence of participatory governance processes,
- Technological convergence resulting from extensive and intensive use of information technologies,
- Widespread use of solutions other than information technology such as resource technologies, green infrastructure, material technologies and circular economy,
- Gain competitive advantages in terms of economy and quality of life with a smart mix of advanced and conventional technologies.

In this context, a component of Smart Energy, Information Technologies and using participatory processes, that serve the objectives of sustainable development of creative-innovative energy solutions and providing services that enhance quality of life, resources are managed wisely, where a system that uses a clever combination of conventional and advanced technologies for the development, operation and management can be defined as.

2.2.4. Smart Energy Definition in 2020-2023 National Smart Cities Strategy and Action Plan

In the Smart Energy 2020-2023 National Smart Cities Strategy and Action Plan, "Highly efficient in terms of energy and resources, and increasingly supported by renewable energy sources, providing cost and energy savings; It is the management of energy with integrated and flexible resource systems for strategic planning, as well as grids based on insight, public value and innovative approaches." defined as.

2.3. SMART ENERGY COMPONENT AND URBAN METABOLISM CONCEPT

Although it is an ancient idea, the concept of urban metabolism in the contemporary sense was first suggested by Abel Wolman (1965) (Fischer-Kowalski and Hüttler 1998). Today, the concept of urban metabolism, which provides an important intellectual integrity in terms of smart energy approach, includes four items:

- Total inputs (energy, materials, capital, information),
- Distribution of inputs within the city to maintain urban functions,
- Total outputs (products, emissions, knowledge or cognitive skills),
- Functions that regulate these flows and distribution (Bai and Schandl, 2010).
- Using an urban metabolism perspective, Bai and Schandl (2010) identify eight material and energy characteristics of urban ecosystems:
- Material and energy budget and route: Which materials and types of energy flow through which channels within the urban ecosystem and what are their global implications?
- Material and energy density: What is the material and energy density per capita or per area?
- Material and energy efficiency: How many services or products can be produced based on unit material or unit energy consumption (and unit benefit from recovery)?
- Accumulation and recovery rate: How much material or energy can be recovered? How long can it be kept in the system?
- Self-sufficiency or external dependency: At what level is the

city self-sufficient?

- Heterogeneity within the urban ecosystem: How are the indicators of material and energy density, efficiency, recovery rate and self-sufficiency distributed within the city? (on the basis of subunits and whole)
- Variation based on time and space: How do material and energy flows differ between different cities?
- Regulatory capacity: Are there effective legal and administrative processes to manage material and energy flows in the urban ecosystem?

The urban metabolic perspective provides an important intellectual framework for smart energy systems to produce efficient and sustainable solutions. Understanding the flows of nutrients such as carbon, nitrogen and phosphorus in the biogeochemical budget of urban ecosystems, as well as understanding the anthropogenic flows in much greater amounts than these, is necessary to calculate the ecological footprint of cities and to manage urban ecosystems effectively and efficiently. Considering that smart cities are described as sustainable, healthy and competitive cities, it is clear that the urban metabolism perspective will contribute to the design of smart energy systems that will serve to create a healthy, strong city in harmony with its environment.

In this context, for example, when the energy losses in the USA in 2001 are examined, it is understood that a significant part of them originates from urban areas and in fact, a significant part of this can be prevented (Figure 5). As can be seen, the greatest losses concern the electricity and transport networks (Figure 6).

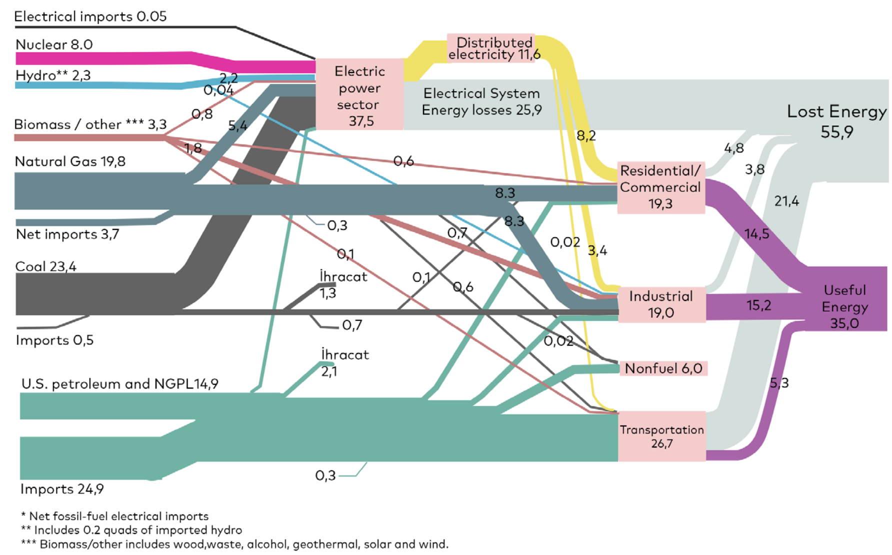


Figure 5:Energy flows and lost energy in the USA in 2001 Source: Amin, 2008

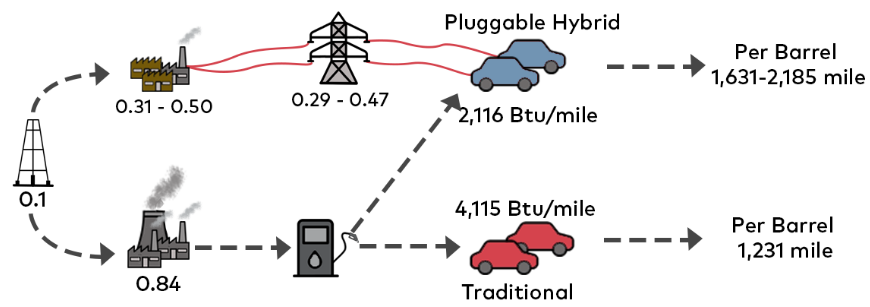


Figure 6: Distance Covered by Conventional Vehicles and Hybrid Vehicles Per Oil Barrel Source: Amin, 2008

3

SMART ENERGY SUB-COMPONENTS

The smart energy subcomponents are summarized below. It should be kept in mind that the following definitions may be limited due to the accelerated technological innovations and technological convergence today.

3.1. SMART GRIDS

Today, we see that drinking water and utility systems or gas systems, especially electricity systems, are becoming state-of-the-art systems with cutting-edge technologies. On the one hand, applications related to a single type of energy such as the smart electricity grid have emerged, on the other hand, systems where different forms of energy can be distributed, stored and redistributed are discussed.

Small electricity grids that emerged piecemeal in the 19th century and became so complex that they damaged each other and the city (Klein, 2010), after the 1960s, thermal power plants powered by fossil fuels, biomass or nuclear energy and hydroelectric power plants operated together in the national interconnected systems began to evolve. In this context, some of the energy is captured in the form of water in dams or by the storage of solid or liquid fuels; A period in which supply-demand imbalances are tried to be resolved in the networks has also passed. However, imbalances in national and federal electricity grids, for example in the USA, began to cause major power outages and associated economic losses in the 1990s. In the early 2000s, the population affected by these cuts continued to increase (Amin, 2008). Investments made to solve these imbalances have started to cause great costs. The sensors added to the systems for their solution and the SCADA systems developed have faced the risk of cyberattacks.

With the emergence of new technologies in this context and the

opportunities offered by information technologies, power grids are becoming smart systems first and then smart systems.

A conventional electricity network is a network of interconnected networks that transmit electricity from the generator to the consumer. In such a system

- Electricity generation stations,
- High-voltage lines (lines that carry long-distance electrical energy produced in remote places outside the city),
- Electrical substations (intermediate stations that reduce the voltage of electrical energy),
- There are distribution lines (short-distance networks that deliver electrical energy to the consumer).

Smart electricity grids (Guizani and Anan, 2014) define smart infrastructure as a combination of an smart subsystem (such as energy or water), an smart information subsystem, and an smart communication subsystem that works holistically. This means that sustainable and more effective services can be delivered to consumers and businesses. It can also be thought that these improve the resilience of cities against disasters and economic crises.

Smart infrastructures are systems that communicate with other systems, adapt to demand conditions from users or connected devices, and connect to larger systems (Royal Academy of Engineering, 2012; Weiss, 2009: Ogie et al., 2017).

Smart grids are composite systems with those characteristics. The electricity, which was taken from a small number of large power plants in the past and distributed to the networks, is now taken from many large power plants and distributed to the networks. Network imbalances created by this, pricing-distribution-sales problems, problems created by idle capacity can be solved through smart grids.

As mentioned above, various energy sources and demand points must be integrated. This is possible with an interconnected relay network, namely the smart grid, with a wide range of capabilities and capacities. The features of a smart grid are:

- **Durability:** Ability to self-repair and adapt,
- Instant damage control capability,
- **Reliability:** Dynamic load balancing,
- **Flexibility:** Being able to host alternative off-grid energy sources,
- **Interaction:** Ability to interact with consumers and markets (adaptive),
- **Availability:** Optimized to make the best use of resources and equipment,
- **Integrated:** Monitoring, control, protection, maintenance, marketing, informatics etc. in a structure where subjects are integrated,
- **Secure:** More secure against hacking and destabilizing events.

A smart grid is an electrical system that conducts monitoring and management activities from power generation points to power consumption points using digital and other advanced technologies. Smart grids manage the needs and capacities of power generation units, grid operators, consumers and electricity market stakeholders. The objectives of the smart grid are to operate the system in the most efficient way, minimize costs and environmental impacts, and maximize electrical system durability, reliability and stability.

Smart grids control electricity flows; power grids adjust for changes in supply and demand. Smart grids provide real-time consumption information to producers and consumers by using the data they receive from smart meters. Consumers can adjust their energy consumption amounts and consumption times depending on the price movements during the day. It can reduce its energy bills by consuming it during the hours when the electricity price is low.

Smart grids improve the integration of renewable energy into power grids. The integration of renewable energy can be planned using energy demand data and meteorological forecasts. Load balancing can be done better in the network. It can be ensured that consumers who produce their own energy respond better to price changes. Producers can sell their surplus production to the grid (Elzinga, 2014).

Electricity grids consist of more than one grid, power plants and businesses. Communication and coordination between the units should be ensured effectively.

Smart grids:

- They facilitate the operation of generation units and their connection to the grid,
- They involve consumers in the optimization of network activities,
- They give consumers more information, offer more manufacturer choices,
- They reduce the environmental impact of all components of the electrical system,
- They increase the continuity and stability of electricity supply.

Smart grids can reduce electricity usage during high-power hours, known as demand management. With smart grids, grid connection of distributed electricity generation units such as photovoltaic panels, small scale wind turbines, micro scale hydroelectric systems, micro cogeneration can be provided. By integrating storage systems into the grid, fluctuations arising from distributed electricity generation can be balanced; malfunctions can be avoided. Smart grids are expected to reduce consumers' energy expenditure and carbon dioxide emissions. Reducing the dependence of countries on external energy sources is also considered as a reason for increasing investments in smart grids. Smart grids are expected to better resist military and terrorist attacks (Vijayapriya, 2011).

3.2. SMART METERS

The energy data consumed by the smart measurement (counter) is collected and assessed in the management system. As a result of this evaluation, production is made as much as the energy to be consumed. The energy needed is transferred to the consumption point via transmission and distribution lines. Thus, by producing

energy in accordance with the instantaneous demands of consumers, energy production, especially from fossil fuels, takes place in the form of demand estimates (ÇŞB, 2019).

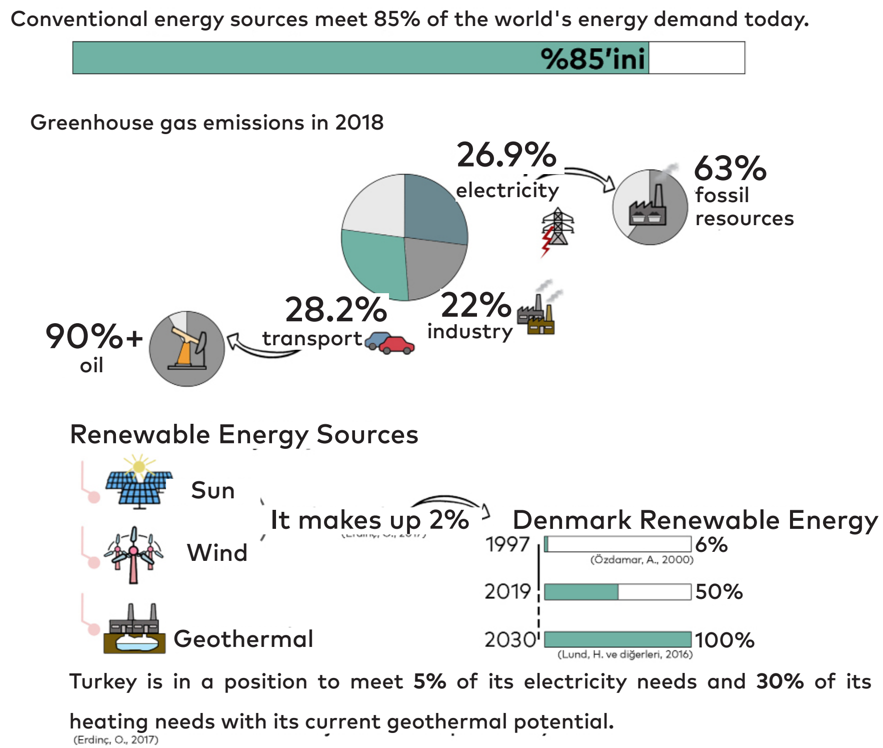


Figure 7:Summary Data on Conventional Energy Sources and Renewable Energy Sources Source: United States Environmental Protection Agency, n.d.

3.3. RENEWABLE ENERGY SYSTEMS

Conventional energy sources such as oil, coal and natural gas supply about 85% of global energy demand (Erdinç, 2017). However, the limited reserves of these resources and the adverse effects of their use on the ecological system show that they are not sustainable energy resources. On the other hand, alternative and renewable energy sources such as solar and wind, hydroelectricity, bioenergy, wave energy and geothermal energy are sustainable and environmentally friendly.

Furthermore, electricity generation accounted for 26.9% of greenhouse gas emissions in 2018. About 63% of the electricity is obtained from the burning of fossil resources such as coal and natural gas. However, the industrial sector accounts for 22% of greenhouse gas emissions, and the use of fossil fuels again comes to the fore when looking at greenhouse gas emissions from industry. Transportation, on the other hand, accounts for 28.2% of 2018 emissions, and its main source is the use of fossil fuels. More than 90% of the fuels used for transportation originate from petroleum (United States Environmental Protection Agency, n.d.). In addition, traditional energy sources are used in many fields such as building heating and agricultural production.

The increased use of renewable energy sources highlights the importance of the smart energy system and its flexibility. Flexibility in smart energy systems is realized with a regional approach. The integration of the energy produced in renewable power plants with smart grids realizes the transfer of energy to the grid in the most efficient way.

3.3.1. Solar Energy Systems

Solar power is the primary energy source on Earth, excluding nuclear fuels. Solar energy is collected from two different sources, such as heat and electricity. Even if it has a simpler system and low cost, it enables the use of the thermal collection method; With the development of technology and the increase in efficiency, systems that directly convert the light falling from solar energy into electrical energy have also been used.

Photovoltaic systems that convert solar energy into electrical energy are long-lasting systems that can exceed 20 years. These systems can operate in all meteorological conditions, but the brightness of the sun affects the amount of electrical energy produced. On the other hand, when mixed with other energy systems, the efficiency of solar energy systems is very low and its performance decreases over time due to the decreasing life of the materials (Erdinç, 2017).

The absorption of sunlight by gases such as CO_2 and ozone, which rise in the atmosphere with carbon emissions, reduces the value of sunlight falling onto the earth. In other words, carbon emissions and the use of conventional energy sources have a bearing on the efficiency of solar energy.

3.3.2. Wind Energy Systems

The thermal differences created by sunlight on the Earth's surface provoke pressure differences. As a result of this pressure difference, the air movement from high pressure areas to low pressure areas is called air flow, that is wind. In other words, like all other sources of energy on Earth, it is solar-based and accounts for 2% of the solar energy that arrives on the world (Erdinç, 2017).

Wind systems can be deployed on land or offshore. Wind farms installed on the sea have a higher wind potential than those installed on land. However, installation, maintenance and transportation of the generated energy are more costly and difficult. In addition, wind energy farms can affect natural life and especially the migration routes of migratory birds due to the air flow and noise they create. This situation points to the importance of site selection in determining wind energy zones.

Denmark, with 6% of its energy production (Özdamar, 2000) in 1997, supplied half of its energy production from renewable energy sources in 2019. Wind energy, whose share was 43% in 2017, increased to 47% in energy production in Denmark in 2019 (İklim Haber, 2020). Again, Denmark aims to produce electricity from 100% renewable sources by 2030 (Lund et al., 2016).

3.3.3. Geothermal Energy Systems

In addition to solar and wind energy, geothermal energy, which is the thermal energy derived from the earth's structure, is also widely used among renewable energy sources. Turkey is in a position to meet 5% of its electricity needs and 30% of its heating needs with its existing geothermal potential (Erdinç, 2017). In addition to geothermal energy, bioenergy, including biodegradable organic materials; The wave energy achieved by the movement of water in the seas and oceans is part of renewable energy sources.

3.4. DISTRICT HEATING AND COOLING SYSTEMS

Remote heating and cooling systems are systems that produce and distribute thermal power. These systems are described in more detail below.

3.4.1. District Heating Systems

The heat generated by district heating systems circulates through the system and is conveyed to the buildings. Heat exchangers in buildings transfer heat to heating systems or hot water systems. The water in the network that loses its heat is sent back to the power plant to be reheated.

The earliest district heating systems were constructed in New York between 1870 and 1880. District heating systems are widely used in Russia, China and the European Union. In Denmark, 50% of the heating demand is met by district heating systems. Achieving similar rates within Europe is considered economically viable. Research continues on the integration of district heating systems with lower-carbon power sources and other networks.

Studies for district heating systems are more than studies for district cooling systems. However, it is expected that there will be an increase in cooling demand worldwide.

For example, factors that create cost advantages such as heat produced in cogeneration systems, economies of scale, and use of wastes as fuel play a role in the development of district heating systems. Today, environmental considerations are driving the development of district heating systems.

Three points emerge from the technological changes in district heating systems:

1. The use of waste heat and renewable energy has resulted in a reduction in carbon emissions from district heating systems in Europe.
2. District heating systems are made more efficient by enabling them to operate at lower temperatures.
3. District heating systems are integrated into energy systems such as cogeneration and heat pumps.

District heating systems play an important part in integrating variable renewables. District heating systems can be used for heat storage.

Thermal power stations, waste incineration plants, waste heat from industrial processes may be considered sources of heat in

district heating systems. Regional heat systems contribute to the more efficient use of fossil fuels. More than 6.000 district heating systems have reduced carbon dioxide emissions by 35% since 1990.

The reduction of carbon emissions from district heating systems is accomplished through the integration of renewable energy systems. Using biomass instead of fossil fuels, obtaining heat from geothermal sources, integrating solar collectors into district heating systems, using excess electricity from wind in electric heaters and heat pumps are among the examples that reduce carbon emissions.

3.4.2. District Cooling Systems

District cooling systems are systems based on the same logic. Cold water flows through the system and arrives at the buildings. In heat exchangers, heat exchange takes place with the cooling systems of the buildings (Galatoulas et al., 2018).

Regional cooling systems are utilized for summer cooling. Sea and lake water, absorption cooling and mechanical cooling are used as cold springs. Heat pumps can be connected to heat storage systems to provide heating and cooling. Urban cooling systems are used instead of less efficient climate control systems.

3.4.3. Low Temperature District Heating

Low-temperature district heating systems are systems with high performance, low impact on the environment and economic benefits. 3rd generation district heating systems operate at temperatures close to 100°C. Low-temperature district heating systems operate at temperatures of 50°C or less. Low temperature district heating systems can reduce the heat losses of the network by 75%, depending on the network temperatures and design conditions. It provides the district heating network, energy conversion processes and optimization of systems in serviced buildings. In this way, low network temperatures and maximum efficiency can be obtained. By evaluating all components of the system together, synergies and economies of scale can be optimized (Li et al., 2017).

3.4.4. Smart District Heating and Cooling Systems

Smart district heating and cooling systems present innovative solutions in the field of heat energy management (Mathiesen et al., 2015). Studies are being undertaken in the areas of smart heat meters, automatic monitoring and control of heat exchangers and heat storage systems. Internet of Things (IoT), thermal energy modeling and optimization, power electronics are areas that need new research (Galatoulas et al., 2018).

Like smart grids, customers can use generation and storage units in smart district heating systems. Thus, consumers can also become producers (Galatoulas et al., 2018).

There are issues around the efficiency of the transition to smart heating and cooling systems. Heat losses in old generation district heating and cooling systems and buildings with low energy performance create these problems. Making improvements in the energy performance of buildings provides economic and environmental benefits in sizing district heating and cooling systems (Galatoulas et al., 2018).

Solar energy sourced district heating systems, geothermal sourced district heating systems, heat pumps, biomass sourced district heating systems, solar energy sourced district cooling systems, water sourced district cooling systems are systems that use renewable energy.

3.5. ENERGY STORAGE AND MANAGEMENT

Energy storage is situated on the energy supply side and includes energy supply when required. In case of demand, energy is supplied towards the grid. The most important disadvantage of renewable energy sources is the high dependence on instantaneous and meteorological conditions. Many factors such as sunbathing, temperature and wind speed depend on climatic conditions as well as daily and seasonally. This situation causes the level of energy produced from renewable energy sources to fluctuate. Energy storage systems are important for balancing the production and consumption of electrical energy generated by renewable energy systems.

Energy storage from renewable energy systems tends to focus on electricity storage. The form of storage where electricity is input and output without being converted into another energy during the process is called "electricity storage" (Lund et al., 2016). But an integrated energy system should be considered alongside smart energy systems. In the integrated energy system, renewable energy systems are integrated into the smart energy system with the most suitable solutions.

Although energy storage from renewable energy sources is carried out on electricity storage, this is not the optimal solution. Since the aim of smart energy systems is maximum efficiency and sustainability, other parts of the energy system need to be integrated and the need for electricity storage; should be considered as a whole with the smart grid approach and flexible electricity demand in electricity supply.

In short; Although renewable energy is sustainable, it is not valid unless the electricity produced is stored (Lindley, 2010).

3.5.1. Electricity Storage

Electricity storage is considered a major component of renewable energy systems. However, on the other hand, efficient storage and power portability are very important to the widespread use of renewable energy. In this context, it is expected that the electricity sector will come to the fore by forming a connection with other sectors and shaped in an integrated manner (Lund et al., 2016). Because the thermal and transportation sectors can offer cheaper and more efficient storage opportunities compared to the electricity sector.

The main difference between the storage of electricity and the storage of other types of energy lies in the cost involved. Even if the exact cost varies due to different factors; In terms of unit capacity investments, the thermal storage cost is 100 times lower than the electrical energy storage cost (Lund et al., 2016). On the other hand, gas and liquid storage technologies are much less costly than thermal storage.

Again, electricity storage has high losses compared to other types of energy storage. In thermal storage, losses are around 5%, largely depending on size and storage time (Lund et al., 2016). Gas and liquid storage forms have close to zero losses.

Although electricity storage takes 400 cycles per year, thermal storage (including gas and liquid storage) involves far fewer annual cycles than electricity storage. Energy can be stored for weeks, months and years in these storage systems due to small investment costs (Lund et al., 2016). This demonstrates that energy storage technologies should include an integrated system for thermal, gaseous or liquid storage of energy from renewable energy sources.

The integrated design of the energy produced from renewable energy sources with thermal, gas and liquid storage systems instead of electricity storage; It should be applied to community-based areas rather than individual buildings. Especially when small-scale and large-scale storage costs are compared (Lund et al., 2016), the regional storage approach is more appropriate than the development of storage capacity for renewable energy sources such as wind and solar.

Losses in heat, gas and liquid storage systems are caused by energy conversion rather than the storage process. The establishment of a lower cost and efficient energy system is possible with an integrated smart energy system.

3.5.2. Heat Pumps

Heat pumps are conversion technologies that contribute to thermal storage by converting the energy generated by renewable energy sources from electrical to thermal energy. Heat pumps and thermal storage systems play an important role in the inclusion of electricity produced from fluctuating renewable energy sources, especially wind, into the integrated smart energy system (Østergaard, 2013). In other words, the inclusion of heat pumps in the district heating system in buildings and urban areas connects the electricity sector and thermal storage (Lund et al., 2016).

3.6. SMART BUILDINGS

All buildings, including farm structures, represent 40% of the world's energy demand (Bertoldi and Atanasiu 2006; IEA 2006; WBCSD 2005). In this context, the transformation of buildings into smart buildings with the help of information technologies and other technologies should be considered as a serious issue within the scope of smart energy systems.

Zero energy buildings are buildings that generate as much or more energy than they use, using renewable sources of energy. In cases where renewable energy production is more than demand, excess energy can be stored and/or given to the grid. In cases where renewable energy generation and/or stored energy cannot meet the consumption, the energy need is met from the grid.

The majority of energy use in buildings is spent on heating and cooling. By shifting the energy consumption of buildings to different time zones, the energy demand flexibility required by the energy grids can be achieved.

Buildings are key to the smart energy transition. Buildings should have demand flexibility in line with the generation and storage conditions of the energy networks. The energy flexibility of a building is its ability to be managed depending on the energy demand, energy production, local climatic conditions, user needs and the working conditions of the energy networks it serves. Energy flexibility of buildings; It can be defined as providing the opportunity to determine the needs of the networks that provide energy services to the buildings, to manage the energy demand of the buildings according to their demands, and to control the energy loads of the building.

The thermal mass of the construction structure can be used to ensure energy flexibility. Physical properties, size and location of the thermal mass in the building; determines the heat storage capacity and the amount of heat it can store. Heating and cooling loads can be shifted with the use of thermal mass by paying attention to comfort conditions. Thermal mass; based on the size of the thermal mass, the heat loss of the building, the heat sources inside the building, the climatic conditions, the behavior of the building users, it can serve from one to two hours to several days.

In addition, energy storage units such as water reservoirs and electrical batteries in buildings can provide flexible demand. Hot water storage tanks can be heated and used when the time comes, for heating the environment and meeting the need for hot water.

In recent years, extensive studies have been conducted to increase the energy efficiency of buildings. Building standards are constantly being improved. Buildings are no longer passive energy consumers and passive energy producers. Buildings must be converted into active consumers/producers in accordance with the operational needs of the energy networks. Buildings are expected to show flexibility in energy use.

Within that context, buildings.

- Increase energy use to times when renewable energy is high,
- Reducing energy consumption in the hours when the energy is low in the network,
- It is expected to provide flexibility by storing energy.

Flexibility can be provided by storage systems where access to energy is expensive; In cases where the energy demand is high, reducing the energy demand can also be achieved by meeting the decreasing energy demand in the future.

3.7. ELECTRIC VEHICLES

While electric vehicles are not a primary consumer product in the automotive sector, environmental concerns are replacing (conventional) fossil-fuel vehicles. by technological developments and investment incentives. The energy regulations and systematic initiatives of cities, which have gained importance with the dominant energy policies in the world and the Smart Cities megatrend, are changing the future of the automotive industry.

Electric vehicles (EV) were invented by Thomas Davenport in 1834. In 1859, Gaston Plante invented the rechargeable battery, reducing electric vehicle costs and increasing vehicle operating time (Sulzberger, 2004).

Though these developments continued until the early 1900s, the use of electrical engine parts in internal combustion engines began in the 1930s. In the 1970s, with the oil crisis, electric vehicles became popular again in the automotive industry (Larminie and Lowry, 2003). Environmental pollution, fluctuations in oil prices in the 1990s and the development of the electrical infrastructure compared to the beginning of the 1900s and the halving of their prices have increased the importance and investments of electric vehicles in the automotive sector until today (Larminie and Lowry, 2003).

In today's world, electric vehicles are expected to be used to a greater extent in the future.

With the acceleration of environmental policies announced by the European Union, the development of the technological infrastructure of cities and the change in global economic policies, more than 200 thousand electric vehicles were sold all over the world in 2013 (Shahan, 2013).

The European market has gained great momentum in the sales of hybrid electric vehicles in recent years due to its structure adapted to electric vehicle technology. Increasing environmental awareness, rapid developments in electric vehicle technology, large investments, interest in hybrid electric vehicles (HEV) by consumers and strong incentive policies have made the conditions suitable for the widespread use of electric vehicles (Yağcıtekin, 2014).

An estimated 35 million electric vehicles will enter the automotive market by 2022 (Pike Research, 2020).

Germany is aiming for 1 million electric vehicles by 2020, whereas China is aiming for 4 million electric vehicles (Zhou et al., 2010). According to studies in the USA, 10% of all new transportation vehicles will have electrical charging plug sockets in the 2020s, electric vehicles will make up more than 20% of all vehicles in 2030, and hydrogen will be used in 5% of all new transportation vehicles in the 2035s. It is expected to be used as a fuel (IEA, 2013).

COUNTRIES	PROJECTION YEAR	QUANTITY-RATIO
Austria	2020	100 000 EV
Canada	2018	500 000 EV
Chinese	2030	20% - 30% EV rate
Denmark	2020	200 000 EV
England	2020	1 200 000 EV + 350 000 HEV
France	2020	2 million EV
Germany	2020	1 million EV
Ireland	2020	230 000 EV
Israel	2012	40 000 - 100 000 EV production
Holland	2020	200 000 EV
New Zeland	2020 and 2040	2020: %5; 2040: %60 EV rate
Spain	2020	2,5 million EV
Sweden	2020	600 000 EV
Switzerland	2020	145 000 EV
USA	2020	1 million EV
Australia	2050	65% EV rate

Table 1: Electric Vehicle Future Projections of Countries Source: IEA, 2014

Considering that the number of electric vehicles in cities will be high in the future and that these vehicles will be fed from the same network, the idea has emerged that vehicles should be used as energy storage units as long as they remain connected to the network. Most EVs will be connected to the grid at night to charge. Thus, since the production and consumption will be less at night, the unit price of electrical energy will decrease. In this case, the vehicle owner will be able to fill his battery with cheap energy and resell the stored energy to the grid at a high price during the high demand for energy (Gören, 2011).

The most expensive components in electric vehicles are their batteries (Erhan et al., 2013). While the cost of batteries used in electric vehicles was $750/kWh on average in 2010, it decreased to an average of $500/kWh in 2012 and to an average of $380/kWh in 2014. This price is estimated to decrease to an average of $300/kWh by 2020 (IEA, 2013). It is thought that this decrease will be reflected in the unit cost of the electric vehicle, thus facilitating the purchasing power in the electric vehicle market (IEA, 2013). In addition, Japan's "New Energy and Industrial Technology Development Organization (NEDO)" aims to complete the next generation battery technology by 2030, which will have a range of 10 times longer (1,600 km) than the current battery technology (Zhou et al., 2010).

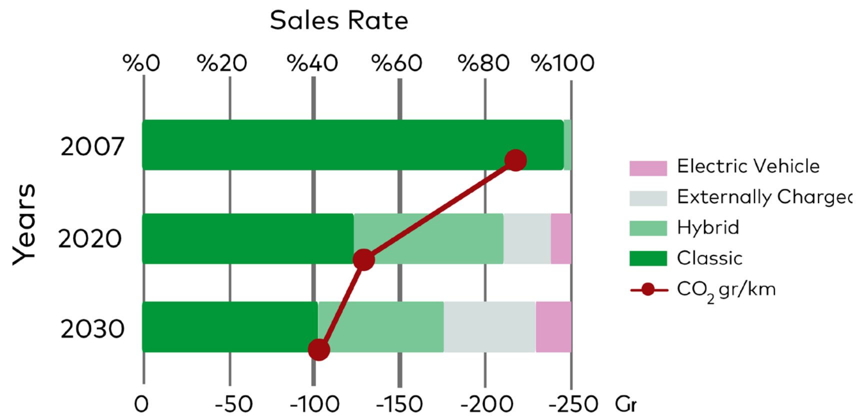


Figure 8: Distribution of Vehicles Planned to be Sold in the World by Types and Average CO2 Emission Amounts Source: Tuncay ve Üstün, 2012

Electric vehicles should not be considered a vehicle-specific concept. Together with the energy production systems and energy consumption policies of smart cities, electronic tools are a technology step and focus for cities.

Electrical engine, battery technology, power transmission systems, power electronics and control systems, etc. in electric vehicle technology worldwide. developments in such areas will increase the interest in electric vehicles. The widespread use of electric vehicles will reduce the quantity of damaged gas released into the environment, while reducing environmental pollution and dependence on oil. It is expected that infrastructure preparations will be required and network security measures will be taken and the number of charging stations to be established in public places will be increased and disseminated, and the legislation, regulations, incentives and tax reductions/exemptions to be made in the supply of electric vehicles will increase the demand for electric vehicles.

4

SMART ENERGY MANAGEMENT

Smart Energy Management is an extensive and complex field. Integrating different energy systems requires utilizing the unique strengths of each type of energy, as well as managing the risks posed by each. Considering the increasing number of interruptions in national interconnected systems since the 1990s, it is understood that even the management of purely electricity networks becomes more difficult as the scales grow. However, it is also understood that a number of technical constraints (efficiency, safe storage, network overload protection, etc.) can be overcome. faced by a single energy type, as explained above, by using different types of energy together. The evolution of software and hardware provides great opportunities for overcoming these challenges in terms of energy management (Amin, 2008).

4.1. MANAGING THE DEMAND SIDE OF ENERGY

While generating, storing and transferring energy to the grid and providing it to the user is the energy supply portion; energy use is the demand side. One of the most important issues in a sustainable energy management is to respond to the hourly, daily and seasonal fluctuations in energy demand. However, what is important here is instead of shaping the production according to the consumer's demand; to shape consumer demand (Erdinç, 2017). This approach includes the increase in demand on the power system at the peak point and the regulation of the use of expensive power plants to meet this increase. In other words, energy demand management, other than production, includes consumer management and direction.

Reducing the amount of energy needed for work with no loss of comfort is defined as energy efficiency. Energy efficiency is essential in smart energy systems and contributes to the reduction of peak points in the power system. Integration of different sources in the energy system and load planning also ensure that the peak level in the power system is reduced and when this point is reached, the demand is answered more efficiently.

In addition, in the management of the demand side, it comes to the fore that the user saves, that is, makes behavioral and functional changes that will reduce consumption (Erdinç, 2017). Price-based and incentive-based policies can be implemented by making a more balanced distribution throughout the day, instead of reaching the peak point at certain hours by intense demand of power by consumers. Tariffs can be applied to encourage electricity consumption in an era of high renewable power generation. In the case of the implementation of such tariffs, IoT can enable demand-side management and thus add flexibility to the system. Automation and digitization of home appliances are also essen-

tial for demand management and demand participation. An energy management system can be created if smart home appliances have features such as monitoring and informing activities during operation, as well as communication, remote control, and instantaneous recording of malfunctions.

Thanks to digitization, all energy consumption in buildings can be monitored. Energy consumption such as heating, cooling and lighting can be saved in the unused parts of the buildings. Like this; With the decrease in the need for new production and the use of conventional fuels, greenhouse gas emissions will also decrease. In addition, a greater focus on alternative solutions can be achieved by controlling electricity consumption costs.

4.2. BLOCKCHAIN

There is a rapid increase in the production of renewable energy. Renewable energy production from wind and sun is variable (Eid et al., 2016). Because of the changing nature of renewable energy, the components of energy systems should be more flexible. Energy supply, energy demand and energy storage systems should work in harmony in order for energy systems to work more safely and stably (Luo, 2015). As a result, energy systems become digital and the number of smart meters increases and is an integral part of them (Zhou et al., 2017).

Energy systems are becoming more complex, distributed systems in which more components play an active role. Advanced communication and data exchange between system components is required. This complicates the management and operation of electrical systems. Control and management technologies should be developed for distributed systems. Blockchain and distributed ledger technologies are designed to facilitate distributed transactions. Blockchain technologies can be used to address issues arising from the decentralization of energy systems (Ahsan and Bais, 2017).

Blockchain technologies distribution and sharing of data structures. Digital transactions are stored in these data structures without the use of a central approval system. With blockchain technologies, smart contracts are executed automatically in peer-to-peer networks (Swan, 2015). Transactions are made with the approval and agreement of all members. Agreement methods vary according to the application areas and researches are ongoing. Every member on the network has a copy of the transactions that took place. With encryption, new transactions are linked to old transactions. Encryption guarantees the safety and stability of blockchain networks. Every network user can verify that their transactions are valid.

The integration of small-scale renewable energy systems, decentralized generation, flexible energy supply and demand, and con-

sumer participation in the energy market require new solutions. Blockchain technologies can be used in the management of complex energy systems and micro-grids that have been decentralized. Blockchain technologies allow transparent and secure platforms to be created to enable producers and consumers to sell energy (Mylrea, 2017).

Blockchain technologies can be used in energy companies' business operations and business models.

- **Automatic billing:** Blockchain, smart contracts and smart meters can be used in billing processes for consumers and distributed producers (Andoni et al., 2019).
- **Sales and marketing:** By using artificial intelligence and machine learning techniques together with blockchain technologies, energy consumption profiles of customers can be determined. Consumer-specific tariffs and energy service packages can be offered (Burger et al., 2016).
- **Trade and markets:** Market transactions, energy market management, commodity transactions and risk management may be carried out on blockchain-based trading platforms. Blockchain systems are being developed for green energy certificate trading (Andoni et al., 2019).
- **Automation:** With blockchain systems, decentralized energy systems and microgrids can be controlled better (Andoni et al., 2019).
- **Smart grid applications and data transfer:** Blockchain applications can be used for communication, data transfer and data storage of smart devices (Burger et al., 2016). Smart grids have smart devices such as smart meters, sensors, network monitoring equipment, energy control and management systems, Energy monitoring and control systems for

smart buildings. With blockchain technology, data standardization is provided as well as secure data transfer (Burger et al., 2016).

- **Network management:** Blockchain technologies can provide services in distributed generation, flexibility, network management and optimization. They can be effective in determining revenues and tariffs (Andoni et al., 2019).
- **Security and identification:** Blockchain encryption technologies can be used to ensure the security of transactions, data privacy, and identification processes (Andoni et al., 2019).
- **Shared use of resources:** Blockchain systems can offer solutions for the joint use of data on electric vehicle charging infrastructure and energy storage systems (Andoni et al., 2019).
- **Competition:** With smart contracts, consumers can easily and quickly change the companies from which they purchase energy services (Burger et al., 2016).
- **Transparency:** The fact that transaction records are unchangeable and processes are carried out in a transparent manner facilitates audits and compliance checks (Andoni et al., 2019). Blockchain technologies have the potential to create new business models while changing the existing roles and business models of energy companies.

4.3. INTERNET OF THINGS

The use of renewable energy and the optimisation of energy consumption are needed for sustainable energy consumption and the prevention of climate change. IoT technologies have many application possibilities in the energy sector. IoT can be used in the fields

of energy efficiency, increasing the share of renewable energy in production and consumption, and reducing the environmental impact of energy consumption. Studies have shown that energy efficiency, reduction of energy use and a high level of integration of renewable energy technologies are required in order to switch to an energy system where fossil fuels are not used (Grubler et al., 2018).

For energy efficiency and optimal energy management, real-time data within the energy supply chain should be analyzed (Tan et al., 2017).

Internet of Things: Smart grids connecting smart devices from both thedemand and supply side

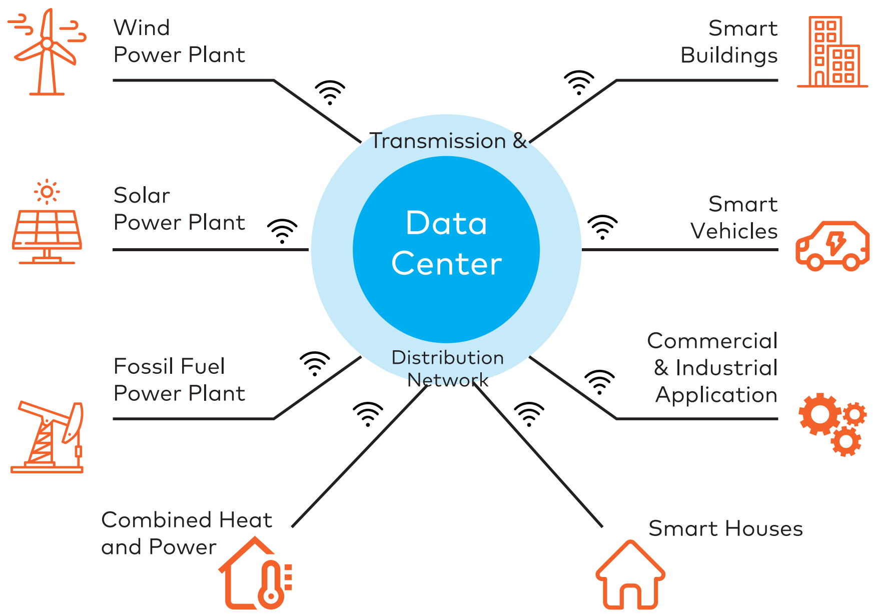


Figure 9: The Internet of Things

IoT appeals to sensors and communication technologies. By transmitting the real-time data obtained, optimum solutions are sought with fast calculations. IoT also facilitates the transformation of the energy sector. There is a transition from a centralized structure to a distributed, smart and integrated energy system. Distributed generation elements such as wind and sun are included in the energy system. Consumers with energy production systems are also becoming a producer. A significant amount of data is collected and real-time analyses are performed using algorithms. By controlling the energy consumption of consumers and appliances, energy consumption is guaranteed to be more effective (Zhou et al., 2016).

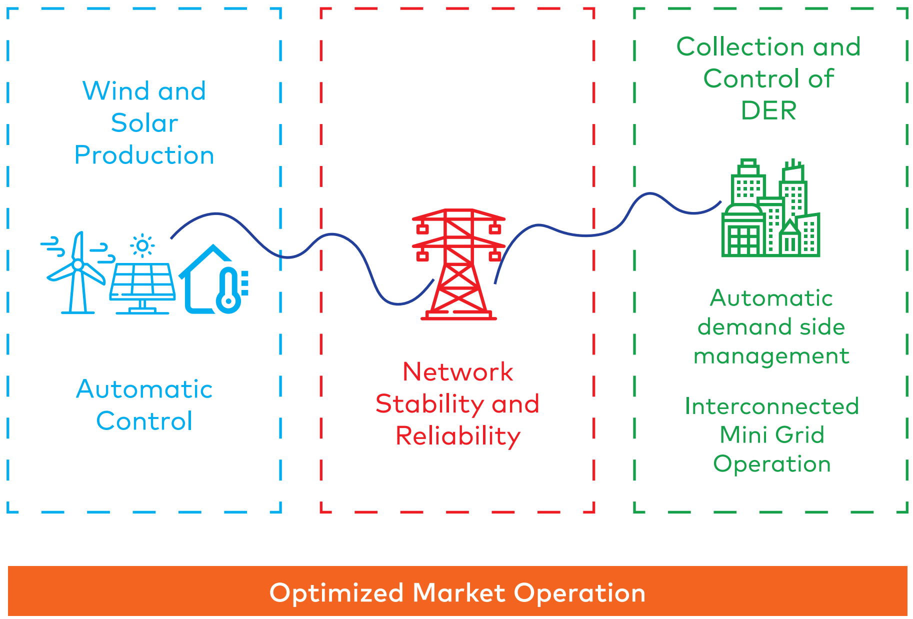
Large transformations are expected to occur in the energy sector with IoT technologies. A large amount of data can be collected at all stages of energy production, distribution and consumption. With this data, better decision support systems (artificial intelligence) can be developed, decisions taken can be executed automatically and millions of devices can be controlled remotely. With sensors and devices connected to the Internet, malfunctions and changes in production can be tracked and necessary warnings for maintenance can be madeThe efficiency and reliability of the systems are increased, while maintenance costs are reduced (Sigfox, Inc. Utilities & Energy, 2019).

With machine learning algorithms, more effective energy use can be achieved by providing the most optimal balance between energy demand and energy supply. It is possible to balance the output of thermal power plants and small photovoltaic systems (Karnouskos, 2010).

4.3.1. Renewable Energy Production Forecast

Data may be collected from wind, solar and water power plants using IoT technologies. Renewable energy forecasts can be developed using historical production levels, meteorological data, and real-time data. A better estimate of the level of renewable energy production will make it easier for renewables to participate in the energy system and energy markets (IRENA, 2019).

Advantages of Internet of Things for Solar and Wind Integration



DER: Distributed Energy Resources

Figure 10: Advantages of Internet of Things for Solar and Wind Energy Systems Integration Source: IRENA, 2019

4.3.2. Automatic Control of Power Plants

More information is available on all factors affecting electricity production. However, it is easier to make more precise predictions about the relevant factors, and in the current situation, predictions can be made with historical data. Day after day, real-time data can be used with historical data, becoming proactive transactions (IRENA, 2019).

4.3.3. Maintaining Network Stability and Reliability

IoT technologies can support stable and dependable systems. Load balancing services can be provided in networks by combining IoT with industrial and residential loads. With the automation of substations, improvements can be made in the operation. A transition to stand-alone energy grids may be achieved (IRENA, 2019).

4.3.4. Collection and Control of Distributed Energy Resources

The increase in distributed energy generation also necessitates the operation of these systems digitally. Distributed power generation complicates the management of grids. Therefore, system operators need to be able to better monitor the changes occurring in the electricity networks. Developments such as bidirectional electric current in networks, fluctuations in renewable energy production, on-site energy storage, and electric vehicle charging make digitalization mandatory (IRENA, 2019). Increasing electrification in heating and transportation is one of the developments that will increase electricity demand. The failure to manage energy demand digitally will require new network investments.

4.3.5. Connected Mini-Grids

Microgrids are networks that combine and control electricity demand and distributed electricity production, and can also be managed separately from the grid.

Mini-grids,

- It can control a lot of devices automatically,
- It can forecast energy demand and energy production,
- It can operate the system,
- It is able to optimise its energy reserves,
- It can control voltage and frequency,
- It can be connected and disconnected from the network.

Mini-grids make these activities more efficient and reduce production costs, resulting in higher revenues for the services they provide to the mainline (IRENA, 2019).

New technologies such as blockchain can ease peer-to-peer commerce in mini-grids by connecting with smart devices. Such technologies can increase transparency, minimize operational costs and provide new sources of income to producers and consumers.

5

SMART ENERGY PRACTICES EXAMPLES

5.1. PROJECT EXAMPLES IN THE WORLD

In this section, Germany's Smart Energy Networks and Management project, Malta's approach to smart energy generation and distribution, and the EU-funded City-Zen project for Amsterdam are discussed.

5.1.1. Smart Energy Networks and Management

Germany intended to connect renewable energy sources to the power grid as part of the DENA Grid Study I project. The project was shaped by the motivations to gradually increase the amount of electricity produced from renewable energy sources, which was 10% in 2004, to 12.5% in 2010 and 20% in 2020. With the integration of renewable energy sources into the system, the German government managed to reduce the carbon emission rate from 859 million tons to 846 million tons per year between 2008 and 2012. The DENA Grid II study was initiated when the results of the DENA Smart Grid Study I project were evaluated, developed and revised. The project identified three key objectives as priorities. These goals are:

- Increasing the rate of electricity produced from renewable energy sources to 39% by utilizing wind and solar energy,
- Strengthening the network infrastructure,
- To provide flexibility to consumers in their electricity purchasing preferences (DENA, 2010).

As part of the project, weak and difficult points of the existing system were identified, active and reactive power controls were made on the first project for the renewal of the system and the expansion of the lines.

Consequently, Germany has gradually incorporated renewable energy sources.with active power lines with a vision of 20 years with the projects "DENA Grid Study I" and "DENA Grid Study II". As a result, the project was carried out on a broader scale by controlling the project throughout the entire project period, realizing the necessary changes, and with consideration the outputs of the first project.

5.1.2. Smart Power Generation and Distribution

The objective of Malta was to replace all electricity and water meters in the country with smart meters over the 5-year period between 2008 and 2013. As a result, Malta is one of the countries with the largest smart grid goal worldwide and achieves this goal. It is aimed to integrate the electricity and water distribution system in the country with each other. With this project, the State of Malta has provided its citizens with a smart infrastructure to make decisions about when and how to use water and electricity, and has started the process of producing energy from environmentally friendly, natural and clean renewable resources instead of external fossil-based petroleum products. This project, which integrates different infrastructure services; It has been ensured that water waste and losses are prevented, electricity distribution systems investments are planned efficiently, resources are used efficiently, and renewable energy sources are integrated into the existing system. In the island country with a population of 409 thousand in 2013 (Malta Government Gazzette, 2013), 250 thousand smart meters have been put into operation for use in the project.; Electricity consumption was reported to local administrations by reporting daily and monthly, users were given the opportunity to choose an optional tariff, and users who consume less electricity and water was paid for and the resources used more efficiently (Enemalta, 2012).

5.1.3. Correct and Efficient Use of Energy Resources

It covers studies conducted for the correct and efficient utilization of energy, which is the most important resource of our time. It is important to inform and raise awareness of the consumer in this regard. The EU funded City-Zen Project, designed for Amsterdam, aims at a city that uses completely renewable energy sources, free from fossil fuels, on urban energy transformation (Cityzen, 2014).

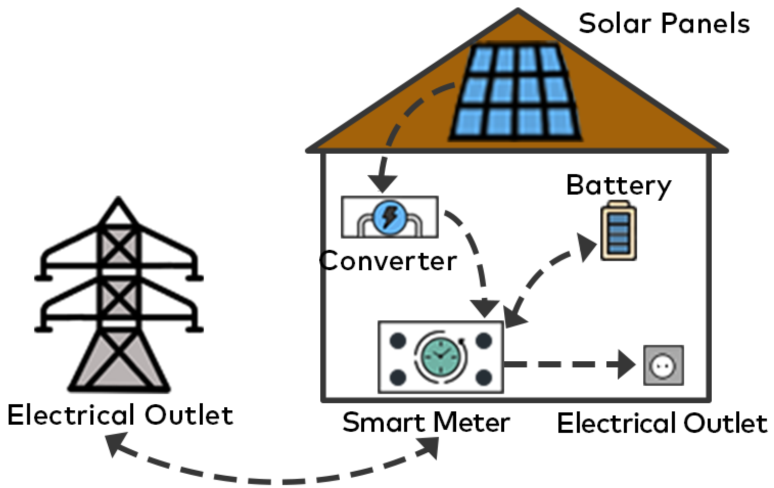


Figure 11:City-Zen Project Housing Unit and Grid Relation Source: The figure in the original source has been redrawn.[1]

The project consists of demonstrations, trainings and research on how to integrate new energy solutions (solar, wind, biomass, geothermal, etc.) into existing buildings, systems and most importantly people's lives. The project, which aims to make the Nieuw-

1 *http://www.cityzen-smartcity.eu/ressources/smart-grids/virtual-power-plant/*

West region Europe's largest Smart Energy laboratory, is a national and international project in cooperation with 23 different organizations and with an investment of 30 million. It is aimed to use resources more effectively and efficiently with the strategy of increasing the consumption understanding of users and the energy sensitivity of future generations. The connected project is one of the largest smart energy projects in Amsterdam, which includes consumers for a sustainable future with lower power consumption and energy use (TU Delft, 2018).

5.1.4. Smart Street Lighting

Smart public lighting is an economic and sustainable option for today's cities, preparing them for the future (MEU, 2019). In street lighting, which constitutes approximately 15% of the average electricity consumption of cities, it is possible to monitor and optimize energy consumption if smart applications are integrated into the existing infrastructure. In systems in which IoT is actively used, it is possible to limit energy consumption and use solar energy with solar panels.

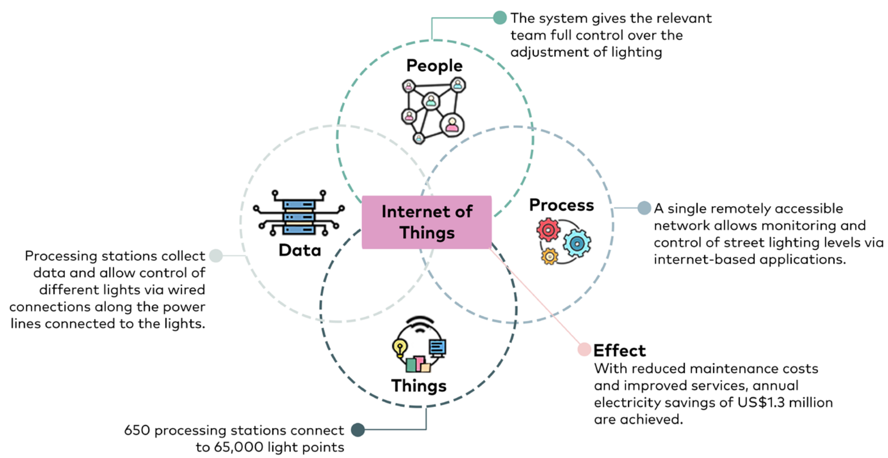


Figure 12: Oslo Smart Street Lighting Project, IoE Connections and Implications Source: Redrawn Figure in Cisco Consulting Services, The Internet of Everything, 2014.

In Oslo, the first city in the world to implement smart street lighting, savings of up to 70% have been realized in the consumption of street lighting (Cisco, 2014).

5.2. PROJECT STUDIES IN TURKEY

This part contains examples of national and local energy projects in Turkey.

5.2.1. Energy Market Regulatory Board R&D Project Supports

25 projects have been accepted by the R&D Commission based on applications submitted during the January 2020 application period under Council Decision 26/3/2020 and numbered 9268 taken by the Energy Market Regulatory Board for the use of R&D budgets given as part of distribution activities to support R&D activities in the Electricity and Natural Gas Distribution Sectors (EPDK, 2020).

Projects approved within the scope of January 2020 applications:

1. Big Data for Open Innovation Energy Marketplace BD4OPEM

The project will be completed in 42 months and is one of the 6 projects supported in the categories Surveillance and control, Communication technology, Storage technology. Within the scope of the project prepared by Osmangazi Electricity Distribution Company, it is aimed to evaluate the system to be used as a balance element, as well as a natural, uninterrupted connection between open innovation and the needs of energy stakeholders and the solutions to be developed. Today, many obsolete measuring, operating and monitoring devices that are not used at all or are used with less data processing than expected have been combined with smart systems. The improvement of existing energy services and the formation of new services such as the Open Innovation Market will be possible by processing this data through the Analytical Toolbox. In this context, the BD4OPEM Project is intended to expand the Analytical Toolbox by enabling big data techniques and tools that will contribute to the effectiveness of business processes. (EPDK, 2020).

2. Enabling Flexibility for Future Distribution Grid (FlexiGrid - Horizon 2020)

The project, which is supported in the category of Developing Technology for System Operation and Improving the Quality of Service, is expected to be completed in 42 months, and the project work was carried out by Osmangazi Electricity Distribution Corporation.

In project scope;

- Develop an integrated architecture for electricity storage, vehicle recharging, energy-to-heat conversion, demand execution and variable output, electricity grid services and flexible measures for lower carbon emissions,
- Defining, testing and establishing electricity markets, market mechanisms, using flexibility in terms of short and long-term grid demand jams and other problems such as voltage spikes faced by distribution companies,
- Establishing advanced grid monitoring and smart grid technologies with higher automation by increasing system security in order to activate the architecture and the market by bringing together actors such as distributed energy,
- With the aim of implementing the technologies of the future and commercial innovation, it is aimed to define the barriers in front of innovation and to create a regulatory reform and business model that will drive regulation through strategic collaboration (EPDK, 2020).

3. Text Based Smart Reply (ChatBot) Project

The project, which is planned to last for 18 months, is accomplished by Sakarya Elektricity Distribution Corporation within the scope of Communication Technology, Monitoring and Control project category. The distribution company has established a call center to meet subscriber demands from different channels within the scope of customer services. With the widespread use of today's mobile and internet technologies, the use of live and written resources is increasing rapidly. Subscribers prefer to submit their requests through channels such as WhatsApp and WEBChat and receive instant answers. Within the scope of this project, it aims to create an smart response robot so that the centres concerned can respond to the growing number of calls in case of malfunctions more quickly and precisely and to provide effective and standard information (EPDK, 2020).

4. Underground Assets Detection Support System

As part of the Network Communication category, the project supported by EPDK is scheduled to be completed within 12 months by Meram Electricity Distribution Corporation.

The aim of the project is to develop an "Underground Assets Detection Support System" that will enable electricity distribution companies to identify existing and newly installed underground assets and to make new inventory records to be added to these assets. Through this support system, existing resources will be determined by staff on the ground, the inventory will be entered into the GIS system and the entry of new inventories will be accelerated. In addition, it is aimed to design the first domestic and national Differential Global Positioning Systems (DGPS) within the scope of the project in order to solve the problems that arise due to the unknown location of the assets in the field. The objective is to integrate the DGPS designed with the ground radar to be provided (EPDK, 2020).

5. Project for Increasing the Continuity of Supply of Critical Loads and Power Plants by Creating Feeder Scaled Islands with Optimum Switching in Emergency Situations

The project, carried out by AKEDAŞ Electricity Distribution Corporation and scheduled for completion in 12 months, is one of the 10 projects supported in the Network Operations category. In the project;

- Investigation of the necessary technical criteria, standards and legislative arrangements on the basis of distribution network level and distributed generation level, for the creation of a -distribution feeder-scale-micro-grid (isolated island) through power plants connected to the distribution network and renewable energy sources in order to improve supply continuity in emergency network conditions,
- "Can networks to be operated in island mode with distribution feeder scale be a rational and economical solution to improve supply continuity indicators in emergencies that cause feeder interruption in the MV network?" Obtaining scientific research and findings based on analysis for the answer to the question,
- The objective is to develop concrete criteria, procedures and recommendations for implementing results from R&D projects on similar issues (EPDK, 2020).

6. Honeypot Intrusion Detection and Target Confusing Project as a Security Measure in Industrial Control System (SCADA) Systems

The project, which was supported in the category Surveillance and control, communication technologies with a project duration of 16 months, was conceived by AKEDAŞ Electricity Distribution Corporation.

In the project, it is planned to develop a hybrid interactive decoy SCADA Honeypot system that protects energy infrastructures against cyber-attackers for industrial control system-specific intrusion detection.

Thanks to the SCADA Honeypot, which will be developed with trap security vulnerabilities, a system that allows attack analysis without damaging the real SCADA network in the event of a possible attack has been developed, and when attackers try to enter the real SCADA network or look for a security vulnerability, they are caught in the SCADA honeypot, and the attackers' behavior on the honeypot, the methods and techniques they use. It aims to analyse and provide system administrators with information about the attackers' profiles, ensuring their integration with the company's information security systems (EPDK, 2020).

7. Smart Detector Vest with Nitinol Material

Via the "Smart Detector Vest with Nitinol Material" to be developed in the Occupational Health and Safety category project of Yeşilırmak Electricity Distribution Corporation, an extra precaution to prevent contact with energized lines in addition to the existing occupational safety measures, measurements, alerting employees with three senses as audibly, visually and emotionally and It is aimed to prevent possible occupational accidents (EPDK, 2020).

8. Complaint Inspection Reporter and New Generation Automatic Meter Adjustment Desk Project in Compliance with the New Consumer Services Regulation

The project, conducted by Boğaziçi Electricity Distribution Corporation and expected to be completed in 12 months, is one of the 5 projects supported in the category of materials technologies. Boğaziçi Electricity Distribution Inc. in the project. and Istanbul Anatolian Side Electricity Distribution Inc. With the minimum investments to be made in the meter laboratory, it is aimed to report the complained meters to the use of the relevant units, as automatically and quickly as possible, away from the initiative of the individual, as approved by the Ministry of Industry and Technology (EPDK, 2020).

9. National Smart Meter Systems Project

The project, implemented by Boğaziçi Electricity Distribution Corporation and scheduled to be completed in 18 months, is one of five projects supported in the Materials Technology category. In the project,

- Within the framework of Turkey Smart Grids 2023 Vision and Strategy Determination Project, determining the minimum characteristics of smart meter systems to be realized within the scope of smart grid transformation, ensuring country-wide application unity, determining the effect of this on the tariff and arranging the regulations and specifications related to smart meter systems in order to spread the application,
- It is aimed to develop the Domestic and National Smart Meter System with all its components, to conduct pilot applications with prototypes to be produced according to these criteria, to measure, analyse and report. (EPDK, 2020).

10. Examining the Problems Related to Grounding Transformer in Distribution and Creating a Solution Suggestion

The project, implemented by Boğaziçi Electricity Distribution Corporation and due to be completed in 18 months, is one of the 5 projects supported in the Network Communication category. In the project, it is aimed to reveal the problems that occur in the grounding transformers that have been developed in the past and that are still in use and that provide appropriate solutions (EPDK, 2020).

11. Harvesting Energy Efficiency in the Electricity Distribution Sector (HASAT)-2.

The project funded under the Energy Efficiency category was prepared by Başkent Electricity Distribution Corporation and is scheduled for completion within 24 months. It is aimed to carry out the pilot applications of the methods examined within the scope of the second phase and the first phase of the HASAT project and for which feasibility studies are being carried out (EPDK, 2020).

12. Green Energy Certification with Blockchain Technology

Supported in the category of Renewable Integration, Low Carbon Technology, and Demand Participation, the project was prepared by Başkent Electricity Distribution Corporation and is planned to be completed within 12 months. The aim of the project is to encourage the production and use of renewable energy by certifying the energy produced from renewable resources to customers with a blockchain-based software. Especially large-medium-sized companies are willing to use the electricity produced from renewable energy sources, which is expressed with the concept of green energy. With this project, it is aimed to increase transparency for the consumer and to have detailed information on the source of purchased energy in kWh scale. With the application to be developed on a blockchain basis, it is aimed to ensure the integration of the certificate with the price fluctuations that will occur in the supply of renewable energy due to storage and distributed generation by enabling consumers to instantly monitor the source of their renewable energies according to time and place, and allowing utilities to control energy generated and consumed from renewable sources (EPDK, 2020).

13. Measuring Digitization Levels in Distribution Companies-Method, Tools and Evaluation

The project conducted by GDZ Electricity Distribution Corporation will be completed within 12 months and is supported by EMRA in the Digitalization category.

- Determining the status of companies that carry out distribution activities in the digitalization processes, and preparing a digitalization maturity model to be used for distribution companies by determining the actions to be taken and the necessary investments in the digitalization process,

- Preparing tariff and legislative proposals for digitalization indexes to be included in the tariff structure to encourage digitalization in distribution companies,
- Better evaluation of the contribution of companies' investments in digital technologies to their digitalization levels and, as a result, their cost-benefits,
- Evaluating the effects of digital transformation practices carried out by different companies and determining the best practice examples and norms based on these examples,
- Examining the effects of digitalization levels on basic technical and commercial parameters and using these parameters in incentive and sanction practices,
- Evaluating the usability of big data collected in EDVARS,
- Creating more flexible and dynamic tariff models depending on the level and development of the digitalization index in determining the budgets of technological investments within the CAPEX budgets,
- Build models based on digitization index targets to drive digital transformation and speed up OPEX budgeting processes
- It is aimed to base the incentive mechanisms that will enable distribution companies to take other cultural-structural change steps that will support digital transformation, especially in cooperation with start-ups, on the digitalization index, and thus ensure that incentives are used correctly and effectively (EPDK, 2020).

14. R&D Project for the Development of Tree Pruning Attachments for Electricity Distribution Lines

It is carried out by ADM Electricity Distribution Corporation as

part of the Material Technology, Occupational Health and Safety, Network Operation project, which will run for 12 months. As part of the project;

- Development of two different types of tree pruning fixtures;
- Modification of vehicles with baskets for lease as part of the project,
- In order to ensure the safety of life and property, in cases where the existing risky trees are cut or pruned in a way that may pose a danger under and/or around the power lines, by taking the necessary precautions, tree cutting or pruning can be done safely without jeopardizing the life and property of the citizen,
- Minimise interruptions from tree branches
- It aims to provide benefits to distribution companies, such as faster and more efficient intervention at hard-to-access points (EPDK, 2020).

15. Development of Cable Fault Detection Device for Medium Voltage Underground Electricity Network

With a project duration of 18 months, the materials technology is done by ADM Electricity Distribution Corporation as part of the network operation project. Overhead power systems have been heavily underground recently due to urban aesthetics, safety, power outages and maintenance issues. However, in underground networks, malfunctions may occur due to workmanship and assembly errors, mechanical external effects, and short circuits. Due to the length of the underground network, the points where the fault occurs can only be detected by devices with advanced features. Since these devices are still not produced in our country, they are purchased with high budgets and there are problems in service and support. In the first stage of the project, it is aimed to develop the prototype of the device by making the main components and software, and in the next stage, mass production will be started and presented to the domestic and foreign markets. To sum up, the purpose of the project is to develop a prototype of the device that can pinpoint the location of the fault with a DC insulation test up to 40 kV and a pulse generator up to 32 kV in case of failure in high voltage underground cable electrical distribution networks (EPDK, 2020).

16. Developing a Method of Protection from Unwanted Contacts with High Voltage Systems

The project, which was supported in the materials technology category, is expected to be completed in 18 months, and the work for the project has been carried out by Uludağ Electricity Distribution Corporation.

As a result of coating to be made on overhead lines with nano-technological insulation material to be synthesized within the scope of the project, it is aimed to eliminate breakdowns, interruptions and losses caused by birds or various reasons in nature, with low cost and long durability (EPDK, 2020).

17. 'Köstebek(Mole)' – Leak Detection System Design in LV Underground Cable Networks

The project, which will be completed through the 15-month project period by Dicle Electricity Distribution Corporation, is supported by EMRA within the scope of Material Technology, Communication Technology, Monitoring and Control category. This project is aimed at developing a detection system the illegal use of LV underground cables, which is very difficult to detect (EPDK, 2020).

Counter intervention, hooking on overhead lines, external lines

drawn from the boards, etc. Illegal use can be made by many known methods. Such illegal uses can be detected relatively easily by specialized leak teams. However, underground cable leaks cannot be seen with the naked eye, they are very difficult to detect unless there is a notice, and this leakage connection can only be made by professional teams. As a result, it is planned to design a system that will systematically determine the leakage zone by using the measurement data obtained from OSOS and smart meters, and also estimate the approximate distance of the leak (EPDK, 2020).

18. Agricultural Energy Optimization Project

It is carried out by Electricity Distribution Corporation, as part of the project to operate, monitor and control the network, with a project duration of 15 months. In this project, after determining the intensity of the root causes of the high level of energy consumed in agricultural areas, it is aimed to establish applicable solution suggestions, algorithms/methodologies and optimization of energy use in agriculture, which can also be beneficial to farmers (EPDK, 2020).

19. Ensuring Concurrency Control in Natural Gas Devices

The funded project in the Network Operation category was planned to be completed within 12 months and the related project was prepared by ESGAZ Eskişehir Urban Natural Gas Distribution Trade and Contracting Corporation. Within the scope of the project, by installing a time relay on the devices consuming natural gas used in the subscribers, it is ensured that the devices are reactivated after the determined time period after the power outage, preventing the devices from being activated at the same time, and eliminating the pressure drop in the PE distribution line caused by the devices that are activated at the same time after the power cut. It is intended to eliminate the negativities encountered in the operation of the network as part of the system withdrawal (EPDK, 2020).

20. Natural Gas Safety Valve

The project, which is expected to be ompleted in 18 months by GAZDAŞ Gaziantep Natural Gas Distribution Corporation, is supported by EMRA within the scope of the Network Operation category. With the project, it aims to guarantee the safety of customers in response to any network regulator or service failures/failures (EPDK, 2020).

21. Integration of Micro Cogeneration Systems into RMS-As

Supported by EMRA under the Network Communication category, the project is scheduled to be completed within 9 months by İZGAZ İzmit Gas Distribution Industry and Trade Corporation. In this project, it is aimed to reduce operational expenses by using more efficient systems for electricity consumption and heating requirements of natural gas in A-type pressure reduction and measurement stations, whose operation and operational expenses belong to natural gas distribution companies (EPDK, 2020).

22. Emergency Response Button for Our Disabled Customers and Integration of WhatsApp to 187 and Call Center

The general purpose of this project, which was created to prevent difficulties that citizens with visual, hearing, speech or older will encounter while using natural gas; While using natural gas, it is both to ensure user satisfaction and to give the impression that they are safe. With the project, in case of pressing the button to be provided to the user during a gas leak while using natural gas, the gas supply to the remote-operated meters is stopped and the record is automatically reduced when it is supplied to the 187 system. Then, with the transfer of 187 personnel there, it is aimed to solve the necessary problems of the concerned citizens. In addition, with the WhatsApp project, the integration of the company with the departments that contact customers will be ensured with the WhatsApp application, which is now a large medium where people communicate, apart from telephone, mail or fax, both in the situations given above and in the changing world conditions. As a result, in addition to serving clients, it will reduce telephone traffic and save time (EPDK, 2020).

23. Telemetric Cathodic Protection and Corrosion Detection System in Underground Steel Pipelines

It is produced by İzmir Natural Gas Distribution Trade and Contracting Corporation in the Network Operations category, with a project period of 36 months. The project aims at establishing an efficient automation system that will provide fast and error-free access to data such as continuous status monitoring of underground transmission systems, current status analysis reports, and related details of the system (EPDK, 2020).

24. Study for Detection of Covered Pe and Steel Valves with the Help of a Detector

It is conducted by İzmir Natural Gas Distribution Trade and Contracting Corporation within the scope of Network Operation category, with a project duration of 24 months.

As part of the project, it aims to prevent lost time and make emergency responses through mounting metal parts under the covered underground valve covers in order to determine the valve location by means of a metal detector (EPDK, 2020).

25. KASVETA (Home Subscribers Hourly Data Collection and Analysis) Project

Torosgaz Isparta Burdur Natural Gas Distribution Inc. It will be finished within 18 months and is supported by EMRA in the Monitoring and Control category.

Within the framework of this project, various regions, cities, geographic and climatic conditions, income groups, etc. It is aimed to obtain daily and hourly real data on natural gas use by evaluating. It also aims to get the most realistic daily and hourly natural gas usage profiles of residential customers in our country with these data (EPDK, 2020).

Projects Approved within the Scope of Applications for July 2020 Term

1. Blade Fuse (NH Plug) Production with New Generation Polymer Thermoset

The project will be completed in 12 months and is among the 6 projects supported in the category of materials technologies. With the project prepared by Yeşilırmak Electricity Distribution Corporation, the body of the NH fuses with blades, which are widely used in low voltage distribution networks, industry, and electrical distribution panels, is made of extraordinary heat and fire resistant material, with BMC injection and TS EN 60695-11-10 standard. It is aimed to be produced from insulating polymer thermoset material suitable for V-0 class according to Thus, it is planned to reduce the cost by 10-20% compared to the steatite body NH plug-in fuses currently used. Additionally, the currently used steatite material is imported, and since the raw material of the polymer thermosetting material will be used locally in the relevant project, it will support our country's locational policy (EPDK, 2020).

2. Development of a Real-Time Discharge Monitoring System Based on Image and Sound Processing for Substations

The project, who has been supported in this category of Developing Technology for System Operation and Increasing Service Quality, It was expected that the project would be completed 18 months from now, and the project was designed by Uludağ Yeşilırmak Electricity Distribution Corporation. With the design to be proposed as part of the project, thermal imaging, sound and magnetic partial discharge monitoring equipment in the MV and/or LV parts of the distribution substations; thermal or excessive electrical stresses; improper installations; It aims to develop a high-performance landfill monitoring system that will prevent manufacturing faults and unsuitable designs without creating a cascading effect (EPDK, 2020).

3. Development of Unique and Superior Joint Detection and Distance Meter Device

The project, which was supported under the category of Developing Technology for System Operation and Increasing Service Quality, was envisaged to be completed in 16 months, and the project was designed by Uludağ Electricity Distribution Corporation. The main purpose of the project is to detect the underground cable splices as a point and transfer them to the GIS with a unique hardware to be developed. In addition, it is planned to show the field personnel in which meter of the cable they are located, thanks to the conductor propagation speeds and the simultaneous receivers and transmitters to be included in the device. Moreover, during the measurement, the cable route can be determined exactly and accurately without being affected by the portable device and other cables. Thus, it is aimed to develop a local and national device that will determine the route with high accuracy without being affected by other network components, apart from the detection of cable splices, which is the main purpose, and which will allow for the spot detection of problematic sites, the size of which is determined by other test devices, thanks to its location determination function (EPDK, 2020).

4. Composite Modular Mast Project to be Produced with Recycled Material to be Used in Energy Distribution Systems

The project will be completed within 24 months and is one of the 6 projects supported under the category of materials technologies. With the project prepared by Uludağ Electricity Distribution Corporation, poles of various body and types were developed, consisting of recyclable, plastic and composite materials, modular, lightweight, insulating, resistant to fire and environmental conditions, and more environmentally friendly, safe, easy to apply, long-lasting and low-cost to the sector. The objective is to earn profitable income (EPDK, 2020).

5. Smart Robot Development R&D Project for Unmanned Supervision and Controls in Distribution Centers

The project funded under the occupational health and safety category will be completed within 14 months.

To be used before maintenance and repair works in electricity distribution centers within the scope of the project; It is aimed to make the first discovery unmanned, to prevent work accidents and fires due to arc formation, to make cutter intervention with a remote controlled robot arm in dangerous situations.

In this context, it is aimed to develop smart inspection and control robot hardware and a mobile application to control the robot in order to prevent occupational accidents with a highly reliable infrastructure and improve occupational health and safety. This project was carried out by ADM Electricity Distribution Corporation and GDZ Electricity Distribution Corporation (EPDK, 2020).

6. Smart Insulator Design and Application Project with Self-Cleaning Coating (Self-Clean Insulator)

The project, which will be completed within 20 months by Dicle Elektrik Dağıtım Anonim Şirketi, is one of six projects supported by EPDK in the framework of materials technology. With the insulator product to which the coating material to be developed within the scope of the project is applied and the field application of this new product, the jumps due to pollution in the insulators will be prevented (EPDK, 2020).

7. Building Measurement Tester Development Project

It is carried out by Dicle Electricity Distribution Corporation within the scope of the Project category of Reducing Technical and Non-Technical Losses and Business Processes, with a project duration of 18 months. With the project, it will be possible to control the measurement errors of the meters in the buildings, to test multiple meters at the same time, to compare the measurement of all the meters in the building with the energy at the entrance of the building and to detect the illegal use within the building or panel with external lines or different methods, it is intended to develop a product capable of detecting errors by examining the data (EPDK, 2020).

8. Developing Artificial Intelligence Based 'Digital Network Manager' and Gaining Digital Network Reflexes for Next Generation Autonomous Networks Pilot Application R&D Project

As part of the Network Communication category, the project funded by EMRA is expected to be completed by Çoruh Dicle Electricity Distribution Corporation within 14 months. The aim of the project is the transformers, cables, etc. operating in the electrical distribution networks. is to create a health index approach by monitoring key equipment with sensors measuring different parameters such as voltage, current, temperature, partial discharge, humidity sensors throughout the project, and monitoring the effects of electrical, mechanical and other physical effects on the equipment that they are constantly exposed to under operation. In addition, multi-directional fault indication devices are installed in order to record fault situations, and it is determined which equipment is affected by the fault and how and to what extent the affected devices are damaged. Thus, it will be installed for equipment with direct measurement capability and will be able to continuously monitor basic values (current, voltage, temperature, humidity, etc.) and advanced measurement parameters (high-frequency harmonic components, partial discharge amount, etc.) It is aimed to create the system infrastructure and analysis algorithm that allows evaluation of the estimation processes for the desired parameters with the measurement values taken for the equipment which is not possible (EPDK, 2020).

9. Smart Electronic Electricity Meter with Gyroscope and Acceleration Sensor

The project is scheduled for completion in 6 months by Vangölü Electricity Distribution Corporation, is supported by EMRA within the scope of Monitoring and Control, Reducing Technical and Non-Technical Losses and Business Processes. In the project, it is aimed to determine and record all physical interventions made to the meters in a complete manner. All axis shifts, trends and instantaneous pulses that will occur in the meter will be recorded (in the meter processor memory unit / EEPROM) thanks to a 3-axis Gyroscope-accelerometer sensor, which will be added internally to the meters and will be fed from the internal battery (in an energy-free environment). If the meters in question are suitable for remote communication (PLC/RF/GSM), axis shift data will be automatically collected and reported. Moreover, it is planned to display these axis data in the obis codes displayed on the LCD screen of each counter (EPDK, 2020).

10. Insulated Terminal Block Design and Production Project for LV Aerial Line Conductors

The project funded under the Materials Technology category will be undertaken by Vangölü Electricity Distribution Corporation for a period of 11 months. The main objective of this project is to produce and disseminate isolated terminal blocks for LV overhead lines, which are not domestically produced in Turkey and which are very important for the network, but cannot be used widely due to their high cost (EPDK, 2020).

11. Scalable Industrial Internet of Things to Produce Descriptive Predictive Results by Monitoring Power Quality in Low Voltage Distribution Network

The project by Akdeniz Electricity Distribution Corporation is funded in the Monitoring and Control category. Project duration is 18 months. With the project, it is aimed to produce analytical results for the whole, clustered or single connection points by using the low-cost, easy-to-install terminals and the data collected from these terminals. Thus, it is planned to offer a power quality monitoring system that the distribution operator can use for many purposes such as technical quality monitoring, energy supply monitoring, monitoring the effects of renewable energy sources and customer disruptions on the grid, and impose sanctions as required (EPDK, 2020).

12. Finding the Location of Faulty Insulators by Developing Arc Fault Finder

The project, which is expected to last 24 months and supported under the Network Communication category, was prepared by AKEDAŞ Electricity Distribution Corporation. Insulators are only a small fraction of the cost of power lines, but they greatly affect the reliability of all power grids. As a result of the researches, more than 20% of all power cuts/failures, especially in humid and salty areas and industrial areas, are failures caused by arc formation in insulators. These failures are mostly temporary and the positions of the isolators that cause the failure are unknown. Therefore, temporary but frequently repetitive faults occur on the same insulator. Therefore, in the project; By using the determined advanced signal processing algorithms and recorded voltage and current signals, it is aimed to develop the "Arc Fault Detector and Central Software Program", which is a product that is not available in the market, to distinguish the arc fault from different fault types and detect

the location of the isolator, locally and nationally, in an economical way. It is also planned to develop fault current detectors that work in integration with the Arc Fault Detector, which will also detect fault currents and will facilitate the determination of the location of the fault by placing them in areas where there is branching in the feeder (EPDK, 2020).

13. Developing Distributed Computing Based Customizable Terminal Hardware and Its Use in Electricity Distribution System Pilot Project

The application was submitted by GDZ Electricity Distribution Corporation, and the project carried out by Meram Electricity Distribution Corporation, Dicle Electricity Distribution Corporation, Boğaziçi Electricity Distribution Corporation is expected to be completed within 24 months. The main purpose of the project is to build a model that can meet the data collection and transmission requirements of more than one system in a distribution center, which can prevent the problem of being idle in developing needs in the electricity distribution system. Thus, it will pilot the "edge computing" approach in the electricity distribution system by developing a hardware that will be flexible enough to meet future needs (hardware or infrastructure variables), and most importantly, will be able to process the collected data on-site and transfer the information, rather than data, to central systems. (EPDK, 2020).

14. Domestic Energy Domestic Technology

Within the scope of the proposed project by GDZ Electricity Distribution Joint Stock Company, in line with the sustainable development goals of our country; By examining the software and infrastructures currently used by electricity and natural gas distribution companies, it is planned to take steps to determine the areas where domestic software will be used, to select appropriate technologies, reduce the annual maintenance costs paid to software of foreign origin and nationalise software used in the energy sector. (EPDK, 2020).

The other project, which is planned to be completed in 12 months by ESGAZ Eskişehir Inner City Natural Gas Distribution Trade and Contracting Corporation, includes more than one gas distribution company and aimed to create the basic building blocks for the localization and nationalization of software such as ERP, SCADA and CBS used in the natural gas distribution sector (EPDK, 2020).

15. Preventing Voltage Increases with Medium Voltage Resistive Surge Arrester Application

The project will be completed in 12 months and belongs to the 6 projects supported in the category of materials technologies. With the project prepared by Trakya Electricity Distribution Corporation, it is aimed to develop a mechanism that will protect network equipment (breaker, disconnector, busbar, cable and overhead line) from instantaneous voltage spikes. It is aimed to create this mechanism from a combination of medium voltage surge arrester and resistance. Depending on the characteristics of the feeders where this equipment will be used, the current, voltage and energy absorption properties of the surge arrester and resistor will vary, and it aims to protect the network by activating during the instant voltage increase and limit the voltage peaks to stay at 5% (EPDK, 2020).

16. Project of Monitoring Primary or Secondary Measured High Voltage Consumers with Current Recorders Against Interventions Outside the Meter

While the project carried out by Boğaziçi Electricity Distribution Corporation is expected to be completed in 24 months, it is one of the 3 projects supported in the category of Reducing Technical and Non-Technical Losses and Business Processes. In the project, it is aimed to control the current profile values of the measurement circuits of primary or secondary measured high voltage consumers in real time, without the knowledge of the customer, to automatically transfer this information to the teams fighting against leakage and to take deterrent measures against the customer group attempting to consume illegally. At the end of the project, it aims to reset all interventions or losses of meter and non-member leaks due to measurement failures of these subscriber groups to which energy is supplied (EPDK, 2020).

17. Distribution Companies R&D Platform Design and Development Project Phase-1

The project, which takes place over a short 4-month period, has been designed by Sakarya Electricity Distribution Corporation. With the companies R&D Platform Design R&D Platform Design and Development Project Phase-1, all project processes are integrated with OFGEM, European Union Horizon 2020, TÜBİTAK etc. It is planned to evaluate and manage the companies on a professional electronic platform, as in the examples. Furthermore, it aims to implement an EMRA R&D platform that will be systematically monitored and communicated by EMRA and distribution companies (EPDK, 2020).

18. Pilot Application of Interphase Spacers in Specific Regions of High Wind Force and Ice Load

The project will be completed in 12 months and belongs to the 6 projects supported in the category of materials technologies. With the project prepared by Meram Electricity Distribution Corporation, analyzes will be made for the use of phase spacer used in transmission lines in MV and LV networks. According to the criteria determined as a result of the analysis, it is aimed to use the interphase spacer in the pilot application region, which will prevent the failures Cause long-term interruptions due to wind strength and ice load and improve average downtime (EPDK, 2020).

19. R&D Project for Automatic Connection Vision Generation Using Artificial Intelligence (AI) Applications

The project, prepared by Meram Electricity Distribution Corporation, is expected to be finished within 14 months. Within the scope of the project, it is planned to check whether the requested data is submitted during the application after the suitability of the application documents is scanned using methods such as optical character recognition and the user information (name, surname, title deed, license, address information, etc.) is automatically read. It is aimed to make the technical evaluation of how the demand of the connection point will be met with artificial intelligence algorithms by automatically obtaining the data related to the network via the Geographic Information System (GIS). Thus, connection opinion

documents will be created automatically (EPDK, 2020).

20. Double-Sided Service Tee Project

It is the only project supported within the scope of the 2020 July Supports in the energy It is the only project supported within the scope of the 2020 July Supports in the energy efficiency category and is expected to be completed in 12 months. It was designed by Bursa City Natural Gas Distribution Trade and Contracting Corporation. In the project, it is aimed to reduce the risk of natural gas leakage and to save labor and materials by using a single Service Tee in PE networks (EPDK, 2020).

21. Smart Indoor Installation Project (AÇTES)

The project sponsored in the category of Communication and Smart Meter was prepared by Bursa Urban Natural Gas Distribution Trade And Contracting Corporation and is planned to be completed within 12 months. Within the scope of the project, it is aimed to cut the gas supply remotely or automatically in case of emergency, fire, gas leaks at gas delivery stations, using the SCADA system in critical public facilities and maintaining a safe and continuous gas supply by monitoring the facility (EPDK, 2020).

22. Portable Calibration Detection System (TAKTES) Project

It was designed by Çorum Natural Gas Distribution Industry and Trade Joint Stock Company, which is planned to be completed within a period of 12 months, supported in the category of Communication and Smart Meter. With the system to be developed within the scope of the project, complaint inspections will be carried out easily and quickly, on site, at a level that will ensure customer satisfaction, without the need to remove meters (EPDK, 2020).

23. Establishing a Face-to-Face Customer Service System

Studies for the project supported in the Communication Technologies category were performed by Armagaz Arsan Marmara Natural Gas Distribution Corporation. In the project, it is aimed to take the first step in providing the remote video customer service business model, which has become widespread in other sectors, in order to contribute to increasing social isolation within the scope of reducing the effects of epidemics that may occur, by structuring it specifically for the natural gas sector (EPDK, 2020).

5.2.2. Smart Power Generation and Distribution

5.2.2.1. Solar Energy

A floating solar power station of 240 kW was commissioned on the Büyükçekmece lake (Istanbul). The total installation area of the power plant is approximately 2,900 m². 30 kW of the power plant was built on land for comparison purposes and the remaining 210 kW was built on the lake. This is the first time that this has been carried out in Turkey. Established as part of an R&D project, the system plays an important role in preventing evaporative water loss by covering 60% of the surface area of the water. There are a total of 960 polycrystalline photovoltaic panels with a power of 260 kWp in the power plant. In the Floating Solar Power Plant, two different floating systems, one consisting of a combination of a pontoon (120 kW) and the other a pontoon construction (90 kW), were used. The Floating Solar Power Plant has the power to meet the annual electricity needs of 202 households and prevents the emission of 164 tons of CO2 per year. It offers the same environmental benefit as taking 135 vehicles off the road and planting 4,200 trees. (https://webdosya.csb.gov.tr/db/cbs/akillisehirler/index.html)

5.2.2.2. Energy Production from Landfill Gas

Landfill gas produced in the Odayeri and Kömürcüoda landfills on the European and Asian shores of Istanbul, respectively, is combusted in a controlled manner and used in energy generation. As part of the power generation studies, 54 MW of electricity is currently produced, 40 MW in Odayeri Sanitary Landfill and 14 MW in Kömürcüoda. This electrical energy, which is completely obtained from landfill gas, can meet the residential electricity needs of approximately 1.2 million people. The revenue from electricity generation is used to reduce costs in Istanbul's city cleaning and other waste management activities. In addition to the flammable and explosive properties of landfill gas, methane in its content has 23 times more greenhouse gas effect in the atmosphere compared to CO2 gas. Thanks to the burning of landfill gas in energy facilities, economic benefits are obtained by selling electricity, as well as a reduction in carbon emissions. An average of 1.2 million tons of carbon dioxide reduction per year is expected within the economic life of the energy production systems installed in Istanbul. This level of reduction is consistent with the carbon emissions from about 800,000 vehicles on the road. (https://webdosya.csb.gov.tr/db/cbs/akillisehirler/index.html)

5.2.3. Electricity Generation from Methane Gas in Konya Solid Waste Facility

The Metropolitan Municipality of Konya established an electricity generating facility in 2011 to assess methane gas formed in the storage of Aslım solid waste, where the solid wastes of the city are stored The capacity of the facility is 5.6 MWh, and the facility can operate at full capacity and meet the daily electricity needs of an average of 26 thousand residences. A 1,200 m² greenhouse has been set up to benefit from the heat generated within the facility. It produces on average 30 tonnes of tomatoes per year. (https:// webdosya.csb.gov.tr/db/cbs/akillisehirler/index.html)

5.2.4. Ankara Electricity Energy Tracking System (ETS)

An energy management system was implemented by monitoring energy quality, active reactive power control, failure conditions and instantaneous voltage-current values in the facilities of the metropolitan municipality. Thus, an energy saving of up to 75% is foreseen in municipal facilities. (https:// webdosya.csb.gov.tr/db/cbs/ akillisehirler/index.html)

5.3. DISTRICT HEATING AND COOLING SYSTEMS IN TURKEY

District heating was originally used in the Esenkent project in Istanbul. The applied system is the thermal power plant and district heating system using natural gas. It was established to meet the heat energy and to produce electricity. The electricity produced is transferred to the national grid. It can generate heat by using waste gases and taking steam from the steam turbine. It can meet the heating and hot water needs of approximately 7,400 residences (year 2000) uninterruptedly (365 days / 24 hours). With the Balçova Geothermal District Heating System, 6,631 homes, 2 hotels and different buildings owned by 2 universities are heated (MMO Zonguldak Şubesi, 2009).

Yatağan-Mugla Project; Ministry of Energy and Natural Resources (MENR), Elektrik Üretim Corporation (EUAS), the Scientific and Technological Research Council of Turkey (TUBITAK), Yıldız Technical University (YTU) and the Electrical Works Survey Administration (EIEI).

Within the scope of this project named "Research and Development of Methods for Converting Waste Heat of Thermal Power Plants to Benefit to Increase Energy Efficiency and Application of Heating in Buildings (TSAD)", investigations and analyzes were completed in 14 thermal power plants affiliated to EUAS.

It was determined that the first application would be submitted to Yatağan Thermal Power Plant. In the first stage, it is aimed to meet the heating and hot water needs of public buildings, and in the second stage, the hot water and heating needs of all buildings in Yatağan District are aimed. With the project, it is planned to heat a total of 16,500 residences, 10,200 in Muğla and 6,300 in Yatağan, and the implementation has been partially started. This project has shown that all thermal power plants have the potential to meet heating and cooling requirements in their region (MMO Zonguldak Şubesi, 2009).

6

ENERGY TRENDS AND SMART ENERGY POLICIES IN THE WORLD AND IN TURKEY

In this section, trends, policies and strategic plans related to smart energy worldwide and in Turkey are evaluated.

6.1. ENERGY TRENDS AND POLICIES IN THE WORLD

Under this title, after a brief overview of global energy trends, global developments and European Union strategies are briefly evaluated.

6.1.1. Global Energy Trends

Global energy demand is growing without slowing down with urbanisation, digitalisation and industrialisation. Global energy consumption increased by an average of 1.5% annually between 2010 and 2017. However, when compared to 2017, global energy consumption increased by 2.9% in 2018. Energy demand is expected to increase by 50% in the next 40 years.

Nowadays, access to energy has become the key to high quality of life and urban and regional competitiveness. On the other hand, it is known that in 2016, 1.4 billion people in the world were still not connected to a certain electricity network, 2.7 billion people were able to cook by burning biomass, and therefore the quality of life of large masses remained low (Overland, 2016). As the urban population is expected to grow by 3 billion by 2050 (UN, 2010), the importance of smart energy systems will be better understood.

In 2018, 6.08% of the world's demand for primary energy was met by hydropower. Other renewable energy sources have a share of only 4% (BP, 2019). Energy obtained from renewable energy sources has a share of 18% in total energy consumption as of 2018 (BP, 2019).

A study by the International Energy Agency (IEA, 2018) showed that from 1955 to 2018, global energy consumption increased by an average of 3.6% annually (except for the financial crisis in 2009 only). In other words, world energy consumption increased 1.8 times between 1950 and 2017. There is a slowdown in the increase in world energy consumption, especially after 2000 (Overland, 2016).

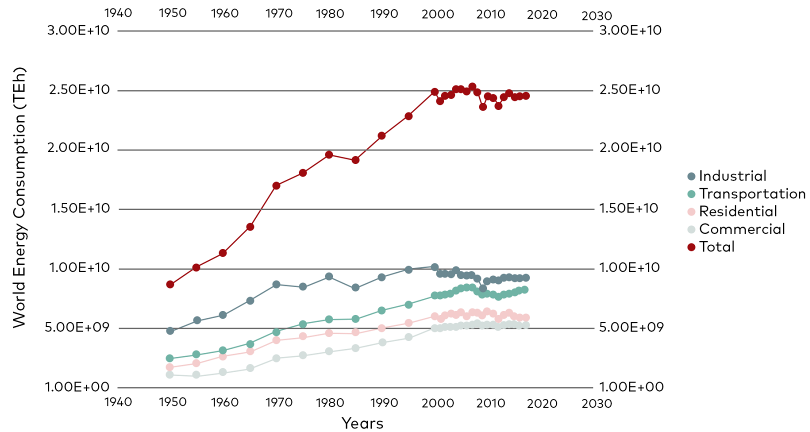


Figure 13: Annual Energy Review Source:Ceglia, 2020 IEA, 2018. Annual energy review. www.iea.org - Accessed: 28 November 2018

Overland (2016) brings attention to energy globalization as an issue barely addressed today. According to him, the globalisation of energy between 1995 and 2015 occurred as follows:

- The emergence of a multipolar market structure that is no longer based on Western economies as in the past, due to the increase in energy consumption in emerging countries,
- Realization of production in more complex and wider geographies due to the increase in oil producing fields,
- New natural gas lines and interconnected systems, new oil and gas technologies, the rise of liquefied natural gas (LNG)

and the creation of new global energy networks,

- Liberalization of trade in energy-intensive commodities, wider exchange of electricity, coal and charcoal thanks to expanding regional energy markets (such as the European Free Trade Area),
- Some types of energy are at a disadvantage and others are becoming more valuable as a result of global climate policies,
- Increasing competition between different energy sources, with an increasing number of electrical machines and the emergence of small producers as well as a large number of primary power plants,
- The emergence of natural gas and oil competition due to natural gas powered vehicles,
- Nuclear energy etc. due to the development of global communication networks. increasing op-

position and popularization of renewable energy sources,

- Increasing rate of domestic consumption of energy exporting countries to exports.

Given the rapidly growing global demand for energy and the emergence of major energy consumers, environmental problems have also become more frequent. The increase in carbon emissions by 1.6% in 2017 and by 2.7% in 2018 also raises concerns (Baleta et al., 2019).

According to Graus et al., (2011) world supply of primary energy increased by 30 percent between 1990 and 2005, from 367 EJ to 479 EJ. According to the International Energy Agency's reference scenario, in the 2007 World Energy Projection, the global energy supply will grow by 55% to reach 742 EJ by 2030 (IEA 2007a). If the situation in the 2000s continues, it is predicted that fossil fuels will constitute 80% of the energy supply in 2030, as in 2005. Given that fossil fuels accounted for 75% of greenhouse gas emissions in 2005 (IRW, 2008), this situation must clearly change.

Graus et al., (2011) forecast that the world energy supply was 439 EJ in 2005 and will reach 871 EJ by 2050. Accordingly, while the energy conversion efficiency was 67% in 2005, it is thought that if the current conditions continue, it will decrease to 66% in 2050. They predict that the demand for energy, which was 293 EJ in 2005, will reach 571 EJ in 2050. After China and India, the highest increase in energy demand is expected to occur in the Middle East. In this context, the importance of actions aimed at improving the efficiency of energy conversion is well understood.

Graus et al., (2011) indicate that light commercial vehicles (48%) and lorries are the source of energy demand in the transportation sector worldwide (26%), however, it is possible to reduce these with technological advances such as hybridization, reduction of friction and drag effects, and lightening of vehicles. By 2030, it is expected that 50% to 30% fuel savings will be realized in heavy-duty vehicles. In air transportation, there is an expectation of 50% fuel savings by 2050. Similar estimates apply in the case of transport by rail, inland waterway and sea.

In industry sectors, the IEA (2008a, b, c) predicts that energy efficiency can be increased from 19% to 32% by 2050. It is emphasized that new technologies can contribute 20-30% more. In this way, it is predicted that an energy efficiency increase of 35-52% can be achieved in total.

All buildings, including farm structures, account for 40 percent of global energy demand. Heating plays an 80% role, hot water 15% and cooking 5% in this share (Bertoldi and Atanasiu 2006; IEA 2006; WBCSD 2005). Thermal insulation alone is expected to

have a 40-50% share in the reduction in the increase in global energy demand. In addition, it is foreseen that up to 60% improvements in the field of home appliances and lighting are technically possible (Graus et al., 2011).

The greatest loss to the energy sector comes from the energy sector itself. In 2005, 70% of the energy supplied in the world was lost during the transformation. The largest share in this belongs to oil extraction and refining processes (6% and 9%). The loss in distribution networks is around 6%. Grauss et al. (2011) state that 40% of global power production was met by coal, 7% by oil and 20% by natural gas in 2005, and they expect that this will not change much in 2050. By 2050, 70% of the total power generation is expected to come from fossil fuels, 9% from nuclear energy and 21% from renewable energy sources. 75% of the energy lost during the energy conversion occurs in thermal power plants working with fossil fuels. This rightly causes greenhouse gas concerns to intensify in these terminals. However, it is also possible to reduce these losses by 40-60% with the technologies of the 2000s (European Commission 2006a, b). It is possible to increase efficiency in terminals burning coal, gas and petroleum products, and commercially these technologies are expected to be implemented after 2020 (Tech-wise A/S, 2003a). Although it is possible to increase nuclear energy from 33% to 39%, the energy efficiency of all non-fossil fuel terminals is projected to increase by 13% by 2050.

To avoid dangerous anthropogenic climate effects worldwide, the annual average temperature should not exceed two degrees Celsius in comparison to the pre-industrial period up to 2100. Even if it remains at this level, it has been agreed that greenhouse gas emissions should be reduced by 40% to 70% by 2050 compared to 2010 and should be brought closer to zero by 2100 (IPCC 2014; Kranz et al., 2015).

6.1.2. Energy Policies in the World and the European Union

Under this heading, the global situation and the strategies of the European Union are briefly discussed.

49% of greenhouse gas emissions come from the power supply sector. As mentioned above, this sector is the sector with the highest losses in energy conversion. Greenhouse gas emissions in the energy supply sector increased much faster between 2000 and 2010 than in the previous three decades. 70% of this occurs in the electricity and heat generation processes. For this reason, many countries focus on renewable energy in their electricity systems and try to make their energy systems "smart". They include supply chains, operations, transport, buildings and networks. Within this context, information technology is used primarily (Climate Group, 2008).

In 2011, the European Commission prepared a roadmap for transformation to a low-carbon model in the energy and production economy by 2050 (European Commission, 2011). While aiming to reduce energy consumption in the long term, it is also aimed to create a more climate-friendly European economy by making cost-effective savings. It aims to reduce carbon emissions by 40 per cent, increase energy efficiency by 27 per cent and increase renewable energy use to 27 per cent by 2030.

Within the scope of the 7th Environmental Action Plan of the European Union, the vision of "good living within the borders of the planet" was defined and the need to "transform the union into an energy-efficient, green and competitive low-carbon economy" by 2050 (Beretta, 2018).

More recently, the EU implemented the Circular Economy Strategy, thereby giving the leading role in this transformation towards eco-innovation. Eco-innovation has been defined as an innovation area that serves not only for energy efficiency, but also for creating employment, increasing economic growth and competitiveness, and protecting the environment. In addition, the EU is strongly committed to smart cities. The instruments created to support the Europe 2020 Strategy (for example, the Horizon 2020 Framework Programme) are used to enhancing the role of eco-innovation and providing financial support for the implementation of the action plan beyond 2013 (Beretta, 2018).

6.2. ENERGY RELATED POLICIES AND PLANS IN TURKEY

In this title, changes and trends in the energy sector in Turkey, decisions and proposals in relevant policies and plans are summarised.

6.2.1. Changes in Energy Demand in Turkey

Our country strives to achieve its development goals, increase social well-being, and raise the industrial sector to a level where it can compete on the international stage. It is calculated that the increase in energy demand will continue in the coming years. Energy supply is expected to increase to $222 million in 2020. The energy supply is increasing by 6% annually (Tanrıöven et al., 2011).

Turkey needs to increase its energy efficiency in the face of increasing energy demand and meet energy needs from more renewable energy sources. Smart systems are used to ensure energy efficiency and integrate renewable energy.

6.2.2. Renewable Energy Resources Support Mechanism (YEKDEM)

The objective of YEKDEM is to make investments in renewable energy more attractive. Thanks to YEKDEM, renewable energy investments have increased in Turkey. Total renewable energy capacity has increased by 250% in the last 10 years.

By the end of 2023, it is aiming to provide at least 30% of the electricity supply from renewable sources. By 2023, it is planned to increase the installed wind power capacity to 20,000 MW and the solar installed power capacity to reach 5,000 MW. In January 2018, EMRA made a regulation change for rooftop solar energy systems. It is expected that the installed capacity of solar energy will increase and consumers will produce their own energy (Deloitte, 2018).

Geothermal energy is one source of renewable energy. Turkey's geothermal energy resource potential is high. 55% of geothermal fields in Turkey are suitable for heating applications. The use of geothermal energy in residential heating can create high economic benefits (Kozak, 2016).

There are 53 geothermal power stations across Turkey. In Turkey, it reaches an installed capacity of 1,498 MW in 2019. It ranks fourth in geothermal energy production in the world.

6.2.3. Energy Efficiency

Studies on energy efficiency in Turkey were undertaken in the early 1980's by the Directorate-General for Electricity Resources Survey and Development Administration (EIA). The General Directorate of Renewable Energy (YEGM) was established on November 2, 2011 (Keskin and Güven, 2020). The Department of Energy Efficiency and Environment of the Ministry of Energy and Natural Resources is continuing its research on energy efficiency.

More efficient studies have been conducted since 2007 in the areas of legislation and policy to guarantee energy efficiency,

- Thermal insulation standard (TSE 825), which limits energy consumption in buildings depending on the region,
- Energy Performance Regulation in Buildings (BEP Regulation),
- Energy Identity Certificate (ECB) arrangement for buildings,
- Allocating heating energy costs in buildings according to actual consumption and making production compulsory in the market with "A" and higher energy labels in electrical household appliances,

- Granting the Energy Manager Certificate for industry and buildings,
- Providing Survey Project Certificate trainings for authorized technical personnel to conduct energy efficiency studies in industry and buildings,
- Formation of Ministry-certified consultancy market, which provides services to the building and industry sector with studies and trainings, with Energy Efficiency Consultancy Companies (EVD),
- To revive the Energy Service Companies/ESCO (Energy Service Company) market, amend the Public Procurement Law (KIK) to enable long-term energy efficiency performance contracts in the public sector,
- Harmonization of efficiency classes of electric motors with international standards.

A number of studies have been carried out in the area of energy efficiency. A large number of regulations have been issued for similar regulations for all sectors, and strategies/action plans and actions have been determined.

2010-2023 National Climate Change Strategy Document, 2010-2023 National Climate Change Action Plan, 2012-2023 Energy Efficiency Strategy Document, Energy Efficiency Improvement Program number 1.14 of the 2014-2018 Tenth Development Plan, Ministry of Energy and Natural Resources 2015-2019 Strategic Plan, 2017-2023 National Energy Efficiency Action Plan are among these strategies.

In the National Energy Efficiency Action Plan, which entered into force in January 2018, 55 actions were defined in 6 categories: buildings and services, energy, transportation, industry and technology, agriculture and measures implemented in every sector. In 2023, it is aimed to reduce Turkey's primary energy consumption by 14%. The cumulative savings to be realized by 2033 are expected to reach USD 30.2 billion (Keskin and Güven, 2020).

6.2.4. Regulations Regarding Energy Transmission and Distribution

Prior to the establishment of the Smart Grid Roadmap in Turkey, the current status of distribution companies was determined. The maturity levels of distribution companies were determined by examining how they performed in different technical components of the smart grid. The main problems encountered are as follows:

- Heterogeneous Maturation Levels,
- Different Technology Dissemination Levels,
- Inability to Evaluate Smart Grid Project Results,
- Low-Scale Pilot Applications,
- Lack of Information Sharing Platform,
- Ineffective Use of Installed Functionality,
- Lack of Competent Human Resources,

- Lack of Process and Organization,
- IT and OT Convergence,
- Low Quality Operational Data,
- Unmanagement of Big Data,
- Solutions Not Meeting Interoperability Requirements,
- Dependency on 3rd Party Communication Infrastructure,
- Insufficient Field Expansion of Operational Management Systems.

The Electricity Market Law came into force on 03.03.2001 to enable the private sector to participate in the energy market. Electricity production has been made by private and public institutions. The electricity distribution sector has been privatized by 85%. Investment allowance has been provided to distribution companies to establish the IT infrastructure and investment infrastructure. It is important for distribution companies to invest in network infrastructure as required by smart grid infrastructure requirements.

In the current energy transmission system, energy disruptions occur due to voltage fluctuations, frequency changes and overload. Energy quality is monitored by establishing a national energy management center.

Turkey continues its efforts to expand the real-time monitoring system for transport routes.

6.2.4.1. Regulations Regarding Smart Grid and Meters

There are studies on smart networks in this country. The basis for this research is the Automatic Meter Reading System (OSOS). The Energy Market Supervisory Board (EMRA) has published the Procedures and Principles Regarding the Scope of Automatic Meter Reading Systems and Determination of Meter Values. The distribution companies stated that the infrastructure designs required for the AOS request should be submitted to EMRA (Yenilmez, 2016).

Efforts to popularize smart metering schemes should be planned. The dissemination strategy is carried out at the initiative of distribution companies. A smart grid commission has been established with stakeholder representatives. Strategic studies to determine the road map have been launched (Deloitte, 2018).

The process of privatisation of distribution companies has ended. Privatization of production facilities continues. Legal unbundling of distribution and supply companies has taken place. A similar line to the European electricity market is followed and the electricity market is liberalized. In this case, the advantages of smart meters are increasingly obvious to Turkey (Deloitte, 2018).

R&D studies for smart networks are also conducted in our country. TUBITAK Energy Institute carries out a system installation project abroad, where remote reading and control operations and subscribers can sell the excess renewable energy they produce to the grid (Yenilmez, 2016).

The OSOS process is very important in laying the foundation for smart grid development in this country.

6.2.4.2. Service Quality Regulation on Electricity Distribution and Retail Sales

In the Service Quality Regulation for Electricity Distribution and Retail Sales, the need for automatic control systems is laid down in order to ensure and control the quality of supply continuity and commercial and technical quality.

6.2.5. Smart Energy in the 2020-2023 National Smart Cities Strategy and Action Plan

There are 4 strategic purposes, 9 goals and 40 actions in the field of application of the 2020-2023 National Smart Cities Strategy and Action Plan. Enhancing the maturity of the Smart Energy component is one of those measures. The institutions responsible for this action are the Ministry of Energy and Natural Resources, the Ministry of Environment, Urbanization and Climate Change - General Directorate of Local Administrations.

Enhance the maturity of the Smart Energy component; energy resources and networks management, energy consumption (supply-demand) optimization, efficient use of energy, use of renewable energy and alternative energy systems goals energy management.

6.2.5.1. High Level Implementation Steps

In connection with the action to increase the maturity of the Smart Energy Component of the 2020-2023 National Smart Cities Strategy and Action Plan, the implementation steps have been determined as follows:

- Energy systems and resources will be leveraged and managed with smart solutions,
- Smartening of energy networks will be ensured,
- Energy consumption will be monitored and optimized,
- Renewable and sustainable energy production and consumption models will be supported and expanded,
- Governance that will enable energy resources and systems to be used effectively and efficiently will be carried out within the framework of the following functions,
- Organization Management,
- Resource Management,
- Service Management,
- Planning and Implementation,
- Operation and Maintenance,
- Monitoring, Evaluation and Change,
- Sustainability,
- Interoperability,
- Stakeholder Coordination,
- Energy Security Management.

6.2.5.2 Expected Benefits

The anticipated benefits of the Smart Energy implementation steps are defined as follows:

- It will contribute to the environmentally friendly evaluation of energy resources,
- It will contribute to the effective and efficient use of energy resources,
- Energy supply and demand will be controlled,
- Energy savings will be achieved,
- Security of supply in energy and security of energy infrastructures will be ensured,
- Services will be delivered in an agile, low-cost and low-risk manner.

6.2.5.3. Related Institutions and Organizations

In the Plan, institutions and organizations associated with the Smart Energy stream are defined as follows:

- Presidency - Digital Transformation Office,
- Presidency - Science, Technology and Innovation Policy Board,
- Ministry of Transport and Infrastructure,
- Ministry of Environment, Urbanization and Climate Change,
- Ministry of Industry and Technology,
- Energy Market Regulatory Authority,
- Energy Distribution Companies,
- Local Administrations,
- Universities,
- Private sector,
- Non-Governmental Organizations.

6.2.6. Provisions Related to Energy in the Eleventh Development Plan

The energy provisions of the 11th Development Plan are as follows:

- It will work to develop local practices and standards in areas such as smart factories, transport, energy, agriculture, health, environment and disaster management.
- In the field of renewable energy; New investment models will be implemented with mechanisms that will include the use of domestic equipment, R&D, technology transfer, and public procurement.
- Local production of new generation lighting devices will be supported by making arrangements for the provincial, district and town municipalities to save energy in outdoor lighting and to use locally produced equipment.
- An inventory report will be prepared to determine the energy equipment that can be produced locally, and a needs analysis will be made for products that can be produced locally.
- Electricity networks and systems will be further strengthened and made flexible.
- Smart grid applications will be expanded.
- Efforts will be made to ensure regional adequacy in electricity supply, and electricity transmission infrastructure investments will continue to be implemented in a way that takes into account the security of the system and the supply-demand conditions of the regions.
- Technical and non-technical losses in electricity will be reduced. In this framework, awareness-raising, incentive and sanction practices will be created to reduce non-technical loss, the use of systems such as smart meters and remote reading will be expanded, and inspections will be increased.
- Studies will be carried out to develop the National Smart Grid Management System (National SCADA) for use in energy kits.

6.2.7. New Economy Program (Medium Term Program) 2021-2023

The following arrangements are included in the program:

- Electricity generation from domestic and renewable energy sources will be increased. Efficiency-enhancing projects will be implemented in order to eliminate the inefficiency and losses of industrial enterprises, especially in the industrial sector, and to recover waste energy.

- Seven percent of products and services such as software, informatics and automation used in electricity generation will be increased.
- By developing technologies for obtaining Rare Earth Elements from ore and waste; Efforts will be made to obtain advanced technological products in many sectors, especially in energy, health, automotive and electronics.

6.2.8. 2010-2023 KENTGES Integrated Urban Development Strategy and Action Plan Provisions

The plan, which was developed earlier, includes the following clauses. Some of these provisions appear to be in place:

- Research, inventory and projection studies will be carried out to meet the urban energy demands with renewable energy sources as much as possible.
- Legislation will be drawn up to expand the use of renewable energy sources in cities.
- Energy efficient and climate sensitive settlement strategies will be prepared.

6.2.9. National Energy Efficiency Plans

The 2017-2023 National Energy Efficiency Action Plan includes strategic purposes, goals and actions related to smart energy.

The 2012-2023 Energy Efficiency Strategy Document contains strategic purposes, goals and actions within the scope of Smart Energy.

Smart grid applications are one of the actions in the Energy Efficiency Strategy Document (2012-2023). The staggered tariff, multinomial counter and smart grid applications are the main points of action.

6.2.10. 2003-2023 National Science and Technology Policies Strategy Document Provisions

More specific questions are addressed as part of the strategy document. The implementation of the provisions of this paper in smart energy practices and approaches may increase the likelihood of success.

- Development of energy-saving technologies for industrial processes,
- To be able to develop and use energy-saving/environmentally friendly technologies in textile finishing,
- Reducing the energy requirements of buildings and providing them with renewable resources,
- To produce cleaner and more efficient energy from our country's lignite,
- To be able to produce energy from renewable energy sources (hydraulic, wind, solar); To be able to develop the necessary production systems for this,
- To be able to produce hydrogen from sustainable sources and develop hydrogen burning technologies, which is one of the alternative energy options.

6.2.11. 2017-2020 National Broadband Strategy and Action Plan Provisions

- The action of "Developing the Smart Cities Program" was included.

6.2.12. 2014-2023 Regional Development National Strategy Provisions

The following policies relate to clean and environmentally sound production, alternative energy sources and energy efficiency:

- The different potentials of the regions in terms of alternative energy sources and the production policies based on renewable and domestic resources offer new opportunities to the regions. It should be ensured that the private sector mobilizes these potentials in the regions through public investment and support practices.
- Cleaner production will be expanded in metropolitan areas, research and production infrastructure will be strengthened in order to develop environmentally friendly production and energy technologies.
- Alternative energy production and use such as geothermal, biogas, solar and wind energy will be supported.
- Renewable energy generation will be supported for environmentally friendly energy use.
- Priority will be given to cities with high populations and industrial or tourism activities, and emphasis will be placed on increasing energy efficiency, the transition to clean production systems, and eliminating environmental infrastructure deficiencies.

6.2.13. Provisions of the 2014-2020 National Rural Development Strategy

Renewable energy sources were mentioned in the National Rural Development Strategy 2014-2020 and there is a policy of "dissemination of the use of renewable energy sources".

6.2.14. Provisions of the 2010-2023 National Climate Change Strategy Document

Promotion of renewable and nuclear energy; conducting research and development studies; In these areas, the domestic industry has policies to increase the share of renewable energy in total electricity generation to 30% by 2023.

6.2.15. Provisions of the 2007-2023 EU Integrated Environmental Harmonization Strategy

H.1: There is a policy to program the investments to be made in industrial facilities such as the development of production techniques, the application of advanced technologies, and the efficient use of energy.

7

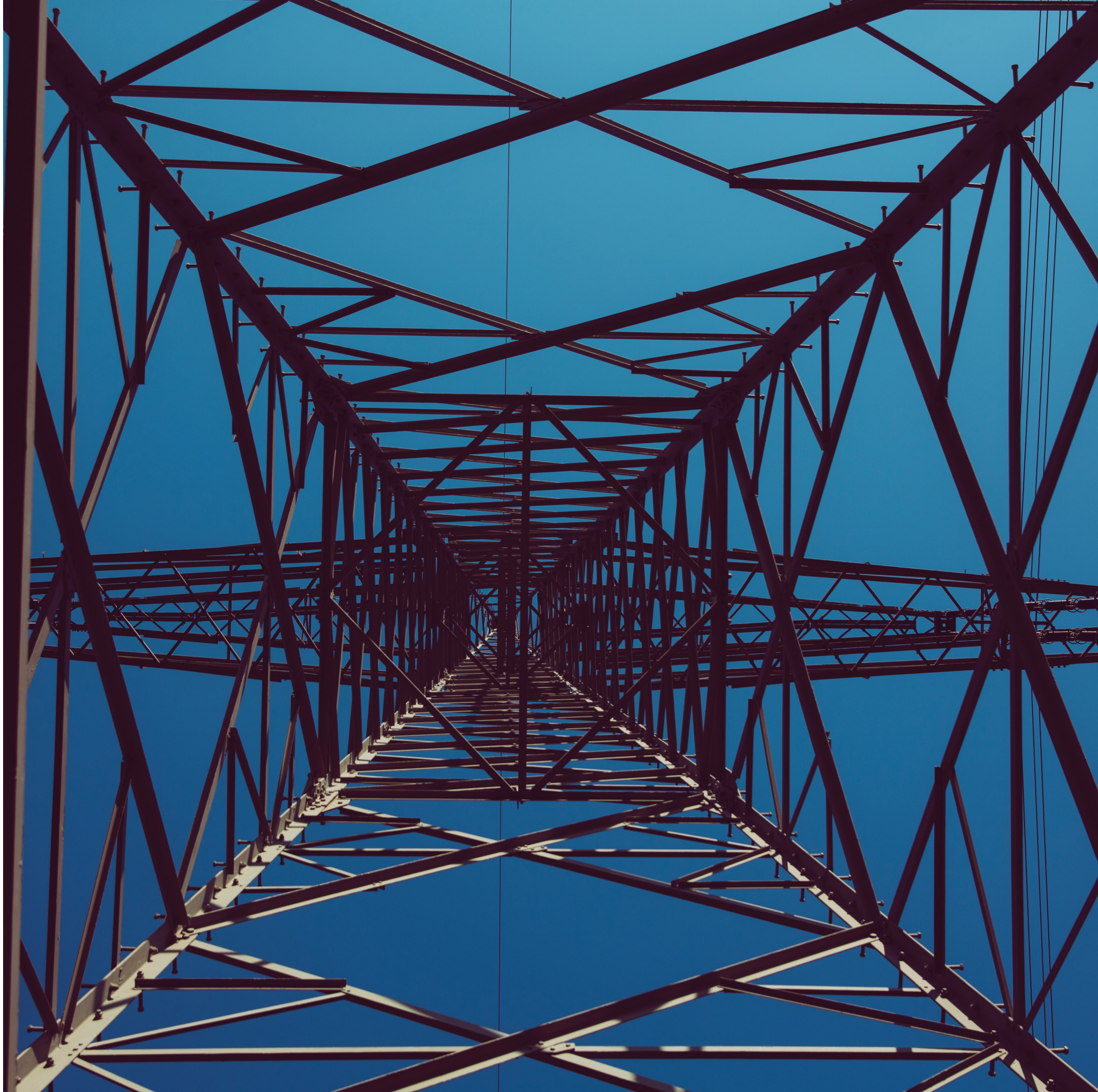
PERFORMANCE INDICATORS AND OPPORTUNITIES RELATED TO SMART ENERGY

In this section, national performance indicators for the smart energy component and international cooperation and related grant opportunities are discussed.

7.1. NATIONAL PERFORMANCE INDICATORS (2020-2023 NATIONAL SMART CITIES STRATEGY AND ACTION PLAN)

Overall, national smart energy performance indicators can be summarized as follows. Local strategies and roadmaps also need to establish a relationship with these performance indicators.

- Number of cities with increasing maturity level of Smart Energy,
- National Smart Energy maturity level increase,
- Electricity loss and leakage rate,
- Electric power consumption rate,
- Electricity use per person,
- The decrease in the average number of power cuts per person,



- An increase in the percentage of total energy produced from renewable resources,
- Self-efficacy rate regarding renewable energy sources,
- The increase in the population of the city using authorized electricity service,
- Annual energy consumption reduction of public buildings.

As can be seen, the performance indicators have been defined fairly exhaustively and in different dimensions. It is understood that technological, organizational and behavioral development should be provided. Factors such as electricity loss and leakage rate, blackouts, renewable energy point to needs such as smart grid investments, widespread use of renewable energy technologies and increasing renewable energy generation capacity.

Self-efficacy rate necessitates an increase in local knowledge and technology development capacity. As well, it is understood that practices like urban transformation are also important. Opportunities to address these needs are covered below.

7.2. INTERNATIONAL COOPERATION OPPORTUNITIES

Within the scope of the Horizon 2020 program carried out by the European Commission, by following the calls on "Smart Cities and Societies", you can get information about R&D studies and findings, support R&D projects, and take part in the development or dissemination of best practices by taking part in these projects can be obtained. As key cities, it is possible to assume leading roles, and as a follow-up city, it is possible to take advantage of best practices without risking R&D.

The European Commission's upcoming framework program Horizon Europe (The European Research and Innovation Framework Program 2021-2027) can be evaluated in a similar context. Apart from this, applications can be made for the financing of research, development and implementation projects for various programs carried out in Turkey under the Instrument for Pre-Accession Assistance (IPA). These programs often offer favorable terms to public-private-university partnerships. To increase the maturity of the Smart Energy component, local universities and local governments may undertake projects in collaboration with international, national and local actors.

It is possible to cooperate with the International Energy Agency on energy savings, energy efficiency and the development of alternative energy sources.

Cooperation can be established with the International Renewable Energy Agency in renewable energy matters.

Energy infrastructure development projects may be undertaken with the World Bank, the German Development Bank, the European Bank for Reconstruction and Development and similar financial institutions.

8

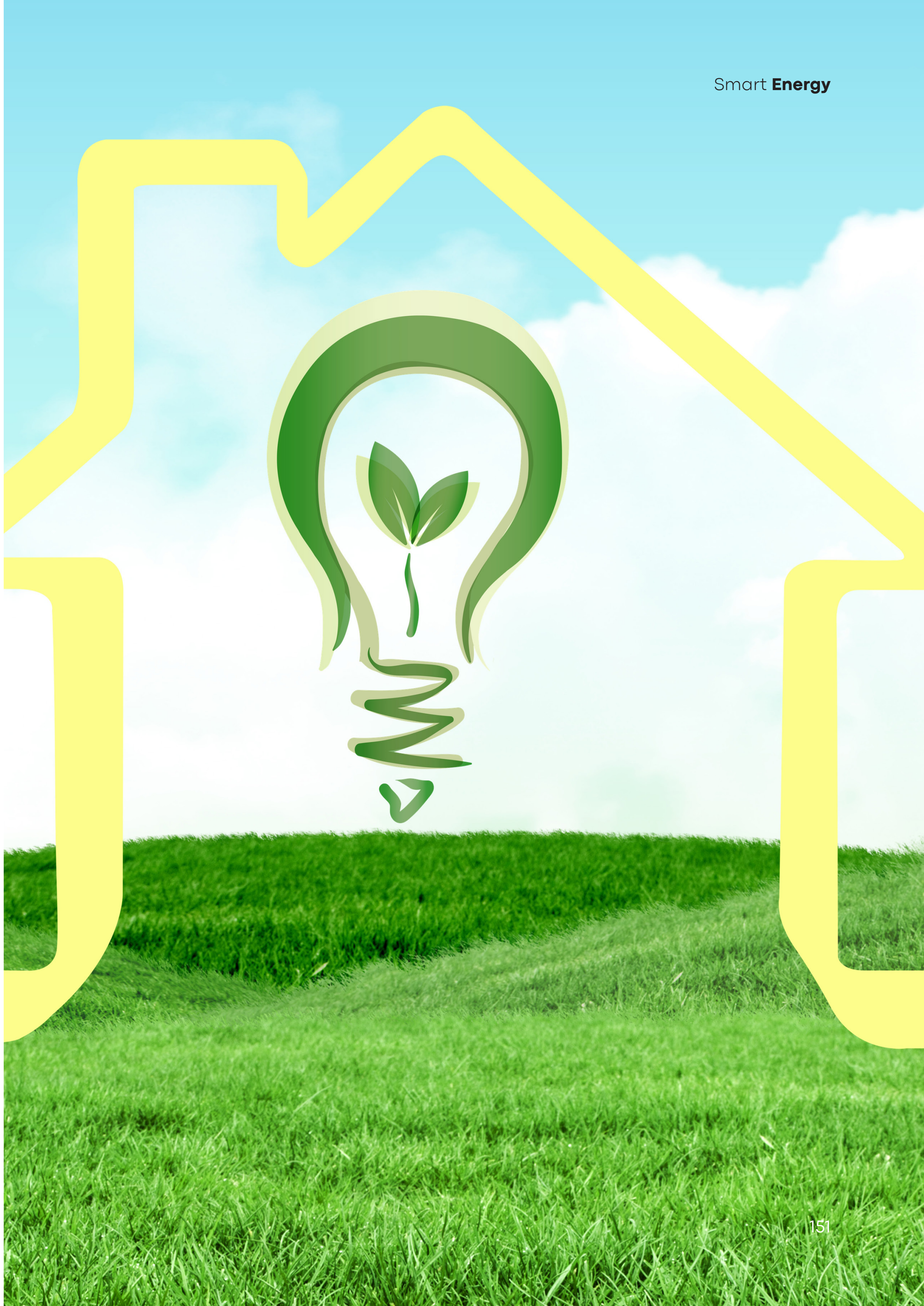
EVALUATION

The transition to smart energy systems is of vital importance in terms of being at the forefront of the Industry 4.0 revolution, achieving the Sustainable Development Goals and reducing the energy risks faced by our country. In fact, it is considered a matter of particular importance and priority in national plans and programs and in international cooperation programs.

There are numerous infrastructure and service options in smart energy systems. In order to be a smart city, each city must create local energy sources, energy needs and sustainable energy planning. It is necessary to work on area-based applications such as district heating and cooling systems, to arrange technical infrastructure areas in accordance with the new standards required by renewable energy, to carry out studies that will create a suitable basis for the development of new buildings and existing buildings not only in terms of energy efficiency, but also in terms of energy production. This will enable the implementation of innovative and sustainable energy systems which increase the quality of life and reduce the cost of living.

Smart energy systems are also systems that can radically alter the transport system and offer many opportunities such as reducing carbon emissions, Enhancing urban mobility and preventing noise pollution. In this context, it will be possible to successfully transform cities into smart cities by determining the common denominators of smart energy systems and transport systems and the selection of applications that create synergy.

During the next period, smart cities will be the cities that make the best use of smart energy solutions that are clean, sustainable, increase the quality of life and reduce living costs.



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Strategy Documents and Policy Documents

2020-2023 Ulusal Akıllı Şehir Stratejisi ve Eylem Planı'nda Akıllı Enerji (Smart Energy in the 2020-2023 National Smart City Strategy and Action Plan)

On Birinci Kalkınma Planı (Eleventh Development Plan)

2018-2020 Orta Vadeli Program Hükümleri (2018-2020 Medium Term Program Provisions)

2010-2023 KENTGES Bütünleşik Kentsel Gelişme Stratejisi ve Eylem Planı Hükümleri (2010-2023 KENTGES Integrated Urban Development Strategy and Action Plan Provisions)

Ulusal Enerji Verimliliği Planları (National Energy Efficiency Plans)

2003-2023 Ulusal Bilim ve Teknoloji Politikaları Strateji Belgesi hükümleri (Provisions of the 2003-2023 National Science and Technology Policies Strategy Document)

2017-2020 Ulusal Genişbant Stratejisi ve Eylem Planı Hükümleri (2017-2020 National Broadband Strategy and Action Plan Provisions)

2014-2023 Bölgesel Gelişme Ulusal Stratejisi Hükümleri (2014-2023 Regional Development National Strategy Provisions)

2014-2020 Ulusal Kırsal Kalkınma Stratejisi Hükümleri (Provisions of the 2014-2020 National Rural Development Strategy)

2010-2023 Ulusal İklim Değişikliği Strateji Belgesi Hükümleri (Provisions of the 2010-2023 National Climate Change Strategy Document)

2007-2023 AB Entegre Çevre Uyum Stratejisi Hükümleri (Provisions of the 2007-2023 EU Integrated Environmental Harmonization Strategy)

In order to be a smart city, each city needs to be able to make local energy resources, energy needs and sustainable energy planning, work on area-based applications such as district heating-cooling systems, and arrange technical infrastructure areas in accordance with the new standards required by renewable energy. In addition, studies should be carried out to create a suitable basis for the development of new buildings and existing buildings not only in terms of energy efficiency, but also in terms of energy production. Smart cities need to implement innovative, sustainable energy systems that increase the quality of life and reduce the cost of living.

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