SHURA Energy Transition Center

Analysis of business models, technologies, and the needed regulatory scheme for power system digitalisation in Turkey

About SHURA Energy Transition Center

Founded within Sabancı University, European Climate Foundation (ECF), Agora Energiewende and Istanbul Policy Center (IPC), About SHURA Energy Transition Center contributes to the decarbonisation of the energy sector via an innovative energy transition platform. It caters to the need for a sustainable and broadly recognised platform for discussions on policy, technological, and economic aspects of Turkey's energy sector. SHURA's mission is to support the debate on transition to a low-carbon Turkey's energy system through energy efficiency and renewable energy by fact-based analysis and best available data. Taking into account all relevant perspectives by a multitude of stakeholders, the center contributes to an enhanced understanding of the economic potential, technical feasibility and the relevant policy tools for this transition.

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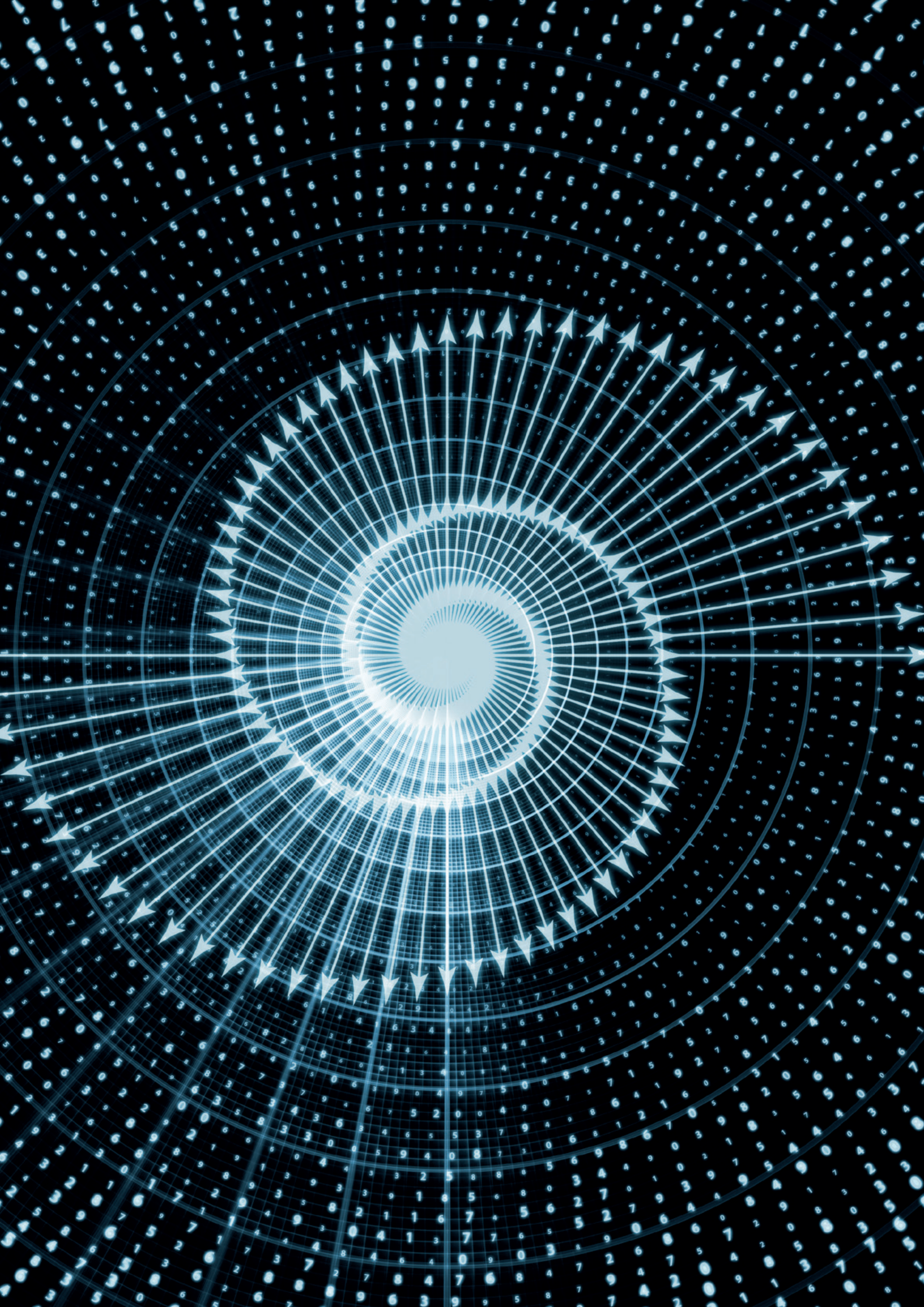

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LIST OF ACRONYMS

AI	Artificial Intelligence
AR	Augmented Reality
AMRS	Automatic Meter Reading System
BRG	Balance Responsible Group
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CBA	Cost-Benefit Analyses
CEE	Chamber of Electrical Engineers
CFO	Chief Financial Officer
C-O	Community-Ownership
DERs	Distributed Energy Resources
DMI	Deloitte's Digital Maturity Index
DSO	Distribution System Operator
EaaS	Energy-as-a Service
EBC	Europe Beyond Coal
ELDER	Electricity Distribution Services Association
EMEA	Europe, Middle East, and Africa
EMRA	The Energy Market Regulatory Authority
EMS	Energy Management System
EPC	Energy Performance Contract
EPC	Engineering, Procurement, and Construction
ESCO	Energy Service Company
ESP	Energy Service Provider
ETSI	European Telecommunications Standards Institute
EU	European Union
EÜAŞ	The Electricity Generation Company
EXIST/EPİAŞ	Energy Exchange Istanbul
EV	Electric Vehicle
GHG	Greenhouse Gases
GIS	Geographic Information System

GW	Gigawatt
HR	Human Resources
ICT	Information and Communication Technologies
IEA	International Energy Agency
IoT	Internet of Things
IT	Information Technologies
KW	Kilowatt
KWh	Kilowatt hour
LCOE	Levelised Cost of Electricity
LTE	Long Term Evolution
MENR	Ministry of Energy and Natural Resources
ML	Machine Learning
MW	Megawatt
MWh	Megawatt hour
OIZ	Organized Industrial Zones
OPEX	Operating Expenditure
OT	Operational Technologies
OTC	Over the Counter
PAYG	Pay-As-You-Go
PDPL	Personal Data Protection Law
PV	Photovoltaic
P&U	Power & Utilities
P2P	Peer-to-Peer Trading
R&D	Research and Development
RPA	Robotic Process Automation
ROI	Return on Investment
SaaS	Software-as-a-Service
TEDAŞ	Turkish Electricity Distribution Corporation
TEİAŞ	Turkish Electricity Transmission Corporation
TOGG	Turkey's Automobile Joint Venture Group Inc.
TOTEX	Total Expenditure
ToU	Time-of-Use
TÜİK	Turkish Statistical Institute
TSO	Transmission System Operator
TWh	Terawatt Hour
UNDP	United Nations Development Programme
US	United States
VPP	Virtual Power Plant
VR	Virtual Reality
V2G	Vehicle to Grid
Wi-Fi	Wireless Fidelity
YEK-G	Renewable Energy Guarantees of Origin
YEKDEM	Renewable Energy Resources Support Mechanism

Key Messages

- Innovative business models involved in the digitalization process that will accelerate Turkey's energy transformation offer multi-faceted benefits by changing the generation, distribution and consumption value chains in the energy sector.

- Distributed energy resource management, electrification management, grid infrastructure, increased energy consumption, evolving consumer expectations and the need for better data management are key drivers of the need for digitalization of the energy sector.

- Supply/demand aggregators, peer-to-peer trade, energy-as-a-service providers, energy service companies, pay-as-you-go and community ownership stand out among the business models that can accelerate the transformation of the energy sector through digitalization.

- The areas of action that may be needed for the implementation of innovative business models can be evaluated under the headings of existing market structure, legislation, socio-cultural conditions, financing, technological infrastructure, grid planning and urban development.

Executive Summary

Main transformation pillars of the energy system and objective of the study

Turkey is among the fastest-growing energy users and emitter of greenhouse gases (GHG) globally, and growing energy usage with its environmental and socio-economic impacts have been forcing the energy system to be transformed in line with technological advancements. Energy efficiency potential accelerated deployment of renewable energy sources, and electrification applications – supported by information and communication technologies (ICT), digitalisation, innovative policies, market instruments, and finance models – lead today's energy transformation.

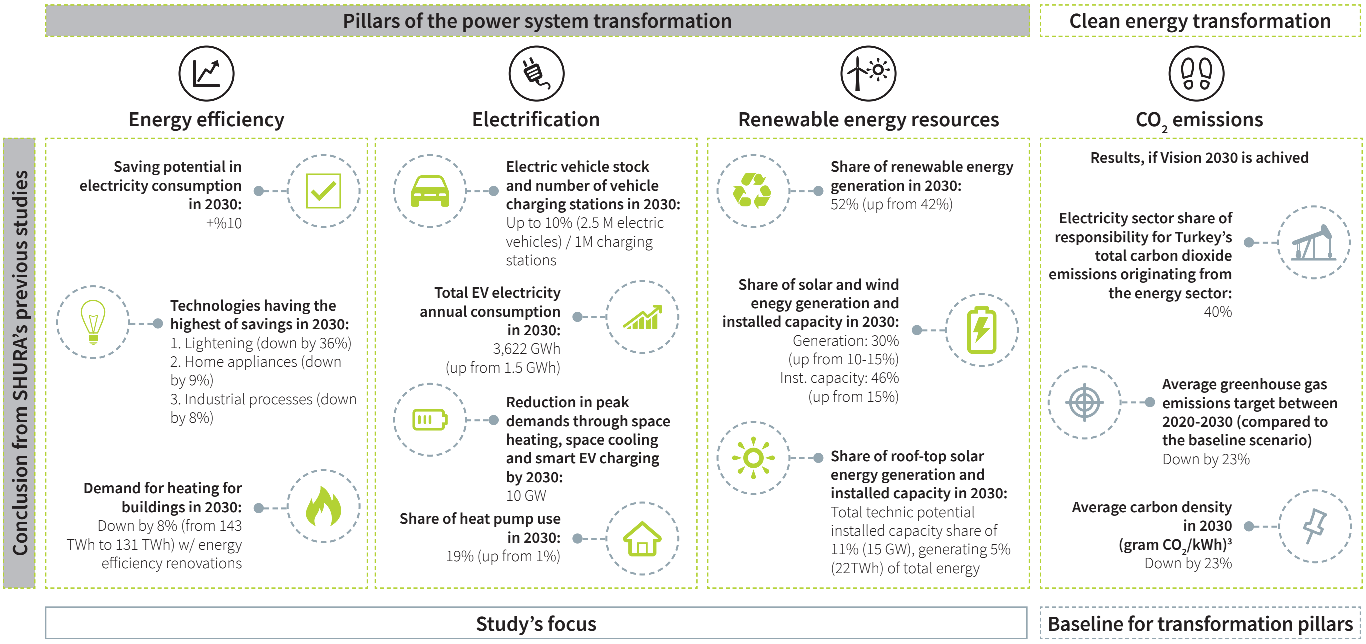
In many previous studies prepared by SHURA, the main pillars of energy transformation, i.e., energy efficiency, renewable energy, and electrification, were covered in detail, and all aspects, including the socio-economic benefits of energy transformation, were analysed from different perspectives.

"Most Economical Contribution for Turkish Electricity System: Energy Efficiency and New Business Models", one of these studies, reveals that there exists a saving potential of 10 percent in electricity consumption relative to the base scenario prepared on the basis of Ministry of Energy and Natural Resources projections, by 2030, as a result of implementing cost-effective efficiency options in the context of energy efficiency, one of the key pillars of energy transformation (SHURA, 2020c).

In addition to managing the demand, minimizing the negative effects of energy supply on the environment is also important. In this sense, the study titled "Turkey's Optimum Electricity Generation Capacity Towards 2030" suggests that it is technically and economically possible to increase the share of renewable energy sources in total electricity supply to 50% by 2030, with solar and wind energy generation expected to have a share of 30%. Furthermore, the study titled "Rooftop Solar Energy Potential" reveals that rooftop photovoltaic panel (PV) systems, a key component of distributed energy resources, have a technical potential of 15 GW (SHURA, 2020a-b).

Another pillar of energy transformation can be thought of as scaling up electrification in the end-use areas of energy in transport, buildings, and industry sectors, which have largest shares in emissions. In relation to the transport sector, where there is a high electrification potential, Ministry of Energy and Natural Resources declared on January 16th, 2020 that they estimated there would be 1 million electric vehicles by 2030 (Anatolian News Agency, 2020). In a study of SHURA, analysing the potential impacts of electric vehicles on the network, titled "Transformation of Turkish Transportation Sector", it was found that minimum 10 percent of total vehicle stock could be transformed into electric vehicles by 2030 and that 2.5 million electric vehicles could be integrated into the network if the planned network investments are to be completed. As highlighted in the study titled "Sector Matching for Integration of Wind and Solar to the Grid", electrification elements such as great pumps and electric vehicles, which are expected to become widespread rapidly, are estimated to further increase electricity consumption, and it is considered that new trends such as smart charging, demand-side participation, etc. will help reduce peak demand and relieve the grid in this sense (SHURA, 2019).

Results from some of the studies conducted by SHURA regarding these pillars of transformation are outlined in the figure below.



The main purpose of this report can be summarized as revealing the importance of digitalization and new business models in the process of realizing these visions within the scope of energy transformation and developing suggestions that may be valid for the energy sector in Turkey. Along with the concerns of increasing greenhouse gas emissions worldwide, energy consumption and the resources from which the energy consumption is obtained have begun to be questioned, and in this direction, issues such as energy efficiency, electrification of things and processes, and generation of electricity from green energy resources have begun to come to the fore. In this manner, energy efficiency studies, rapid development of renewable energy use, distributed energy resources and electrification rate have increased significantly.

In line with the transformation in energy systems, digitization activities and digital technologies are also becoming more common to help transform the electricity sector value chain. The benefits of integrating digitalization technologies into energy assets and processes are endless, and the fact that the energy sector is one of the last to benefit from the digitalization revolution reveals an unexplored potential. Some digital technologies will transform the way businesses are managed, while others will enable the creation of new business opportunities.

As the energy sector transforms and digital technologies introduce new concepts to the energy sector, new opportunities and challenges arise that did not exist before. The main challenges encountered include management of proliferating Distributed Energy Resources (DER), managing the growing electrification burden, making the infrastructure grid reliably sustainable, managing the increasing energy consumption levels of consumers, addressing changing consumer needs, and lastly effectively managing data to unlock the potential of digitization.

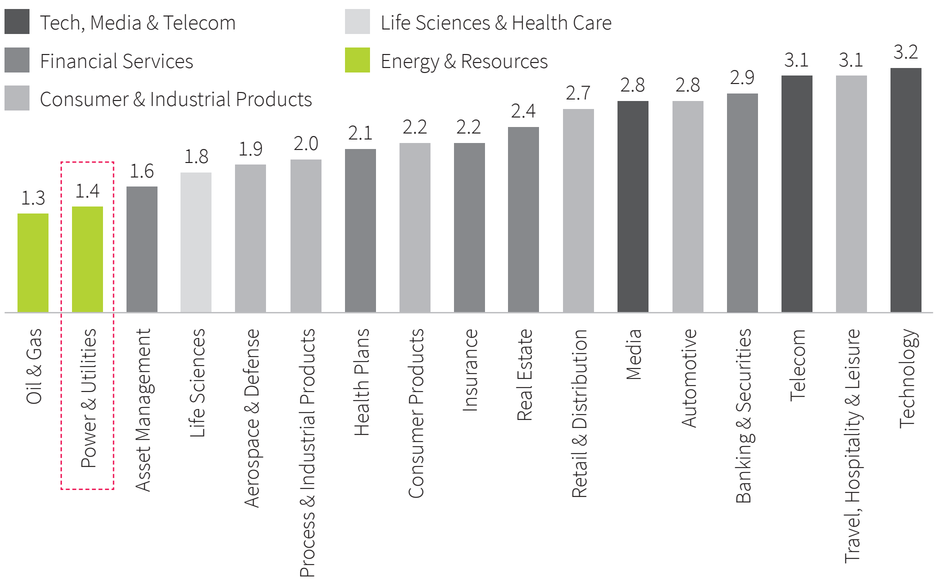
Innovative business models using digital technologies are seen as a solution to address these new needs and challenges. Even if such models focus on different targets and target customers, the common goal of all of them is to ensure a healthy transformation of energy sector. The integration of new business models will serve to provide a balanced grid, as well as high flexibility opportunities and innovative energy solutions provided to end consumers.

Although newly introduced business models offer the opportunity to improve the energy system in many ways, they may not be among the priorities as they may have relatively less impact on the system or be difficult to implement due to the current conditions in Turkey. In order for new business models to be implemented smoothly in the Turkish market, it is essential to prioritize the models' potential impacts on the energy sector (end consumers, service providers, financial impacts) and feasibility. In conclusion, in Turkey's energy transformation in the near future, viable business models with great potential for all stakeholders in the energy sector should be given priority. In this framework, the obstacles encountered in the implementation and dissemination of new business models should be examined in more detail in order to better understand the feasibility of new business models, taking into account the Turkish energy market during the development and implementation of new business models. In line with the assessments compiled during stakeholder interviews, the main obstacles encountered in the Turkish energy sector include the existing market structure of the country, legislation, socio-cultural conditions, financial conditions, technological infrastructure, grid planning and infrastructure, and the level of urban development. This report was needed to provide a comprehensive evaluation of these barriers and ensure development of recommendations through the research of global examples and practices as well as facilitation of energy transformation.

Latest trends in digitalisation

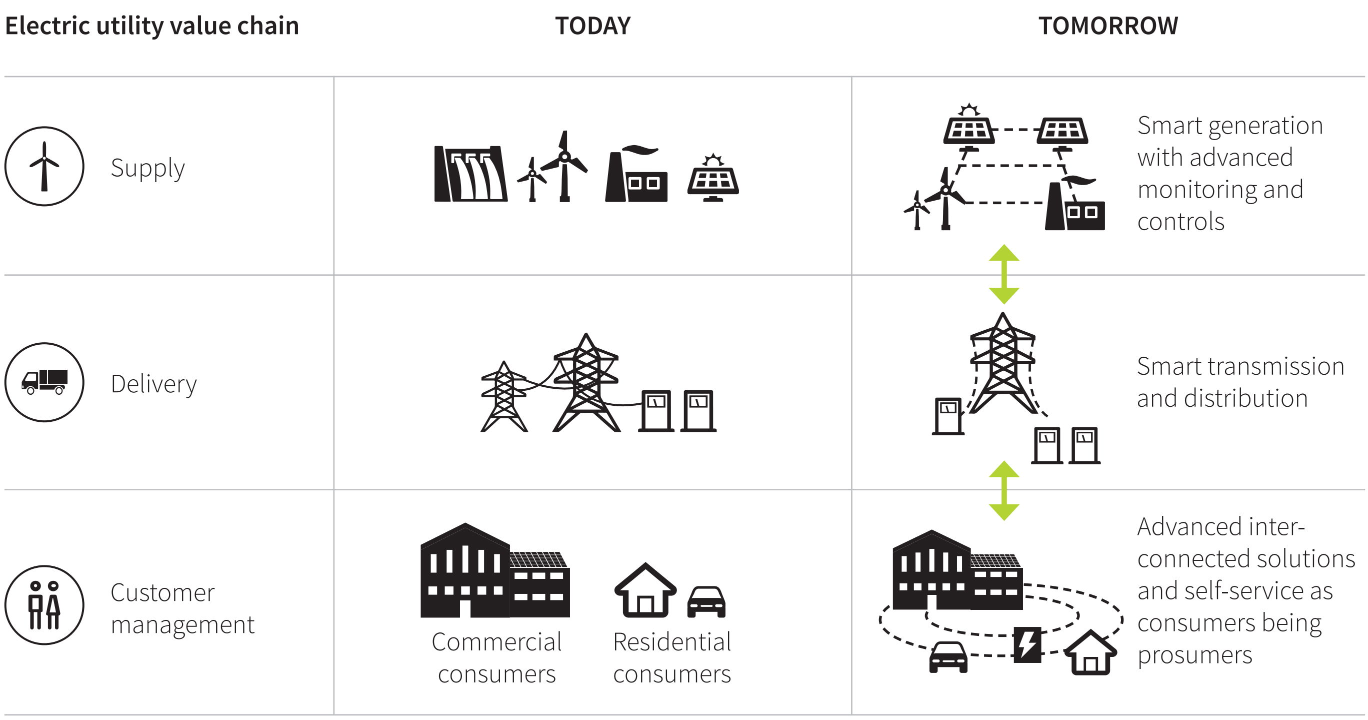
Transformation of the power system and the transition to clean energy occur in tandem with the sector's digital revolution. On one hand DERs proliferate, electrification increases, and efficiency applications become more common, whilst on the other, digital technologies are restructuring the entire utility value chain. Digital technologies and new business models that utilise them can address new challenges that are expected to arise with power system transformation while potentially bringing up several new barriers. Increased digitalization is possible through developments in data, analytics, and connectivity. These developments are defined, respectively, as increasing volumes of data, rapid progress in advanced analytics and computing capabilities, and greater connectivity.

The integration of digitalisation technologies to energy assets and operations would allow benefits in (i) helping improve safety in energy systems all around the world, (ii) productivity/efficiency, (iii) accessibility, and (iv) sustainability of the energy systems as well as (v) better satisfying the expectations of customers. However, according to Deloitte's Digital Maturity Index (DMI) framework study on companies in S&P 100 respectively, the energy sector has been one of the last industries to face the transformative wave of digitalisation. Most of the large companies in the energy sector manage to develop digital strategies and begin to implement them, yet there are still many areas within operations in which data remains untouched, with its potential to be reached and used.



Source: Deloitte's digital maturity index (DMI)
Note: Monitor Deloitte developed the DMI based on a study of the digital capabilities of the S&P 100 companies.

The digital revolution is transforming the utility value chain at every level. Renewables, distributed generation, smart grids, and smart customer solutions demand new capabilities and trigger new business models. The digital economy players disrupt the industrial landscape with new products and management options, while governments and regulatory bodies aim to generalise smarter measuring systems and greener standards for power generation and consumption. With the completely digitalised utility value chain of tomorrow, supply will have a diverse and decentralised structure with intelligent monitoring and automated controls, delivery will be managing two-way power flows and finally customer management will be enhanced with self-service applications, communication, and energy management solutions.



Source: Deloitte analysis

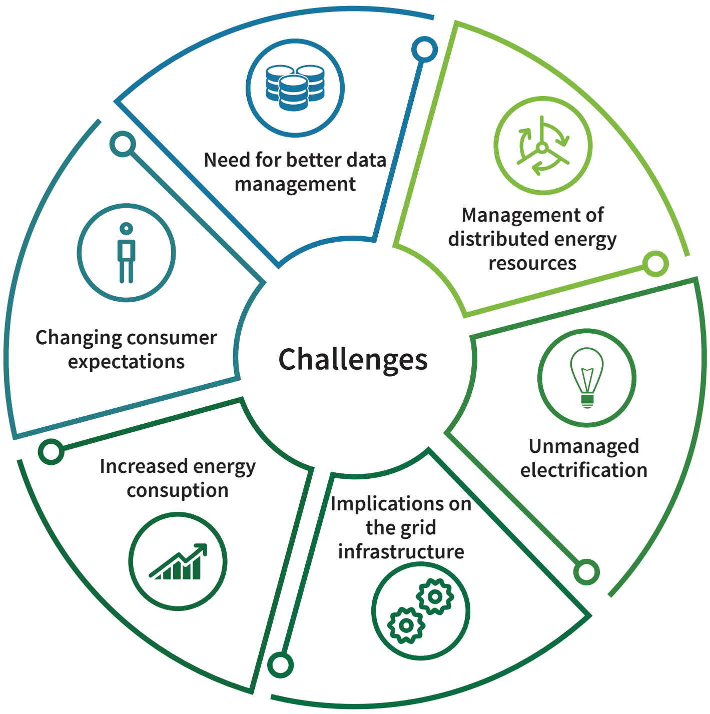
Among offerings towards the digital transformation of the energy industry, five digital technologies: robotic process automation (RPA), AR & Wearables, IoT, AI-Machine Learning (ML) & Big Data, and Blockchain, come to the forefront with their extensive use cases in the sector. IoT, AI & ML and big data and blockchain technologies play a critical role in transforming data to value. On the other hand, RPA and Augmented Reality & Wearables are mostly used for system optimization in back office and field processes.

With the energy transition and transformation into a more data-driven and connected system, Turkish power sector began acknowledging the importance of building digital competencies. To integrate digital technologies into the energy value chain, plenty of technology service providers have entered the Turkish market especially in the last five years. Despite following global trends from relatively behind, Turkish power sector has been putting great effort to digitalise itself, which has become almost an obligation for maintaining a manageable and an efficient system while focusing especially on end-consumers. The focus of energy sector has been system optimization and to this end, RPA has the widest areas of application for repetitive transactions. Although the adoption of digital technologies with higher impact potential in Turkey accelerated especially with the beginning of 2016, the maturity level of these technologies has not reached the desired level yet. Current efforts rely on technology prioritization studies, encouragement of the adoption of digitalization technologies and support for data analytics projects relating to energy in Turkey.

Potential challenges and new needs emerging from energy transformation in Turkey

Power system is going under a transformation and with higher digital technology integration into the sector and some new needs arise while addressing various challenges. As discussed in the previous sections of this report, there are major shifts in the overall value chain – ranging from changes in how energy is generated to how it is transmitted and distributed and how it is consumed. With proliferation of DERs, their intermittent, variable, and disperse nature alongside their market- and asset-related implications introduce new challenges in terms of their management. Similarly, as electrification increases in both the mobility and the built environment settings, it brings along new needs such as managing implications on the grid and eliminating the need for fossil fuels to cover the newly introduced demand – all of which can be managed with smarter systems utilising digitalisation technologies. On the other hand, besides newly electrified areas that bring along new demand to the picture, total energy demand increases as well as both the economy expands, and industrial activities accelerate. This total increase forces end-consumers to take responsibility in their demand management while consuming energy efficiently. Even further, as it is seen in every sector, consumers are becoming more demanding in how they receive services – and energy sector is no different. Simply put, consumers no longer want to receive just the energy as a commodity but rather they want utilities to help them in areas where energy management issues occur, and new solutions may be applicable. Alongside all these changes that bring new challenges, digitalisation comes to forefront as a solution while bringing new needs specifically in terms of data-related areas. Data and how you treat it will become an integral part of decision-making processes. Hence, data quality, standardization, administration, and effective use of tools are needed to be ensured for a more efficient and secure energy system.

The more connected, digitalised, decentralised, and customer-centric energy system requires a proper management of energy resources, the consumption, electricity grid, data, and the energy markets simultaneously. To this end, potential challenges in the power sector can be categorised under six main topics, which are explained in detail below: (1) management of distributed energy resources, (2) need to manage electrification, (3) implications on grid infrastructure, (4) increased energy consumption, (5) changing consumer expectations, and (6) need for better data management.



Business models in the scope of energy system transformation

Potential challenges that arise with the transformation of the power sector have created a need for innovative solutions, which are enabled by digital technologies. These innovative solutions may address the existing or potential challenges in the power sector.

As being innovative and problem solvers, target business models are grouped under seven categories, depending on requirements in terms of structure, product, and experience. These business models have assimilated second level sub-categories, which perform similar core activities with different purposes and target customers.

1. Supply aggregators / virtual power plants aim to optimise energy operations by combining various energy resources and governing these DERs through a centralized IT system. Its advantages consist of allowing real-time balancing of big-scale power plants, integration of small-scale prosumers to the market, providing ancillary services to TSOs, and optimisation of internal DERs. In addition, virtual power plants can decrease the marginal cost of power by eliminating the need for large power plant generation. The model addresses five challenges that emerge in the power transformation. Although management of distributed energy resources and the need for better data management are undertaken by all the sub-business models; changing consumer expectations, increased energy consumption and impacts on grid infrastructure are supported by different sub-categories.

2. Demand aggregators meet the need for spreading demand over time to avoid increased electricity consumption during peak hours, by providing demand-side management services to grid operators. The value created by demand aggregators is revealing the flexibility of power consumers. To do that, demand aggregators use mainly IoT and AI technology for real-time optimisation of energy consumption. The single business model under demand aggregators addresses four challenges that emerge in the power transformation. These challenges are the management of distributed energy resources, the need for better data management, implications on the grid infrastructure, and increased energy consumption.

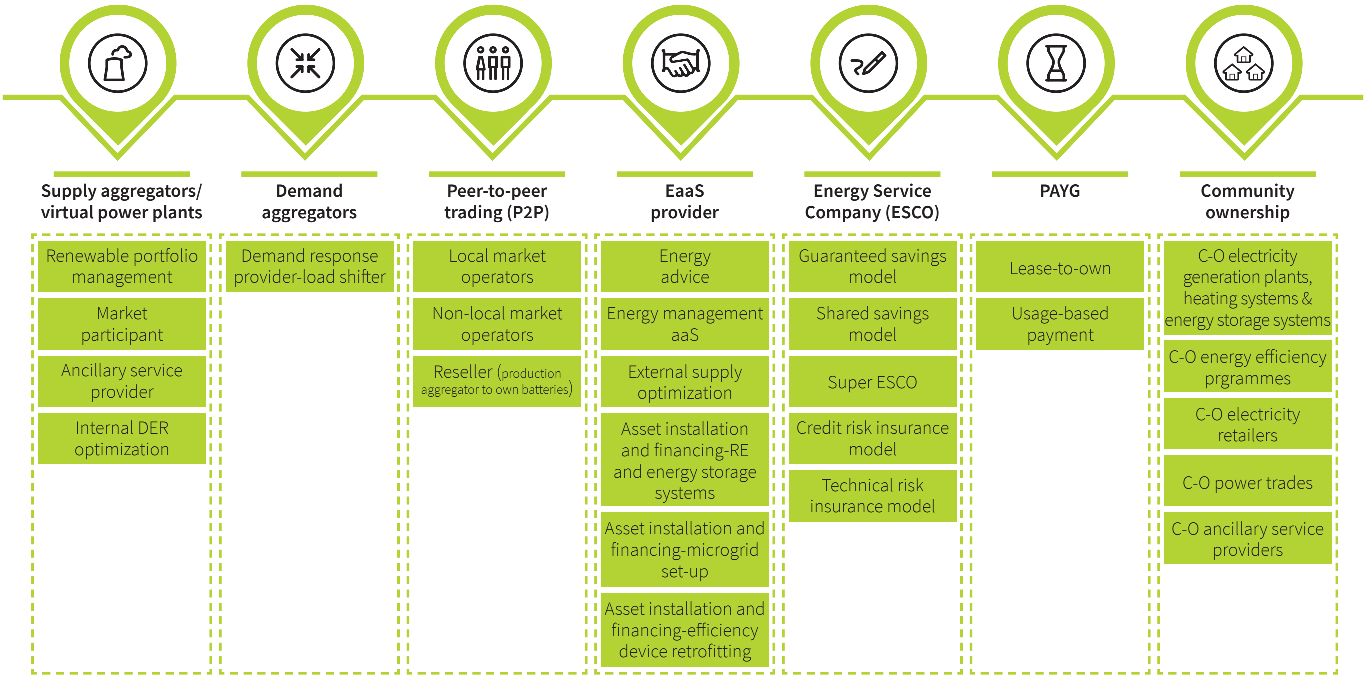
3. Peer-to-peer (P2P) energy trading is built on a blockchain based platform architecture that allows users and producers to engage directly to share the benefits of DERs. In addition to the fact that it supports the increased deployment of DERs, it can also be used for balancing activities, congestion management and ancillary services for the grid. Although management of distributed energy resources and the need for better data management are undertaken by all the sub-business models, the remaining three pinpoint different sub-categories. These challenges are implications on the grid infrastructure, changing consumer expectations, and unmanaged electrification.

4. The Energy as a Service (EaaS) model offers energy-related services to its customers. EaaS presents an integrated approach that combines hardware and software related services in line with increased digitalization. Key benefits of EaaS emerge as enhanced deployment and management of DERs and increased grid flexibility via demand-side participation alongside efficiency solutions. Furthermore, it also offers simplification in energy service offerings. Differing from other business models, the changing consumer expectations challenge is undertaken by all the sub-business models. The remaining are increased energy consumption, management of DERs, the need for better data management, and unmanaged electrification.

5. An energy service company (ESCO) focuses on offering energy services such as implementing efficiency projects and providing DERs on a turn-key basis. The primary purpose has been to reduce the energy cost of buildings through end-to-end solutions. In addition, it offers the customers with the possibility to deal with their primary functions only. The most distinctive feature of ESCO models is that the revenue model is built on the energy saving created by the project. All five sub-business models under ESCO model address the same three challenges: increased energy consumption, changing consumer expectations, and the need for better data management.

6. Pay-as-you-go (PAYG) model usually includes a home solar system, rented, or sold, for which the customers pay via mobile payment technologies and mobile phone credits. The PAYG model is an innovation that was emerged to address the energy access challenge and to provide electricity generated from renewable energy resources at affordable prices. While eliminating the need for grid expansion investments, the PAYG model also enables other innovative business models such as P2P energy trade and community ownership. The two sub-business models under the model address the challenges of changing consumer expectations and implications on the grid infrastructure.

7. Community ownership (C-O) enables the actors, including households, individuals, and businesses to unite in obtaining energy-related assets such as DERs, battery systems, district cooling, and heating systems. The ownership of assets belongs to all members, and the obtained systems are managed collaboratively. The C-O drastically reduces upfront costs of DERs depending on the number of participants in the community, taking advantage of economies of scale and consequently increasing the deployment of DERs. In addition to reduced initial investment costs, community members can reach sustainable low-cost energy solution rather than dependency on the main grid. The model addresses five challenges in total that emerge in the power transformation. The need for better data management challenge is undertaken by all sub-business models. The second most common addressed topic is changing consumer expectations. The remaining are management of DERs and implications on the grid infrastructure.



Source: Deloitte analysis

Prioritization of application areas for business models

To assess the potential success of new business models, the study's target business models and their sub-models are prioritized based on their potential impact on the power sector and feasibility of their implementation in Turkey. The impact analysis covers the end-consumer side, the energy and service providers in the industry, and the financial aspects. Feasibility, on the other hand, considered technical requirements, regulatory requirements, and the roles of stakeholders in implementation.

The prioritisation study illustrates that (9) EaaS: Energy advice and (11) EaaS: External supply optimization are the most prioritized models in terms of their feasibility and applicability. An in-depth analysis of the seven target business models provides a clearer picture. It is seen that aggregator sub-models are scattered across the matrix due to differentiating impacts and applicability. The P2P model's categories are clustered closely around the second quadrant, being difficult to implement. Third, the EaaS sub-models are found in the high-feasibility and high-impact quadrant, meaning they could emerge in the short-term. Furthermore, the ESCO and PAYG sub-categories are divided between the first and second quadrants, diverging due to their feasibility. Lastly, the community ownership model's sub-categories are positioned in several quadrant; (24), (25), and (26) are thought to have the relatively lowest impact among all business models, resulting in their clustering around the third quadrant.

Barriers to the spread of new business models and recommendations for solution

Innovative business models focused on digital technologies are viewed as a solution to take advantage of the opportunities brought about by energy transformation and to deal with potential difficulties. Although the business models introduced newly at the global scale offer the opportunity to improve the energy system in many ways, they are either not implemented at all or implemented at a limited extent or fail to realize their full potential due to certain obstacles. As a result of the research conducted and stakeholder meetings held during the preparation of the report; potential obstacles that could arise in the introduction of new business models in Turkish energy sector were analysed specifically with regard to existing market structure, legislation, socio-cultural conditions, financial conditions, technological infrastructure, grid planning and infrastructure, and urban development.

In order to develop recommendations for the elimination of potential difficulties identified, these obstacles have been analysed in detail and conclusions have been presented comprehensively.

		Supply aggregators	Demand aggregators	P2P	EaaS	ESCO	PAYG	Community ownership
Existing Market Structure	The need for improvements in ensuring liberal market conditions	x	x		x	x		x
	Non-deterring level of imbalance costs	x	x		x			x
	Limited tariff options		x		x			x
	Renewable energy incentives		x		x	x	x	
	Net settlement application on unlicensed generation	x		x	x		x	x
	Subsidized consumer prices	x	x	x	x	x	x	x
	Additional technology investments not being reflected to consumer tariffs		x		x	x	x	x
	Barriers to consumer involvement in the market		x		x			x
	Implementation of capacity mechanism	x	x		x			
	Need to shorten trade times in organized wholesale markets	x			x			x
	Areas for improvement in the practice of balance responsible party	x	x	x	x			x
	Organized industrial zones' role and conflicts of interest regarding innovative business models	x	x	x	x	x	x	x
	Retail companies' responsibility area for electricity trade through distributed generation	x	x	x	x		x	x
	The absence of a mechanism to encourage battery systems	x	x	x	x		x	x
	Assessment of overall impact level	◕	◕	◕	●	◑	◑	◕
Legislation	Areas for improvement in legislation quality and consistency	x	x	x	x	x		x
	Complexity of bureaucratic processes	x		x	x	x	x	x
	Lacking regulations	x	x	x	x	x	x	x
	Need for authorizations	x	x	x	x	x		x
	Assessment of overall impact level	●	◕	●	◑	◑	◔	◑
Sociocultural conditions	The current digital literacy and awareness levels of residential consumers	x	x	x	x	x	x	x
	Current approaches and digital maturity levels of commercial and industrial consumers	x	x	x	x	x	x	x
	Operational practices, perspectives of digitalization, and level of awareness of the public sector	x	x	x	x	x	x	x
	Lack of qualified workforce	x	x	x	x	x		
	Assessment of overall impact level	◕	◕	●	●	●	◕	◕

Financial Conditions	Investment cost of energy facilities and long payback periods	x		x	x	x	x	x
	Infrastructure investment need and high costs	x	x	x	x	x	x	x
	Technology investment need and high costs	x	x	x	x	x	x	x
	Currency pressure	x	x	x	x	x	x	x
	Low profit margins in the electricity sector	x			x		x	x
	Limited company budgets	x			x	x		
	Lack of synergy between banking and energy sectors	x	x	x	x	x	x	x
	Insufficient funding	x	x	x	x	x	x	x
	Assessment of overall impact level	●	◑	◕	●	◕	◕	◕
Tech. Infrastructure	Barriers to access to and use of hardware	x	x	x	x	x	x	x
	Barriers to software	x	x	x	x	x	x	x
	Barriers to communication protocols	x	x	x	x	x	x	x
	Assessment of overall impact level	◕	◑	◕	◑	◑	◑	◔
Grid planning and infrastructure	Need to increase effectiveness in grid planning approach	x	x	x	x		x	x
	Need to improve distribution and transmission network cooperation	x	x	x	x		x	x
	Lack of smart grid approach	x	x	x	x		x	x
	Lack of alternative (local and autonomous) grid approaches	x		x			x	x
	Need to regulate voltage levels	x	x	x			x	x
	Need to manage the increased load on the grid due to electric vehicles	x	x	x	x			x
	Assessment of overall impact level	●	◑	●	◔	○	◕	●
Urban Development	increase in vertical structuring, and the fact that urban transformation projects are not planned in a way that regards the installation of renewable energy, and infrastructure requirements	x		x	x	x	x	x
	Assessment of overall impact level	◑	○	◕	◑	◔	◑	◕

Although it is possible to argue that potential obstacles affect almost all business models, it appears that the extent or impact of these obstacles could be different in each business model. The P2P model stands out as the most affected one, therefore being the most difficult to implement in Turkey, having the highest level in each category, except urban development, when compared to other models. This is because this model requires a structure supported by both technological and grid infrastructure and related regulations, in which market participation is ensured and consumers are allowed to consciously sell/buy the energy obtained from smart grids on a platform. This is due to the fact that this model necessitates a structure supported by relevant regulations and both the technological and grid infrastructure where market participation is enabled, and consumers are allowed to sell/purchase energy derived from smart grids deliberately on a platform. Consumer participation also requires a certain level of awareness and recognition of the benefits offered by the business model. However, as in the case of P2P operators, EaaS and ESCOs are also the most affected by socio-cultural conditions since these models necessitate efforts and active participation of consumers. On the other hand, the EaaS model, involving individual energy solutions for end-consumers, is believed to offer the most potential for implementation, with legislation and grid planning being the least influential barriers and having a below average impact. Furthermore, it is seen that the extent of urban development barrier is the lowest when compared to other barriers, but it poses a significant threat to the community ownership model. The vertical structuring in Turkey prevents the installation of smaller renewable energy sources, which is the key requirement of the C-O model. Moreover, although there are differences between the categories, it is understood that the supply and demand aggregators are affected at the same rate when considered collectively. It is understood that these models have difficulties in becoming widespread since they are not defined in the legislation which prevents them from participating in the market by trading activities to support balancing activities. In addition, the low predictability of the market and subsidised electricity prices hinder the creation of potential value to the industry. Moreover, aggregators are the most negatively affected business models by the technological infrastructure since the needed technologies are still not fully adopted in Turkey. Supply aggregators benefit from a centralized IT system consisting of all the components of the technological infrastructure, while demand aggregators benefit from IoT and AI technology, highlighting the importance of software.

The detailed analysis of the obstacles to the implementation of new business models gives a comprehensive idea on how to overcome these obstacles. Complementary to the views discussed here, steps that can accelerate the integration of new business models brought about by energy transformation in Turkey into the energy sector are discussed below.

Existing market structure

The effective functioning of any business model depends on the correct functioning of each the dynamics making up the market individually (especially the aspects affecting competition). In a highly regulated sector such as the energy sector, it is critical to ensure that competitiveness and market surveillance aspects function efficiently, while regulated areas to not negatively affect competition on the other hand. Recommendations for addressing the barriers relating to existing market structure discussed in Section 6.1 are presented below.

- It should be essential that energy prices are determined in a manner that covers all costs. Subsidies provided to end consumer prices should be avoided to the extent possible, and direct support should be provided to vulnerable consumer groups who are in need of support.
- It should be ensured that the prices formed in the wholesale markets are determined according to the supply-demand balance that will occur under actual conditions, value of lost load calculations should be taken as a basis in setting the price caps that will negatively affect price predictability, while avoiding other price interventions.
- With regard to the continuity of the support provided for rapidly developing technologies (such as renewable energy resources) in case the cost reductions in these technologies reach competitive levels in the market, they should be competitively placed in the markets. It should be considered that the direct incentives provided may create an obstacle to new business models after the need for incentives does not exist anymore.
- The imbalance penalties incurred by market players should reflect the actual cost of imbalance. Deterring imbalance costs that will encourage market participants to reduce their own imbalances, will pave the way for innovative business models.
- It should be ensured that energy commodity prices are determined competitively, and it should be essential that regulated tariffs are minimized. Multi-time and dynamic tariff options may be offered if regulated retail tariffs are applied.
- Instantaneous generation/consumption requirements cannot be taken into account in the monthly settlement practice, which is currently used in unlicensed electricity generation, hence there exists no incentive for eliminating imbalances. After a certain level of distributed generation integration, the monthly settlement practice may be replaced by different methods that will take into account the actual costs of the system.
- The costs of energy surveillance devices, smart meters and other equipment required to maximize the value offered by new business models could be allowed to be reflected in tariffs.
- Legislative amendments should be introduced so that consumers can become active players in the market.
- Although it is important to provide reserve capacity for system reliability and implement a capacity mechanism to assure this, the capacity mechanism should be re-visited in a way that highlights flexible resources and should have a structure that does not create inefficiencies.
- The Intraday Market is particularly important in terms of the effective functioning of all wholesale markets and the reduction of imbalances in renewable resources among them, so that new business models can be operationalized. If the transactions in this market take place in time periods closer to the real time, it will be possible to trade the imbalances that occur, which will enhance the accuracy of generation forecasts decrease imbalances in the market. In this context, the gate closure times of trades in organized wholesale markets should be reduced to a level close to real time.
- Although the practice of Balance Responsible Group (BRG) is a good instrument for managing financial imbalances, it can have negative consequences in terms of physical balancing and inflict additional costs on the system operator. The definition of BRG could be revised and obligations could be introduced in terms of physical balancing.

- As organized industrial zones have the right to establish and operate distribution facilities in their own regions, to distribute electrical energy and to perform other related services, the success in the implementation of innovative business models in these regions could be limited to the success of OIZs in that area. The constraints and benefits related to this issue should be re-evaluated in the future.
- Generator companies should be allowed to become active market players in electricity trade executed through distributed generation method.
- The legislative work to pave the way for the use of battery technologies at the grid scale and behind the meter should be completed and incentives should be provided to support this technology, which is not yet competitive.

Legislation

Since the energy sector is highly regulated, relative to many other sectors, most of the activities in this sector are carried out in compliance with the provisions of the legislation. There is a need to develop new legislation in order to implement some of the new business models discussed in this report. Furthermore, along with definition of new areas, it will also be necessary to ensure alignment with the legislation in force and/or improve its enforcement. The steps that need to be taken in the field of legislation, for the implementation of new business models, are summarized below.

- It is important to review and harmonize the regulations that cause inefficiencies in the current legislation, not only for the introduction and effective functioning of new business models, but also for the effective functioning of existing practices in the energy sector. This will also allow the regulator to identify responsible parties and improve their communication and coordination.
- Undertaking the investments to pave the way for new business models in the energy sector are subject to bureaucratic processes. In particular, there is a need to simplify the defined bureaucratic processes for implementing unlicensed solar power plant investments. Simplifying the existing 9-step lengthy bureaucratic process for getting permits for establishment of solar power plants, which tales 4 months, would also be useful in increasing the motivation of consumers to adopt new practices regarding energy.
- The implementation of new business models will require the creation of many new concepts, the development of necessary regulations relating to them, and the development of practices that will make sure that these new regulations will be enforced on the ground.
- Definition of new concepts and a framework of responsibilities will facilitate the dissemination of these models; aggregators and the build-operate-transfer model should be clearly defined in the regulations, the regulations on energy storage activities should be improved to include small participants and to allow the sharing of excess energy. Finally, although the term ESCO has already been defined, the mechanisms such as the arbitration mechanism required by this model should also be incorporated into the regulations.
- Digitalization applications in energy require significant technical infrastructure and implementation. Rapid adoption and reliable operation of value-added systems require establishment of the technical standards of such systems and the authorization of third parties to supervise these systems. Certification of EPCs with qualification prerequisites to ensure institutionalization after the relevant training and testing will also secure the success of energy projects and will help ease the burden of auditing each EPC application of distribution companies.

Socio-cultural conditions

Even if technological facilities are offered, the widespread implementation of business models will only be possible if energy system users believe in the benefits of energy transformation and demand new services. For the energy transition to be fully adopted in Turkey, it will be critical for consumers, industry players and public institutions in the market to reach a certain level of awareness. This could be achieved by providing trainings on digital literacy skills, the energy transformation itself, and the potential benefits of new business models. Moreover, collaboration of industry players to develop user-friendly solutions minimizing the operational effort required by end-consumers is of high importance. This would also allow cooperation between new and existing industry players, improving the competitive environment of the market. The endeavor of the public sector is also believed to be crucial; development of a consistent and long-term roadmap for the industry and its transparent sharing would motivate new models to emerge. The examination of global cases and applications could be advantageous during the preparation of the roadmap. Lastly, the acquisition and retention of qualified workforce is significant for the industry to progress, and measures must be taken to achieve this.

The actions recommended in the sociocultural field are listed below:

- Programs should be developed to increase the digital literacy levels of energy consumers.
- Programs should be implemented to increase the level of public awareness on energy transformation.
- It is crucial to raise awareness among commercial and industrial consumers about the benefits offered by energy transformation.
- Due to the leading role of the public sector in the energy industry, roadmaps with clear objectives regarding energy transformation and the application of new digital technologies in the energy sector should be developed, shared with the public and their implementation should be followed up closely.
- In order to improve the competencies of employees in the sector, training programs should be delivered on professional subjects, particularly including software development.
- Importance should be attached to retaining the labor force and supports and incentives should be provided to ensure that all human resources, especially R&D personnel, are satisfied with their work.

Financial conditions

The implementation of any investment and its supporting business models requires a proper set-up of financial conditions. The obstacles brought by the financial difficulties in the energy sector delay the implementation of new business models and increase the need for new solutions. Innovative models that include technical/credit risk hedging mechanisms would be crucial in the spread of business models, especially for ESCOs. To alleviate the financial and performance-based risks of these projects, a guarantee and insurance mechanism can take place, which ultimately would reduce the amount of collateral the banks collect from project-owners. Moreover, the financial incentives are of high importance for potential investors who struggle with high upfront costs of energy assets, infrastructure, or technology, as well as currency pressure and limited budgets.

The recommendations for improvement of financial conditions, one of the most critical areas in implementing new business models, are presented below:

- Providing the financial conditions required for the realization of new business models will only be possible if basic parameters such as inflation, exchange rates and commodity prices are predictable.
- Incentives for potential investments should be defined due to the high initial investment costs of new facilities and infrastructures that will enable new business models. However, as mentioned earlier, it is also important to terminate obsolete incentive mechanisms in a timely manner.
- It could be considered to provide the necessary budgets for the installation of critical technological infrastructures required for digitalization applications in energy, in the tariffs.
- Coordination should be ensured between the banking and energy sectors to provide the financing opportunities needed by the energy transformation.

Technological infrastructure

Transformation of the energy sector and digitalization of the sector require a substantial technological transformation. the following steps should be taken to make this technological transformation possible:

- Dissemination of three technological applications that will support the transformation in the energy sector –i.e., internet of things (IoT), smart meter infrastructure and battery storage– should be supported.
- In order to determine the standard meter requirements and implement pilot applications, the roadmap created for smart meters in the "Smart Grid Roadmap of Turkey" should be followed.
- The minimum limit for the installation of AMRS should be reduced to increase adoption of remote metering applications.
- Necessary steps should be taken towards regulatory adjustments for the determination of the energy storage systems' role in networks as well as their ownership rights as well as the establishment of an all-inclusive environment where the power limitations of smaller consumers are reduced.
- Standards and reference-language should be determined for software and data sharing; processes for data validation and quality control should be developed and supported by changes in regulations to resolve conflicts with the Personal Data Protection Law (PDPL).

Grid planning and infrastructure

In Turkey, with increasing use of distributed energy sources and electrification trends, discussions have begun on how the grid infrastructure will transform. Going forward, it is clear that the scope of distribution grid planning should include distributed generation, new forms of demand and flexibility options. The steps required to be taken so that the grid infrastructure develops in a manner that supports new business models are listed below:

- Grid development plan should include demand-side participation, energy efficiency, energy storage facilities or other resources that the distribution system operator will use as an alternative to system expansion.
- Distribution and transmission system operators should increase their cooperation and coordination for grid development planning purposes.
- Holistic plans should be prepared, and implemented, for smart grid development. In this context, practices like smart meter installation, consumer access to consumption data, real-time monitoring of the grid, common sensor, and big data analytics applications, and addressing of grid capacity and restrictions through market platforms should be handled under the smart grid umbrella.

Urban development

Finally, to electrify the urban areas and meet the increased energy demand with greener energy resources, proliferation of renewable energy and electrification trends (e.g., heat pumps and EVs) are highly dependent on building the required infrastructure. Provided that Turkey is a country with a lot of urban transformation projects, authorities should consider the energy transition involvement in these projects for both achieving maximum efficiency from distributed energy sources such as solar PV proliferation and for electrification targets including widespread use of EV charging stations and heat pumps. Consequently, the compatibility of new constructions with the application of technologies such as rooftop solar PVs, battery systems, electric vehicle charging stations and heat pumps will pave the way for the widespread dissemination of these innovations.

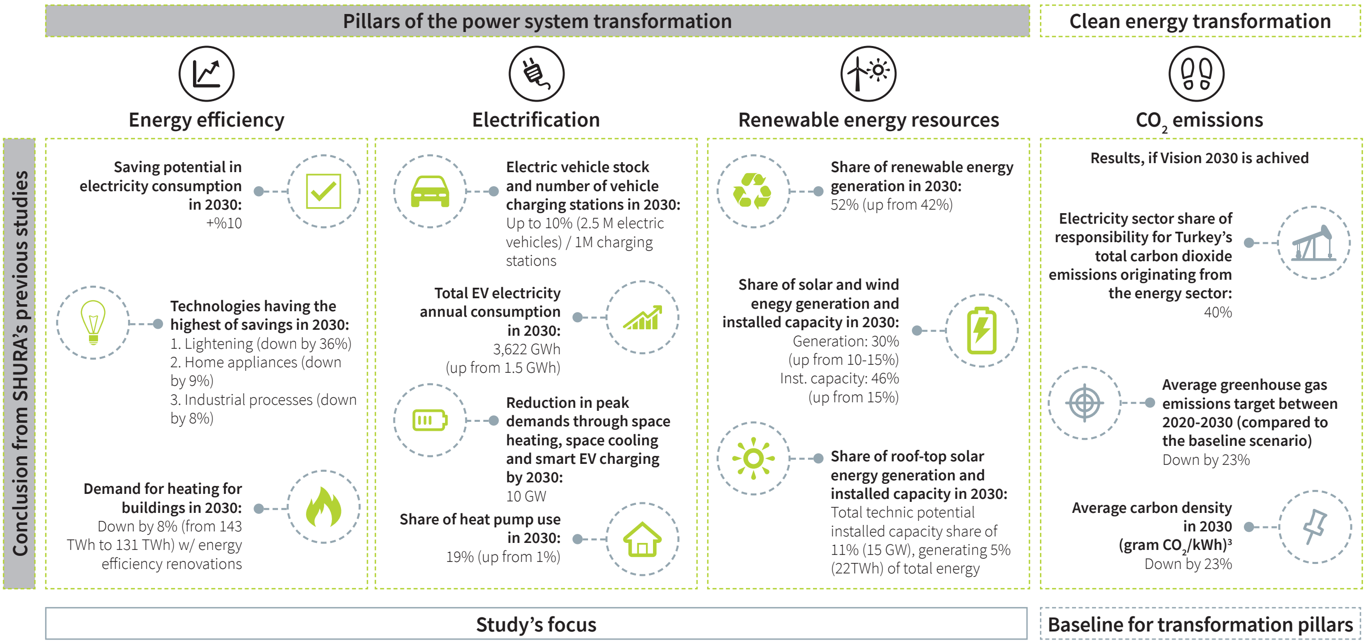
Introduction

Turkey is among the fastest-growing energy users and emitter of greenhouse gases (GHG) globally, and growing energy usage with its environmental and socio-economic impacts have been forcing the energy system to be transformed in line with technological advancements. Energy efficiency potential accelerated deployment of renewable energy sources, and electrification applications – supported by information and communication technologies (ICT), digitalisation, innovative policies, market instruments, and finance models – lead today's energy transformation.

While framework agreements targeting response to global warming and climate change, such as Kyoto protocol, serve as steps triggering this transformation, Turkey's declaration of its decision to sign this protocol in 2008 and the subsequent enactment of the authorizing bill as a result of steps taken in 2009 have been key milestones in this process. In addition, following Turkey's signing of Paris Agreement, a comprehensive climate agreement covering global energy transformation initiatives, on April 22nd, 2016 and its ratification through Presidential Decision on October 07th, 2021, our country has also set ambitious targets in taking steps forward towards this journey of transformation.

In many previous studies prepared by SHURA, energy efficiency, renewable energy and electrification issues were covered in detail, and all aspects, including the socio-economic benefits of energy conversion, were analysed from different perspectives. With the energy efficiency actions, which is the first of these issues, there is a 10% saving potential in electricity consumption by 2030, and the technologies that can save the most are lighting (36%), household appliances (9%) and industrial processes (8%). It is among the predictions that the heating demand in buildings may decrease by 8% with energy efficiency upgrades (SHURA, 2020c). In addition to managing the demand, minimizing the negative effects of energy supply on the environment is also important. In this sense, studies suggest that it is technically and economically possible to increase the share of renewable energy sources in total electricity supply to 50% by 2030, with solar and wind energy generation expected to have a share of 30% (SHURA, 2020a). It is revealed that rooftop solar panels, which are the main element of distributed energy resources, have a technical installed power potential of 15GW (SHURA, 2020b). Another pillar of energy transformation can be thought of as scaling up electrification in the end-use areas of energy in transport, buildings, and industry sectors, which have largest shares in emissions. In relation to the transport sector, where there is a high electrification potential, Ministry of Energy and Natural Resources (MENR) declared on January 16th, 2020 that they estimated there would be 1 million electric vehicles by 2030 (Anatolian News Agency, 2020). In a study of SHURA, analysing the potential impacts of electric vehicles on the network, it was found that minimum 10 percent of total vehicle stock could be transformed into electric vehicles by 2030 and that 2.5 million electric vehicles could be integrated into the network if the planned network investments are to be completed (SHURA, 2019). Although electrification elements such as electric vehicles and heat pumps, which are thought to become widespread rapidly, are expected to increase electricity consumption, it is thought that new trends such as smart charging and demand-side participation will reduce peak demand and relieve the grid in this sense (SHURA, 2021a). Results from SHURA's studies on the mentioned transformation pillars are summarized in Figure 1.

***Figure 1:** Summarized conclusions from SHURA's previous studies*



The main purpose of this report can be summarized as revealing the importance of digitalization and new business models in the process of realizing these visions within the scope of energy transformation and developing suggestions that may be valid for the energy sector in Turkey.

Along with the concerns of increasing greenhouse gas emissions worldwide, energy consumption and the resources from which the energy consumption is obtained have begun to be questioned, and in this direction, issues such as energy efficiency, electrification of things and processes, and generation of electricity from green energy resources have begun to come to the fore. In this manner, energy efficiency studies, rapid development of renewable energy use, distributed energy resources and electrification rate have increased significantly.

With today's increasing energy consumption, energy saving targets that can be brought at both industrial and residential consumption levels and energy efficiency studies play an important role in energy transformation. On the other hand, the spread of renewable energy sources lays the groundwork for the development and support of other distributed energy sources such as distributed energy generation and behind-the-meter batteries. Moreover, the current potential of rooftop solar in Turkey can increase the adoption level of distributed energy resources and make a significant contribution to the energy transformation. Similarly, efforts in mobility and the electrification of buildings are expected to make great progress through the adoption of electric vehicles and the increased use of heat pumps in buildings.

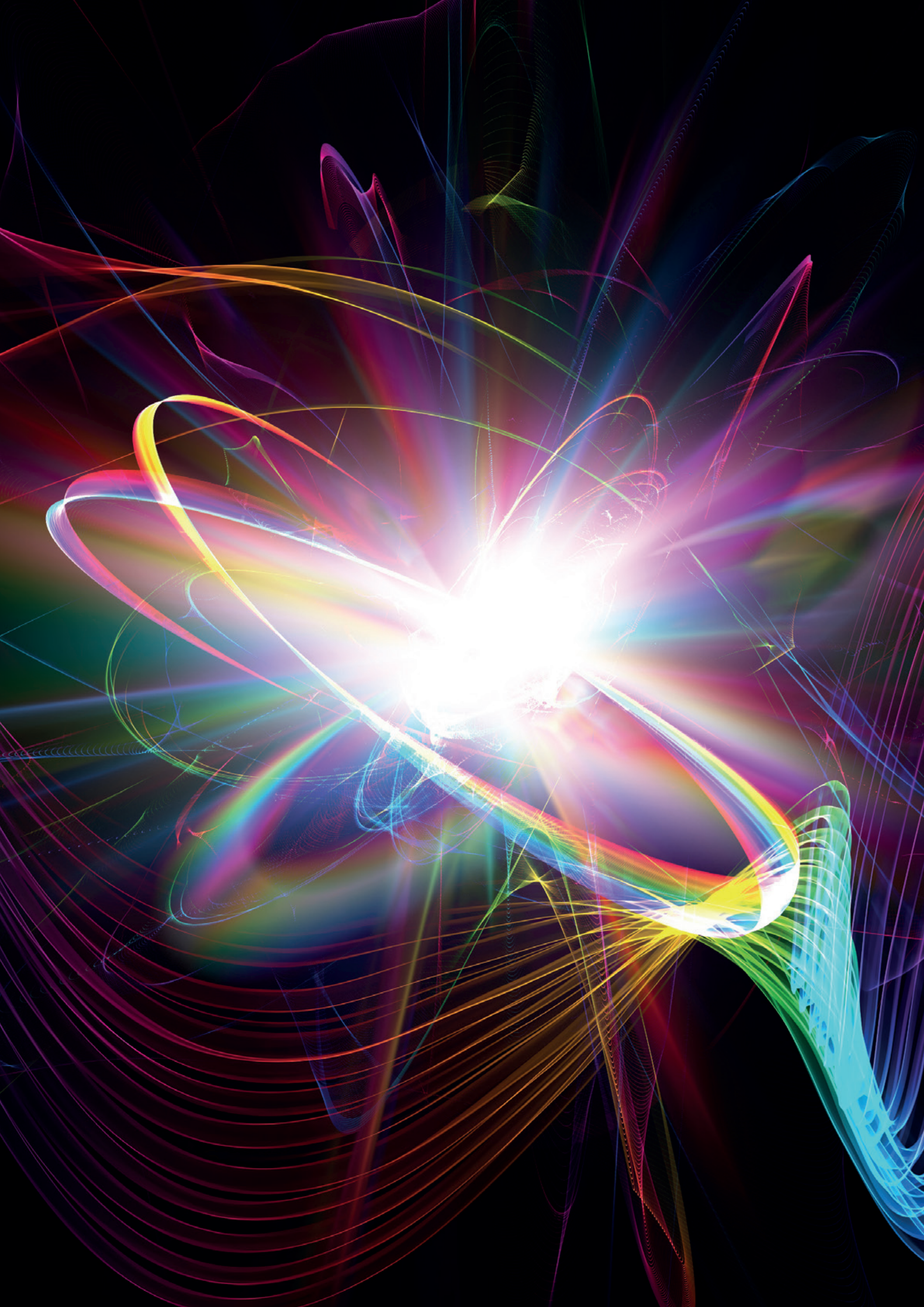
In line with the transformation in energy systems, digitization activities and digital technologies are also becoming more common to help transform the electricity sector value chain. The benefits of integrating digitalization technologies into energy assets and processes are endless, and the fact that the energy sector is one of the last to benefit from the digitalization revolution reveals an unexplored potential. Some digital technologies will transform the way businesses are managed, while others will enable the creation of new business opportunities.

As the energy sector transforms and digital technologies introduce new concepts to the energy sector, new opportunities and challenges arise that did not exist before. The main challenges encountered include management of proliferating DER, managing the growing electrification burden, making the infrastructure grid reliably sustainable, managing the increasing energy consumption levels of consumers, addressing changing consumer needs, and lastly effectively managing data to unlock the potential of digitization.

Innovative business models using digital technologies are seen as a solution to address these new needs and challenges. Even if such models focus on different targets and target customers, the common goal of all of them is to ensure a healthy transformation of energy sector. The integration of new business models will serve to provide a balanced grid, as well as high flexibility opportunities and innovative energy solutions provided to end consumers.

Although newly introduced business models offer the opportunity to improve the energy system in many ways, they may not be among the priorities as they may have relatively less impact on the system or be difficult to implement due to the current conditions in Turkey. In order for new business models to be implemented smoothly in the Turkish market, it is essential to prioritize the models' potential impacts on the energy sector (end consumers, service providers, financial impacts) and feasibility. In conclusion, in Turkey's energy transformation in the near future, viable business models with great potential for all stakeholders in the energy sector should be given priority. In this framework, the obstacles encountered in the implementation and dissemination of new business models should be examined in more detail in order to better understand the feasibility of new business models, taking into account the Turkish energy market during the development and implementation of new business models. In line with the assessments compiled during stakeholder interviews, the main obstacles encountered in the Turkish energy sector include the existing market structure of the country, legislation, socio-cultural conditions, financial conditions, technological infrastructure, grid planning and infrastructure, and the level of urban development. This report was needed to provide a comprehensive evaluation of these barriers and ensure development of recommendations through the research of global examples and practices as well as facilitation of energy transformation.

In this context, in Chapter 2, the pillars of the energy transformation, the triggers of these pillars and the innovations that await Turkey in the energy sector in the process towards 2030 are evaluated. The development of digitalization trends in the world and in Turkey, which is an important part of the energy transformation and considered as the enabling factor in this transformation, is analysed in detail in Chapter 3, and then its potential effects in Turkey are discussed. The challenges, needs, and new business models that may emerge to overcome these challenges are set out in Chapters 4 and 5. These innovative business models were evaluated through the meetings and workshops held with the sector stakeholders, and a prioritization study was carried out taking into account the business model's impact and feasibility. Following a detailed analysis of the developments in the world, digital technologies, current challenges, and new business models, in the last part of the report (Chapters 7 and 8), the barriers to the spread of these models in Turkey were evaluated and suggestions were developed to overcome these barriers.



1. Pillars of the power system transformation

“Transition to carbon-neutral energy system”, which has emerged in line with the goal of minimizing the environmental damages of energy ecosystem, lays the groundwork for the main pillars that form the basis of the energy transformation in the world and shape the future. The main pillars of energy transformation are as follows:

(1) “Energy efficiency”, which has long been in focus due to the rapid increase in energy consumption,

(2) “Renewable energy sources” that support carbon-neutral energy generation, provide a more local balance of generation and consumption, and offer benefits in providing consumers with greater independence; and

(3) “Electrification”, which reduces the use of fossil fuels, in line with the carbon-neutral energy system”, against the increase in electricity consumption, and enhances the potential for using renewable energy.

These pillars can be considered as the root causes and triggering factors in the emergence of new business models along with the digitalization trends emerging in the energy sector.

1.1 Transition to carbon-neutral energy system

Decarbonization has become a global obligation for all countries in the world that attempts to eliminate the use of fossil fuels and disposal of pollutants such as carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons. To that end, countries and authorities have been setting medium/long-term targets and strategies for the future to alleviate the harmful effects of GHG emissions. An instance would be the target of a 1.3% growth rate set for renewable energy in heating/cooling (European Parliament, 2021). Electricity generation, manufacturing industry and transportation are major contributors to GHG emissions, and hence, decarbonization of the whole energy system, primarily including the electricity sector, is crucial. Decarbonisation is also the principal motivation for increasing renewable energy share in total electricity generation, electrifying the areas emitting carbon dioxide and other GHG, and reducing demand by using electricity efficiently. Therefore, clean energy transformation sets the baseline for the overall power system transformation.

In Turkey, electricity sector is responsible for 40% of the total carbon dioxide emissions, which is a crucial contributor to GHG emissions. Thus, actions to be taken in the electricity sector can have significant results on reducing harmful impacts on the environment.

1.2 Energy efficiency

Although renewable energy resources gained significant ground in Turkey's energy strategy in recent years, energy efficiency has long been at the centre. This is because of the high diversity, low costs, and benefits of energy efficiency technologies and solutions across multiple sides. Furthermore, for countries like Turkey, where energy consumption is rapidly growing, attaining energy efficiency in new power plants, industrial facilities, and buildings is technically much easier.

The ways of doing business in Turkey are expected to be affected by numerous countries' targets of zero carbon emissions by 2050, particularly those of Turkey's main export markets. Actively participating in energy efficiency solutions, initially in industrial facilities, then in commercial buildings, and lastly in residential structures can help accomplish climate targets. To this purpose, SHURA estimates that Turkey will save 10% of its electricity consumption by 2030 (SHURA, 2020c). Areas with the largest savings are anticipated to be lightening (down 36%), residential appliances (down 9%), and industrial processes (down 8%). Apart from that, heating is viewed as an area where energy efficiency may be improved, with energy upgrades predicted to save 8% of energy by 2030 (SHURA, 2021a).

1.3 Renewable energy resources

As one of the key pillars of the power system transformation, renewable energy resources hold the promise of supporting decarbonised generation, enabling a more local generation and consumption balance, and proving more independency to consumers. Renewable energy sources can be considered as grid-scale facilities and distributed energy capacity installations. Distributed energy facilities are faster and lower-cost options than grid-connected energy facilities and installation of new transmission lines. Considering the future of energy, it is predicted that distributed energy resources will become widespread very rapidly (IRENA, 2019). DERs offer the potential for lowering investment costs, improving service reliability, and increasing power quality. Overall targets for distributed energy resources until 2030 can be structured with a top-down approach beginning with a goal for the share of renewable energy generation, continuing with solar and wind's share in both power generation and installed capacity, and concluding with roof-top solar energy's potential.

The end goal for decarbonisation in Turkey is the same as it is in the world and enhancing renewable energy resources' role is crucial for the clean energy transformation. The share of renewable energy in the electric energy supply, which was 42% in 2020 (SHURA, 2021), can be raised above 50% by 2030, which has been shown to be technically and economically possible (SHURA, 2020a).
Currently, the most affordable electricity generation options, solar and wind, are the most promising renewable energy resources, but a high unused potential remains in Turkey. As the cost of solar and wind installation decreases, these energy sources will play an even more significant role in power generation in the future, accounting for about one-third of total electricity output with a 46% installed capacity share (SHURA, 2020a).

In Turkey's final energy consumption, buildings have the second-largest share after the industrial sector. Due to rising urbanisation and population growth, total energy demand in buildings is likely to increase further. Roof-top solar energy generation with over-the-top solar PV systems can minimise reliance on grid electricity while also helping improve system efficiency by reducing distribution losses with on-site generation. The overall technical potential of installed capacity for roof-top solar energy panels is now 15 GW, and this capacity could account for 22 TWh of total energy generation (SHURA, 2020b).

1.4 Electrification

The electrification of energy end-use sectors that depend on fossil fuels is poised to be a vital component of Turkey's energy transition strategy. For a carbon-free future, it is necessary to electrify areas where fossil fuels are used and then cover the increased electricity demand with renewable energy.

Transportation and the built environment and industry are primary areas where electrification can become an option. In general, these areas are predicted to have a high adoption rate in Turkey. Electric vehicle (EV) stock has the potential to reach 2.5 million by 2030, accounting for 10% of Turkey's total vehicle stock. The annual electricity consumption of these EV's will be approximately 4-5 TWh, which will be provided by 1 million charging stations across the country (SHURA, 2019). On the other hand, if the uptake rate of heat pumps increases, 50% of new buildings and 10% of the existing ones, across all climate zones, will adopt heat pumps. Approximately 1.9 million heat pumps are expected to be deployed across Turkey, increasing their share from 1% to 19% of buildings by 2030. Although it is a fact that consumption will increase as a result of the use of heat pumps for space heating and cooling and of electric vehicles for transportation, it is anticipated that demand side participation could lower peak demand by as much as 10 GW by 2030 (SHURA, 2021a).

When these three main pillars of energy system transformation are evaluated holistically, it appears that innovative solutions and business models will be needed to enable and accelerate this transformation. Digitalization and related technologies stand out as the most important solutions to emerging needs due to this transformation. In this context, it is essential to understand why digitalization is important, evaluate global digitalization trends in detail from the perspective of energy sector and lay down the areas of use of digital technologies. These issues are discussed in Chapter 2.

2. Latest trends in digitalisation

Transformation of the power system and the transition to clean energy occur in tandem with the sector's digital revolution. On one hand DERs proliferate, electrification increases, and efficiency applications become more common, whilst on the other, digital technologies are restructuring the entire utility value chain. Digital technologies and new business models that utilise them can address new challenges that are expected to arise with power system transformation while potentially bringing up several new barriers.

Before understanding how digitalisation technologies and new business models that use them act as a catalyst in the overall transformation, several conceptual topics and the as-is situation in Turkey need to be analysed. First, it needs to be understood why there is a need for digitalisation in the first place and where power and utilities sector is in the digital maturity curve compared to other industries. Afterwards, digitalisation needs to be put in the context of disruptors and forces shaping the energy industry. This enables understanding the utility value chain of tomorrow and different use cases of key technological advancements across this new value chain. Finally, maturity assessment of Turkish power sector in terms digitalisation needs to be made.

2.1 Why digital?

Digitalisation can be considered as the increasing interaction and convergence between digital and the physical worlds (IEA, 2017). The digital world has three fundamental elements, which are data, analytics, and connectivity. The trend towards greater digitalisation is enabled by developments in all three of these elements:

- Data: Increasing volumes of data through declining costs of sensors and data storage,
- Analytics: Rapid progress in advanced analytics and computing capabilities, and finally,
- Connectivity: Greater connectivity with faster and cheaper data transmission.

Through these developments, digital technologies are becoming more prevalent in all industries, including the power and utilities (P&U) sector (IEA, 2017).

Integration of digitalisation technologies to energy assets and operations provide benefits in five main areas: helping improve safety, productivity/efficiency, accessibility, and sustainability of energy systems all over the world, as well as putting the customers at the centre of the energy system to better satisfy their expectations (IEA, 2017).

Figure 2: *Benefits of digitalisation*

Source: Deloitte analysis

Digitalisation grants accessibility to accurate real-time data that facilitates obtaining fast and automated responses for the energy sector. It also enables reliable access to energy resources improving the safety of the system both in terms of ensuring energy security and enabling a proper functioning market. Moreover, it provides improved process controls to enable significant energy savings with shorter payback periods. Lastly, the energy system needs to be sustainable, which can be satisfied with infrastructure management through digitalisation technologies. Alongside all these benefits, digital technologies hold the promise of better serving customers to improve their overall journey.

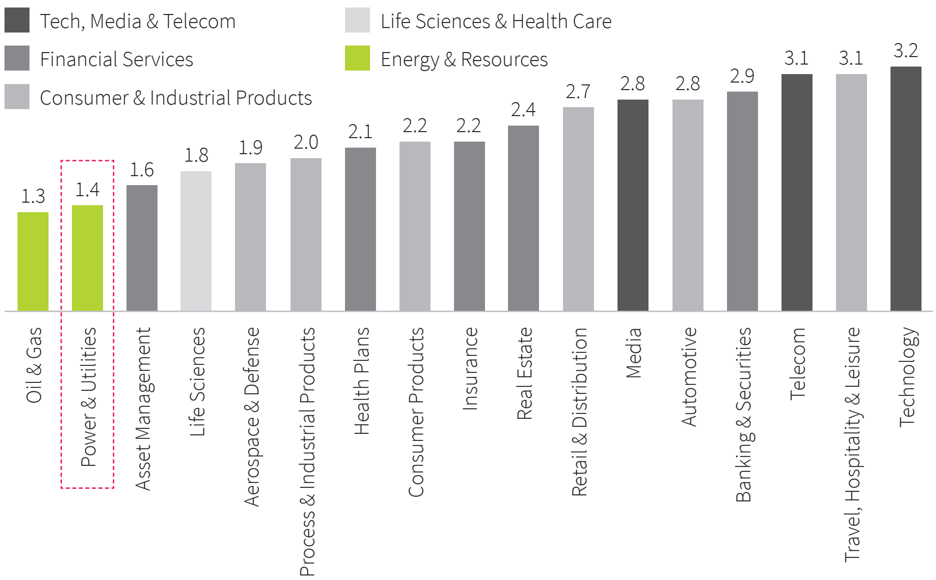
Digital technologies are also changing the competitive landscape of the P&U sector. Digitalisation provides cost advantages that increase revenues while minimizing business risks. As a result, industry players facing significant opportunities for transformation could achieve success through digitalisation rather than traditional methods.

2.2 Digital maturity in the energy sector

While digitalisation has several significant promises, adoption rate of such technologies varies among different sectors. Digital maturity is an expression of how well industries and organisations use digital technologies to achieve their goals and increasing number of companies from different sectors are investing in digital transformation by integrating such technologies into their core businesses. However, it's not necessarily about investing in as much cutting-edge technology as possible. Instead, the key to a successful digital transformation includes reaching an optimum digital maturity level that enables organisations to achieve their desired business outcomes at the lowest costs.

According to Deloitte's Digital Maturity Index (DMI) framework study on companies in S&P 100 respectively, the energy sector has been one of the last industries to face the transformative wave of digitalisation. Most of the large companies in the energy sector manage to develop digital strategies and begin to implement them, yet there are still many areas within operations in which data remains untouched, with its potential to be reached and used.

Figure 3: *Average digital maturity by sector*



Source: Deloitte's digital maturity index (DMI)
Note: Monitor Deloitte developed the DMI based on a study of the digital capabilities of the S&P 100 companies.

2.3 Digitalisation in the context of disruptors and forces

Three pillars of power system transformation form the baseline of the new energy system and disruptive forces that have been evolving and converging for more than a decade are reshaping this transformation and driving it toward a new future. They include:

- Changes in fuel prices,
- Influx of solar energy,
- Changing load patterns,
- Changing consumer behaviour,
- New performance challenges and expectations,
- Unpredictable weather conditions,
- New entrants to markets, and
- Increased cyber-attacks.

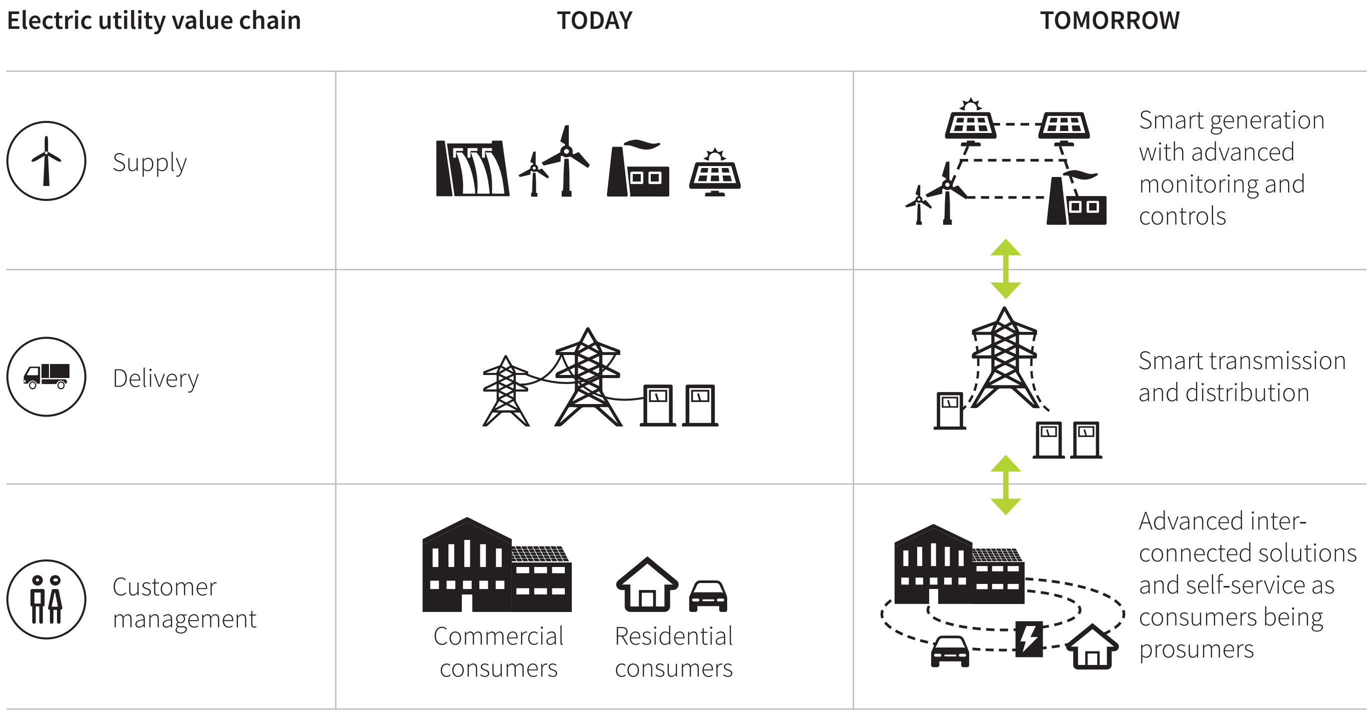
Different offering and solutions, such as digital technologies, digital innovation models, culture and change management, digital foundry - setting up a core digital team to support agility and drive value more quickly -, cybersecurity, workforce management, and cloud solutions can address these disruptors in various ways. Among these solutions, digital technologies play a crucial role. Faster, cheaper, more powerful computing and improved connectivity are fuelling the growing deployment of technologies such as sensors, mobile, advanced analytics, robotics, additive manufacturing, cloud computing, Internet of things (IoT), Artificial intelligence (AI) and machine learning (ML), blockchain, and virtual and augmented reality (VR and AR).

2.4 Digital transformation of the utility value chain

The digital revolution is transforming the utility value chain at every level. Renewables, distributed generation, smart grids, and smart customer solutions demand new capabilities and trigger new business models. The digital economy players disrupt the industrial landscape with new products and management options, while governments and regulatory bodies aim to generalise smarter measuring systems and greener standards for power generation and consumption.

To satisfy these expectations, the utility value chain of tomorrow will be completely digitised. Digitalisation holds the potential to build new architectures of interconnected energy systems, including breaking down traditional boundaries between demand and supply. The one-way flow of energy and information will be transformed into a two-way flow via the enhanced communication among different levels of the value chain.

Figure 4: *Electric utility value chain of today and tomorrow*



Source: Deloitte analysis

The first level of the value chain, which is related to supply, illustrates that generation will evolve toward a more diverse and decentralized network of lower capacity, more flexible units with the intelligence to self-ramp, self-balance/stabilize, and self-diagnose. Comprehensive monitoring, intelligence, and automated controls that increase heat rates, availability, and demand responsiveness will be the enablers of this transformation. The energy delivery will be through a communication-enabled self-healing network, that is able to act as a balancing entity by seamlessly managing two-way power flows, complex demand management/response, and asset health that dramatically reduces asset intensity and operating costs while increasing reliability.

Customer management is also subject to massive changes with energy transformation. Utilities will enhance their relationship and knowledge of their customers by implementing advanced customer self-service, mobile applications, data analytics, communication, and energy management solutions.

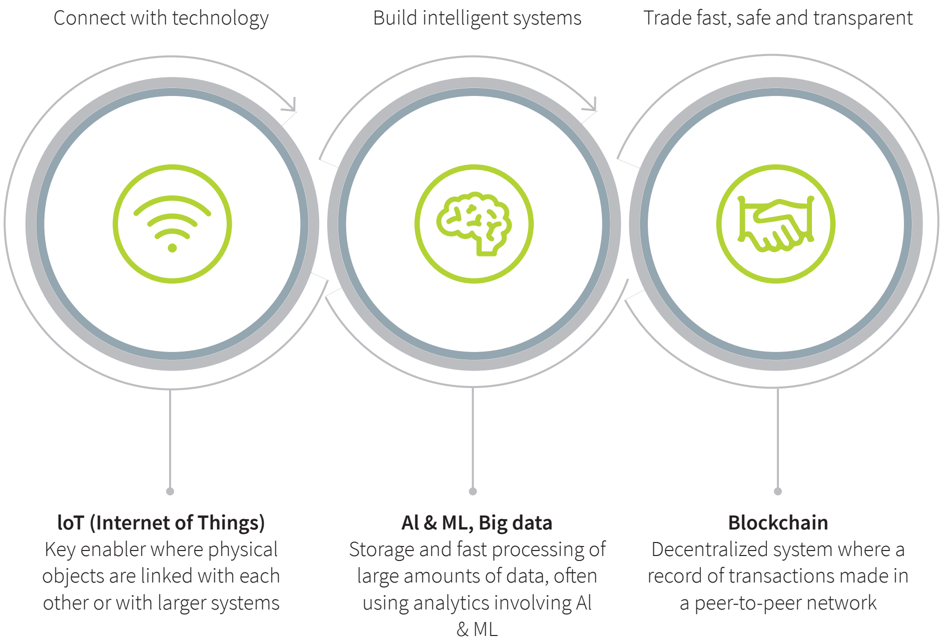
2.5 Applications of digitalisation technologies along the value chain and their benefits

For the power sector, digitalisation means converting data into value. From this perspective, several key digital technologies are unlocking new possibilities in the power sector, changing the boundaries and dynamics of the industry, and helping businesses optimize their assets. Among offerings towards the digital transformation of the energy industry, five digital technologies: robotic process automation (RPA), AR & Wearables, IoT, AI-Machine Learning & Big Data, and Blockchain, come to the forefront with their extensive use cases in the sector. RPA is a software technology used to automate repetitive tasks, while AR allows the real-life environment to be altered by adding sound, visual elements, or other sensory stimuli. On the other hand, IoT describes the network of physical objects equipped with sensors, software and other technologies for devices and systems to exchange data. Data collected from these physical objects can be interpreted with the help of intelligent machines (AI) that can simulate human thinking and behaviour and can even feed a structure (ML) that allows machines to learn from data without being explicitly programmed. Blockchain technology, which is a distributed database system in which data, information and transactions are transferred and recorded, can also be considered as the last link of this system. As deploying renewables increases power sector complexity and the need for flexibility, three of these technologies stand out: (1) IoT, (2) AI & ML and big data, and (3) blockchain (IRENA, 2019). On the other hand, RPA and Augmented Reality & Wearables are evaluated as the technologies to be used in in the field processes covering the installation, maintenance and repair of energy assets and back office covering departments such as human resources, information technologies and accounting, which are non-consumer functions of companies. Unlike the three leading technologies, which played a role in the emergence of new business models, the technologies used in back office and field processes make existing business models more technological and help to improve efficiency and optimize existing systems.

2.5.1 Key digital technologies with higher impact potential

Digital technologies are reshaping the energy system with the collection and analysis of large amounts of data, increasing controllability and system flexibility. IoT technology, which connects physical objects with each other in the collection of large amounts of data, AI and ML technologies that are widely used in the storage, analysis, system control and evaluation of flexibility options, and finally, blockchain technology allowing peer-to-peer trade and other transactions to be recorded in a decentralized system are positioned as key digital technologies with higher impact potential in the energy sector.

Figure 5: *Key digital technologies*



Source: Deloitte analysis

Internet of Things

IoT interconnects devices, people, data, and processes by allowing them to communicate with each other seamlessly. IoT can help improve different operations to be more quantifiable and measurable by collecting, processing, and exchanging a large amount of data through appropriate sensors and communication networks. This exchange occurs among electricity demand centres (residential, commercial, and industrial facilities) and the electricity grids, creating new opportunities in the P&U industry by making electricity systems more efficient, reliable, and "smart". Integrated control of EVs and vehicle to grid (V2G) solutions are among the other application areas of IoT in grid operations.

An energy management system based on IoT can monitor real-time energy generation and consumption levels at any step of the value chain. This situation not only improves the security of supply, but also eases asset usage and management, accelerating the response to lost load. In addition, IoT systems can facilitate improved service reliability, distinguishing any failure in operation or abnormal decrease in energy efficiency, alarming the need for maintenance. Furthermore, IoT offers flexibility in balancing generation with demand, reducing the challenges of deploying renewable energy resources. Consequently, IoT enables the efficient delivery of sustainable, economic, and secure electricity supplies for consumers.

For the consumer side of the value chain, IoT technology has also a critical role to play. With energy customers positioned at the centre of the value chain, they are provided by extensive comfort and complete control over their assets through smart homes utilised by IoT. In return, the ability to control energy assets enable new flexibility options for the grid. Central control via IoT (i.e., by shedding, shifting, or levelling a load of many consumers by analysing the load and operation of appliances) allows changing the power consumption of consumers, which is called demand-side management. Also, battery energy management, advanced metering infrastructure, and smart buildings are other key application areas of IoT to have access to detailed load variations, control the appliances optimally, determine the optimal strategy for charging/discharging batteries and consequently improve the energy efficiency.

AI & ML, Big data

Big data and AI play an increasingly important role in our modern lives, from mobile virtual assistants to image recognition and translation to many other uses. Big data allows energy companies to collect, store and analyse a vast amount of information (generation/consumption of energy, etc.) through analytics tools. Over the coming years, innovative uses of these technologies are expected to be dominant in energy systems by changing the behaviour of the system without being explicitly instructed.

With developments, AI technology would allow for a substantial number of automatically controllable resources responding to needs from several stakeholders (e.g., consumers, generators, transmission and distribution operators, retailers). This advanced level of control enables optimisation of the system with more distributed resources while maximising system flexibility and reducing the cost of operating a system with high shares of DERs. Although, most of the advances have been in weather and renewable power generation forecasting and predictive maintenance, there is a big potential for AI and big data in other areas as well. These include enhancing demand-response activities, condition monitoring, inspection, supply chain optimisation, decision making, and planning of energy management activities. These automated, occasionally real-time, control of energy assets and energy flow can be highly exploited by innovative business models offering energy management solutions.

Machine learning, a subfield of AI, allows computers to take action without being explicitly programmed. Through ML, machines have access to large data sets, learn from these data sets and make decisions (IEA, 2017). ML is used in many areas such as energy consumption anomaly detection, energy demand forecasting, optimum energy price determination, real-time monitoring of energy, and control of energy generation in the energy sector.

Among the plenty of application areas, AI & ML and big data are widely used in renewable energy generation forecasts. This approach allows utilities to be better positioned at the wholesale & balancing markets and to increase the dispatch efficiency and to reduce the need for operating reserves for system operators. Furthermore, AI can also be used in predictive maintenance and site assessment and planning in the supply side of the utility value chain.

Asset utilization optimisation through AI can eliminate capital expenditures for expanding investments and reduce the grid congestion by better use of existing lines as a function of weather conditions. Optimal load calculation and disturbance detection are the other main application areas of big data and AI technology, which provide improved safety, reliability, efficiency, and stability in the grid. The power system as a complex structure naturally encounters security of supply risks in the presence of complex algorithms and equipment exposed to real-time operational threats. To reduce blackout risks, Virtual Power Plants (VPP), an innovative business model, can bundle and control DERs to provide real-time operating reserve capacity that can participate in ancillary markets by using intelligent systems enabled by AI (IRENA, 2020).

More importantly, customer engagement part of the value chain has very critical areas that can benefit from AI. Together with IoT, AI improves demand-side management and optimise economic load dispatch by being used in demand forecasting. Other than demand forecasting, AI can optimise the energy management by using weather forecasts, occupancy, usage, energy prices and patterns identified in consumer behaviour. Through these, AI can significantly reduce bills for end-consumers. For instance, a smart household service provider offers energy assistance for residential consumers by giving intelligent information about appliances and electricity usage in their homes, helping tackle their bills, reducing carbon footprint, and keeping their homes safe. This Energy-as-a Service (EaaS) package uses IoT to gather consumption data and ML to let the consumers know about the energy consumption behaviour of new appliances by also giving an alert if they have been left turned on too long (Cambridge, 2019). Also, customer segmentation and personalization allow power retailers to better target their customers and offer personalized solutions based on their consumption behaviour.

Blockchain

As the power system transforms, maintaining reliable services, meeting new objectives, and handling rising complexity make room for new solutions to come to life. Blockchain technology is a way to record and verify transactions without requiring a central entity to maintain or validate the ledger. Moreover, recording and trading attributes of sustainability (e.g., carbon credits) are possible via blockchain to accelerate clean energy deployment and carbon emission reduction.

Blockchain technology is expected to enhance existing markets for trading electricity or even creating new ones. The most intuitive - and popular - application of blockchain to the power sector is to turn the electricity grid into a peer-to-peer network for customers to trade electricity with one another, for example, by buying and selling excess rooftop solar power that bypasses a central utility or retail energy provider. This newly designed system enables consumers to monetise and trade the value created by their assets (solar energy, EV charging, etc.) automatically, immediately, safely, and transparently (Cambridge, 2019). It also results in increased competition by bringing down prices and increased grid efficiency by optimising DERs.

Another application area of blockchain is electric mobility. That is, private owners of charging infrastructure can sell charging services to EV owners via blockchain. To illustrate, an initiative of such a platform would enable households that own chargers to rent those to EVs, in a fashion similar to how a homeowner might rent a room to a guest via Airbnb. This approach could reduce transaction costs and allow automatic and secure P2P payments through smart contracts. Furthermore, it would functionalize the underutilized chargers and result in a higher adoption rate of electric vehicles and even distributed renewable energy resources.

Controlled power and storage flow automatically result in balanced supply and demand by also creating flexibility options. It also allows different parties of the energy system to trade safe, transparent, fast, and cheap. For example, Virtual Power Plants can balance activities with increasing renewable energy trade while Transmission System Operator (TSO) and DSOs can track the transactions and intervene when needed through a blockchain platform.

This technology could also be used to track the generation of clean energy. Further, using blockchain could be a way to make it easier to pay for charging EVs, raise funds to deploy clean energy by broadening the pool of potential investors supplying capital, manage customer appliances, and more. It is critical to emphasize that since the power sector is highly regulated, policymakers will play a crucial role in determining how much of blockchain's potential can realize.

2.5.2 Other digital technologies for system optimisation

In addition to leading digital technologies that play a role in the emergence of new business models, RPA and augmented reality and wearable technologies, which make existing business models more technological and make operations and systems efficient, are positioned as necessary technologies for system optimization. These technologies are widely used in non-customer-oriented functions, which are described as back offices, and field processes of energy companies.

Robotic Process Automation

Digitalisation, increased complexity, and the goal to improve efficiency are the main drivers of automation. The RPA technology, predominantly used in back-office processes, focuses on automation in recurring and rule-based processes and takes over activities such as data processing, data checking and extraction, form filling, creating reports, operating systems, and processing simple queries.

The energy industry could make use of RPA due to the many standard processes available. By implementing RPA, utilities can recognise increased productivity through faster and better-handled processes with fewer errors. Automated processes result in better customer experience, simple scalability even with high volumes during disasters and crises, and more compliance with policy changes in the industry, which are crucial for the P&U companies to have a competitive advantage in the market. Some of the tasks that can be automated using RPA are as follows:

- Meter reading validation: RPA allows detecting errors before billing the customer and removes necessity for revisions.
- Correcting misreads: Customer´s meter misreading can be fixed in just a few steps with RPA.
- Billing and statements: By automating payment requests, RPA can manage receivables, correct overcharges, or process payments
- New account setup: RPA can speed up account opening by reducing errors such as wrong information provided by customers.
- Complaints management: RPA can resolve customer complaints on specific issues helping utilities develop deeper insights into customers' needs.

- Procurement: RPA can help hold recording of inventory, respond to customer/supplier requests and notify contract renewals.
- Human resources (HR): RPA can automate processes in HR operations such as employee management, HR compliance and reporting.

Augmented Reality & Wearables

The potential of AR keeps growing as companies explore new use cases beyond pilot applications. The primary value of AR is to bring components of the digital world into a person's perception of the real world through the integration of immersive sensations perceived as natural parts of an environment. AR can benefit in streamlining operations, increasing overall safety level, and substantially cutting operating expenses.

Wearable devices (e.g., viewers, lenses, or glasses), whose purpose is to create and insert a virtual level into the real world with a networked, multimedia computer worn as clothing, can be used to support AR technology to enable a closer association with the user.

Some of the use cases are as follows:

- Manufacturing engineering augmented reality: Augmented reality assist workers in handling repair operations with visual clues and indicators. This assistance brings about faster, safer, and better-quality repair and engineering operations in the field.
- Geofencing for safety: Sensor-enabled wearable devices continuously track field workers' location and health to help maintain employee safety.
- Virtual/augmented reality trainings: Simulated trainings can be offered to employees focusing on field operations to enhance user experience with lower costs. These trainings enable delivery of realistic dangerous scenarios to test safety and compliance protocols at lower costs in case of an emergency incident.

2.6 As-is situation of Turkey in adopting digitalisation technologies

With the energy transition and transformation into a more data-driven and connected system, Turkish power sector began acknowledging the importance of building digital competencies. To integrate digital technologies into the energy value chain, plenty of technology service providers have entered the Turkish market especially in the last five years. Despite following global trends from relatively behind, Turkish power sector has been putting great effort to digitalise itself, which has become almost an obligation for maintaining a manageable and an efficient system while focusing especially on end-consumers.

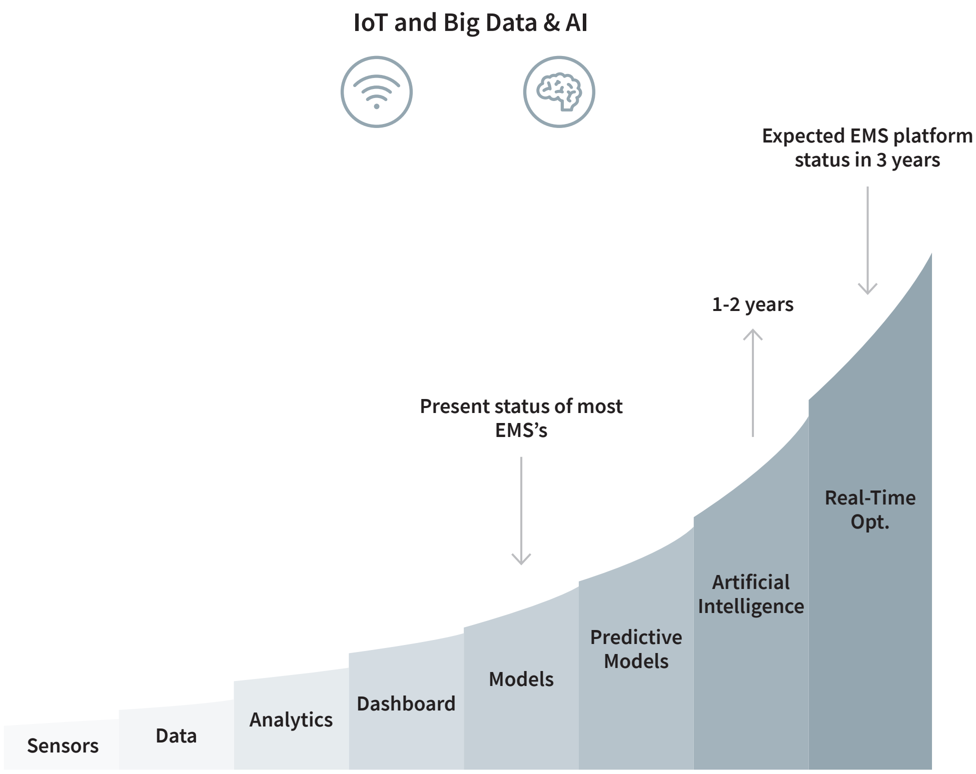
2.6.1 Key digital technologies with higher impact potential in Turkey

Adoption of digital technologies with higher impact potential in Turkey accelerated especially with the beginning of 2016 - which resulted in the launch of the country's first digital power plant integrated with cloud-based advanced digital, asset performance management and operations optimisation solutions (International, 2017). Similarly, digital technologies such as IoT, big data, and AI & ML are already being used in the energy sector by different players in Turkey. However, the maturity curve of these technologies is still not at its intended levels.

With the increase in deployment of renewable energy resources, collecting data through sensors, analysing, and making sense of this data for consumption and generation forecasts are gaining even higher importance day by day. In Turkey, there are many hardware providers that operate in the Turkish market to offer products such as meters and sensors that enable collecting accurate and continuous data. However, the challenging part for the overall energy value chain is converting this data into insights to create more value and enable predictive and automated actions. When the status of energy management systems (EMS) reaches the final stage of the capability spectrum through real-time optimisation, innovative business models are expected to become more widespread in Turkey.

Another critical point to understand is that there is a trend of moving from cloud to edge analytics, which moves the computation away from data centres towards edge of the network, benefiting from smart objects and network gates. Hardware and software providers in Turkey are becoming more equipped with such capabilities that focus on distributed computing paradigm bringing computation and data storage closer to the source of data.

Figure 6: *IoT and Big Data & AI capability spectrum*



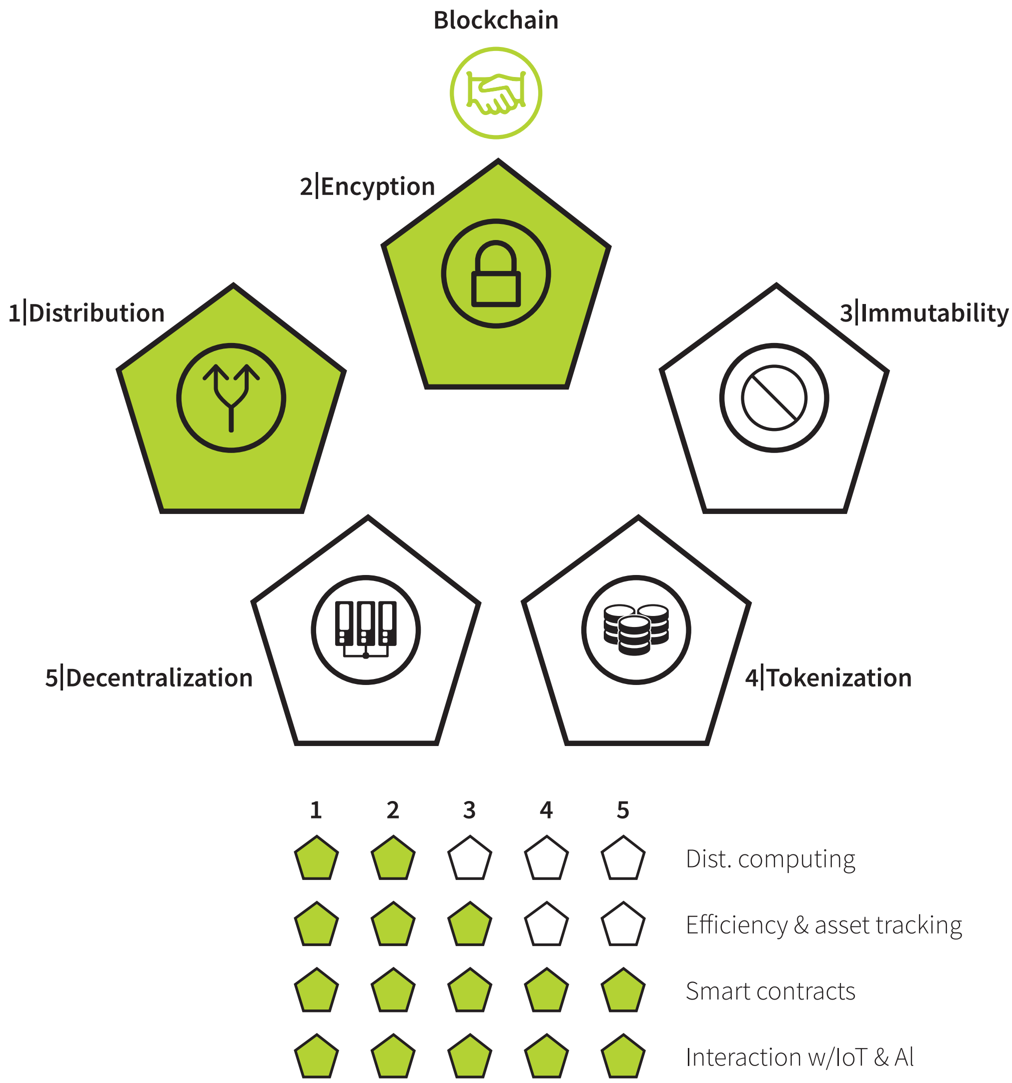
Source: Gartner big data analytics report

Relative to the digital technologies such as IoT, AI and ML, blockchain is observed to have a narrower application spectrum in Turkey. Even though it has several application areas in the energy sector, blockchain is still in its early stages. For blockchain to enable new business models and deliver a full-value proposition in the industry, all five elements of the technology - which are distribution, encryption, immutability, tokenisation, and decentralisation - need to be utilised. In Turkey currently, the most applicable area of blockchain is foreseen to be at asset management rather than innovative areas such as P2P trading or others in the immediate future. Such applications of the technology may help DSOs overcome several difficulties such as tracking equipment failures and maintenance activities; yet this limited area is not enough to unleash blockchain's potential.

However, latest developments in Turkey can be interpreted as a signal that blockchain technology will become more widespread in the energy sector. Energy will become accessible to all with blockchain-based Renewable Energy Guarantees of Origin (YEK-G) System developed by the Turkish Energy Exchange (EXIST). The YEK-G System will allow consumers to choose the source of energy they buy, in addition to documenting the use of renewable energy sources for electricity generation and consumption at all stages in power supply and distribution companies' sustainability reports (EPİAŞ, 2021).

In the mid- to long-term, with the spread of P2P trading and progress of energy transition, blockchain technology may become the building block of the energy sector in Turkey. With higher integration rates of distributed energy resources, end-consumers will start becoming prosumers, who are both the consumer and the producer of energy at the same time. For prosumers to trade energy and information they generate, there may be a need for a common platform, which blockchain can play a role in. In addition to enabling energy trades, blockchain technology may also allow measurement and verification processes among different parties by standardizing data protocols such as structuring or sharing of data in Turkey as well.

Figure 7: *Blockchain capability spectrum*



Source: Gartner blockchain spectrum

To incentivise the utilisation of these digital technologies in the energy industry, TÜBİTAK conducted a high-level technology prioritisation study in Turkey. In this target-oriented study, TÜBİTAK examines the priority R&D and innovation areas under two categories of digital technologies: smart energy networks and big data & data analytics technologies. The study shows that IoT technology - coupled with advanced metering infrastructure - will support data management and demand-side participation in addition to the new prosumer opportunities created by blockchain. Additionally, TÜBİTAK will be supporting big data & data analytics projects focusing on energy-use behaviour analysis, energy self-sufficient buildings, monitoring, and management of the grid integration of large-scale renewable energy facilities, and integration of different modes of transportation (i.e., EVs) (TUBITAK, 2020).

2.6.2 Other digital technologies for system optimisation in Turkey

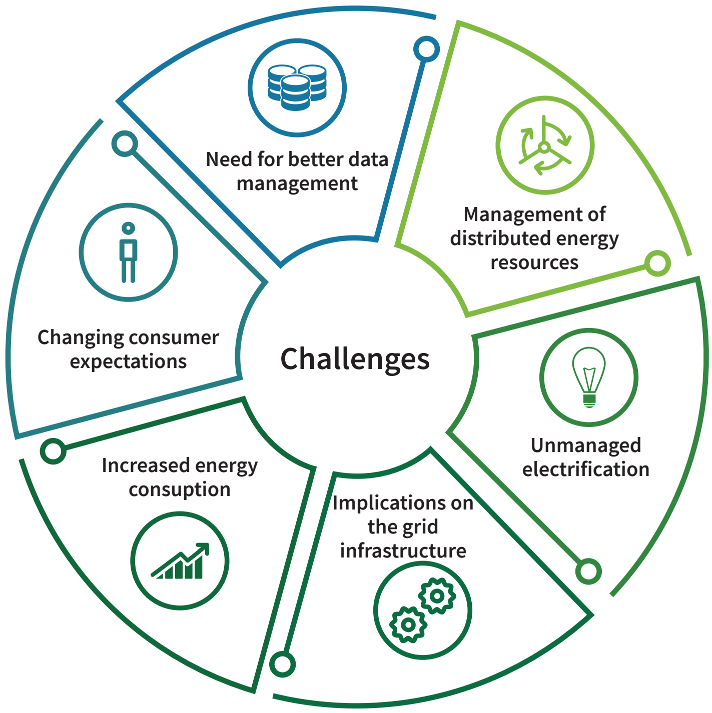
Currently, digital technologies that focus on system optimisation are quite heavily utilized in the Turkish market. The first digital technology having one of the widest application areas in Turkey is RPA. It is especially being utilised by utilities that aim to automate their multiple and repetitive back-office operations such as finance, purchasing, call centre, information technology back-office, and invoice objection. Utilities' main goal in utilising RPA technology stand out as to make their systems more efficient rather than facilitating new business models in the sector. Similarly, AR & wearables are promising tools in overcoming occupational accidents that utilities may encounter during their field operations. Since such incidents are among the greatest threats in the country, benefiting from digitalisation tools to minimise such risks are being evaluated by different sector players.

3. Potential challenges and new needs arising with power system transformation in Turkey

Power system is going under a transformation and with higher digital technology integration into the sector and some new needs arise while addressing various challenges. As discussed in the previous sections of this report, there are major shifts in the overall value chain – ranging from changes in how energy is generated to how it is transmitted and distributed and how it is consumed. With proliferation of DERs, their intermittent, variable, and disperse nature alongside their market- and asset-related implications introduce new challenges in terms of their management. Similarly, as electrification increases in both the mobility and the built environment settings, it brings along new needs such as managing implications on the grid and eliminating the need for fossil fuels to cover the newly introduced demand – all of which can be managed with smarter systems utilising digitalisation technologies. On the other hand, besides newly electrified areas that bring along new demand to the picture, total energy demand increases as well as both the economy expands, and industrial activities accelerate. This total increase forces end-consumers to take responsibility in their demand management while consuming energy efficiently. Even further, as it is seen in every sector, consumers are becoming more demanding in how they receive services – and energy sector is no different. Simply put, consumers no longer want to receive just the energy as a commodity but rather they want utilities to help them in areas where energy management issues occur, and new solutions may be applicable. Alongside all these changes that bring new challenges, digitalisation comes to forefront as a solution while bringing new needs specifically in terms of data-related areas. Data and how you treat it will become an integral part of decision-making processes. Hence, data quality, standardization, administration, and effective use of tools are needed to be ensured for a more efficient and secure energy system.

The more connected, digitalised, decentralised, and customer-centric energy system requires a proper management of energy resources, the consumption, electricity grid, data, and the energy markets simultaneously. To this end, potential challenges in the power sector can be categorised under six main topics, which are explained in detail below: (1) management of distributed energy resources, (2) need to manage electrification, (3) implications on grid infrastructure, (4) increased energy consumption, (5) changing consumer expectations, and (6) need for better data management.

Figure 8: Business challenges



3.1 Management of DERs

Hard-to-predict and intermittent nature of renewable energy resources, inevitably creates several challenges especially in terms of their management. As such decentralized small-scale renewables proliferate – which can be evaluated as a goal - their impact in the overall value chain enhances. Hence, managing their nature and impacts become even more crucial for a sustainable energy sector. In a broad sense, these new challenges can be categorised under six main topics:

Maintaining system balance (which is partly covered in implications on grid infrastructure), matching consumption and generation, accurately forecasting power generation and managing its implications for market operations, integrating new and small-scale players (prosumers) into markets, finding ways of reflecting growing adoption of DERs to tariffs, and managing challenges arising due to asset-ownership issues.

To start with, by nature of renewable energy sources, the changing weather conditions cause intermittencies in the energy generation and consequently occasional insufficiencies in meeting the demand might occur. This can create an issue in two areas. First, as maintaining the overall system balance is quite critical, intermittencies can result in power outages in the grid when demand exceeds energy supply or due to unfavourable weather conditions restricting renewable energy generation. With decreasing investment costs of DERs energy-intensive industrial facilities have started installing renewable energy resources at their production sites where continuous supply of energy is crucial, which has given rise to the need for energy management. To ensure the continuance of their main businesses, high-energy-consuming enterprises such as iron, steel, cement, and other manufacturers may require third-party services for their energy management, energy supply, storage, and demand forecasting needs. Secondly, the relative difficulty in predicting weather conditions makes the forecast of renewable energy generation challenging. As a result, the consumption and trading quantities may be subject to deviations, resulting in potential problems.

The increasing volatility of supply has amplified the importance of intraday markets, which can be used to balance deviations resulting from positions taken in the day-ahead market and the actual demand. This also resulted in that electricity and utility companies are less willing to pay high amounts for renewable energy to hedge themselves against the volume risks. To handle the fragmented and complex structure of DERs, there is a need for a generalized and unified system for their management. In Turkey, even though DERs can be monitored by IoT, there are still difficulties in controlling and managing the energy flows automatically via AI, and still relying on the human involvement for their management. This makes it hard to perform real-time optimisation of the energy generation to satisfy the ever-changing needs of the electricity grid and end-consumers.

On the other hand, the typical size of distributed renewable energy resources is much smaller than those of conventional power plants and as DERs become more common, number of generators, and the number of people participating in a trading scheme increases. These prosumers will want to make the most of their existing assets but will not be able to act as market participants due to regulatory barriers and scale-related issues. This necessitates an innovation that paves the way for the integration of large number of small players into the market. Small-scale producers' integration into the markets has a significant potential for boosting market competitiveness and offering opportunities for both prosumers themselves and grid operators. However, the challenge remains in how to bring together these small and dispersed players with the bigger traders in the market while enabling them to trade small amounts of energy.

Aside from the market participation of small-scale energy producers, it is also a challenge to reflect the increased expenses due to DER integration to local people benefiting from these resources. Currently, with the growing number of DERs in rural areas, regional costs are becoming increasingly crucial. Provided that there is no micro-grid set up in the region, it may become costly to connect many renewable energy installations to the grid. The basis of distribution company-specific tariffs is that the network users in the relevant region bears all the costs brought by themselves. However, due to the tariff structure in Turkey, DSOs are unable to incorporate these expenses in electricity tariffs of the regions having plenty of DERs (SHURA, 2021b).

Finally, whether it is electric appliances, electric vehicles, battery energy storage, or a roof-top solar PV, all behind the meter generation and consumption, are invisible to network operators. Therefore, all of these are considered as a single net load for the energy system. Unless the system is built so that this net load can be monitored and controlled to serve the grid, there would be a large unmanageable load in the system (SHURA, 2021b). The energy grid may be vulnerable to power outages if asset owners are hesitant to let outside interventions on their energy assets' management. And finally, not having complete control on energy assets for decisions such as energy efficiency and load shifting purposes hinder these assets' potential.

3.2 Need to manage electrification

Although electrification of the transportation sector, built environment, and industry underpins decarbonization efforts, in case it is not managed properly it may pose some threats for end-consumers and the grid infrastructure. With the growing demand due to the introduction of EVs, overloading and voltage drop problems could occur in the distribution grids if the required expansion in the transformer capacity and distribution grid lines are not realized (SHURA, 2019). In Turkey, however, the expansion of the electricity grid infrastructure for EVs is challenging due to vertical building structure and insufficient infrastructure in buildings for establishment of charging stations in cities. The areas to establish charging stations are crucial with the reason that it should be compatible with the grid capacity and EV user expectations. As the first alternative, gas stations might be considered to accommodate charging stations. However, they might not satisfy the charging infrastructure need of EVs, and the requirement for social facilities to be used by EV users while waiting for the completion of charging. Secondly, if these stations are located mostly in public areas rather than residential buildings – which lack the needed infrastructure - consumers may have to charge their electric vehicles during peak demand periods, putting additional strain on the grid infrastructure. Furthermore, if the increased energy demand cannot be satisfied with the existing generation capacity, fossil fuels may be utilized to offset increasing demand, adding to the energy system's carbon footprint. In such a case, the result would be the opposite of the intended low-carbon future.

When challenges are considered, there might be a need for comprehensive optimization studies for the smooth integration of EVs into the grid infrastructure. As revealed by the study prepared by SHURA, analysing the impacts of the transformation of Turkish transportation sector and of electric vehicles on the distribution grid in Turkey, the optimisation could be through a common platform managing the services, such as energy trade, charging point operations, and route selections for EV users, as well as enabling enhanced communication between EVs and the system operators (SHURA, 2019). Also, according to the study on enabling demand side participation in the electricity market, smart charging technology can manage the battery systems and make automated decisions to charge and discharge EVs through price signals. In this manner, smart and fast charging technologies, and optimised decisions for charging times – enabled by AI - are critical not to create overload in the electricity system and to favour further electrification (SHURA, 2021d).

In addition to EVs, the increasing prevalence of heat pumps can increase electricity consumption by replacing natural gas usage at residencies. It will be critical to manage this increased electricity demand and shift peak demand to low demand periods of time. Wholesale companies may need to implement projects to use energy efficiency potentials and improve energy efficiency.

3.3 Implications on the grid infrastructure

As previously mentioned, the increase in distributed generation and the widespread use of electric vehicles may bring about several challenges as well as the costly grid expansion investments in the distribution grid. In the conventional electricity systems, the electricity flows from the high voltage transmission lines to the distribution level under certain capacities. With increasing number of DERs, the electricity should be flowing from distribution level to high voltage when the generation exceeds the consumption. Also, wide adoption of EVs may increase the total load in the grid at peak times, pushing the limits of grid capacities. Unless these are managed properly, there may be voltage management problems, exceeded load capacities of grid equipment, difficulty in fault detections, and system flexibility problems in the electricity network.

Due to the intermittent nature of DERs, after a certain level of prevalence, technical issues may arise in the distribution grid and even in the transmission system unless precautions are taken. Even though Turkish electrical system has a strong infrastructure, there is a need for technical solutions and regulations to manage bidirectional flows and load fluctuations in the grid. To preserve the balance of the grid, flexibility options or a micro-grid approach may address the needs of grid infrastructure by eliminating overload. In Turkey, however, the microgrid strategy, and consumer flexibility opportunities, including battery systems and demand-side participation, are not yet used at full potential, as revealed by the study prepared by SHURA, analysing options available for increasing system flexibility (SHURA, 2021b). Furthermore, grid infrastructure will require ameliorations with the prevalence of EVs. In the medium/long term, the planned EV charging stations will have a significant influence on demand, resulting in power disruptions due to insufficient grid infrastructure and lack of good energy management. To address this issue, data collecting via sensors and IoT technologies, data analysis, and smart grid applications may be prioritized as future development areas.

In Turkey, the current regulations enforce DSOs to run power lines to any rural area without using analyses such as Cost-Benefit Analyses (CBA). That is, the distributors may incur high costs and low returns on some projects due to the obligation. Moreover, these investments are conducted in a unified way and are reflected to all customers directly via tariffs. When Turkey's geographical condition is considered, it can be imagined that there are too many residencies to supply electricity from the main grid, which brings serious financial burden on both the DSOs and the other bill payers.

3.4 Increased energy consumption

Increasing energy consumption and inefficient use of the energy in Turkey can make it difficult to realize decarbonisation targets, and to achieve a greener future, consumers need to be aware that consuming excess energy may have a greater consequence in the future. Similar to how industries increase their production as the economy expands, consumers have raised their electricity usage in residential structures as their use of electric devices has increased. Since generally, rising electricity usage is not measured by smart monitoring systems, users are unaware of possible energy savings. Moreover, consumers may not be familiar with tariff structures, resulting in increased demand at peak hours and consequent overburdening on the grid infrastructure. Besides implications on the grid, this demand during peak periods may trigger deployment of conventional sources such as coal, increasing consumers' carbon footprint. In addition to the increased consumption, consumers may also be unaware of novel revenue-generating uses such as flexibility offerings for the grid or selling self-generation directly to their peers. By sharing the energy consumption and generation, end-consumers may collectively use energy more efficiently.

3.5 Changing consumer expectations

Consumers in Turkey have always had three main demands regarding their energy supply: an uninterrupted energy supply, notification in the event of a power outage, and electricity at a reasonable price, however as seen in every other industry, these expectations saw additions and a shift with changing consumer behaviour. First, notifying customers about potential outages now necessitates the effective use of data and technologies. To assess the type and root-cause of failures and determine how long it will take to resolve the failure when it occurs is quite reliant on data analyses. Consumers also want to be updated in a timely manner as services take place. Second, nowadays consumers prefer value-added services from their utility providers and not just simply the electricity supply. They are willing to delegate their energy management responsibility to expert companies that provide insights about daily consumption and energy efficiency solutions. Moreover, as they become more environmentally conscious, they demand new value-added services such as being informed about the source of energy that is being supplied to them. Lastly, with the widespread use of DERs, consumers have started to evaluate the advantage of becoming a producer of their own and currently financing conditions still hinder such enthusiasm. Hence, consumers look for alternative approaches so that they can overcome their concern related to financing and service-related issues.

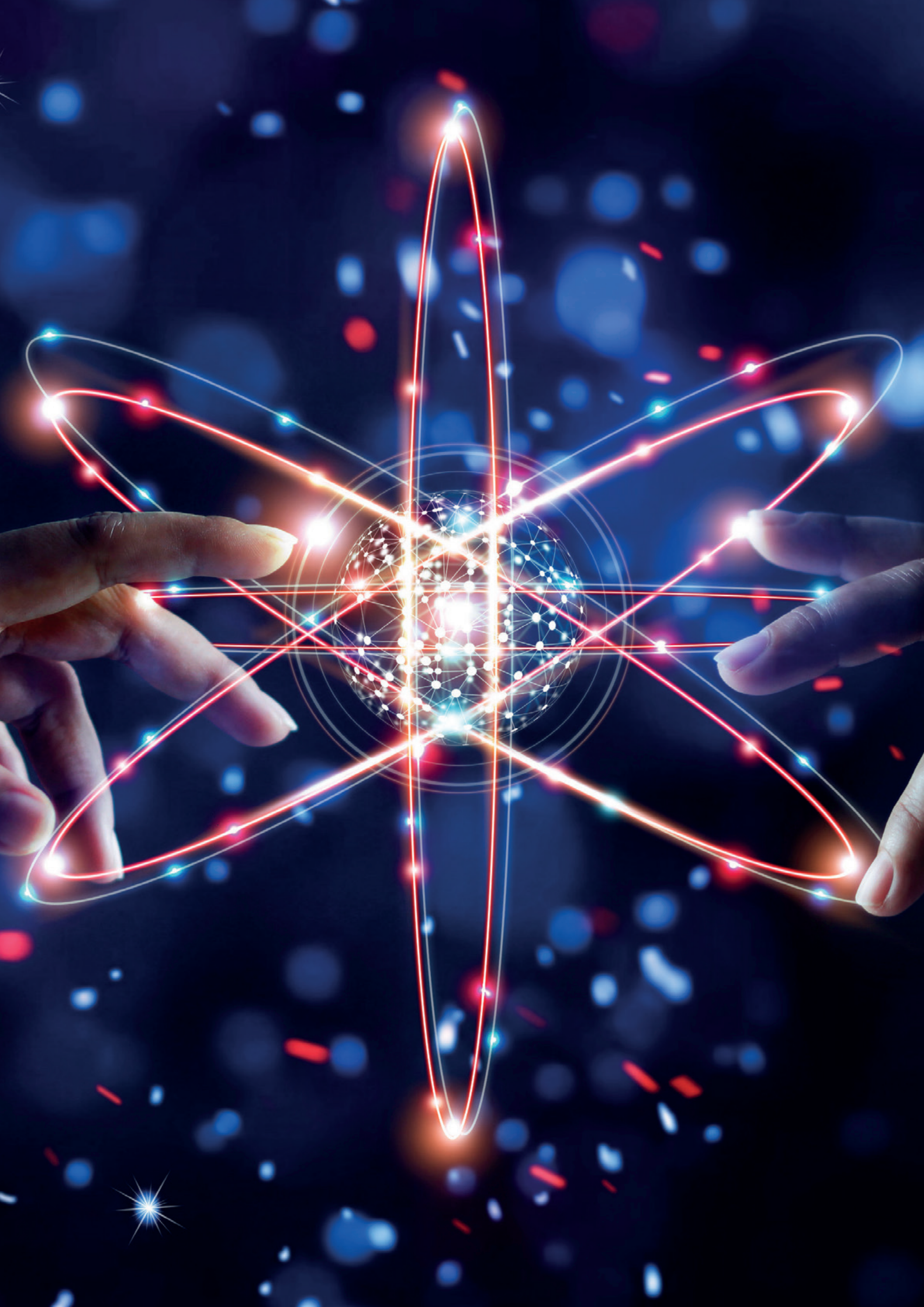
3.6 Need for better data management

Through digital transformation, data has become the main driver of innovative solutions for the power sector. Yet, how to collect and manage data can cause new challenges to face with. From a data management standpoint, several challenges in data quality and standardisation, data administration, and the availability of advanced data tools may be encountered.

Data quality and standardisation challenges could be observed in every step of the value chain of the power system. Regarding the supply side, data sharing infrastructure is critical to monitor DERs continuously for balancing. However, the non-standardised data protocols and data sharing practices stand as a challenge. Moreover, the accuracy and security of data hold significant importance in the market. There is a need for providing OT-side security aside from IT and OT-side monitoring. Data analytics problems can cause data quality problems in GIS success and service to customers. Data verification is another significant concern regarding data quality. Measurement verification is necessary for revenue generation in performance contracts, and it needs to be carried out with arbitration committees or different mechanisms, which stands out as another challenge in Turkey.

The fact that different service providers cannot manage data collaboratively can also cause friction in having a mutual congestion management by TSO and DSOs. Similarly, distribution and retail companies may be unable to manage data collaboratively, and the data is tracked in different structures. The lack of collaboration hinders the development of data integration.

In general, Turkey falls behind the Europe, Middle East, and Africa (EMEA) region in terms of IoT, AI, data analytics, and cloud-based intelligence firms, which pave the way for real-time optimization in three to five years. However, concepts such as data modelling and optimization, cloud architecture, and the establishment of an institutional memory platform have an improvement area in Turkey. Due to the ceaseless collection of data, there is concern about cloud expenses and data dumping in energy firms as the cloud becomes more common and the market transforms into a continuous structure. The structural evolution of the market is causing traditional software to be discarded technologically, and this process can exacerbate data integration and data collecting issues.



4. Business models to address the power system transformation

Challenges that arise with the transformation of the power sector, besides the multi-faceted benefits of transformation, have created a need for innovative solutions, which are enabled by digital technologies. These innovative solutions may address the existing or potential challenges in the power sector.

One of the biggest challenges mentioned in the previous section is maintaining the balance of supply and demand due to higher integration rates of DERs. For balancing activities, the energy flow of many DERs require real-time optimisation simultaneously to maintain the stability of the grid. To do that, energy management of many energy resources and consumption points may be conducted collectively by a third party. Nevertheless, real-time optimisation occasionally cannot be done due to the uncontrollable nature of renewable energy generation. Thus, flexibility options - such as battery technologies or demand response - also need to be facilitated both in the supply and demand side. Even further, a third party may be involved to trade the flexibility resources in ancillary markets.

A third-party involvement could be also useful for prosumers to monetize the value they create in the energy system. Apart from only generating energy, it is also a question for prosumers how to benefit from the excess energy they possess. With the new design of the energy system, they may either prefer to sell it in energy markets, to the grid, or to their peers. As mentioned in the previous section, for small-scale producers, it is not viable to trade in large-scale energy markets, and this poses a requirement for an aggregation of many energy resources by another third-party service provider. Similarly, if a prosumer prefers to trade with a peer, this would be only possible via a trustable platform where the transactions and mutual agreement is approved. In addition to the energy transaction, the trades among peers also requires a comprehensive data management to be handled by outside authorities.

Another concern for the energy system is discussed as the need for managing electrification and the how to meet the additional electrical loads to be created by electric vehicles and heat pumps, in particular. Not to create this overload in the grid, increasing the prevalence of behind-the-meter energy generation to charge EVs is crucial. Even though every EV owner cannot have a solar PV, energy need can be satisfied through peers directly. Furthermore, if a trading is possible among peers in the local level, the main grid is not exposed to a load transfer, which help maintain the reliability of the grid. The micro-grid approach not only enables avoiding overload for the grid but also may help supply electricity for off-grid regions with renewable resource installations.

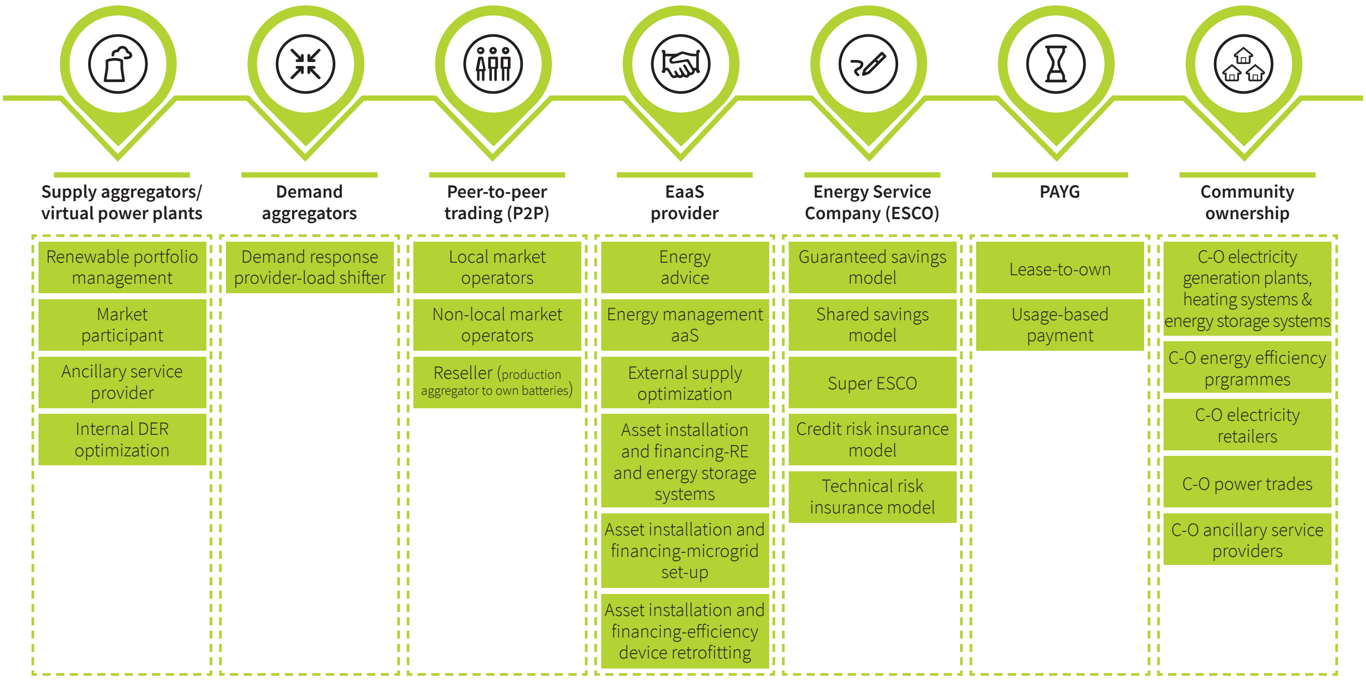
Again, as previously tapped in, with energy consumers becoming the centre of the whole energy system, their expectations and behaviours are evolving. Engagement and transparency between energy providers and customers, quality of energy and compensation for the services may be improved with the emergence of new business solutions. End-consumers are not only becoming more aware of the concepts like energy efficiency and renewable generation, but also find ways to finance new energy-related projects through different offerings.

4.1 Business model structuring

The business models arising with the different needs in the sector require to involve innovative solutions in terms of configuration, product, and experience. Network orchestrators, which provide common platforms for bringing multiple parties together to work in harmony, will be at the forefront of the electric utility value chain in the future. Moreover, the energy-related services bundling various solutions such as energy management, trading platform, or energy efficiency packages are expected to be in fashion.

As being innovative and problem solvers, target business models can be structured under seven categories: (1) Supply aggregators / Virtual Power Plants (VPP), (2) Demand aggregators, (3) Peer-to-Peer Trading (P2P), (4) Energy-as-a-Service (EaaS), (5) Energy Service Company (ESCO), (6) Pay-as-you-go (PAYG), and (7) Community ownership (C-O). These business models have assimilated second level sub-categories, which perform similar core activities with different purposes and target customers. Moreover, each of these sub-models may be enabled by hardware and software technologies using different digitalisation technologies such as IoT, AI and blockchain. These digital, hardware, and software technologies can also be considered as the enablers of the target business models.

Figure 9: *Business model structuring*



Source: Deloitte analysis

4.2 Target business models

4.2.1 Supply aggregators / Virtual Power Plants

Supply aggregators combine different energy resources, and by using a centralized IT system, they control these DERs to optimise their operations.

They offer various benefits for the power system. These benefits include real-time optimisation of big-scale power plants for balancing activities, integration of small-scale prosumers in the energy markets by aggregating the energy generation of DERs, providing ancillary services for TSO, and internal DER optimisation with collective energy management processes of small-scale renewables, behind-the-meter batteries and EV charging. In addition, VPPs may optimise investments in power system infrastructure by avoiding investments in peak generating capacity and decrease the marginal cost of power by eliminating the need for large power plant production for tiny fluctuations in the demand (IRENA, 2020).

According to analyses, supply aggregators can be categorized under four sub-business models.

Figure 10: *Supply aggregators sub-business models*

Supply aggregators	Addressed challenges	Main benefits	Key features	Revenue model	Customers	Distinction point
Renewable portfolio management		• Large power plants taking advantage of the arbitrage in changing energy prices in the market	• DERs • Information exchange with DSOs about capacity, location, type of DERs • IT systems • Smart meters • Communication infrastructure • Energy storage systems • Accurate data (weather forecasts, load projections, wholesale prices) • Analytics tools	• Flexibility services to DSOs • Sharing the gain from arbitrage in energy prices with utility-scale generators	• Utility-scale generators	• Management of big scale power plants including dispatchable and non-dispatchable units
Market participant		• Enables small-scale prosumers to be participants in wholesale organized markets and OTC trades		• Wholesale or OTC electricity trade	• Small scale prosumers	• Single entity conducting energy trade on behalf of multiple participants
Ancillary service provider		• Balancing demand and supply for the grid		• Sell balancing services to TSOs	• Prosumers • TSOs	• Providing grid services such as frequency regulation or operating reserve capacity
Internal DER optimization		• Optimising DERs by offering energy management solutions locally		• Self flexibility services to DSOs • Sell energy management services to prosumers	• Prosumers • DSOs	• Focuses on local level optimization

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Renewable portfolio management

Supply aggregators may conduct renewable portfolio management as a single management entity with the aggregation of big-scale renewable power plants to optimise power generation by controlling dispatchable (CHP, biogas, etc.) and non-dispatchable units (solar, wind power, etc.) and energy storage units. Companies practicing renewable portfolio management play an important role especially in eliminating the imbalance created by grid scale renewables. In the process, the energy generation data from dispatchable and non-dispatchable units, the grid conditions and are monitored and controlled to ensure optimum generation and trade decisions.

In France, CNR manages bundling, real-time monitoring, and efficient remote control of wind and solar parks depending on the price signals from electricity exchange. Moreover, with an individualized configuration, the Virtual Power Plant (VPP) can be adapted to meet the specific requirements of the French electricity market. VPP platform connects, monitors, and controls a set of decentralised power-generating units in CNR's direct-marketing portfolio. In addition to the direct marketing of wind and solar power, CNR also offers this as a service to other wind and solar plant operators. The operations of CNR include curtailment of renewable energy portfolios in case of negative EPEX spot market prices.

Market participant

The market participant model enables a supply aggregator to sell combined electricity produced by small-scale prosumers in the wholesale organised markets and OTC trades. That is, small producers who are unable to participate in the energy markets can become players through peer aggregation. As previously mentioned, one of the aspects of changing consumer expectations is being able to trade in the energy markets. In addition to satisfying consumer expectations, integrating new and small-scale prosumers into the market also ease the management of DERs by diversifying and growing the market with additional resources.

Statkraft, the largest VPP in Europe, operates more than 10 GW installed capacity from over 1,000 power generators that equal to ten thermal power plants, which could power a major city. Statkraft can, through the combination of optimized power predictions of fluctuating and decentralized generators of electricity, optimally integrate these resources into the power grid and efficiently market the generation on the power exchange. Statkraft's Virtual Power Plant monitors the operations of more than 4,000 MW in Great Britain, consisting of wind and solar power, battery storage, and flexible gas motors, by comparing these with the constantly updated Day Ahead, On-the-Day, and Cash out-Price predictions and allowing for the real-time optimization of electricity trading in the British energy market.

Ancillary service provider

Supply aggregators may act as ancillary service providers to cope with fluctuations in the grid. They may offer different options such as reserve capacity or frequency control reserves. These services are becoming more crucial today because of the need to cover the challenging implications on the grid, brought by increasing number of DERs and new electricity consuming elements in our lives. As an ancillary service provider, Statkraft -with the help of battery storage- deploys 80 MW of primary balancing power for the grid in Great Britain. Further balancing power is made possible via the gas motors integrated into the virtual power plant.

Internal DER optimization

The internal DER optimization model provides flexibility at the DSO level and optimises the energy generation of small-scale DERs locally where individual small energy resources cannot yield flexibility on the power exchanges themselves.

In Germany, a company called Sonnen uses a virtual energy pool to serve community members who are unable to meet their energy needs. The sonnenCommunity is developed by sonnenBatterie, which is a storage manufacturer in Germany. SonnenCommunity allows sharing of self-produced renewable power by individual consumers who are using sonnen's batteries. A central software links up and monitors all sonnenCommunity members - while balancing energy supply and demand at the local level. The model differs in that surplus energy is not fed back into the grid, but rather into a virtual energy pool. The electricity price of the pooled energy is fixed at around USD 25 cents/kWh (EUR 23 cents/kWh) and the monthly usage fee for the platform is EUR 20.

4.2.2 Demand aggregators

Demand aggregators act as load shifters in the power system, by affecting the realization times of load. With the increasing energy consumption today, there arises a need to spread the demand over time to avoid the peak hours. To this end, Aggregators can enable real-time shifting of commercial and industrial loads to provide demand-side management services to grid operators based on price signals and collected data. The value created by demand aggregators is revealing the flexibility of power consumers. To do that, demand aggregators use mainly IoT and AI technology for real-time optimisation of energy consumption. Also, there should be an ancillary service market to use the flexibility options. These activities of the demand aggregators result in deferred investments in distribution and transmission grid infrastructure. While the implementation of demand response aggregation is a very regional phenomenon today (US, Australia, Europe) and often limited to commercial and industrial power consumers, it holds great potential once tiny flexibilities on the household level (e.g., EV batteries, heating pumps, AC units) are aggregated and become more active on the energy market.

According to analyses, load shifters are the only sub-business model that positions itself as a demand aggregator and enables demand-side participation.

Figure 11: Demand aggregators sub-business models

Demand aggregators	Addressed challenges	Main benefits	Key features	Revenue model	Customers	Distinction point
Load shifting		• Enables real-time shifting of commercial and industrial loads, providing flexibility for the grid.	• DERs • IT systems • Smart meters • Energy storage systems • Data (weather forecasts, load projections, wholesale prices) • Digital technologies (IoT, AI)	• Flexibility services to grid operators	• Prosumers • DSOs	• Providing flexibility through demand-side management

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4.2.3 P2P operators

Given the increasing integration of DERs into power systems, peer-to-peer (P2P) energy trading is based on direct interaction between users and producers via a blockchain-based platform architecture. DERs include distributed generation, energy storage (behind-the-meter batteries, etc.), other controllable loads such as EVs, power-to-heat systems, and demand response. With P2P electricity trading, prosumers can share the benefits of these resources with communities they belong, while also contributing to the power sector's needs.

The benefits of the P2P trading model are plenty. At the end of the value chain - consumer side - electricity trading among the peers empowers prosumers and consumers by sharing the value created, which leads to the sizeable deployment of distributed renewable energy resources. Additionally, P2P models can be used in balancing activities, congestion management, and ancillary services for the grid. P2P trading platforms enable better management of decentralized generators by matching demand and supply and avoiding the injection of electricity into the grid, which may cause congestion. P2P operators can act as a VPP in a micro-grid arrangement by providing ancillary services to the main grid.

According to analyses, the P2P model includes three sub-business models. All P2P models are enabled by blockchain technology for transactions in a transparent and secured way.

Figure 12: *P2P sub-business models*

Peer-to-peer trading (P2P)	Addressed challenges	Main benefits	Key features	Revenue model	Customers	Distinction point
Local market operators		• Daha yüksek yenilenebilir enerji yaygınlaşması • Tüketiciler için enerji erişiminin iyileştirilmesi	• DERs • Smart meters and smart grids • EVs • ICT Network • Trading platform (market operator) • Forecasting for supply and demand • Blockchain technology • Storage system	• Platform services for local seller and buyers	• Platform services for local seller and buyers	• Trading among individual neighbors via distribution/ mini grid
Non-local market operators		• Şebeke için dengeleme ve kısıt yönetimi • Küçük topluluklar veya mikro şebekeler arasında ticareti mümkün kılmak		• Platform services • Ancillary services for the grid operators	• Prosumers and consumers • Third parties (other communuties, industrial buildings, shopping centers, holiday resorts etc.)	• Trading among small communities/mini grids/ mini grids to main grid
Reseller (production aggregator to own batteries)		• Tüketicilerin enerji üretimi için sürekli bir alıcının varlığı • Piyasa koşullarına bağlı olarak arbitrajdan yararlanan aracılar		• Gains profit margin due to differences of spot prices of electricity		• Storing electricity in self-owned batteries to sell during peak times

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Local market operators

Local market operators allow trading among individual neighbours via distribution grid or micro-grid set-ups, enhancing the involvement of prosumers in the energy trade. Peer-to-peer trading is a newly introduced solution for prosumers who may have different kind of energy resources. At the local level, these energy resources such as solar PV panels, and behind-the meter batteries can be managed optimally through local market operators resulting in better management of DERs and EVs. And consumers may take advantage of the new way of earnings and easy access to energy resources.

In Switzerland, Prosume's platform allows optimal management and tracing of energy flow within a community or a local energy market. Consumers and prosumers use their unique IDs to automatically acquire locally produced electricity or share/sell the energy surplus generated by their PV plant. Moreover, Smart Community Energy Aggregator Development is for participating in specific aggregator requests of energy demands, where the consumers choose different energy sources like green, local, or fossil.

In another example in the USA, a company called LO3Energy provides blockchain-based innovations to revolutionize how energy is generated, stored, bought, sold, and used, all at the local level. This technology platform offers a simple way to account for local distributed energy resources and enable new incentives for customers. They measure a building's energy generation and communicates with the network to collectively manage energy. Then, blockchain is used in a decentralized digital ledger in which private computers verify transactions automatically. The application programming interface (API) enables collaboration. It creates an open path that encourages participation and innovation from members across the network. The grid connection is accomplished using the LO3Energy platform to create a community of buildings that generate, store, and trade energy locally.

Non-local market operators

P2P trading may not always happen at the local level. Non-local market operators enable trading mechanisms among small communities, mini-grids, or between mini-grids and the main grid.

Ponton, located in Germany, is a Business-to-Business (B2B) IT company focusing on energy trading, grid management, and customer-related processes. The company provides solutions for energy trade (power, gas, and CO_2 certificates) and grid operation. Ponton, being a part of the Enerchain project, is a decentralized energy trading platform for the over-the-counter wholesale energy market in which locally produced energy is exchanged among prosumers, DSOs, and aggregators. Moreover, the platform simplifies and standardizes how market participants (TSO, DSOs, aggregators, suppliers, and generators) collaborate and communicate in the grid management process by performing as an "orchestrator". Ponton is known as the first platform in Europe to accommodate an energy trade over blockchain.

Reseller

The P2P model also facilitates a dynamic market mechanism for the energy trade. Resellers are taking advantage of the arbitrage in the energy market by storing the energy when energy prices are low and selling it when the prices go up. In this model, reseller P2P market operators can purchase electricity from prosumers and store it in their self-owned battery systems. The stored energy is sold during peak times when demand lags the generation.

4.2.4 EaaS

Rather than simply supplying electricity in the form of kWh, the Energy as a Service (EaaS) model provides clients with a variety of energy-related services. It utilizes a holistic approach combining hardware, software, and related services for customer needs through increased digitalisation.

Key benefits of EaaS emerge as enhanced deployment and management of DERs and increased grid flexibility via demand-side participation alongside efficiency solutions. Moreover, customers take advantage of the simplification of increasingly multifaceted energy service offerings because EaaS behaves as an intermediary agent for all energy-related needs. These energy services are provided by Energy Service Providers (ESPs) with various technologies, including smart meters, time-of-use tariffs, storage technologies, and IoT and AI for energy management solutions.

According to analyses, the EaaS model includes six sub-business models that offer energy advice, energy asset, and energy management solutions at the top.

Figure 13: *EaaS sub-business models*

EaaS provider

	Addressed challenges	Main benefits	Key features	Revenue model	Customers	Distinction point
Energy advice		• Offers tailored strategies and identify opportunities for optimizing consumers' consumption	• Benchmarking – identifying best practices • Advanced energy modelling software • Electricity price forecasting	• Enabler of other revenue streams	• Commercial and industrial buildings • Residencies	• Not having a direct revenue model yet it provides an attraction point for the customers
Energy management as a service		• Energy consumption optimization, considering consumer's comfort • Increased flexibility through demand-side management	• Smart home appliances • Digital technologies Smart meters • Real-time optimisation • Dynamic pricing	• Subscription or performance-based contracts		• Providing energy management solutions through monitoring, remote control and optimization of the load
External supply optimization		• Reduction in costs supplying energy	• Digital technologies (AI)	• Performance-based contracts	• Commercial and industrial buildings	• Purchasing optimization with certain agreements on the energy purchasing side
Asset installation and financing – RE and energy storage systems		• Enhances the deployment of DERs • Customers generating revenue from self-generation of electricity	• DERs • Battery storage systems	• Revenue via margins on hardware installations • Subscription based contracts	• Commercial and industrial buildings • Residencies	• Renewable energy projects and battery storage system solutions
Asset installation and financing – Microgrid set-up		• Increases prevalence of the decentralized grid systems	• EV smart charging infrastructure • Battery storage systems • DERs			• Installation of micro-grids operating autonomously and independently
Asset installation and financing – Efficiency device retrofitting		• Customers saving on electricity bills	• Energy efficient appliances			• Creating opportunities for customers to save on electricity bills

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Energy advice

The energy advice model leverages advanced modelling software using customers' electricity data, electricity price forecasts, or historical data to put a clear picture of energy consumption costs by comparing with prevailing market prices. This model aims to provide a diagnostic picture for customers to pinpoint opportunities regarding energy consumption which requires attention in Turkey for a carbon-free future. By providing insights through engagement with customers, the model leads to revenue streams for companies such as inclusive energy management packages.

Energy management as a service

Energy management as a service model allows customers to delegate their energy management responsibility to a company whose core activity is providing energy management solutions through tracking, remote control, and optimisation of energy usage. Smart meters are essential for this model for tracking and remotely controlling energy consumption. Furthermore, time-of-use tariffs are the other critical prerequisites for energy usage optimisation and taking advantage of the differentiation in the energy prices. In residential buildings, the model operates through smart home appliances, which can be remotely controlled. However, there may be other applications in commercial or industrial buildings, such as providing energy management solutions for lightening, machinery operations, and so forth.

External supply optimization

In Portugal, EDP, a smart home offering that received the European Utility Week Energy Retail Award, performs a distinctive use of this model. EDP enables customers to manage their home equipment and energy consumption via a smartphone app. With its EDP Smarthome product bundle, it combines four of its products and places itself on each aspect of the smart home industry – solar energy, energy storage, energy management, and electric mobility – to empower energy users. An EDP re:dy box is connected directly to the customer's smart meter and provides a tonne of information regarding their energy consumption. All this information is then transformed into actionable insights so that customers can optimise their consumption based on monthly energy reports. By subscribing to EDP Smarthome, customers may choose to have an efficient and more sustainable way of living. This project also helped to cross-sell services. For example, a customer that buys an electric car may also subscribe to EDP re:dy to control the energy consumption of their vehicle and optimise the charging station power.

Similarly, Inspire, a USA-based company, helps the planet with 100% clean energy and provide clean energy with no interruptions and no installations. It aims to create the world's first comprehensive "smart energy" experience for the home. Inspire offers several rate programs, including 24- and 36-month plans with a fixed per kilowatt-hour rate and a monthly variable rate product for customers who don't want to make a long-term commitment. However, the flat monthly subscription is the company's marquee product. The method begins with a big-data platform measuring how a customer consumes energy, allowing the corporation to price each subscription for each member in advance. Data science and computational approaches are used in the pricing process. Subscription prices for the "Smart Energy" subscription model start at USD 39/month and include energy management services as well as 100% clean electricity. On the other hand, external supply optimisation specializes in making certain agreements for energy purchases to optimize costs, energy resource preference, and energy quality. The increase in the energy consumption in factories with the acceleration of industrialization requires the optimisation of the purchasing process of this energy. As a solution, EaaS offers strategic guidance based on pricing comparison for the customer in terms of electricity supply ranging from conventional energy resources to DERs.

Asset installation

Lastly, asset installation and financing services have seen a rising demand with the trend in renewable energy generation and energy efficiency solutions reaching even end consumer level. Both the increase in environmental awareness and the realisation that end-consumers can use energy as a source of income are among the factors that accelerated this trend. Asset installation and financing include three related sub-models. In the first one, ESPs can provide end-to-end services associated with the installation of on-site or off-site renewable energy projects and battery storage systems, increasing the overall deployment of DERs. With these projects, ESPs make revenue through margins on hardware installations. Second, the installation of renewable energy projects and battery storage systems can lead to the creation of micro-grid setups that operate independently of the main grid. Also, microgrids pave the way for revenue generation opportunities for prosumers through P2P trading within the micro-grid environment. The last sub-model covers the topic of efficient device retrofitting for customers. Customers can reduce their energy bills with the installation of energy-efficient appliances. For instance, in addition to the energy management activities, Inspire syncs up smart technologies, including controllable LEDs and smart thermostats to a mobile app enabling customers to monitor and control their energy usage, and get money back through the app every time that they save.

4.2.5 ESCO

An energy service company (ESCO) is a company that offers energy services that may include implementing energy-efficiency projects or providing DERs on a turn-key basis. The primary purpose has been to reduce the energy cost of buildings through end-to-end solutions such as project design/implementation, maintenance and overhaul, retrofits for energy efficiency, monitoring and evaluation of savings, and equipment supply. The most distinguishing characteristic of ESCO models is that the revenue is generated upon the realization of energy savings created by the project.

The main benefit of the ESCO model is that customers can merely focus on their core activities rather than management of energy-related issues such as monitoring and taking actions for energy efficiency, which require dealing with huge chunks of data. Especially for energy-intense facilities, ESCO solutions help save a considerable amount of expense. Furthermore, customers do not have to deal with considerable upfront equipment expenses because ESCO may pay initial expenditures through customer cost savings.

According to analyses, the ESCO model includes five sub-business models depending on the scale and requirements of the project.

Figure 14: *ESCO sub-business models*

Energy Service Company (ESCO)	Addressed challenges	Main benefits	Key features	Revenue model	Customers	Distinction point
Guaranteed savings model		• Improved energy efficiency • Reduced energy costs • Increased deployment of DERs	• Energy savings tools (digital technologies, physical equipments etc.)	• Payments based on realized energy savings from project	• Municipalities • Universities • Schools • Hospitals • Government buildings • Manufacturing plants • Public institution (for Super ESCO)	• ESCO provides savings guarantee to the client for the project
Shared savings model			• Methodologies to measure and verify energy savings • Project risk forecast • Clear risk analysis	• Savings are shared according to the predefined terms		• The agreement between ESCO and customer specifies how savings are shared, measured and verified • ESCO and customer share the performance risk
Super ESCO			• Government financing, institutions, bureaucracy	• Payments are based on energy cost savings		• Government-backed ESCO model
Credit risk insurance model			• Default risk premiums for customer's loan paid by ESCO	• Payments based on realized energy savings from project		• Client's financial risk for the bank loan is hedged by insurance company
Technical risk insurance model			• Technical risk premiums paid by ESCO			• ESCO hedges its risk if energy savings are not realized

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Guaranteed savings model

In the guaranteed savings model, ESCO provides a savings guarantee of the project to the customer. With this model, ESCO owns the performance risk of the project, and the customer gains an exceptional advantage for the future risks of project implementation. As agreement verdicts, ESCO doesn't receive payment unless the project delivers the expected energy savings or services.

Shared savings model

Compared to the guaranteed savings model providing a protective shield to customer, shared savings model offers a risk-sharing model for both stakeholders. The agreement among stakeholders specifies how savings are shared, measured, and verified. Moreover, this agreement partially removes ESCO's performance risk in the long run. However, procedures regarding energy efficiency measurement and verification may require the involvement of external parties due to possible conflicts between stakeholders.

Super ESCO

Super ESCOs are government-backed institutions that aim to serve the public sector for energy efficiency projects. Due to governmental power, the model facilitates financing and procedural issues such as procurement and contracting for the projects. Innovative financing methods can help customers pay for the upfront investment through loans, capital leases, or bond issuance. Super ESCO also provides project financing like bank and customer's payment is based on cost savings from the project. Due to coverage of implementation costs, Super ESCO is likely to drive the adoption of energy efficiency projects.

Credit risk insurance model

The credit risk assurance model is similar to the guaranteed savings model. In this model, ESCO implements the project with a savings guarantee. Furthermore, ESCO pays premiums to an insurance company to hedge the client's risk against the bank loan. If the customer experiences a default, the insurance company provides credit default coverage to the customer with the premiums paid by ESCO. Consequently, the cash flow from the customer is guaranteed.

Technical risk insurance model

On the other hand, the technical risk assurance model supplies a protective shield for ESCO. By paying premiums to the insurance firm, ESCO hedges its risk of not meeting the agreed-upon terms on saving rates when the project is implemented with a savings guarantee. In case of a non-realization of energy savings, the loss is compensated by the insurance company.

4.2.6 PAYG

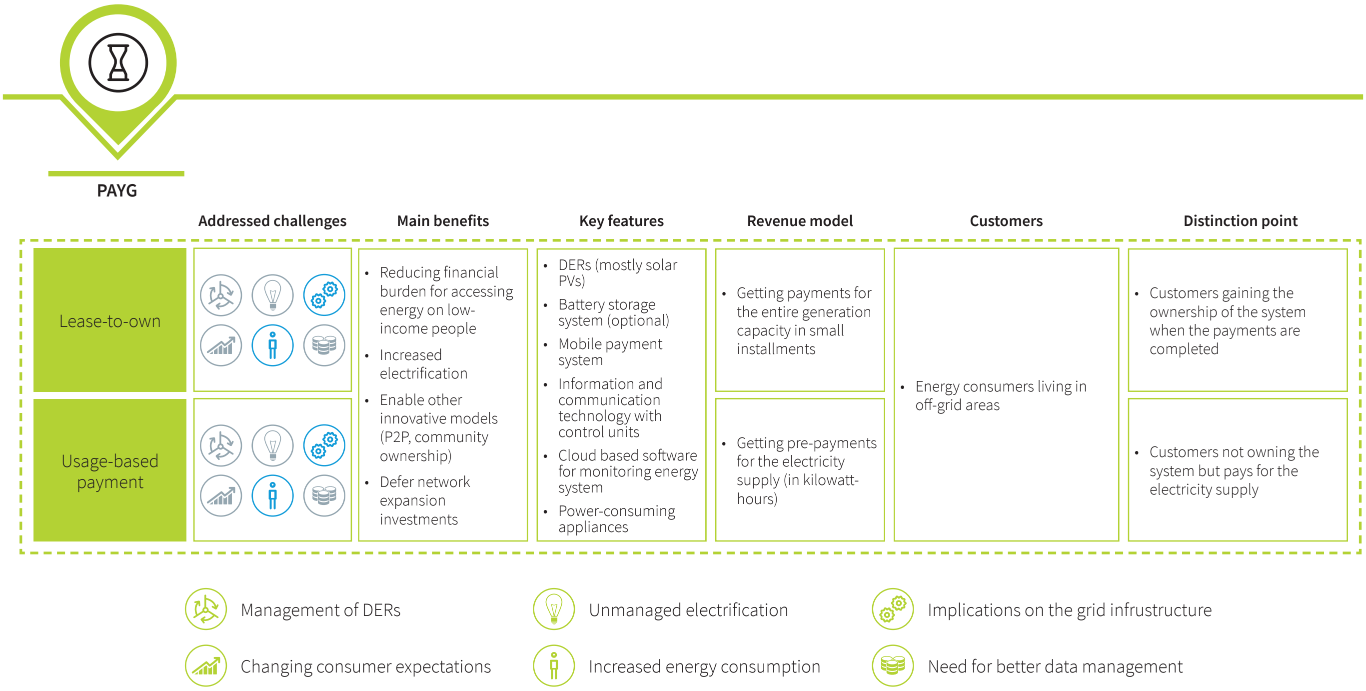
Pay-as-you-go (PAYG) model usually includes a home solar system, rented, or sold, for which the customers pay via mobile payment technologies and mobile phone credits. In cases of non-payment, the service provider can remotely disconnect the service.

The PAYG model is an innovation that was emerged to address the energy access challenge and to provide electricity generated from renewable energy resources at affordable prices.

PAYG model provides several advantages by eliminating the need for network expansion investments for off-grid areas (rural, mountainous, desert/forest villages, etc.), preventing the grid from excess load and improving energy access in these areas. PAYG model also enables other innovative business models such as P2P energy trading or community ownership.

According to analysis, PAYG model includes two sub-business models.

Figure 15: *PAYG sub-business models*



Lease-to-own

The lease-to-own model, also referred to as consumer finance retail, involves customers paying for the entire generation capacity in small instalments for a period. Over 90% of solar PV systems are under the lease-to-own model (IRENA, 2020).

In Kenya, off-grid solar solution supplier d.Light developed a PAYG solar system that can provide lighting, charge mobile phones, and power radios. It has sold over 120,000 units of its product. Most of the sales were made in East Africa, with the Kenyan market accounting the majority. Payments can be made using a wide variety of mobile platforms. As long as the payments are made on time, the D30 device remains unlocked. Once paid in full, the Pay-Go solar home system is unlocked forever, and customers then own their systems. These mobile platforms enable customers to make a down payment of USD 25 and then make daily payments of USD 0.4 for a year, after which the customer owns the system. Thanks to its ability to operate like a personal power grid for homes and small businesses, d.Light claims its system has gained widespread acceptance in low-income rural parts of the world, making it possible for the people to switch from costly kerosene and enjoy the advantages of sustainable power supply.

Usage-based payment

The usage-based model, also referred as “micro utility”, involves customers prepaying for the electricity supply (in kilowatt-hours). Customers prepay for electricity, and once that electricity is consumed, the ESP turns off the solar PV system automatically via a remotely monitored control system until the next payment is made. Different from the lease-to-own model, the customers never own the system but only consume the electricity generated.

4.2.7 Community ownership

Community ownership enables the actors, including households, individuals, and businesses to unite in obtaining energy-related assets such as DERs, battery systems, district cooling, and heating systems. The ownership of assets belongs to all members, and the obtained systems are managed collaboratively.

The community ownership drastically reduces upfront costs of DERs depending on the number of participants in the community, taking advantage of economies of scale and consequently increasing the deployment of DERs. In addition to reduced initial investment costs, community members can reach sustainable low-cost energy solution rather than dependency on the main grid. Community ownership models also contribute a lot to the power system, in addition to the community itself. When connected to the main grid, community owned power plants can provide power and other ancillary services by increasing the system's flexibility. The main system of large and centralized power plants is vulnerable to massive outages caused by natural disasters or acts of terrorism. The community ownership concept combines smaller, decentralized local renewable energy resources, diversifying the energy supply, and lowering the danger of grid disruptions. Besides, the model serves the macro perspectives such as local decarbonization goals. In Scotland, community owned, managed, and maintained company Eigg Electric produces 95% of the island's electricity from DERs, eliminating carbon-intensive diesel used in electricity generation.

According to analyses, community ownership model includes five sub-business models.

Figure 16: *Community ownership sub-business models*

Community ownership	Addressed challenges	Main benefits	Key features	Revenue model	Customers	Distinction point
Electricity generation plant, heating systems and energy storage systems		• Lower energy cost for the community • Improved renewable energy access • Increased deployment of DERs • Improved flexibility in the grid	• DERs • Combined heat and power plants • Battery systems	• Revenue via margins on hardware installations • Savings in utility bills	• Community members	• Collective prosumers self-consuming the energy produced
Energy efficiency programmes		• Increased awareness on energy efficiency	• Building retrofits	• Implementing energy efficiency retrofits for community members • Selling related know-how to third parties	• Community members • Local authorities	• Holistic approach to increase self-sufficiency by reducing consumption
Electricity retailers		• Enabling trade among group of small communities or mini-grids	• DERs • Trade mechanisms (pricing etc.) between communities and / third parties	• Selling energy produced by the community to other communities or third parties	• Other local communities • Third parties (businesses etc.)	• Enabling P2P trading among the communities
Power traders		• Enables collective prosumers to be participants in wholesale organized markets and OTC trades	• DERs • Price forecasting	• Wholesale or OTC electricity trade • Commission fees taken from prosumers	• Community members (prosumers)	• Single entity conducting energy trade on behalf of multiple participants
Ancillary service providers		• Balancing the power grid	• DERs • Provided services: frequency control, voltage stability congestion management, system restoration and enhanced power quality	• Selling ancillary services to the main grid	• Grid operators	• Balancing activities

Management of DERs
Unmanaged electrification
Implications on the grid infrustructure
Changing consumer expectations
Increased energy consumption
Need for better data management

Electricity generation plant, heating systems and energy storage systems

Electricity generation plant, heating systems and energy storage systems represent a holistic approach to meet energy needs of a community. In this model, consumers, bundled in communities, self-consume the electricity produced, satisfy their heating needs, and operate batteries to store electricity generated locally or consumed from the grid to meet the peak demand of the community. The fact that the community owned generation plants, heating systems and storage systems are physically located in the same place, makes it easier to manage them while supplying electricity for a local area. Furthermore, these local areas may not have to rely on the grid anymore by also alleviating the load on the grid. The community owned generation power plants can be solar PV plants, wind power plants or biomass plants, while heating systems may include biomass, wood pellet, solar, geothermal, or combined heat and power plants.

Eigg Electric exemplifies how a solar power plant can be used to meet electricity and heating needs of community buildings. Eigg is not connected to the mainland electricity supply. After decades of diesel generators, Eigg Electric provided 24-hour power for the first time in February 2008. It is a community owned, managed and maintained company which provides electricity for all island residents from the renewable sources of water, sun, and wind, comprising 110 kW hydro projects, 24 kW wind turbines and a 20-kW solar PV plant, totalling 184 kW. Power is distributed from the renewables via 11km of underground cable that was laid to form an electricity grid for Eigg. This high voltage grid delivers electricity around the island, while transformers convert the power to domestic voltage into homes and businesses. Power is regulated and stored in a control building. Nearby are back-up generators, for periods when renewable sources are in short supply. Renewable sources have provided around 95% of the island's electricity from the three renewable resources.

Energy efficiency programmes

Energy efficiency programs aim to encourage community members to take actions to reduce their energy consumption or invest in building retrofits. In the process, they may use direct investment supports, educational campaigns, technical and financial advisory, or partnerships with local authorities.

Electricity retailers

Electricity retailers can buy wholesale electricity from community-owned generation plants and sell related energy services to other local communities and external parties. This model shows similarities to P2P trading since decentralized communities become energy trading partners rather than injecting their excess energy back to the grid.

Power traders

Power traders, on the other hand, act as market participants by collecting the excess power generated by the community. Power trading can be realised using either short-term trades or long-term agreements.

Ancillary service providers

When connected to the main grid, community-owned power plants can provide ancillary services such as load balancing, reserve capacity, and frequency control reserves. That is, community ownership of smaller units with a shorter reaction time can play a vital role in levelling out the fluctuations in the grid. To illustrate, when peak demand occurs in the grid, it would be possible for the community to transfer load from the utility-scale batteries, provided that the mini-grid of the community is connected to the main grid.

4.3 Matching business models, technologies, and power system transformation pillars

Target business models and sub-categories that will meet the needs and difficulties in the energy sector serve different pillars of energy transformation with hardware, software, and digitalization technologies, which are described as enablers. Sub-categories of each business model may use certain hardware and software technologies for the solutions it offers in the energy system. However, digital technologies with higher impact potential are indispensable for business models with data-driven parties. As a result, these models will play a role in accelerating the energy efficiency, renewable energy sources and electrification trends, which are the pillars of energy transformation.

4.3.1 Matching business models with enabling hardware and software technologies

Target business models and their sub-categories are enabled by a variety of technologies. These enabling technologies comprise both the physical infrastructure and software technology required to support, for example, greater systems integration, data collection and dissemination of system resources, and enhance the efficiency of energy systems by also facilitating greater deployment and use of renewable energy.

Supply/demand aggregators are considered as key players of energy transformation and their operations are only possible through different technologies. These technologies range from batteries to smart meters to communication infrastructure or central IT control systems and energy management systems. Even though supply aggregators and demand aggregators target different customers with different activities, they mostly use similar technologies for their operations.

Similarly, P2P operators use hardware such as behind-the-meter batteries, EV smart chargers, smart meters, and communication infrastructure, while making use of software such as energy management systems and central IT control systems, where trading operations are also facilitated. Resellers, among P2P operators, differ from other sub-models and use wholesale price forecasting software to benefit from energy price arbitrage.

Figure 17: *Matching Aggregators & P2P operators with enabling technologies*

		Behind-the-meter batt.	Utility scale batt.	EV smart chargers	Smart meters	Communication infrastructure	Microgrid developers	Smart grids	Self-learning weather and renewable forecasting	Wholesale price forecasting	Dynamic pricing (time-of-use tariffs)	Load projection	Central IT control systems	Energy management systems
Supply aggregator	Renewable portfolio management		✓		✓	✓		✓	✓	✓	✓	✓	✓	✓
	Market participant	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Ancillary service provider	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓
	Internal DER optimization	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓
De.	Demand response provider – Load shifter	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓
P2P Operators	Local market operators	✓		✓	✓	✓	✓						✓	✓
	Non-local market operators	✓		✓	✓	✓		✓	✓				✓	✓
	Reseller (production aggregator to own batteries)									✓				

De: Demand Aggregators — Hardware — Software

The fact that the Energy Service Providers (ESPs) might offer different solutions, besides the electricity as kWh, requires hardware and software enabling factors. When EaaS is considered, smart meters and dynamic pricing (time-of-use tariffs) are essential for energy advice, energy management solutions and external supply optimization. ESPs also provide end-to-end services associated with the installation of on-site and off-site renewable energy projects and battery storage systems, micro-grids, smart meters, and energy efficient appliances by leveraging mostly hardware technologies.

Energy efficiency projects with ESCO model are generally implemented to the large industrial facilities or commercial buildings. Therefore, utility scale batteries are utilised alongside with the other hardware technologies such as smart grids, micro-grids, and communication infrastructure. Because ESCOs' revenue model focuses on energy savings in a facility or building, energy management systems and central IT control systems play a crucial role to push the limits.

Figure 18: *Matching EaaS & ESCO model with enabling technologies*

		Behind-the-meter batt.	Utility scale batt.	EV smart chargers	Smart meters	Communication infrastructure	Microgrid developers	Smart grids	Self-learning weather and renewable forecasting	Wholesale price forecasting	Dynamic pricing (time-of-use tariffs)	Load projection	Central IT control systems	Energy management systems
EaaS	Energy advice (benchmarking, insights…)	✓			✓	✓					✓		✓	
EaaS	Energy management aaS	✓		✓	✓	✓		✓			✓		✓	✓
EaaS	External supply optimization									✓	✓		✓	
EaaS	Asset installation and financing – RE & energy storage systems	✓				✓	✓		✓					
EaaS	Asset installation & financing – Microgrid set-up					✓	✓							
EaaS	Asset installation & financing – Efficiency device retrofitting					✓								
Energy Service Company (ESCO)	Guaranteed savings model		✓			✓	✓	✓	✓		✓		✓	✓
Energy Service Company (ESCO)	Shared savings model		✓			✓	✓	✓	✓		✓		✓	✓
Energy Service Company (ESCO)	Super ESCO		✓			✓	✓	✓	✓		✓		✓	✓
Energy Service Company (ESCO)	Credit risk insurance model		✓			✓	✓	✓	✓		✓		✓	✓
Energy Service Company (ESCO)	Technical risk insurance model		✓			✓	✓	✓	✓		✓		✓	✓

Hardware — Software

PAYG models rely on the installation of a renewable energy system and get recurring payments as long as the end-consumer benefits from the resource. Therefore, for PAYG packages, it is important to track the consumption data through smart meters and central IT control systems, remind the payments and get information on the charge left in batteries through communication infrastructure and forecast the weather for the energy generation predictions.

Similar to PAYG models, community ownership models use micro-grid solutions. However, a community-owned power plant may or may not be connected to the main grid. If connected, smart grid technologies can be used in these models. Moreover, different from PAYG models, community ownership may be composed of larger scale generation plants, which require utility scale batteries as a flexibility option.

Figure 19: *Matching PAYG & Community ownership model with enabling technologies*

		Behind-the-meter batt.	Utility scale batt.	EV smart chargers	Smart meters	Communication infrastructure	Microgrid developers	Smart grids	Self-learning weather and renewable forecasting	Wholesale price forecasting	Dynamic pricing (time-of-use tariffs)	Load projection	Central IT control systems	Energy management systems
PAYG	Lease-to-own	✓			✓	✓	✓		✓				✓	
	Usage-based payment	✓			✓	✓	✓		✓				✓	
Community ownership	C-O electricity generation plants, heating systems and energy storage systems		✓		✓	✓	✓	✓					✓	
	C-O energy efficiency programmes		✓		✓	✓	✓	✓						
	C-O electricity retailers		✓		✓	✓	✓	✓						
	C-O power traders		✓		✓	✓	✓	✓						
	C-O ancillary service providers		✓		✓	✓	✓	✓						

Hardware Software

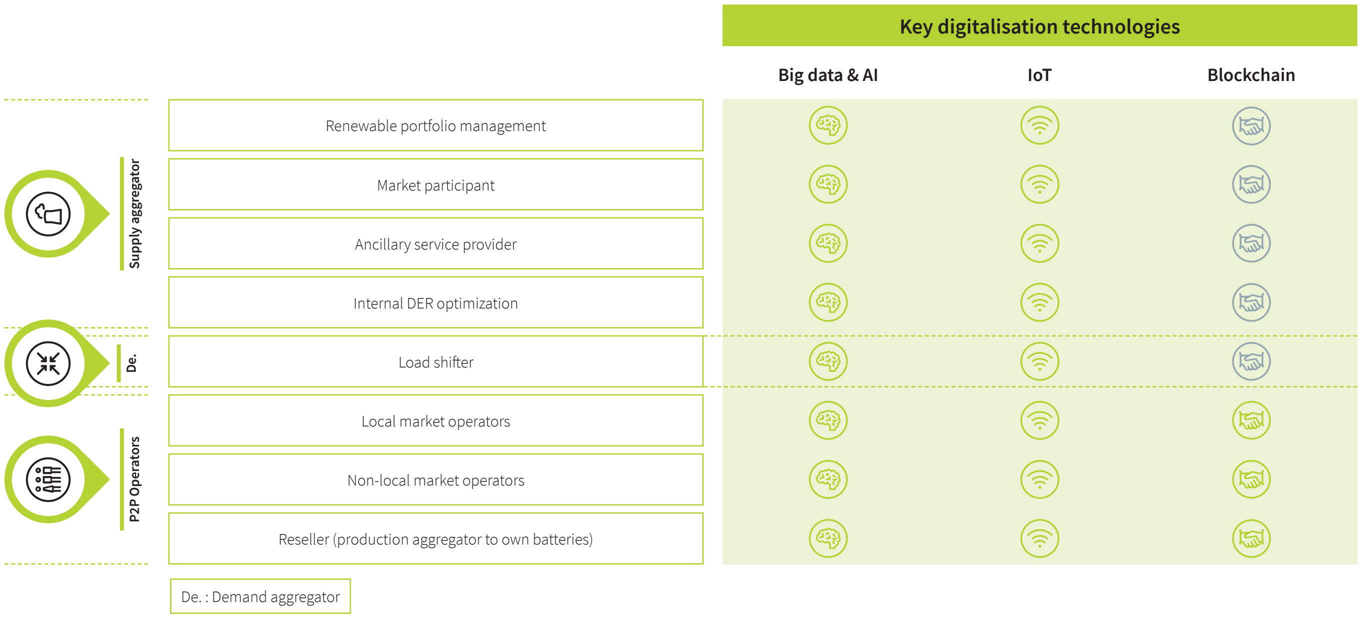
4.3.2 Matching business models with key digitalisation technologies

Innovative business models in the energy sector are enabled by mainly three digitalisation technologies as mentioned previously. Digitalisation is essentially converting energy-related data into value and allows value transaction for the power system.

The target business models can benefit from these digitalisation technologies in various ways. To begin with, real-time data acquisition from DERs is necessary for the creation and operation of an aggregator. IoT devices are critical for the collection of data. Also, advanced forecasting tools such as AI is essential to predict power generation from renewable energy and demand in the power system for deriving an optimised schedule of dispatchable DERs.

In addition to IoT and big data & AI technologies used for gathering data and make the decision process automatised, P2P operators also benefit from blockchain that enables increased direct trading and sharing of verifiable information, removing the need for the middleman, and lower-cost operating models on a smaller scale.

Figure 20: *Matching Aggregators & P2P operators with key digitalisation technologies*



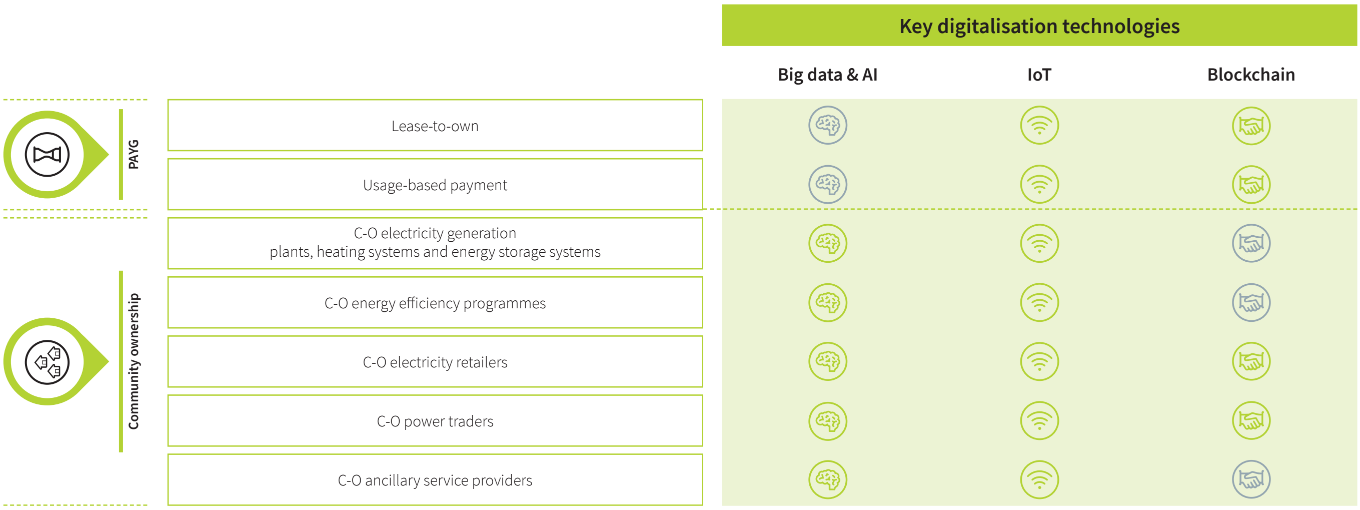
With increasing digitalisation in the sector, consumers are exploring new ways to optimise their consumption and better manage their electricity costs. When new consumer needs and the shifting power paradigm to a renewable based decentralised and digitalised system is considered, there is a need for an integrated approach to delivering new energy solutions and services. EaaS and ESCO models offer these new energy solutions by taking advantage of IoT and big data & AI digital technologies. These technologies enable companies to collect energy generation and consumption data to be mainly used for energy management and energy efficiency solutions. However, EaaS sub-business models that include asset installation and financing do not need Big data and AI technologies unless solutions as energy management are offered.

Figure 21: *Matching EaaS & ESCO model with key digitalisation technologies*

To track the consumption data and for transactions of PAYG package owners, IoT and blockchain platforms are essential. As in P2P trading, lower cost operating models on a smaller scale facilitate fast and transparent payments made by homeowners at rural areas. In PAYG models, the main focus is on asset installation, monitoring of energy consumption and healthy monitoring of payments rather than energy management.

Community ownership projects are composed of renewable energy resources that need to be managed for the use of community and for trading the excess energy generation if the power plant is connected to the main grid. In this context, IoT and AI technologies are widely used to collect data, make sense of it, and feed it back to the system. The electricity retailers or power traders can sell this excess energy via a blockchain platform.

Figure 22: *Matching PAYG & Community ownership model with key digitalisation technologies*



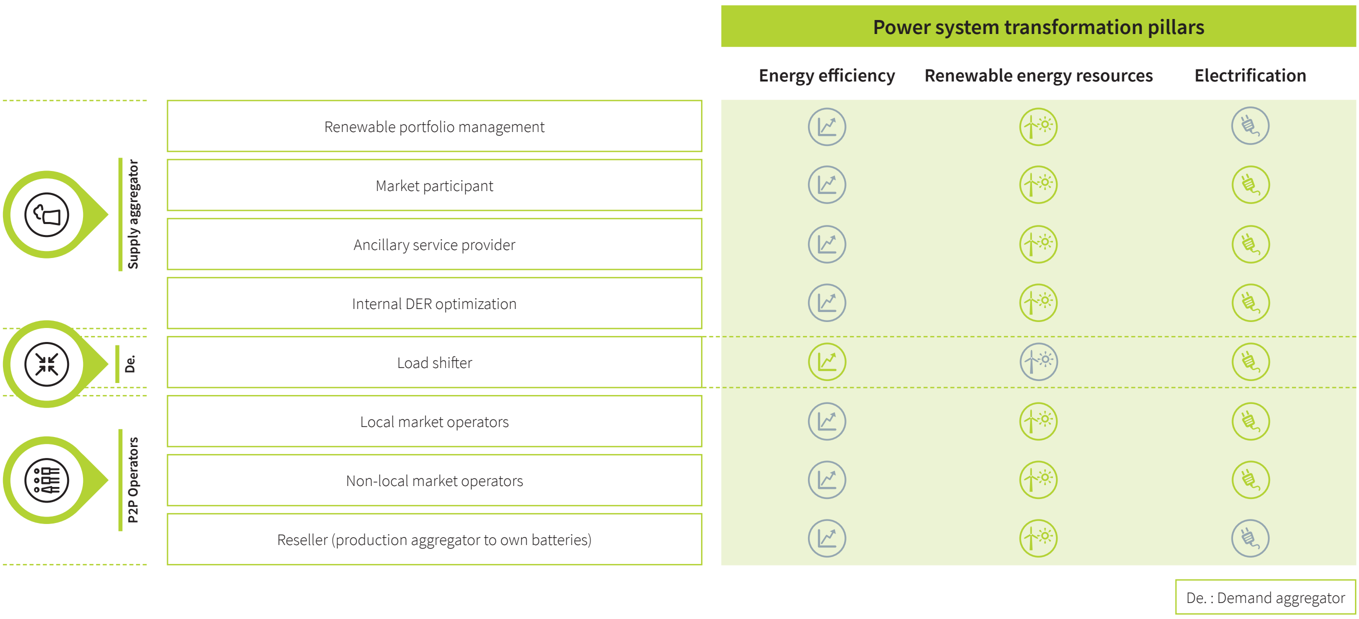
4.3.3 Matching business models with power system transformation pillars

Each of the innovative business models of energy sector contributes to the power system transformation pillars. They either facilitate DERs, contribute to electrification purposes, or provide energy efficiency solutions to end-consumers.

Supply aggregators mainly remotely control the DERs and optimise their operation by taking advantage of flexibility options. They usually operate many DERs together and create sizeable capacity for the energy system. The management of this sizeable capacity by a single mechanism provides benefits in creating a holistic efficiency in the energy system. Meanwhile, they also can take control of EV charging systems and use them as energy resources when needed. Thus, supply aggregators are thought as one of the main contributors to renewable energy resources and electrification pillars of the power system transformation. On the other hand, demand response providers are at the consumption side of the value chain, by managing the demand for balancing activities. These activities may include the management of household electrical appliances or natural gas energy used for heating buildings, as well as when and how much energy to be consumed in commercial buildings or industrial facilities.

Other than aggregators, P2P operators also empower prosumers and consumers, leading to increased deployment of renewable energy resources by enabling prosumers to trade their excess electricity generation. The fact that end-consumers can have a gain from electricity trade is a big motivation for them to be involved in the generation part of the energy value chain. Also, P2P trading allows consumers to monetise and trade the value created by their EV charging stations. For example, the fact that consumers who own charging stations can sell the excess energy they generate to EV owners can increase initiatives in the field of electrification.

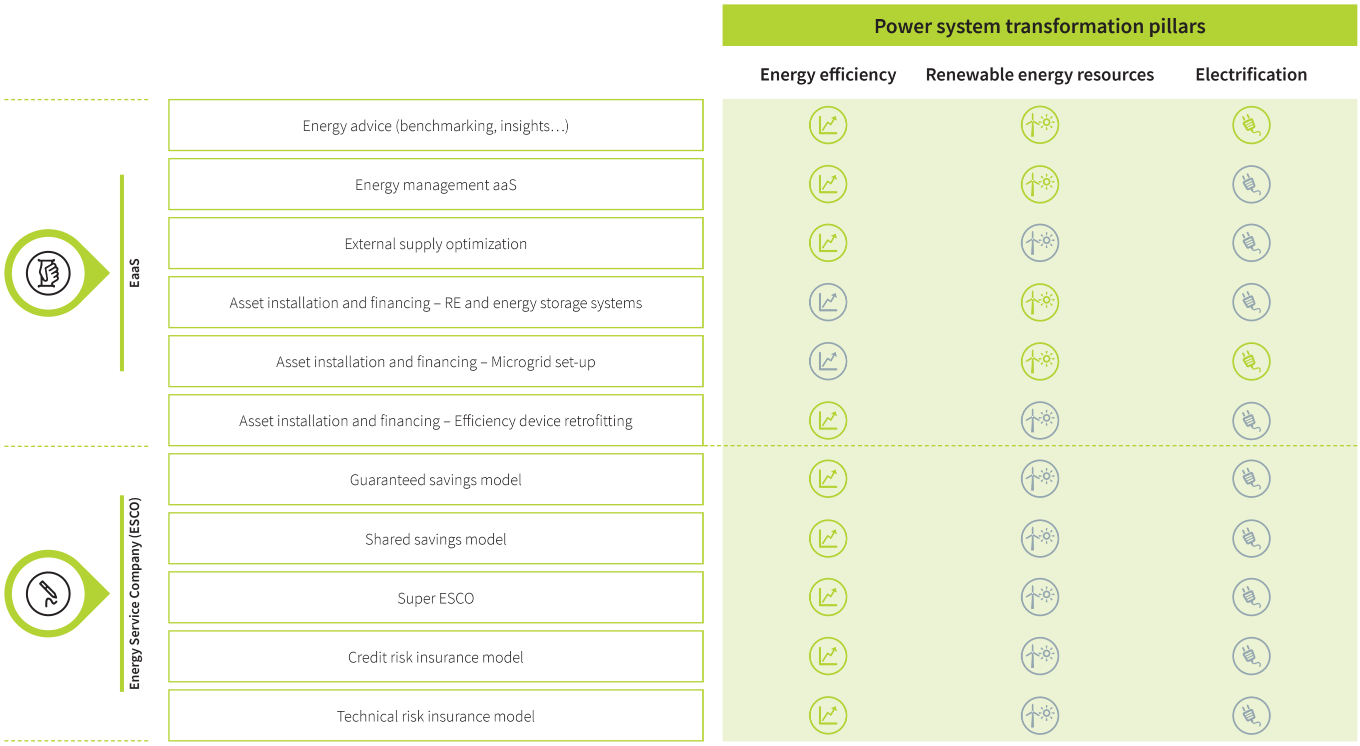
Figure 23: *Matching Aggregators & P2P operators with power system transformation pillars*



Energy-as-a-service model supports deployment and operation of renewable energy resources and DERs by supporting renewable energy facility installations and financing, and also by providing energy management activities. It is an innovative business model whereby a service provider offers various energy-related services rather than only supplying electricity. By either installing assets or giving energy management and energy advice services, EaaS companies not only facilitate DERs but also contribute to electrification of the energy consuming devices and offer energy efficiency solutions as a service. In particular, efficiency device retrofitting and external supply optimization, supporting services for energy purchases, focus only on energy efficiency solutions.

ESCO models allow companies to carry out energy services without the clients having to invest their own capital into the projects. Although ESCOs combine different services and options, these projects focus on the energy savings of industrial facilities or buildings and are based on gaining from the savings created. For this reason, the main condition for the survival of ESCOs can be considered as the realization of energy efficiency.

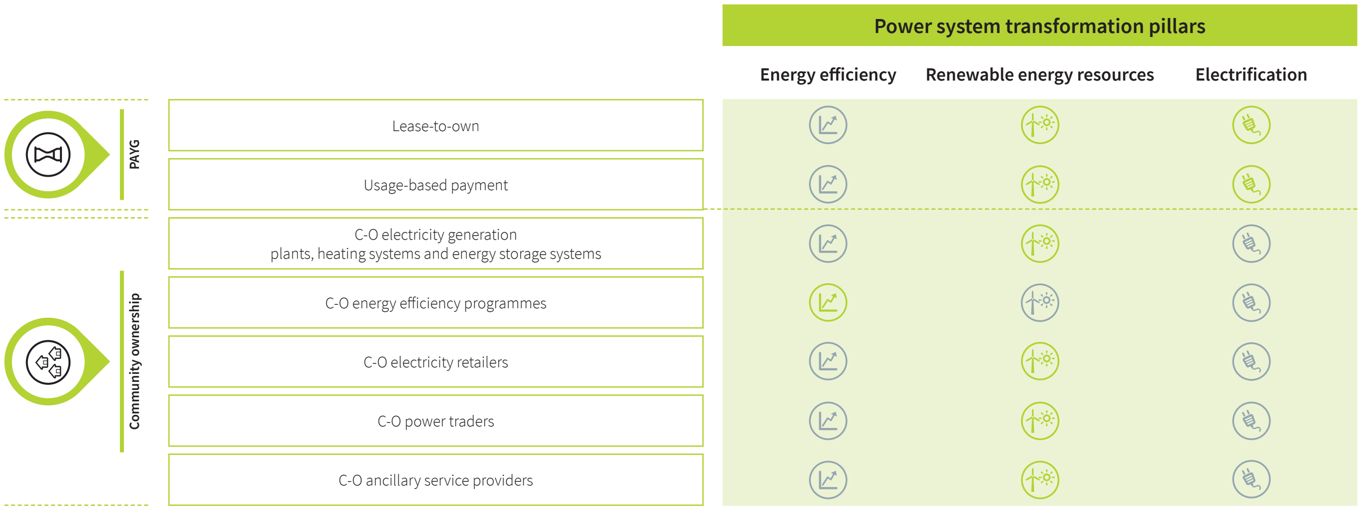
Figure 24: *Matching EaaS & ESCO model with power system transformation pillars*



The energy need of off-grid areas, which are far from urban areas and which are difficult to bring energy to, can be satisfied via PAYG models. With rising consumer awareness and high investment costs for grid expansions, PAYG models become a prominent solution to energy access challenge by providing electricity generated from renewable energy sources at affordable prices, with payments facilitated by technologies available in these areas. The model requires a configuration involving power consuming appliances (LED bulbs, mobile phones, lighting), where electrification strategy plays a crucial role. The requirement that consumers use electric devices so that the PAYG model can be used supports the electrification trend.

Community ownership models provide low-cost renewable energy to the local community. The model structures, in the context of the global energy transition and the decentralisation of power systems, refer to the collective ownership and management of energy-related assets, usually DERs. In this context, feeding the energy needs of a whole community with renewable energy is a trigger for the expansion of renewable energy sources, which is one of the most important transformation pillars. In addition to facility installations, electricity retail sales, energy trade and ancillary services increase the benefits obtained from renewable energy sources. Moreover, either as a core or complementary activity, they offer energy efficiency programmes encouraging members to take measures to reduce their consumption or invest in building retrofits.

Figure 25: *Matching PAYG & Community ownership model with power system transformation pillars*



5. Prioritization of application areas of business models

While proposing new business models for the common good of sector stakeholders, country-based evaluations should also be made to prioritise these models in terms of applicability and their impact. When considering the current situation in Turkey, there are plenty of factors to assess the potential success of new business models. For instance, these factors include whether new challenges are addressed by these innovative solutions, whether there are technical insufficiencies or simply new regulatory requirements are needed. Simply put, for a business model to be prior, it should both add real value into the power sector – specifically in the short- to mid-term- and it can be implemented considering the current conditions of the country and the sector. At the end of this analysis, twenty-six sub-business models are mapped on the prioritisation matrix to determine the ones with greater potential in Turkey's energy sector in the near future.

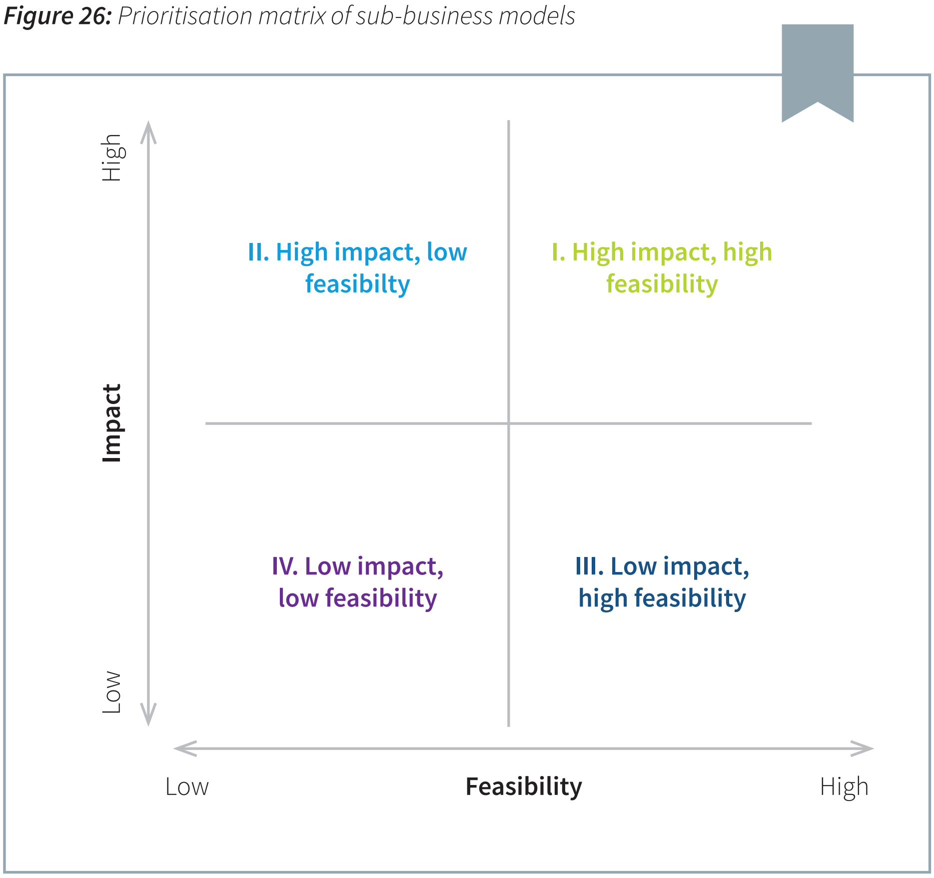
5.1 Prioritisation matrix

The study's target business models and their sub-models are prioritized based on their potential impact on the power sector and feasibility of their implementation in Turkey.

The analysis includes evaluating business models' impacts firstly on the end-customer side who is at the centre of energy transformation. Second, the assessment takes a step further by determining how new business models may affect energy and service providers in the industry. In addition, as new competitors, services, and products enter the market, revenue models, cost structures, and financial activities of energy firms may alter, as well as opportunities to create value for end-consumers. As a result, the financial aspects are assessed as the third factor to arrive at a comprehensive assessment of the implications of business models.

Although some business models have a high industry impact, they may not be feasible to implement due to technical insufficiency, regulatory requirements, and the fact that different stakeholders have different roles and responsibilities, and each stakeholder must do their part to ensure implementation. Therefore, for the near future of Turkey's energy transition, effective and feasible business models - with great potential for all stakeholders in the energy industry - must be prioritized.

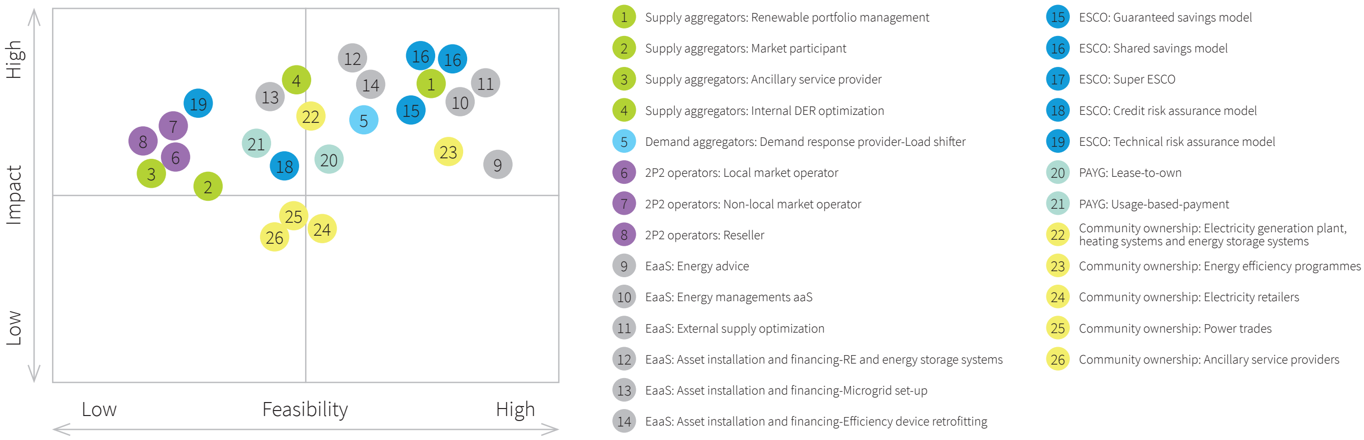
Figure 26: Prioritisation matrix of sub-business models



Sub-business models are mapped in the prioritisation matrix based on impact and feasibility criteria. According to the analysis, business models in Quadrant I are can be evaluated as more impactful and more feasible, while those in Quadrant III are less likely to be considered in Turkey's energy system planning soon.

5.2 Prioritisation of business models

Figure 27: Evaluation of business models



From a macro point of view, based on evaluations ***(12) EaaS: Asset installation and financing – RE and energy storage systems, (17) ESCO: Super ESCO,*** and ***(16) ESCO: Shared savings model*** seem to have the highest impact compared to other sub-business models. On the other hand, ***(9) EaaS: Energy advice*** and ***(11) EaaS: External supply optimization*** are the most prioritized models in terms of their feasibility and applicability.

When a deep-dive assessment for each seven of the target business models is done, a clearer picture can be seen. First, aggregator sub-models are scattered across the prioritization matrix, meaning that while some have higher impacts and higher feasibility, others are regarded as having a mediocre impact and lower applicability potential. When compared to other aggregator models, ***(1) Supply aggregators: renewable portfolio management*** of big scale power plants and ***(5) Demand aggregator*** sub-models can be evaluated as having a greater priority. This is in accordance with current Turkish market developments since supply aggregation of big-scale power plants will be applied to existing power plants, and demand response is already on the power system's agenda.

Second, when analysing P2P operators, it can be seen that ***(6) local market operators, (7) non-local market operators,*** and ***(8) resellers*** are clustered closely in Quadrant II. This indicates that P2P sub-models are difficult to implement since they rely heavily on factors such as growing adoption of blockchain technology among prosumers, increased residential penetration of DERs, and micro-grid developments.

Third, EaaS models are given special consideration in the prioritization matrix because five of the sub-models, namely ***(9) energy advice, (10) energy management aaS, (11) external supply optimization, (12) RE and energy storage systems*** and, ***(14) efficiency device retrofitting,*** can be found in Quadrant I, indicating that EaaS sub-models are about to enter consumers' daily lives. However, because Turkey's current investments and infrastructure are heavily reliant on the centralized grid system, (13) microgrid set-up is not regarded as a viable model in the short-term.

Regarding ESCO sub-models, since they are already being implemented in Turkey and the relevant regulation have been in the process of being enacted, different stakeholders have already started to take a role in the business model especially starting with industrial clients. ***(15) Guaranteed savings model, (16) shared savings model,*** and ***(17) super ESCO*** are clustered within Quadrant I, highlighting their prevalence in Turkey. (16) Shared savings model keeps the highest prioritization and feasibility among sub-models as risk sharing approach among stakeholders reduces the burden on the energy company. In ***(18) credit and (19) technical risk assurance models,*** generally energy companies take significant financial and operational risks. Through factors such as high financial burdens - which may include interest rates and premiums - and technical risks, these models are clustered around Quadrant II to offset models' risks. So, it can be debated that complex structures and financing needs of these models might obstruct their feasibility in Turkey.

On the other hand, among PAYG models, ***(20) lease-to-own*** model is thought to be easier to be implemented than ***(21) usage-based payment.*** In Turkey, middle class is highly keen on maintaining multiple home ownership (summer houses etc.) beginning from early ages with a life-time investment mindset. ***(20) The lease-to-own*** model emerges as a priority model because it paves a way for asset ownership especially in the vicinity of summer houses such as Aegean region compared to ***(21) usage-based-payment*** model. With the tendency of demography, lease-to-own model can accelerate the deployment of renewable energy resources and decentralized approach, which can explain why they are being clustered in Quadrant I.

Finally, among community ownership models, ***(24) electricity retailers, (25) power traders,*** and ***(26) ancillary service providers*** are thought to have relatively low impact, resulting in a cluster around Quadrant III. Energy efficiency programs, on the other hand, are positioned in Quadrant I, emphasizing the importance of local efforts to reduce energy use. Individual investors don't have sufficient capital accumulation or aren't inclined to be a part of DER projects in Turkey. Though, unified structures, such as co-operatives, reduce initial investment costs drastically, and these structures are highly prevalent in Turkey especially for home-ownership projects. Due to its similarity to the co-operatives model and society's high level of consciousness about co-operatives, community ownership may be implemented smoothly. Although it leads to a relatively low impact, it may change the mindset of power system stakeholders.

6. Barriers for widespread use of new business models and potential recommendations

Innovative business models that can address existing and newly introduced challenges in the energy system in Turkey may face some barriers in the implementation phase. These barriers can relate to the physical constraints such as infrastructural issues, and also administrative, financial, and socio-economic ones, where human factor gets involved.

Within this section of the report, the barriers are categorised and clearly defined to come up with recommendations that can facilitate the energy transition and pave the way for innovative business models. These barrier categories can be presented under 7 subjects: (1) Existing market structure, (2) Legislation, (3) Socio-cultural conditions, (4) Financial conditions, (5) Technological infrastructure, (6) Grid planning and infrastructure, and (7) Urban development. The barriers affecting the target business models under these categories are outlined in Figure 28.

Although these barrier categories address almost all new business models, their level of impact on each model differentiate. The impact of barriers on the models are discussed in detail starting from the section 6.1. Therefore, it is crucial to make determined efforts to deal with the difficulties associated with the models.

To this end, we believe that the examples experienced abroad will also shed light on this journey in Turkey. Therefore, the challenges experienced to adopt new business models especially in Europe, USA, and Australia have also been examined in the related parts.

Figure 28: *Impact of barriers on business models*

		Supply aggregators	Demand aggregators	P2P	EaaS	ESCO	PAYG	Community ownership
Existing Market Structure	The need for improvements in ensuring liberal market conditions	x	x		x	x		x
	Non-deterring level of imbalance costs	x	x		x			x
	Limited tariff options		x		x			x
	Renewable energy incentives		x		x	x	x	
	Net settlement application on unlicensed generation	x		x	x		x	x
	Subsidized consumer prices	x	x	x	x	x	x	x
	Additional technology investments not being reflected to consumer tariffs		x		x	x	x	x
	Barriers to consumer involvement in the market		x		x			x
	Implementation of capacity mechanism	x	x		x			
	Need to shorten trade times in organized wholesale markets	x			x			x
	Areas for improvement in the practice of balance responsible party	x	x	x	x			x
	Organized industrial zones' role and conflicts of interest regarding innovative business models	x	x	x	x	x	x	x
	Retail companies' responsibility area for electricity trade through distributed generation	x	x	x	x		x	x
	The absence of a mechanism to encourage battery systems	x	x	x	x		x	x
	Assessment of overall impact level	◕	◕	◕	●	◑	◑	◕
Legislation	Areas for improvement in legislation quality and consistency	x	x	x	x	x		x
	Complexity of bureaucratic processes	x		x	x	x	x	x
	Lacking regulations	x	x	x	x	x	x	x
	Need for authorizations	x	x	x	x	x		x
	Assessment of overall impact level	●	◕	●	◑	◑	◔	◑
Sociocultural conditions	The current digital literacy and awareness levels of residential consumers	x	x	x	x	x	x	x
	Current approaches and digital maturity levels of commercial and industrial consumers	x	x	x	x	x	x	x
	Operational practices, perspectives of digitalization, and level of awareness of the public sector	x	x	x	x	x	x	x
	Lack of qualified workforce	x	x	x	x	x		
	Assessment of overall impact level	◕	◕	●	●	●	◕	◕

Financial Conditions	Investment cost of energy facilities and long payback periods	x		x	x	x	x	x
	Infrastructure investment need and high costs	x	x	x	x	x	x	x
	Technology investment need and high costs	x	x	x	x	x	x	x
	Currency pressure	x	x	x	x	x	x	x
	Low profit margins in the electricity sector	x			x		x	x
	Limited company budgets	x			x	x		
	Lack of synergy between banking and energy sectors	x	x	x	x	x	x	x
	Insufficient funding	x	x	x	x	x	x	x
	Assessment of overall impact level	●	◑	◕	●	◕	◕	◕
Tech. Infrastructure	Barriers to access to and use of hardware	x	x	x	x	x	x	x
	Barriers to software	x	x	x	x	x	x	x
	Barriers to communication protocols	x	x	x	x	x	x	x
	Assessment of overall impact level	◕	◑	◕	◑	◑	◑	◔
Grid planning and infrastructure	Need to increase effectiveness in grid planning approach	x	x	x	x		x	x
	Need to improve distribution and transmission network cooperation	x	x	x	x		x	x
	Lack of smart grid approach	x	x	x	x		x	x
	Lack of alternative (local and autonomous) grid approaches	x		x			x	x
	Need to regulate voltage levels	x	x	x			x	x
	Need to manage the increased load on the grid due to electric vehicles	x	x	x	x			x
	Assessment of overall impact level	●	◑	●	◔	○	◕	●
Urban Development	increase in vertical structuring, and the fact that urban transformation projects are not planned in a way that regards the installation of renewable energy, and infrastructure requirements	x		x	x	x	x	x
	Assessment of overall impact level	◑	○	◕	◑	◔	◑	◕

6.1 Existing market structure

6.1.1 Market and balancing prices

The need for improvements in ensuring liberal market conditions
"Strategy Documents", prepared by the Council of Ministers in 2004 and 2009, has guided the Turkish Electricity Market for many years to support implementation of the Electricity Market Law, highlighting liberal market model as the ultimate solution for the electricity market. In line with this, a series of government actions such as the establishment of EMRA, reducing the share of the public involvement in generation, distribution, and retail sectors through privatisations, and establishing market mechanisms have been successfully implemented. As a result of the mentioned steps, a series of successful results such as ensuring security of supply, increasing the share of domestic/renewable energy, increasing the service quality and economic supply opportunities have been achieved. The liberal market model, in which bilateral agreements complemented with organized power markets and forward electricity trade are the main focal points for the Turkish electricity market. In general, the following basic criteria must be met for a well-functioning liberal electricity market (Energy Traders Association , 2017):

1) **Predictability:** For a predictable market, the ability to predict the price in the short, medium, and long term is one of the most fundamental issues. To ensure that, there should be a stable regulatory environment where the regulations do not change frequently, and the change process is governed taking into consideration all relevant stakeholders. Additionally, every market participant should be able to access the data to be analysed under equal conditions.
2) **Competitiveness:** For service quality and price competition to occur in a market, there must be a large number of buyers and sellers and they must have limited power that cannot significantly affect the market price.
3) **Healthy price formation:** The most important indicator of liberalization is how transparently price formation is determined in the market.
4) **Freedom of choice:** Healthy price formation can only occur in a market where buyers are not subject to certain obligations and where consumers have the opportunity to choose/diversify their suppliers.

Given the history of Turkish electricity market, the fact that market prices may not fully represent incurred costs and market prices can be affected by publicly owned energy utilities (EÜAŞ, BOTAŞ) reduces the level of predictability.

In the long run, price forecasting difficulties and uncertainties on the market may raise concerns about return on investment (ROI) and thus investors may hesitate to invest in new projects in the sector. Moreover, the inability of the power plants to reflect their costs to the final prices also makes it difficult for these players to hold on to the sector. In the final consumer side, price controls whereby it is not possible to reflect costs to final consumer prices from time to time, prevents load shifting appetite and motivation because the affordability of current prices renders such alternatives unnecessary. Considering these effects together, the market shall function on a truly cost-based system. The cost-based operation of the market is also critical for renewable power plants whose purchase guarantee support is expiring, or for new investments based on merchant model.

To establish a free market mechanism, it is critical that publicly owned energy companies do not deteriorate market price signals in the organized markets and provide predictability in their OTC operations. In fact, for price formation to accurately reflect supply and demand, non-market factors and/or monopolistic effects should be minimized.

Level of imbalance costs

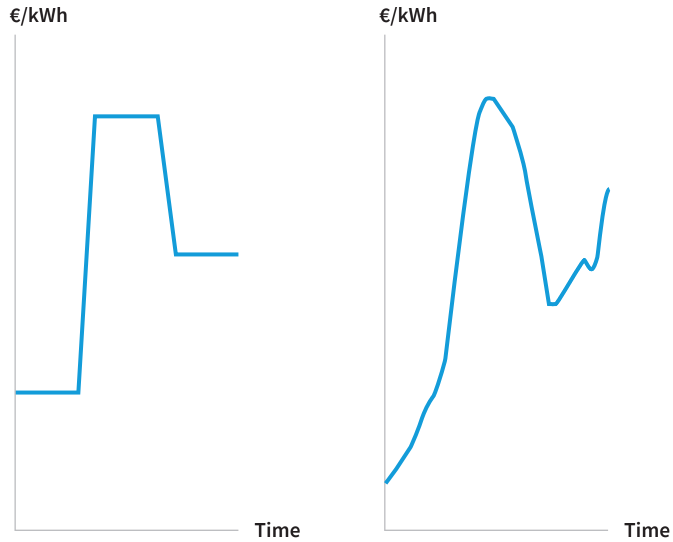
Getting the imbalance pricing right is important as it supports efficient pricing in the Day Ahead and Intraday markets, where most of the flexibility is traded. In this way, a more efficient holistic electrical system will be formed. In the current situation, the imbalance penalties applied in Turkey are not deterrent enough and the imbalance costs are lower than the costs of the solutions to eliminate the imbalance, which cannot enable market participants to act in this regard. That is, there are not enough incentives under the current system to enable Day-Ahead market participants to better forecast their generation, increase the use of storage systems, and integrate digital technologies to avoid or reduce their imbalances. For example, large-scale thermal and dam type hydroelectric power plants have the opportunity to earn more income from the instructions given in the balancing power market compared to the income they will gain from the Day-Ahead, Intra-Day markets by joining a balancing responsible group (SHURA, 2021c). In short, since the imbalance penalties are low compared to the penalties applied in the European markets, it does not provide sufficient motivation for the market participants to reduce their imbalances.

6.1.2 Tariffs

Limited tariff options

With a Time-of-Use (ToU) tariff scheme, customers can adjust their electricity consumption voluntarily (either through automation or manually) to reduce their energy costs. As the name indicates, the price signals are time-varying, determined based on the power system balance or on short-term wholesale market price signals. Significantly, ToU tariffs unlocks demand-side flexibility and can thereby help to increase the penetration of renewable energy by eliminating the challenges that they create. Also, they reduce grid peak load and investments required in grid infrastructure (IRENA, 2019).

Figure 29: *Static (determined in advance) vs. Dynamic (determined in real time based on actual system conditions)*



Source: IRENA

The fact that retail sales tariffs in Turkey are one-time or three-time (day, peak, night) eliminates consumers' appetite for shifting loads and reduces the value created by new business models offering energy management solutions. To begin with, the EaaS offerings benefits from ToU tariffs to encourage better consumption management by utilising smart home devices. Moreover, the energy management of DERs such as EVs, behind-the-meter batteries, solar PVs requires time-of-use tariffs to benefit from the arbitrage by deciding on load shifts as a function of price signals. Aggregators may also need ToU tariffs for both demand response purposes and for actions to value generated energy by prosumers. These actions may include when to charge the EV, store the energy, consume, or monetize it in the wholesale market or ancillary markets.

With the emergence of new usages, retailers will have to be more and more creative in the design of their offerings. For instance, Centrica/British Gas has launched a new smart time-of use tariff that offers homeowners cheaper electricity overnight to charge their car. In a pilot conducted in Gotland, Sweden, customers participated in a programme that used price signals. During the initial stage of the programme, 23% of total electricity consumption was experienced during the five most expensive hours. This fell to 19% and 20% in the first and second year of the programme, respectively (IRENA, 2019).

Renewable energy incentives eliminating the need for alternative energy solutions

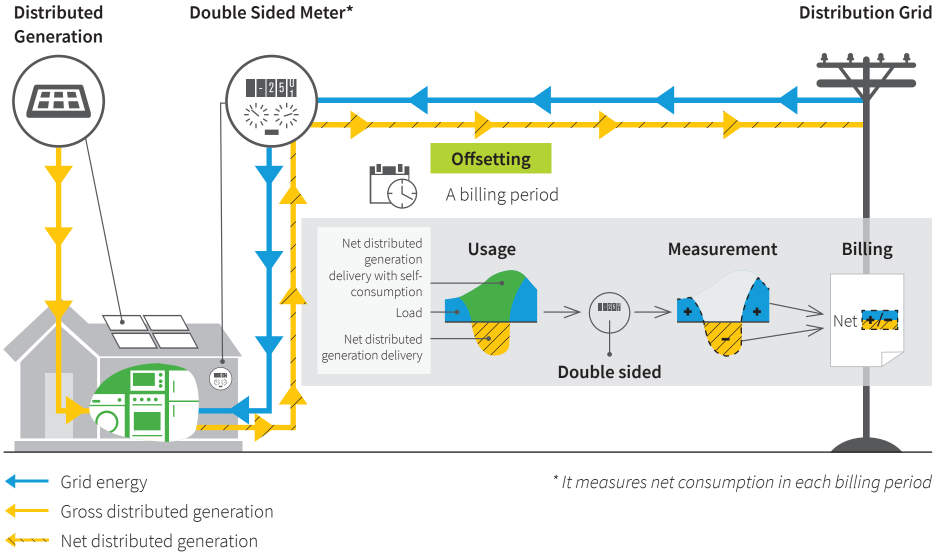
"Regulation on Unlicensed Electricity Generation in the Electricity Market ", published in 2013, was finalised with "Regulation on Certification and Support of Renewable Energy Resources (YEKDEM)", enabling distributed generation facilities to benefit from YEKDEM prices for the excess electricity supplied to the system (Resmi Gazete, 2013). The YEKDEM regulation has been effective in the establishment of unlicensed distributed generation facilities and the rapid increase in facility capacities by being associated with all renewable energy sources, both licensed and unlicensed. However, the fact that the surplus electricity produced can be sold to the grid at a price higher than the market prices has driven the prosumers away from alternative energy solutions. Under normal circumstances, storing the energy produced when the supply exceeds demand resulting in a decrease in prices or using it in peer-to-peer trade would be a suitable option, renewable energy incentives make these alternatives difficult to implement.

The Virtual Power Plant in South Australia (VPP-SA) project was the first VPP project of its scale announced in Australia in late 2016. The project was based on the sale and installation of 1,000 behind the meter battery energy storage systems (BESS) across metropolitan Adelaide. However, as an outcome premium feed-in tariffs constituted a barrier to battery adoption. A high fraction of prospects chose not to continue with a battery installation because they would lose their premium feed-in tariff (PFiT) by participating in the program. As a solution to this, participants were offered to earn rewards for allowing Energy Australia to remotely manage their energy storage system to help support the grid. Participants' energy storage system, along with others in the community, would be enrolled in a software platform designed to enable the aggregation of multiple energy storage systems (Energy, 2020).

Net metering application on unlicensed generation

With "Regulation on Unlicensed Electricity Generation in the Electricity Market", the monthly net settlement application was started to be implemented. With this application, the total generation and total consumption amounts of rooftop solar PV systems are settled on a monthly basis. Retail single-time active energy unit prices announced by EMRA for different subscriber groups are applied for the amount of electricity that these installations give to or draw from the grid (SHURA, 2021b).

Figure 30: *Net metering application*



Source: NREL, 2017

While the net metering application on a monthly basis is an important subsidy system to ensure more widespread use of distributed generation, it may have some disadvantages for the energy system. This method assumes the price of electricity as static regardless of time. Thus, the real-time energy optimisation is not incentivised for prosumers and this may cause troubles in the energy system. That is, prosumers provide electricity to the system at prices higher than market prices and cannot act in accordance with the actual conditions of the system, even if electricity prices are lower, when supply exceeds demand in the system.

Subsidised consumer prices

Subsidies applied to consumer prices in the electricity sector reduce the value to be shared for the new business models. Price ceilings are applied in wholesale market and these price ceilings limit the necessary variability in prices during times of electricity scarcity. The price controls that limit cost reflectivity of costs to system users at certain times, shrinks the value to be shared, especially the benefits that can be offered by innovative business models such as demand-side participation and energy efficiency projects. For example, the profit models of energy efficiency projects offered by ESCO models, whose activities have become widespread in Turkey in recent years, are provided through the savings to be made. The limited energy savings to be created in an environment where prices are subsidised limits the revenue to be generated for the ESCO company and also prevents impactful changes on the consumer side. On the other hand, it is also possible that a demand aggregator that provides income flow by monetising demand-side participation in ancillary markets may not get the desired benefit from load-shifting activity. In other words, price liberalisation is a necessity for the sustainability of new services to be offered to the consumer in order to create and share the value among the service providers and end-customers.

Additional investments not being reflected to consumer tariffs

Digitalisation investments have been hampered by the fact that energy monitoring devices, smart meters, and other installations, which are a requirement for new business models to maximize the value they offer, cannot be reflected in consumer tariffs by energy service providers as per regulations. For instance, energy monitoring device investments, which are of great importance in energy projects, can be enabled through Retail Companies by reflecting related costs to consumers and this may be a gateway solution to enable new business models. To do that, these companies first should see these investments as worthy to generate income and proceed accordingly.

6.1.3 Consumer involvement in the market

The process of establishing organised electricity markets in Turkey has progressed simultaneously with the increasing use of renewable energy. Licensed wind and solar power plants, which were not required to make a generation planning in the first period, have been obliged to plan their generation and bid in the market since 2016, even if they are within the scope of YEKDEM, and have been included in the market structure. Renewable power plants play an active role in the Day-Ahead and Intraday Markets. System flexibility can be increased through the market as well. Therefore, changes and improvements in the market structure will play an important role in the successful integration of renewable energy sources into the system (SHURA, 2021c).

The change in the markets is required not only because of licensed producers but also the unlicensed ones. With the widespread use of distributed energy sources and the fact that the end consumers are becoming energy producers, the change in the markets has become a necessity. Currently, the end-consumers are not active market players in the energy markets, whereas they could take part in energy trade and consumption management. In fact, multi-faceted benefits could be derived as the market can be exposed to price signals by enabling the participation of distributed energy sources in wholesale electricity markets, ancillary services market, and capacity markets, if any. To illustrate, a prosumer may monetize the excess energy they produce in the wholesale market, support the grid by demand response, contribute to frequency control in ancillary services market, or add value to the system with reserve capacity. This will increase the flexibility of the system. In addition, the creation of new revenue streams for distributed generation also encourages the expansion of these resources. This participation can be achieved through aggregators or directly by lowering the participation limits in these markets. It is not possible for distributed energy resources to participate in the specified markets in Turkey because a legislative infrastructure has not been established in which the Aggregators are defined and determined.

Voltalis, a France-based energy service company, combines the demand of more than 100,000 homes and businesses in France and extends their flexibility to the organized energy markets (wholesale markets and balancing markets) and it offers them for use in congestion management without the grid investments planned by distribution companies in the medium term. Demand aggregation includes energy storage and distributed generation as well as distributed loads such as electric vehicles, heating, ventilation, and air conditioning. Benefits for the grid include peak demand management, congestion management, frequency control and reduction of renewable energy outages (curtailments). On the consumer side, up to 15% can be saved on invoices thanks to the optimization of demand, self-consumption and behind-the-meter production (SHURA, 2021b).

6.1.4 Structural conditions

Reserve capacities

In every power system, it is a necessity to keep a certain level of reserve capacity to meet the peak demand. In case excess reserve capacity is kept, this will create additional costs, however not being able to meet the peak demand would have its own associated costs.

The capacity mechanism for domestic coal, natural gas and some reservoir hydroelectric power plants was established in 2018 and an installed power of approximately 2GW was activated. The amount of resources distributed within the scope of the mechanism increased by more than 50% between 2018 and 2020 (1.4 billion Turkish Liras in 2018, 2.2 billion Turkish Liras in 2020). In 2020, 54% of the total budget allocated for this mechanism was transferred to power plants using domestic coal, 37% natural gas, 7% hydroelectric power with reservoirs, and 2% using a mixture of imported and domestic coal (EÜAŞ, 2020). The main purpose of this application is to ensure that some resources remain in the system for the reliability of the power system.

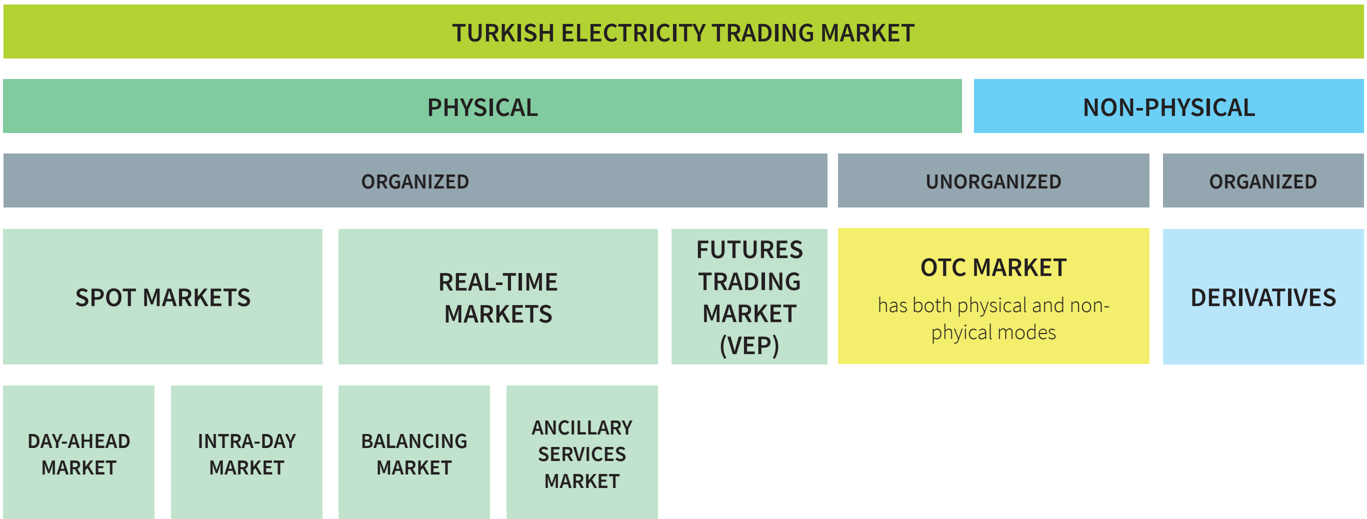
The capacity mechanism applied in the current situation has some negative effects on the market. As currently implemented, the capacity mechanism is paid only on the installed power and no efficiency or flexibility criteria are used in determining the payment amounts. In this case, some low efficiency natural gas and domestic coal power plants are kept in the system. On the other hand, capacity mechanism payments are made from TEİAŞ budget and this cost is reflected to all producers and consumers through transmission tariffs. Considering the residual capacity created in the market, it may be considered to phase out the capacity mechanism or to change the mechanism to give priority to more flexible resources. A certain minimum load increase rate standard and maximum CO_2 emission limit can be introduced for power plants as a prerequisite for participation in the capacity mechanism. In addition, ensuring that demand-side and energy efficiency practices are included in the mechanism will play an important role in increasing system flexibility and renewable energy integration. Under the scenario where domestic coal guarantees, forming the basis for capacity mechanisms, are abolished, EUAS's costs have been observed to decrease by 36% compared to the baseline scenario (SHURA, 2021c).

Various capacity mechanism designs that are being implemented around the world can also be an important guide for Turkey's decision on this issue. The "Clean Energy Package for All Europeans" (CEP) legislative package, recently adopted by the European Union, allows for forward-looking capacity-based interventions in special cases where concerns about security of supply are raised. The package demonstrates that a well-executed energy and ancillary services market can contribute to the creation of a fit-for-purpose portfolio of system resources. Under the UK's Electricity Balancing Act, published in 2014, a reserve scarcity pricing mechanism is implemented (OFGEM, 2018). Under the system, the scarcity reserve is priced based on the amount of supply deficit in the system. Similar implementation of the mechanism in Turkey may fulfil the function undertaken by the capacity mechanism (SHURA, 2021b).

Bilateral agreements and intraday market trade volumes

Currently, electricity trade in Turkey can be evaluated under two main headings as physical and non-physical (financial) electricity trade. Financial electricity trading can be made as bilateral agreements or in derivatives markets through Borsa Istanbul, while the main options in physical electricity trading are organized spot market, real-time market, OTC market (bilateral agreements), and future trading market (VEP).

Figure 31: *Turkish electricity trading market*



Source: Deloitte analysis

According to the latest EPİAŞ data, physical trade was realized in the amount of 181.4 TWh in the Day Ahead Market, 6.8 TWh in the Intraday Market and 7.4 TWh in the Balancing Power Market in 2020. In the same period, bilateral trade agreements amounted to 255.4 TWh (EPİAŞ, 2021). Within the scope of the Ancillary Services Market, an hourly average of 273 MW primary frequency reserve control and 918 MW secondary frequency reserve control tenders were held in 2020 (EPİAŞ Transparency Platform, 2021). Looking at the numbers, the Intra Day Market volume constitutes a very small portion compared to the Day Ahead Market volume in Turkey. Intraday Market, being critical for resolving near real-time imbalances, acts as a balancing mechanism between the Day Ahead and the Balancing Power Market. It is seen as the market where new business models - especially Aggregators - will make the most transactions to contribute to real-time balancing activities. Therefore, in the future, it is critical that the volume of the intraday market increases and creates a playground for new business models.

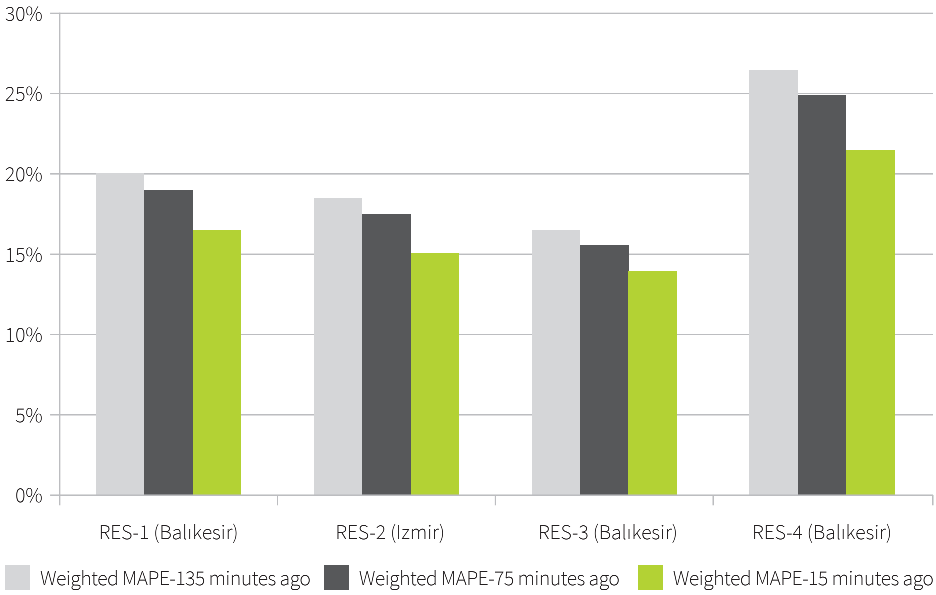
The need for decrease in gate closure times

Solar and wind power plants depend on weather conditions and thus generate electricity intermittently. Consequently, this makes wind and solar power generation forecasting challenging, which also results in challenges in bidding in the energy markets.

The healthy functioning of the Intraday Market is of great importance for the flexibility of the electricity system. Imbalances that cannot be resolved in the Day-Ahead Market are eliminated in the Intraday Market as a first step. Since the physical delivery of electricity in this market can be made one hour after the transaction, the generation estimates can be closer to reality compared to the Day Ahead Market. Nevertheless, in Turkey, in order for the renewable energy generation estimates determined as a result of meteorological forecasting to be subject to trade, this interval needs to be narrowed down. Reducing this time interval to 15 minutes might be evaluated to have significant benefits in eliminating imbalances. Likewise, reducing the Balancing Power Market settlement period to 15 minutes could also provide significant benefits. Reducing the gate closure to close to real-time would increase the accuracy of renewable energy generation forecasts and reduce imbalances in the market.

Selected from different parts of the country, generation forecast deviations of 4 sample wind farms at different time intervals are given in Figure 32.

Figure 32: *Hourly generation forecast deviations in different timeframes for 4 sample wind farms in Turkey in a month of 2020*



Source: SHURA

According to the data, generation forecasts made in 15 minutes, compared to forecasts made in 75, contains 2.6% less errors. This situation is the indicator of the fact that the gate closure times of Intra Day Markets are so important that it can determine the reduction in imbalance amounts.

Balance Responsible Groups (BRGs)

In Turkey, the Balance Responsible Group (BRG) is defined as a group formed by market participants by notifying the market operator and in which a market participant from within the group undertakes the balance responsibility obligations on behalf of the group (Resmi Gazete, 2009). Settlement of energy imbalances in a BRG is made on a monthly basis, taking into account the day-ahead market, intraday market, balancing power market transactions, the bilateral agreement amounts and the realized give/withdrawal values (Resmi Gazete, 2009). BRGs are basically responsible for financial balancing, rather than offering a solution needed from the physical balancing perspective. The main reason for this is that market participants in different regions - who cannot deliver electricity energy easily to long distances for balancing activities - can be in the same BRG and there is no real-time physical balancing incentivised by the regulation. In other words, market participants in the same BRG in different regions will not face any penalty if they balance their energy output and withdrawal at the end of the month.

Organized industrial zones and innovative business models

Organized Industrial Zones (OIZs) in Turkey can carry out generation or distribution activities within their approved borders by obtaining an OIZ production or OIZ distribution license from the institution, without seeking the requirement to establish a company in accordance with the Regulation on Electricity Market Activities of Organised Industrial Zones (EMRA, 2014). To meet the electrical energy needs of its participants, the OIZ may produce electrical energy within the framework of the provisions of the regulation or purchase electrical energy as an eligible consumer.

In addition, the OIZ carries out the activities of establishment and operation of distribution facilities, distribution of electrical energy, and fulfilment of other related services within its approved borders.

The commercial benefit that OIZs derive from these activities is a factor that makes it difficult to implement innovative business models. For example, in these regions, which are seen as one of the areas where P2P energy trade will become widespread in the future, innovative solutions interrupting the commercial activities of the OIZ may lead to a conflict of interest. That is, when an energy trade is realised within OIZ or between OIZ and a near town via P2P operators, the fees such as electricity, distribution, connection and/or assurance may no more be charged to consumers. Secondly, with the VPP activities of energy management, demand response, and other solutions would mean that the value has to be shared among more parties from OIZ's perspectives. That is why these innovative business models may encounter a barrier while operating in OIZs in Turkey.

Retail companies' responsibility area for electricity trade through distributed generation

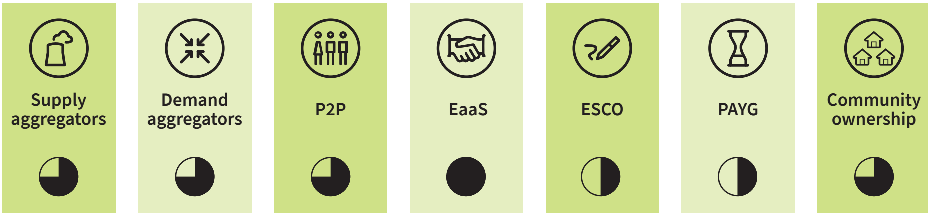
With the spread of distributed energy sources, unlicensed production has increased considerably, especially in solar energy. According to the latest data, 91.7% of the unlicensed electricity generation in June 2021 was from solar PV installations (EMRA, 2021). This share, which increases with the role of end consumers in energy generation, is one of the main factors that will trigger new business models that will emerge in the future. Yet, it is not possible for the owners of distributed energy resources to take advantage of the financial benefits of free trade. In accordance with the "Unlicensed Electricity Generation Regulation in the Electricity Market" published in Turkey, the retail companies are responsible from the commercial activities of unlicensed generation. Therefore, the implementation of business models such as peer-to-peer trading and community ownership models requires changes in the regulations for the energy to be traded between peers rather than needing an intermediary.

The absence of a mechanism to encourage battery systems

In Turkey, the aim of the regulation to use unlicensed generation facilities only for self-consumption has become an opportunity for investors who want to benefit from YEKDEM without obtaining a license. Although this situation helped the capacity development of distributed generation, it created practice gaps that caused unlicensed generation to move away from self-consumption. Therefore, rather than the establishment of solar PV projects for self-consumption, it has led to the establishment of power plants with a much greater capacity than their own consumption. Even though it has decelerated with the latest changes made by EMRA, unlicensed producers may still cause considerable imbalances in the grid.

In Turkey unlicensed power generation plants currently operating in the market are not held responsible for the imbalances. The fact that the unlicensed installed power, mostly composed of solar power plants, is not responsible for the balance may increase the imbalances in the market. Therefore, the system costs arising from these imbalances should be reflected to those responsible for the imbalances. The variable generation of these power plants directly connected to the distribution network has the potential to be an issue that needs to be managed in the future for distribution system operators. In the monthly net settlement, which is being implemented in Turkey today, the costs for possible imbalances are included in the tariffs and the distributed generation owners are exempt from this responsibility. After a certain integration rate of distributed generation, a transition should be made to systems that encourage more self-consumption with the use of behind-the-meter batteries with pricing practices such as Billing or Buy-Sell, where the real cost of the system will be reflected on the prosumers, as in the examples around the world (SHURA, 2021b). Currently, the absence of a mechanism in the market to limit the direct sale of distributed unlicensed energy generation to the grid does not encourage battery systems and leads to the use of the grid as batteries. It will be very important for the utilities to act according to the real conditions of the market and the grid, together with behind-the-meter battery technologies.

Figure 33: *Extent of existing market structure barrier on business models*



Existing market structure in Turkey poses a threat especially for the business models that can act as a market participant. Supply/demand aggregators and P2P operators' value proposition includes the trading activities in Spot and Real-time markets to support balancing activities and benefit from arbitrage. Therefore, an energy system where these players are no defined restricts the range of motion for these business models. Additionally, unpredictable, and subsidised electricity prices leave no room for aggregators and P2P operators to add value into the system. Thus, existing market structure seems as the most prevailing subject to be revised to pave the way for innovative business models.

6.2 Legislation

Several structural improvements around relevant legislation alongside pinpoint recommendations around different barriers will pave the path for new business models to be implemented in Turkey. To begin, the regulations' understandability should be improved to avoid any potential for ambiguity. Also, because multiple parties are involved in the formulation of policies, a multi-layered structure occurs in the Turkish energy industry and this makes it difficult for the parties to cooperate and for the addressee to consult the appropriate party when a problem arises. Second, permits essential for the execution of business models are subject to bureaucratic processes, several of which are considered to be lengthy, which increases their estimated time to completion. Moreover, loopholes in the legislation exist governing the definition of new business models. Finally, there are subjects that require authorizations that can be managed with appropriate legislative actions.

6.2.1 Legislation quality

Improving the quality of legislation in the energy industry will require making it more clear and minimizing its openness to alternative interpretations by different parties. With a concentration on private law, EMRA promulgates regulations governing the generation, transmission, distribution, and sale of electricity. The administrative provisions can, however, contradict the general principles of contract law No. 6098 at times. The objective of meeting technical and operational needs appears to be increasingly dominant in the regulations (Aker, 2017). Moreover, in 2013, the Chamber of Electrical

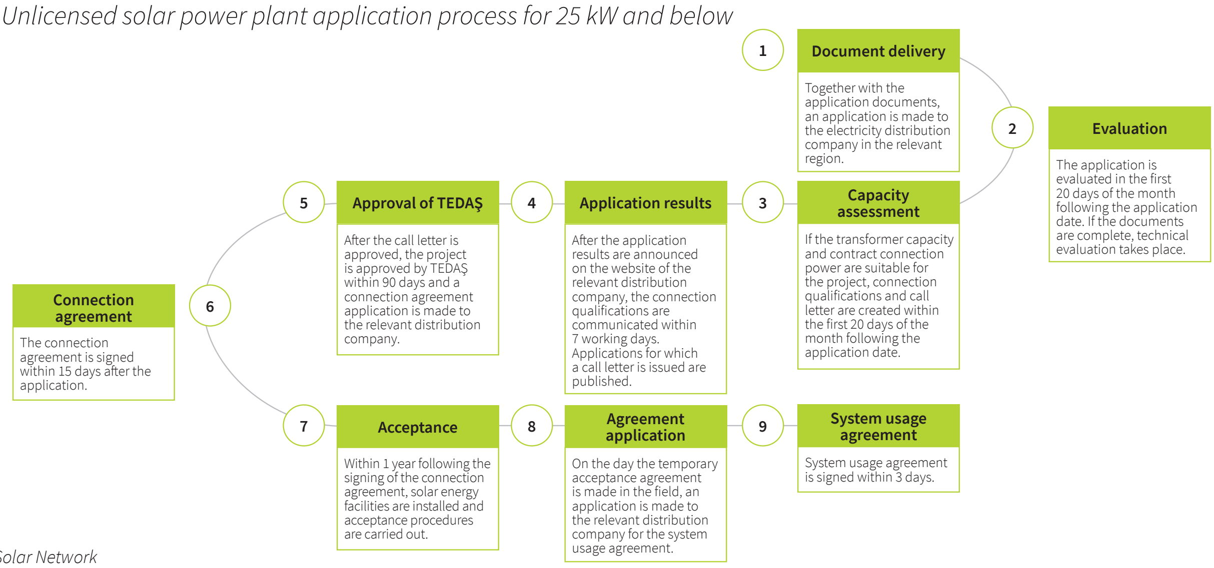
Engineers (CEE) wrote to the Energy Market Regulatory Board, warning them about the secondary legislation's ambiguity. According to CEE, there were inconsistencies in the content, format, and publication of various regulations, which made it difficult to interpret and recognize which rule pertained to which subject (TMMOB, 2013). Starting with regulation number 6446, simplifying wording and phrases, making arguments clearer and more precise to minimize any possible ambiguity, and avoiding excessive categorisation can be beneficial for improving the legislation quality. The corresponding regulation, although has at most 3 levels of clauses, there are instances where the third level has 8 articles, which can increase the length and complexity. The methods and principles for unlicensed generation applications, for example, have been submitted with the announcement that great care has been made to keep the legislation straightforward and understandable because the legislation's addressee might be anyone.

When a revision or interpretation of the law is required, the appropriate institution as a point of consultation needs to be more specific. For example, there are times when it is not known whether to consult TEİAŞ, EMRA, or the Ministry. This is since the Turkish industry is defined by a complex, multi-layered structure in which powers related to energy policies and the regulations of the sector are shared by different actors. Although Law No. 4628 states that the Ministry of Energy and Natural Resources is responsible for making energy policies, the regulation of the market structure is within responsibility of EMRA. Therefore, the compatibility of these institutions should be developed so that they can act in accordance with each other.

6.2.2 Bureaucracy

Complex and intense bureaucratic processes prolong the relevant permit periods and make it difficult for end consumers and investors to take innovative steps. Thus, procedures must be simplified and reduced in number. To illustrate, acquiring permits for solar power plant installation takes approximately 12 working days in Germany, and it takes around 3-4 months in Turkey (Green Solar Network, 2021). The application processes in Turkey differ for installed capacity below and above 25 kW installed power. When the processes are examined for residential subscribers with less than 25 kW installed power, the first step is to choose a solar panel according to the roof area desired to be installed on and the contract power. This could be done by the customer themselves if they have the necessary knowledge or with the help of a solar energy EPC company. The whole process consists of 9 different steps: document delivery, evaluation, capacity assessment, application results, approval of DSO, connection agreement, acceptance, agreement application, and system usage agreement.

Figure 34: *Unlicensed solar power plant application process for 25 kW and below*



Source: Green Solar Network

Basic energy processes in Turkey are also being simplified with recent changes in the legislation. With the legislative update made by EMRA in February 2021, barriers to digitalisation have been removed and 47 million electricity subscribers were enabled to perform all electricity-related transactions, including supplier changes through digital channels for the first time, without the need for physical documents.

6.2.3 The need for the definition of new concepts

In addition to the structural improvements in the current legislation, making contextual adjustments will be advantageous to the sector. Legislations that define the identification of new business models and the framework of responsibility have not been defined or have not been finalized:

- No regulations define the concepts of aggregator and direct marketing. Thus, aggregators cannot participate in the wholesale electricity market and ancillary service markets due to a lack of definitions. There is mandatory participation in Turkey, where all commercial operations of the unlicensed firms are managed by the incumbent utility in that region. Since these actors are not allowed to sell deliberately, they cannot create an additional income stream. Although new steps have been taken regarding demand management, there is still a long way to go. The procedures and principles regarding the determination of the basic consumption value within the scope of the demand side reserve service were published in August 2021.
- Aggregators have sprung up all over the world in recent years as a result of favourable regulation and the opening up of energy markets. In 2017, over 20 players in the UK alone developed aggregation activities. While the dynamic market conditions in England, France and Belgium increased the number of "demand-side aggregators", Germany and Spain could not catch this momentum due to strict regulations (Baes & Carlot, 2018).
- While several actors are available, the desired growth for the rooftop solar power plants market cannot be achieved due to undefined grey areas in the leasing legislation of No. 6361. If the framework of the build-operate-transfer model is determined, the market is expected to double in size. Moreover, regarding unlicensed solar energy production, the regulation known as "roof legislation" in public restricts the access of end consumers to the market due to the lack of a defined model where users could easily and swiftly install solar panels on the roof. Projects with maximum 10 kW installed power are allowed.
- Regulations regarding energy storage activities in the market are also considered to be late introduced, in May 2021, and insufficient, due to deficiencies in terms of participation and the implementation rules. The electricity storage facility integrated into the consumption facility can only be installed for the needs of the relevant consumption facility. Furthermore, independent electricity storage facilities, directly connected to the grid without any connection to any generation/consumption facility, require a supply license and cannot have installed power less than 2 MW.
- Regulations on operation of electric vehicle charging stations are lacking, but it is addressed in the "Regulation on Opening a Business and Working Licenses", which regulates the license obligations of charging stations. Operations in Turkey are proceeding in a structure where the service is provided regardless of who the electricity subscriber is. The TOGG initiative of Turkey to produce an electric vehicle brand could take a part in the establishment of future regulations. The European Union defines charging stations since 2014 in the Alternative Fuel Infrastructures

Directive 2014/94. In addition, some provisions on the subject are also included in the Electricity Market Directive 2019/944.

- Lastly, ESCOs are also defined in Law No. 5627 regarding energy efficiency, however, in Turkey, the mechanisms and institutions that will guide the verification side and act as an arbitrator in cases of conflict are not defined in legislation, which creates an obstacle to the dissemination of the new business models, especially ESCOs.

Figure 35: *Legislation status of energy concepts*

Concept	Status
Aggregator & direct marketing / Demand management	Not defined / Not finalized
ESCO	Not finalized
Build-operate-transfer model	Not finalized
Energy storage	Not finalized
Operation of EV charging stations	Not defined

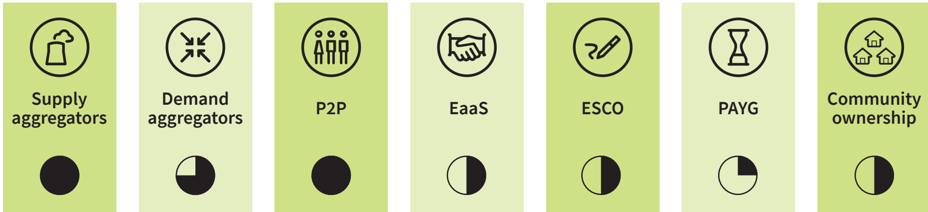
Source: Deloitte analysis

6.2.4 Need for authorisations

Due to the lack of certification practices, problems may arise in ensuring certain standard levels in new service areas and inspection processes can be time-consuming. Since EPC companies are not subject to any certification process, anyone can apply for the permit process and TEDAŞ, the distribution company, inspects them one by one. If the relevant certification processes were in place, it would be possible to ensure that the services offered by the operating companies are within the framework of certain quality standards and the necessity of a central institution such as TEDAŞ to conduct an inspection would be eliminated. World-renowned German quality control company TÜV Rheinland, conducted a research in 2015 on the performance and profitability of solar power plants by examining 100 plants with installed capacities ranging from 100 kW to 30 mW. The experts detected system errors and performance losses in one out of every 3 plants; among those plants with performance loss, 50% had installation errors and 25% had incorrect application of procedures in the planning and implementation guide. It was understood that most installation errors were due to EPC companies' decision of outsourcing some of the work and the employment of unqualified personnel (Yiğit, 2015). If mistakes on this scale can occur in Germany, Turkey should be cautious, being a newly developing market for new business models. For this reason, it may be considered to issue certificates to EPC companies after successful completion of certain training and tests. The licensing of EPC companies could reduce the burden of both regional distribution companies and TEDAŞ.

Another lack of authorization issue comes from the existence of mechanisms like R&D centre requirements for innovative business models such as crowdfunding or electric vehicle charging stations to be in practice. "Regulation on Opening a Business and Working Licenses," which regulates the license obligations of EV charging stations, was updated with the amendment regulation published in April 2021. Earlier, EV charging was specified as a secondary activity in the license, based on the operator's main field of activity. With the last amendment, it has been stipulated that if the operator of the vehicle charging station and the workplace where the station will be established are different persons, a separate license will be issued. These stations cannot be community-owned (whether crowdfunded, cooperative, or personal purchase, etc.) since the "authorized administration" is defined in the legislation, and it is necessary to have an R&D centre to be authorized.

Figure 36: *Extent of legislation barrier on business models*



When the impact of the regulations in Turkey on new business models are examined, it is understood that the P2P model faces severe challenges in the market due to the fact that a structure where consumers are allowed to sell/purchase energy deliberately is lacking. The aggregator models also have difficulties in becoming widespread since they are not defined in the legislation which prevents them from participating in the market. Although the ESCO model is defined in the legislation, it has not been finalized and necessitates adjustments, therefore the legislation impact could be expressed as moderate.

6.3 Socio-cultural conditions

With the expected increase in power demand and a higher share of renewable energy sources in the energy supply mix, consumers will need to be better informed about their electricity usage and take an active role in managing it. To maximize the level of consumer awareness, industry players, technology, and service providers should be engaging with consumers to communicate the value and benefits that could be achieved.

6.3.1 The current digital literacy and awareness levels of residential consumers

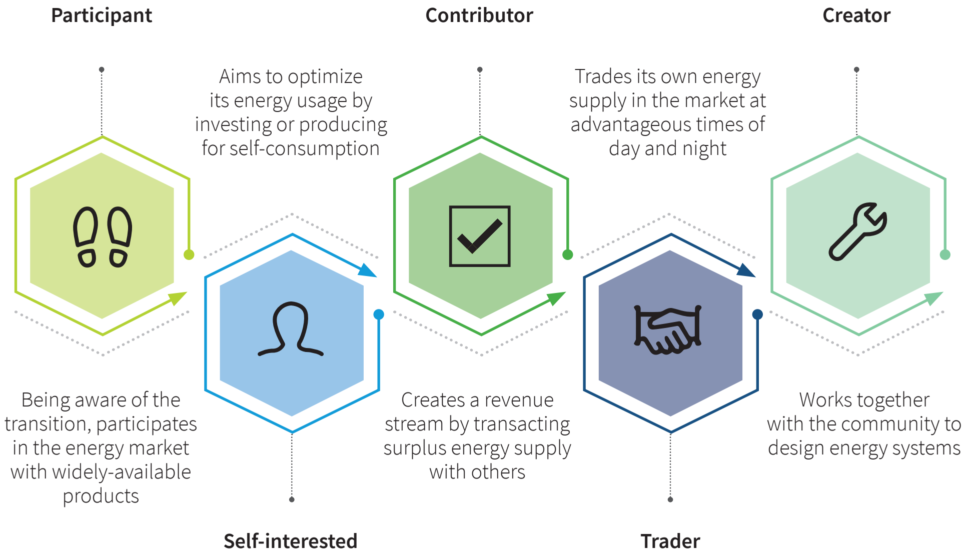
Considering that new business models and most energy efficiency solutions will involve technological applications, awareness must begin with technology. For this, the digital literacy level of end-consumers should be developed as they are in the position of users of digital technologies. As in the whole world, internet usage in our country continues to become widespread day by day. Internet penetration, which was 58% in Turkey in 2016, increased rapidly and reached 76.7% by 2020. When compared to other countries, Turkey, which outperforms developing countries such as Brazil, India, and China in terms of internet penetration rate, still lags developed countries' rates of 90% (Euromonitor, 2020). The possession of smartphones in Turkey has also grown rapidly between 2010-2019, with a CAGR of 18.6%, reaching 72.3% of all households (Euromonitor, 2019). Despite the fact that 72% of households possess a smartphone, it is seen that Turkey is still behind developed countries in individual smartphone penetration with 62% (Euromonitor, 2020). Although penetration rates are above average, internet usage rate also varies by age group, with 24-35-year-olds positioning as the leader (TÜİK, 2020). Therefore, it is evident that not every Turkish consumer has the same level of digital literacy. To adapt to emerging technologies, the digital literacy skills of consumers should be cultivated through educations on critical thinking and already available and new technologies, as well as bringing the applications of the digital world and physical world together. Moreover, in the world, to overcome this obstacle several suppliers, aggregators, and equipment manufacturers are teaming up to provide consumer-friendly solutions. For instance, REstore, an independent European demand-response aggregator firm headquartered in Belgium now acquired by Centrica Business Solutions, has partnered with Itho Daalderop, an electric boiler and heat pump manufacturer, to install its control chips in their products, which would allow the connection of all household appliances through a platform without any effort from the consumer (Arthur D Little, 2020). Similarly, in Turkey, it will be crucial to carry out digitalisation practices without adding any burden on consumers.

Second, consumers' awareness of energy transition and energy efficiency studies taking place both in Turkey and in the world remains relatively insufficient, and their perspective on this transformation should be broadened. Endoks, a technology service provider for the energy industry in Turkey, carried out a 1-year R&D project to break down energy consumption in homes and raise awareness accordingly through a ~400 household survey. 70-80% of participants have stated that they desire to learn more about their energy consumption, were willing to pay for related services, and even showed interest in monitoring device installations with a fee of 288 Turkish Liras. However, despite the free installation, only a total of 50 households agreed in the sample study. The Endoks case illustrates a significant gap between the discourses and actions of end-consumers, and it is seen that the level of awareness is crucially low. Another example would be a study realized in 2020 to measure the level of energy awareness of Finnish households. In the study, the participants were asked several questions regarding their interest in receiving more information to increase their energy awareness. On average, 70% of the respondents stated they were interested. However, when the data were analysed further, it was seen that respondents with higher awareness levels were interested while unaware participants were not willing to improve their knowledge (Trotta, 2020). Ærø municipality, an island of Denmark, being a pioneer in renewable energy projects, made plans to install community-owned wind turbines in 2000. When the community shared project plans publicly, it faced resistance from a group of inhabitants through a campaign in the media. The ads published in the media mentioned groups' concerns regarding the expected fall in property prices, along with pictures of local sights (Energize Co2mmunity, 2002). Therefore, projects should be implemented in very close communities and a trusted institution could act as an intermediary.

Consumer habits play a critical role in the level of awareness itself as well. Consumers still demand to be the decision-maker in their energy-related issues. As a result, although the technology is advanced enough to enable automated decision-making with prescriptive applications, consumers opt only for diagnostic solutions, hampering the development of digital business models. It is thought that the main desire of end-consumers is not about energy saving but monitoring their energy consumption. In addition, subsidized prices also hinder the development of consumers' awareness of energy efficiency. If the consumers had to pay sizeable amounts of bills for their energy usage, they could be inclined to learn more about ways to optimize their electricity usage. Another point regarding consumer habits and their impact on awareness levels is that residential consumers perceive energy not as something that produces value, but only as a cost. The end-consumer cannot acknowledge the benefits on itself, and for instance, decide to use household appliances when the electricity is cheap. Therefore, the benefits of the energy transformation must be presented correctly.

Lastly, the lack of information about new business models that can address the energy transformation in Turkey and their potential prevent these solutions from becoming widespread. A five-stage path followed by consumers, starting from participants to creators, would allow them to embrace the full potential of new business models. The first step would implicate that consumers understand and participate in the energy market to reduce their costs and carbon footprints by switching their providers and acquiring smart devices. It later invests in distributed energy resources to generate its power and new transport methods. In the third step, contributors aim to offer spare supply available generated from their own power sources to others when needed to reduce the reliance on the grid. Thereafter, they start hedging their generation and turn into virtual traders on digital platforms. Lastly, they complete their journey by designing value-added systems with the help of the community.

Figure 37: *The journey of an energy consumer*



Source: Deloitte Analysis

Since energy efficiency awareness is higher in industrial players than residential and commercial consumers, energy supplier companies need to develop solutions at a customer-level to engrain new habits. The purchasing decision of these consumers is formed after observing best practices in others. Therefore, another possible solution to increase awareness could be establishing continuous PR activities and incentive mechanisms like competitions.

6.3.2 Current approaches and digital maturity levels of commercial and industrial consumers

The evaluation of current approaches of commercial buildings and industrial consumers in Turkey reveals that the establishments refrain from investing in new business models due to several reasons: their perspective on the related costs, their perspective on digitalisation, and competition. Digital technologies, which may necessitate recurring expenses rather than one-time single payments, are in general perceived to be more costly. Furthermore, digitalisation applications are not yet prioritized, which makes it difficult for consumers to comprehend the benefits of business models. Lastly, the cooperation of different actors, which is necessary for the realization of new business models, is perceived as a novelty and requires time to adjust.

While digital technologies have the potential of reducing total project costs, currently in Turkey there is a tendency of corporate companies to make financial comparisons between recurring expenses and capital expenditures. This tendency poses a barrier specifically to performance-based contracts as opposed to capital investments due to the fact that there is a long-standing practice of prioritizing capital investments when making investment decisions. These new projects are not pursued because performance-based contracts are viewed as indirect expenses by businesses and are thought to be higher than capital expenditures. It must be realized that while capital expenditures are of vital importance in the purchase/investment process, performance-based contracts come into operation only after the purchase. These contracts cover a period of time and also include maintenance, operating expenses, consultancy services, measurement/verification services; the contract cost being presented through cost items could be beneficial. Moreover, if the annual cost of the contracts is taken into account instead of the total cost valid during the contract period when a financial comparison is realized, it will be illustrated that the costs are not as high as thought.

On the other hand, there is a need for the digital maturity level of commercial and industrial consumers to reach a level in which they will allow the management of energy-related processes. Current digital maturity levels result in insufficient utilisation of the benefits of digitalisation in the energy sector. Therefore, players attempting to operate in new business models and those who will be served should be of like mind and have a shared understanding of the intended benefits. Hence, it may be beneficial for the senior ranks of companies that will be served to play an active role in these meetings with industry players to come to an agreement. Otherwise, the number of meetings held to narrate the benefits of transformation could mount, also increasing the effort and operational load required. Furthermore, it is observed that the role distribution of the public and private sectors has become heavier in the private sector. However, new initiatives in large companies that dominate the market remain as ideas and cannot be translated into action due to bureaucracy and lack of motivation.

On a side note, due to the low digital maturity level, consumers are also insensitive to cyber-security issues. They prefer to carry on with their traditional working methods to keep costs competitive, not being aware that implementing cyber-security applications will grant significant savings in the future. With the introduction of compelling provisions, solutions for cyber security will begin to be in demand.

Lastly, the collaboration culture in the energy sector have room for improvements. New entrants to the sector may be perceived as competitors rather than potential solutions partners. There is a need for models that support small companies and increase cooperation models more.

6.3.3 Operational practices, perspectives of digitalization, and level of awareness of the public sector

When the public sector is scrutinized, it is revealed that it is necessary to consider operational activities, digitalisation applications, and awareness level regarding the energy transformation in Turkey as a whole. The energy sector necessitates defined targets for the future, which also highlights the need for holistic and sustainable policies and regulations that would support the sector roadmap. Therefore, the actors should be assessing their current operations and pinpointing the development areas to embrace new practices. The understanding of these practices would also require a certain level of digital maturity. Moreover, with the sector transition through the increased use of renewable energy sources, the awareness that new needs may arise in the future and they could be addressed with new business models should be achieved. Last but not least, observation of international case studies and practices would be essential for the implementation in Turkey.

There is a need to clarify the targets regarding the expected energy sector structure in the medium and long term. It would be beneficial to develop a long-term roadmap on renewable energy, installed capacity structure, energy efficiency targets, and emission reduction goals with a holistic perspective and make this roadmap publicly available so that different stakeholders would act accordingly. For instance, while Turkey's recent decision to ratify the Paris Agreement supports the adoption of long-term practices to achieve decarbonization targets, it would be beneficial to take further efforts to support it. As one of the biggest causes of the climate crisis and air pollution is coal-fired power plants, Europe Beyond Coal (EBC), a part of the leading non-governmental organizations, is working on climate and energy issues in Europe and they have announced that European countries have the will to close their coal-fired powerplants; France by 2022, Greece by 2028, Netherlands and Denmark by 2030, Germany by 2038 and so on. In Turkey, on the other hand, the establishment of new coal plants is still incentivized within the framework of the goal of reducing energy imports. Thus, considering that digitalization in energy is a key instrument in achieving the decarbonization goal, a clear mid-to-long-term strategy that is made publicly available would indisputably be beneficial for new business models to emerge and spread.

Legislative decisions should also be made by considering the long-term needs of the sector and the effects of relevant decisions holistically, while ensuring consistency and continuity. To systematically monitor its energy-related targets, the European Union, has set targets for 2020, 2030 and 2050; The Climate and Energy Framework determined renewable energy, energy efficiency and greenhouse gas emission targets for the EU until 2030. These objectives enable investors to understand the relevant issues clearly and precisely. However, in Turkey, pressures regarding emissions are relatively low. High flexibility is offered to old, non-complaint plants which creates an uncertainty in the sector. On the other hand, the Law No. 6446 and the secondary legislation enacted under this Law, since 2013 have undergone changes for 9 times for different reasons and purposes such as preserving the economic balance between licensees and consumers after privatisation of distribution firms, adjustment of tariffs according to changing economic conditions, the steps taken by the government within the framework of domestic and national energy use policy, increasing resource diversity in electricity generation, and restructuring of institutions with the transition to the presidential government system (Kızıl Voyvoda & Voyvoda, 2019)(Official Gazettes). These legal amendments also create uncertainties over the introduction of new business models.

In addition, there are areas for improvement in terms of the culture of reviewing current ways of doing business and evaluating innovative approaches. Planning and implementation of the steps for digitalization improvement require that the culture of innovation be integrated into the way how the organization functions. In particular, it seems inevitable that this change will take time to materialize, for public institutions working with traditional methods.

Similar to the benefits it brings to residential, commercial, and industrial users, the adoption of digital technology and applications will benefit from the enhanced level of digital maturity of public institutions. To date, digitalisation has been embraced with a focus on operation and productivity improvement while the customer experience has been understated. It is necessary to determine well what the technological transformation will serve, and it should be positioned as a tool rather than an end. For instance, the local and global launch of the management and automation system successfully developed by EÜAŞ should be considered to achieve sustainability in the long run.

Energy operations, which are easily carried out in the current situation, need to be restructured, considering the future, with the increase in the share of renewable energy sources. In the current situation, for instance, the operational situations that can be solved with the “load reduction” instruction given to the balance responsible parties will not be solved with the increase of new energy sources in the supply mix. It is critical to prepare now for new needs. Emerging needs of the industry can only be addressed through new business models.

There may be disruptions and delays in the implementation of the good practices observed by public institutions in line with their global collaborations, like the Global Energy Association and World Energy Council, and international case studies under Turkey conditions. Countries such as Russia, Japan, and Australia can be followed, considering their technical achievements. For example, for battery solutions, island countries like Australia and United Kingdom; for off-grid solutions, Russia can be examined.

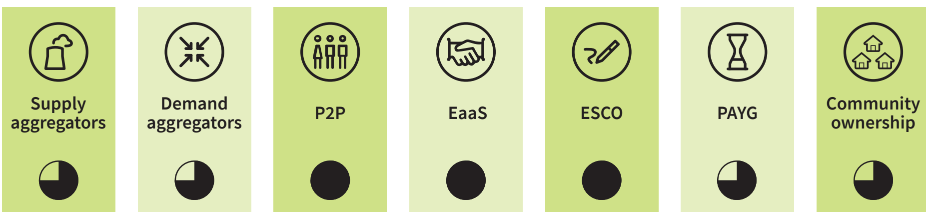
6.3.4 Qualified workforce

There is room for improvement in the establishment of a workforce with a qualified education and field experience, which is critical within the scope of energy transformation. Moreover, it is difficult to find innovative employees, who have a high level of sectoral knowledge and have a good command of technology. Turkey has provided a total of approximately 88 thousand job opportunities in the renewable energy technologies market in 2019 (IRENA, 2019).

A Turkish initiative has been established to combat this barrier. The “Increasing employability for Syrians and host community members in the renewable energy sector project” implemented under UNDP Turkey aims to contribute to sustainable development, local socio-economic development, and social cohesion in Turkey by creating a trained workforce in the field of renewables. In training held in Bursa, Kocaeli, and Konya with the participation of 66 Syrian and host community member trainees, the participants were given vocational and technical skills training on the installation, maintenance, and repair of existing equipment and systems of power plants producing renewable solar and wind energy (UNDP TR, 2021). In addition to the studies on vocational education, it may be beneficial to provide trainings in the software departments of universities in order to create a workforce that can make sense of the technologies that will play a role in the digitalisation of the sector.

It is also difficult to retain the qualified workforce in the market due to several reasons such as limited development of the sector and the prominence of the benefits, e.g., increased wages, provided by other sectors. A decision given by EMRA to provide incentives to support the transformation could spark a long-term interest in the market. For instance, knowing that EMRA pays a significant part of the personnel salary working in customer touchpoints, such as R&D personnel working in the grids and call centre personnel, this incentive could also be extended for digital transformation areas.

Figure 38: *Extent of socio-cultural barriers on business models*



The barrier scoring analysis illustrates that socio-cultural conditions in Turkey and the awareness that comes with it affect all the new business models with at least half the potential impact. The P2P operators, Energy-as-a-service firms, and ESCOs are the most affected since these models necessitate the recognition or the active participation of consumers. Likewise, level of awareness also constitutes a significant barrier to making sure that the benefits offered by aggregators are understood by all parties and that prosumers are able to use community ownership within different structures.

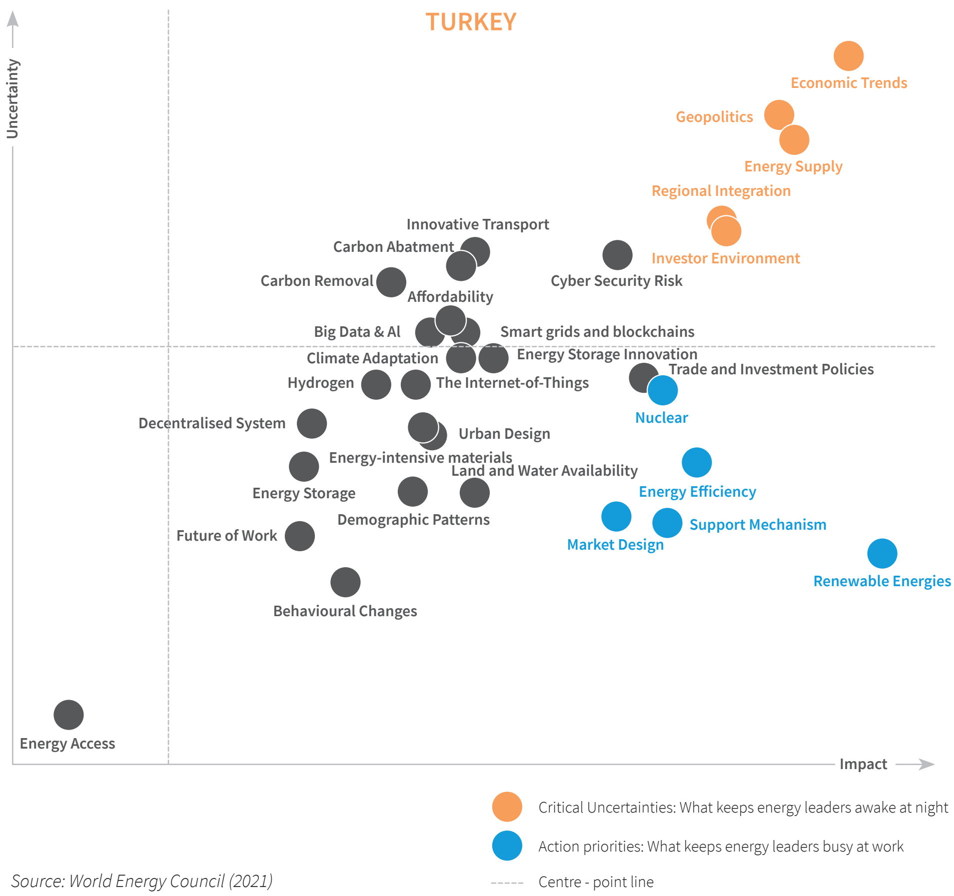
6.4 Financial conditions

The Turkish economy is going through a period of striking a balance, with the main risk factors being inflation, exchange rate volatility, and commodity prices. Conditions of the economy are the primary drivers of developments in the energy sector. Thus, the applicability of innovative business models can also be related to the economy as a whole and the financial condition of end consumers and companies.

In this manner, The World Energy Issues Monitor provides a unique overview of:
1) The action priorities or areas where Turkey is acting pragmatically to progress in their energy transition
2) The critical uncertainties or issues which are in the energy leaders' radar as areas of concern

Map below provides a visual snapshot of the critical uncertainties and action priorities that policymakers, CEOs, and leading experts strive to address, shape, and manage energy transitions.

Figure 39: *Turkey energy issues map*



Source: World Energy Council (2021)

As seen in the map, economic trends are at the forefront as the dominant critical uncertainty in Turkey. Critical uncertainties are unsurprisingly dominated by economic trends and the associated uncertain investor environment, with geopolitics, energy supply and regional integration also falling into the critical uncertainty domain. Highlighting the investor environment reflects concerns about continuing investments, the availability of funds, and on what or where these should be invested within the energy sector. Also, energy supply investments can be related to the price volatility posing a risk to stability of energy supply and investments. These conditions may create further obstacles to the innovative business models in energy sector, which are listed and explained in detail in the following sections.

6.4.1 High initial investment costs

Cost of energy assets and long return on investments

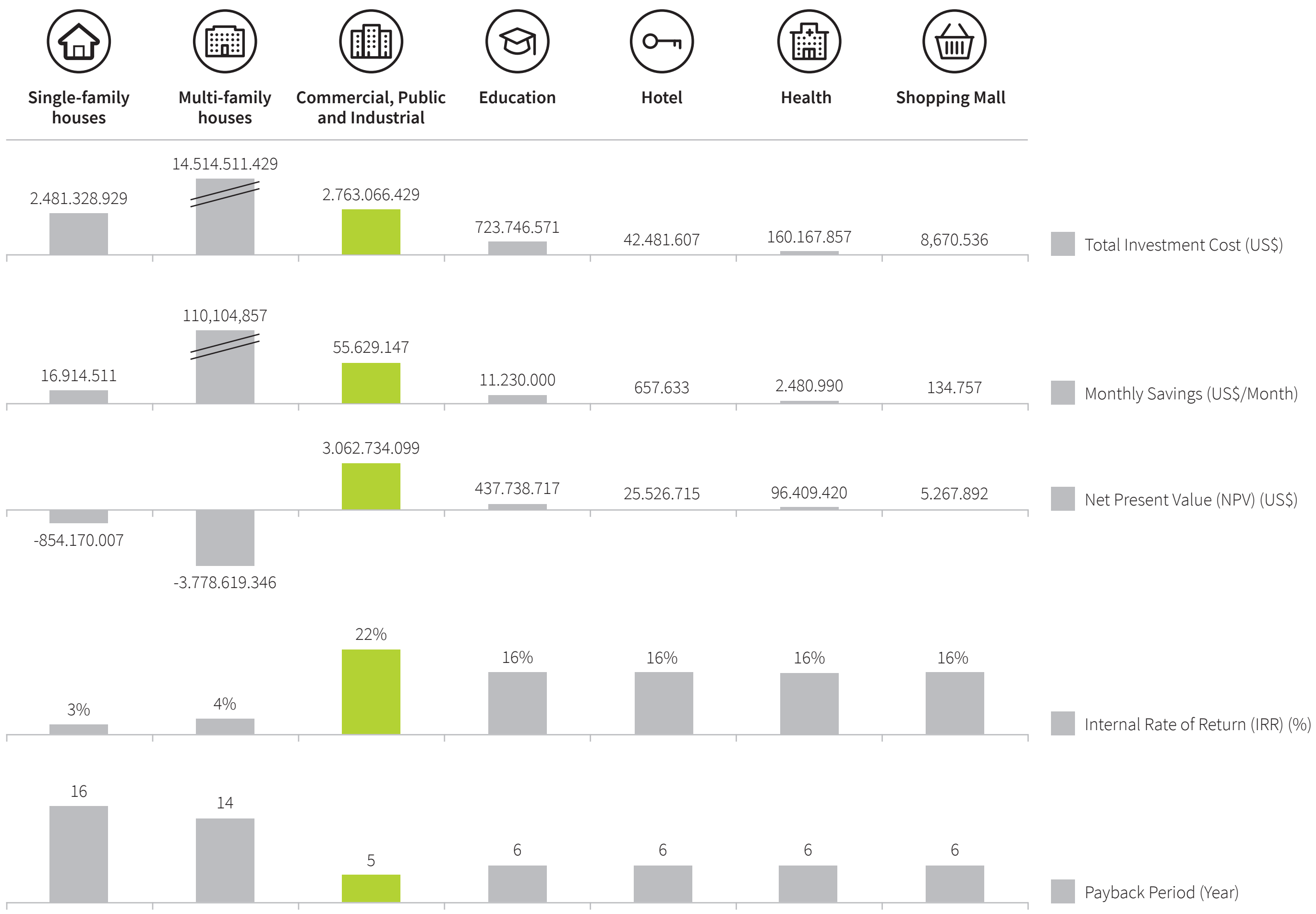
The initial installation costs of PV solar panels, batteries, electric vehicle charging stations, electrification of systems in buildings and industry are an obstacle for investors. High initial costs of these assets are due to:

- High renewable technology costs
- Limited number of suppliers
- Insufficient generation of energy assets in Turkey
- Various import duties for energy asset exports - Especially the surveillance tax and anti-dumping tax for PV solar panel exports

Based on SHURA's study, an average cost of PV systems ranges between US$1,500-2,000 per kW in residential buildings in Turkey in 2020 and investment costs of PV systems decrease by 10% to 15% every year. On the other hand, these cost levels can be down to a range from US$600 to US$1,200 per kW for larger capacities in other building types (10 to 1,000 kW). Yet, when levelised cost of electricity (LCOE) of PV system investments are calculated to compare PV systems' viability, LCOE of rooftop PV systems in residential buildings turns out to be approximately 30% to 50% higher than the grid tariff, whereas in non-residential buildings this appears much lower (SHURA, 2020b). Today, these costs are observed to be declining rapidly.

The PV payback periods is also an important metric for investors to evaluate whether the investment is profitable or not. PV payback periods and other indicators in different building types are shown in the figure below.

__Figure 40:__ PV investment payback periods and other indicators across Turkey



Source: SHURA (2020)

According to the figure above, with negative Net Present Values, considerably high investments costs and long payback periods, family housings are not preferrable for investors compared to other building types. However, it is observed that they have reached investable levels today. In contrary, commercial, public, and industrial buildings come to the forefront with 55,629,147 US dollar monthly savings despite its reasonable investment cost, 3,062,734,099 US dollar Net Present Value and 22% IRR resulting in the shortest payback period as 5 years. Considering the conditions in Turkey, the investors are avoiding long-term contracts (more than 5 years) due to the macroeconomic, sectoral, and project-specific uncertainties, which can be seen as a major obstacle to the solar PV projects.

As an example, to high initial costs and how they may hinder energy projects, in a VPP project conducted by AGL Energy in Australia, the company encountered some challenges on the battery deployment in residential houses. The upfront cost of the battery was the most sensitive variable in attracting sales leads. Targeted marketing campaigns at lower price points demonstrated much higher conversion rates. This campaign had only limited success, with upfront cost of the battery being the primary issue. Acknowledging that the upfront cost of the battery was the primary determinant for sales, a successful local marketing campaign would need to consider a compelling price point. Through a very small trial within two low voltage feeder zones in late 2018, AGL offered eight homes batteries at a sub-$1,000 price point and found that take-up rates were significantly higher than in the previous targeted marketing campaign (Energy, 2020).

Due to the high initial investment costs of energy assets, financial incentives to potential investors are important. Generally, once these assets are operational, operating costs are relatively low. After the financing is provided, while the return of the projects gains importance in order to make loan repayments for the investors, it is necessary to clearly determine the pricing model or the electricity costs avoided by making the investment so that potential investors can conduct feasibility studies (SHURA, 2021b).

Cost of infrastructure

Transforming the energy system is not only about installing energy assets, but it is also about investing in more flexible infrastructure. Additional investments in smart grid infrastructure such as smart meters, sensors, control systems, and digital connections are required to implement new business models that put the end consumer in the centre. In particular, there is a need for the management of electricity demand in the manufacturing industry and buildings, and the establishment, operation and planning of supporting infrastructure such as smart meters, sensors, control systems, in order to ensure that consumers are involved especially in demand-side participation and also contribute to power generation. However, the cost of these infrastructural investments can be considerably high, which constitutes an obstacle to the implementation of innovative business models.

According to the ELDER (Association of Electricity Distribution System Operators) statement, there are nearly 42 million consumers in Turkey, and 37-38 million of them are residencies. In case of replacing these 37-38 million mechanical electric meters with smart meters, a minimum of 70-80 euros per meter, totalling up to 3 to 3.5 billion euros will be required. Therefore, it is thought that the transition to smart meters, capable of transmitting instant data, will have to be spread over time when the financial difficulties and budgetary requirements are considered (Ajansı, 2018).

Considering the VPP operator, real-time data acquisition from DERs is necessary for the creation and operation of the virtual power plant. This would require smart meters, broadband communication infrastructure, network remote control and automation systems (network digitalisation). Real-time communication between VPP operators and the connected DERs is needed. This helps in improving network efficiency since the data gathered can be used to better forecast demand. Two-way communication network devices are essential, whose initial costs can be burdensome for the energy system stakeholders (IRENA, Business Models Collection , 2020).

Cost of technology

Technology is developing at an exponential speed and technological developments are changing every aspect of our lives. Artificial intelligence is the chief factor that is driving technological developments. However, the fact that the initial investment cost of these smart solutions is high, prevents investors from taking action in Turkey. In particular, smart solutions using AI such as demand-side participation and smart home technologies are considered to be higher cost technologies compared to the electricity tariff.

AI can be an expensive solution for businesses due to its proprietary and purpose specific nature. It requires investing in gathering, cleansing, and labelling data and hardware technology as well. To determine the AI costs, it is crucial to understand the factors affecting the current pricing.

- **The type of software:** The cost of AI differs based on its complexity, performance, and the purpose of the software.
- **The level of intelligence of the AI application:** The intelligence level of an AI application can be determined according to the level of human instruction need to perform tasks.
- **The performance of the AI algorithm:** The higher the accuracy and efficiency of the AI predictions have, the more the cost of implementing these solutions incur.
- **The complexity of the AI solution:** The cost of creating proper AI software, with a cloud-driven back-end, ETL (i.e., extract, transform, load) / streaming tools (for processing and movement of real-time data from one place to another), voice assistants, cloud dashboards, and other services is an important factor.
- **The amount of data the AI application will consume:** AI devices perform according to the data loaded in the system. Especially unstructured data can create high costs for the system.

Figure 41: *Artificial intelligence pricing based on different portfolios*

1. Identify requirements	2. Prototype Implementation	3. Minimum Viable Product (MVP)	4. Product Release
Conducting research on the project goals and requirements, as well as analyzing the feasibility of AI project	Developing a prototype to help companies avoid potential pitfalls before commiting to a full solution development	To be able to find out if the AI product can actually delivers any value for the intended outcome	A complete development with full set of functionalities and features as expected to be released to market
FREE	~USD2,500	~USD8,000 - ~USD15,000	~USD20,000 - ~USD1,000,000

Source: Analytics Insight (2021)

Although, leveraging AI technologies might not cost a fortune today, 76% of organisations are barely breaking even on their AI investments because of their high initial costs (PwC, 2021). It is still at not its intended level considering the conditions in Turkey as well. While the number of start-ups focused on AI in the U.S. and China has reached 2,000, this number is around 200 in Turkey (Anadolu Ajansı, 2021). This number is expected to grow with the decreasing implementation cost of AI and wider adoption of these technologies in businesses.

6.4.2 Currency pressure

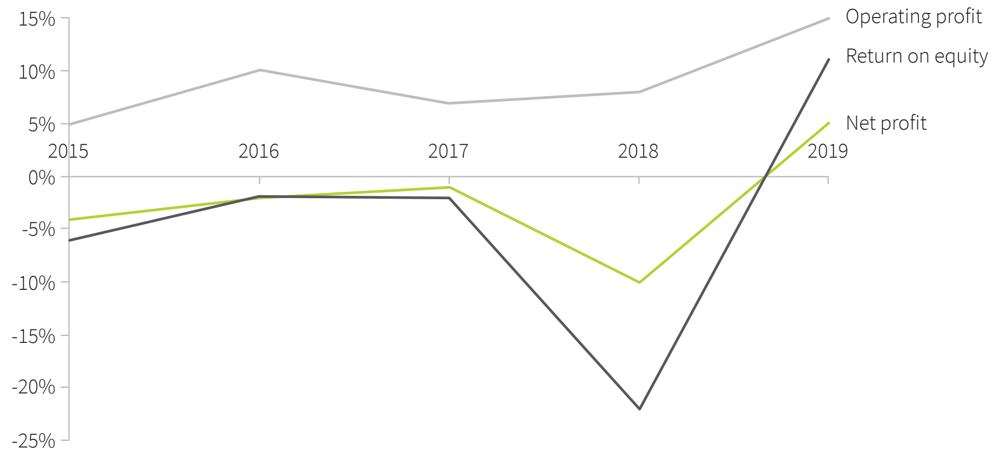
In terms of macroeconomic conditions in financing investments in Turkey, there is a relatively fragile structure. Including fluctuations in exchange rates, uncertainties affect the feasibility and return of investments. Investments and the fact that the financing is generally in foreign currency stands out as an important barrier coming out. For these reasons, political mechanisms are expected to be designed to mitigate the structural negative effects such as exchange rate and maturity mismatch (SHURA, 2019a).

Currently in Turkey, companies occasionally struggle with finding funds. The fact that expenses for the electricity sector in Turkey are in foreign currency and incomes are in Turkish Lira creates uncertainty for investors. In particular, for an industrial investment, the project contract on the client's side involves foreign exchange and financing risks. On the other hand, the fact that customers see long investment periods in new businesses, makes these investments lose their attractiveness. For these reasons, industrialists do not approach to do long-term business and do not engage in projects not having short-term return on investments.

6.4.3 Profit margins

Low profit margins in the electricity sector are one of the major factors that arise as an obstacle to the emergence of innovative business models. Because the energy companies operate at low margins, the value to be shared among stakeholders are decreased. The graph below shows the profitability ratios of electricity energy sector by years. In the graph, it is seen that the net profit margin and return on equity ratio are both below zero until 2019.

Figure 42: *Global development of profitability rates of the electricity energy sector by years*



Source: Analysis of the Financial Performances of the Electric Energy Sector Using the Ratio Analysis Method – by JOURNAL OF BUSINESS RESEARCH

In another study of Istanbul Chamber of Industry (ICI), conducted for the largest 1,000 industrial establishments in Turkey, it has been found that 13 industries' return on capital invested (ROCI) is higher than their weighted average cost of capital (WACC), while in the food, energy, and textile sectors -sectors with higher asset sizes-profitability remained below costs (SHURA, 2019a).

When the situation in Australia is examined, a continuous downward movement in electricity prices is observed. Even negative prices occur in a significant time period. Under these circumstances, it will be more difficult to share the value that will be revealed when the VPP model is considered. One of the biggest obstacles for all new business models is the low energy price and its negative effects on the profitability. As a starting point, in addition to the energy sold in kWh, different services might be offered to the end consumers to find new ways to create value.

6.4.4 Limited company budgets

In Turkish energy sector, as in other sectors, there is a lack of capital accumulation for investments. The reason for this is that energy companies have limited resources and also allocate a limited share to these investments in budget planning due to their high expenses. The share of energy investments in total fixed capital investments in Turkey increased until 2009 - up to 5.3% - and then decreased continuously (T.R. Presidency of Strategy and Budget Department, 2019). In addition, the increase in the shares of other sectors due to the acceleration in investments may also be a reason to this proportional decrease in energy investments. Moreover, data available to date shows limited venture capital activity in energy start-ups based in Turkey, with a handful of relevant deals in energy efficiency recorded since 2015 (Agency, 2021). In the upcoming days when innovative business models are on the agenda, it is important for companies to allocate more resources for energy investments for the realization of these business models.

6.4.5 Lack of synergy between banking and energy sectors

According to the predictions of International Renewable Energy Agency, there is an investment need of 110 trillion US dollars between 2018 and 2050, and an average of 3,4 trillion US dollars on an annual basis, globally to achieve the global targets of having a climate friendly trajectory in the next 30 years. Considering the breakdown of the required investment of 110 trillion US dollars, over 37 trillion US dollars will be required for energy efficiency solutions, 27 trillion US dollars for renewables, 13 trillion US dollars for electrification of end-use sectors (e.g., for electric vehicles, and heat pumps), and 13 trillion US dollars for power grids and energy flexibility measures, such as smart meters and energy storage. If the current situation continues, investment needs appear to be above current investment levels (IRENA, 2020). From both the perspective from energy transformation and from the maintenance of the current situation, the need for expanding the volume of financing for investments and the creation of additional resources are becoming vital. In Turkey, although the energy sector is one of the sectors that benefit the most from the financing opportunities - especially for natural gas and oil utility scale investments - the risk perception of the innovative solutions such as renewable generation, micro-grid consumer offerings, EV charging stations, VPP funding, or application of ESCO models is quite high from the banking sector perspective. Thus, very clear communication of these projects and lots of time and effort are required for the success of finding financing options at reasonable interest rates.

6.4.6 Inadequate funding

The inadequacy of company capitals creates the need to use financing in energy transformation projects. The past 30 years have been a period in which access to finance and financial deepening on a global scale gained great importance. Despite this, medium- and long-term resources that can be directed to infrastructure investments, including energy, have remained limited. Directing private sector savings more towards energy transformation will play an important role in providing the needed financing.

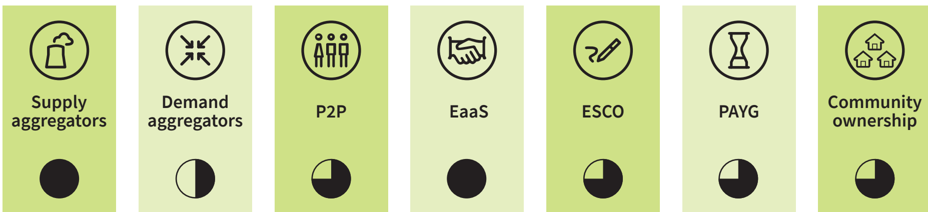
High rate of financing instruments used for energy efficiency and renewable energy investments in Turkey indicates that financing options in investments have been commonly used in energy sector compared to other sectors. In fact, while total banking loans increased by 340% in the 2002-2018 period, energy sector loans increased by 2,750%. Additionally, the total loan liability of the energy sector is around 57.4 billion US dollars, and 45 billion US dollars of this amount, or 79%, is composed of medium-long-term debt stock. The borrowing rate of energy transformation investments is around 60-65%. As a result, a significant experience has emerged for financing the sector, both on a national and international scale, in the context of the needs and priorities of the period in terms of volume, resource diversity and financing models. However, difficulties arose in the Turkish economy with the rapid depreciation of Turkish Lira since mid-2018 (SHURA, 2019a).

While the cyclical squeeze caused a temporary pause in long-term planning in the energy sector, it highlights new needs and priorities from the perspective of energy transformation in the sector. At this point, since financing costs are too high, it becomes difficult to finance energy projects in Turkey. To illustrate the struggle, ESCOs have lost their practical power financially. Although a 20% gain in practice seems fair, financing can now be found at 25% costs, which complicates the practical world for ESCO companies.

A similar financial struggle has been faced by Smalininkai village association in Lithuania, which was the first community wind project in the country. Although the project had high expectations, it turned out to be unsuccessful due to the project's low generation of electricity and difficulties regarding project funding. Companies have a significant advantage over community-based organizations regarding money borrowing for renewable energy projects. The original idea was to fund 40% of the project through a bank loan and the remaining 60% by a grant. Another barrier faced by the village association was difficulty in finding a bank that would provide them with a loan. This was because, as they were the first community wind project in Lithuania, banks were not accustomed with the funding procedures for community-led projects. In addition, since the village association did not have any assets, the project leaders had to give their own houses as a guarantee for the loan. The interest rate on the loan was originally 6%, however due to the financial crisis that was striking Europe at that time, kept increasing until it reached 16% (European Union - co2mmunity , 2018).

In order to achieve progress in energy transformation in Turkey, a comprehensive evaluation of financing opportunities, diversification of financing resources in line with the opportunities offered by new technologies, and examination of innovative financing models are required. As an example, innovative models that include technical/credit risk hedging mechanisms in the ESCO model, including financial institutions, will be crucial in the spread of this business model. Depending on who the contracting entity is, a guarantee and insurance mechanism might be formed. In this way, banks can also reduce the amount of collateral by using the insurance. A system that ensures design and performance can be established in Turkey. Currently, very few solar energy projects are insured, yet large international insurance companies are not willing to do this for energy efficiency projects at the moment.

Figure 43: *Extent of financial conditions barrier on business models*



The barrier scoring analysis reveals that financial conditions in Turkey have a big impact on the innovative business models. Although demand aggregators seem to be affected relatively less due to the lack of necessity of installing costly assets (renewable plants, storage systems etc.), the financial conditions are considered as an important factor that needs to be overcome.

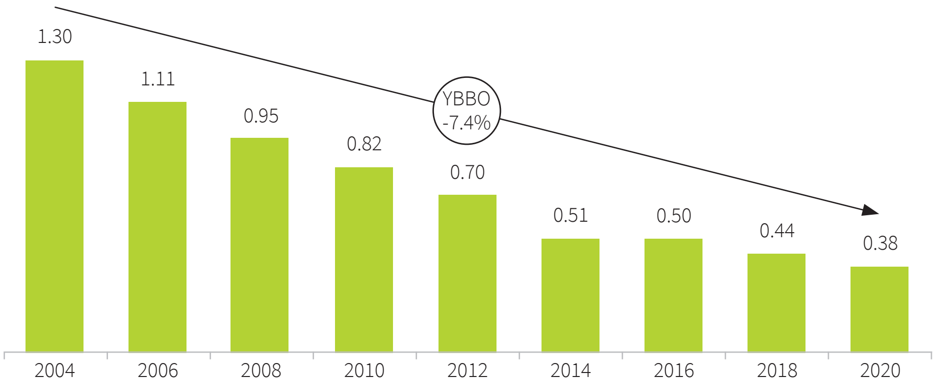
6.5 Technological infrastructure

6.5.1 Hardware

Access to data is critical for the realization of new business models that will play a role in the Turkish energy sector's transformation, but 3 main hardware constraints are slowing their dissemination. For starters, Internet of Things applications that use sensors to track energy generation and consumption are still in their early stages of development in Turkey and will take some time to mature. Furthermore, due to a lack of smart meter adoption and the continued use of mechanical meters, data cannot be accessed in real time, posing a risk to data dependability and quality. Finally, the utilization of storage systems is still in its infancy, making it difficult to derive the most value from renewable energy sources.

The Internet of Things (IoT) connects multiple devices, people, data, and processes by allowing them to communicate with one another in real-time by employing sensors. These sensors, which are used in each step of the energy generation process, allow for monitoring energy patterns, computations, and optimal decision-making with the use of intelligent algorithms. Sensors were far more expensive to maintain and run before the widespread use of the Internet of Things, which resulted in limited usage in the energy industry, however, they have become more economically viable as IoT applications have become more common. An IoT sensor's average price has dropped from 1.3 US dollars in 2004 to 0.44 US dollars in 2018 (Microsoft Dynamics 365, 2019). Thus, it is expected that access to data through sensors will gradually become easier in Turkey. Skysens, an IoT start-up company based in Turkey, has developed a sensor infrastructure that can operate for 10 years with a single battery with its low-energy long-distance module and can transfer data to the internet from a range of 15 km. The founder expressed the advantages provided were easy installation and low cost, and the low-energy sensors were in high demand (Şahbaz, 2021).

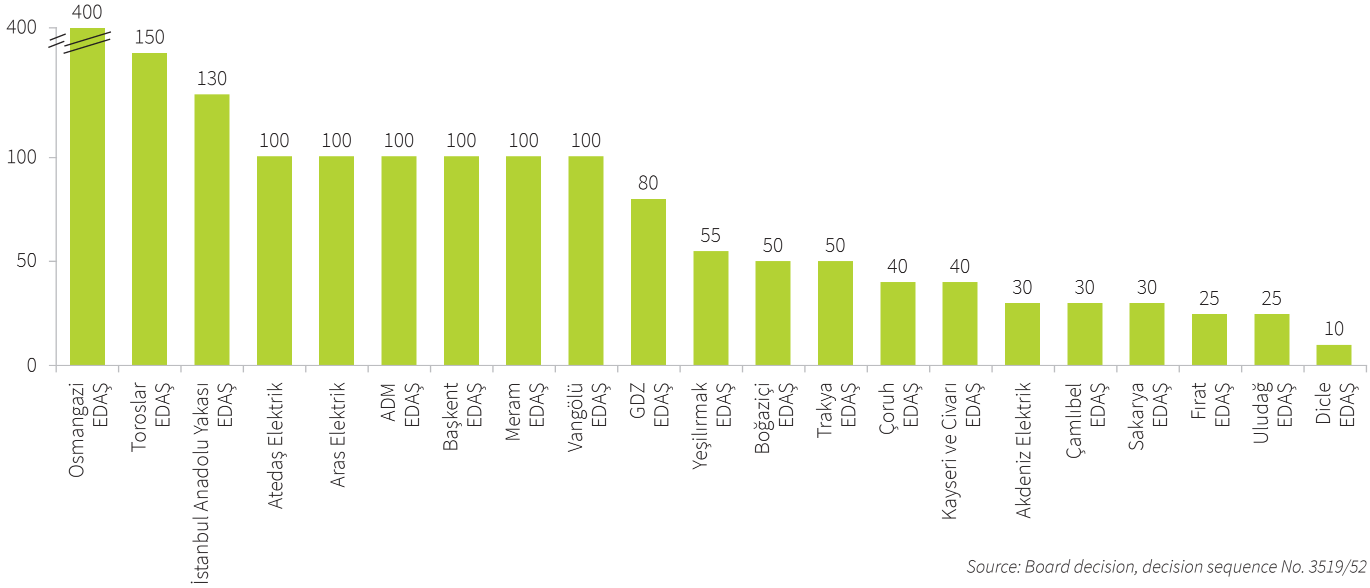
Figure 44: *Average cost of IoT sensors, USD*



**CAGR: Compound annual growth rate*
Source: Statista, Deloitte analysis

Smart meter applications are an important part of smart grid systems, which combine electrical networks with information technologies to enable the most efficient use of energy in the generation, transmission, and distribution phases. Smart meter applications are designed to allow for remote meter reading, decrease business activities such as invoicing, and manage energy use. The basis of the studies on smart grids in Turkey is the Automatic Meter Reading System (AMRS/OSOS). Communications are realised in one-way in AMRSs and only meter data is transmitted to the central system. For subscribers of distribution companies above a certain consumption capacity, it is mandatory to be in the scope of AMRS. These determined limits indicate that the level of prevalence of the application still has room to grow. This rule also leaves small consumers out of the scope, knowing that a regular end-consumer's yearly energy consumption is approximately 1.6 MWh (EMRA, 2020). Distribution companies are responsible for providing the necessary infrastructure for AMRS data sharing. Although these companies cannot charge a fee for the information shared every billing month, in shorter periods, a fee is requested to gather additional AMRS data. However, the collection, management and sharing of data poses a potential obstacle to Personal Data Protection Law.

Figure 45: *AMRS consumption limit of distribution firms, MWh/year*

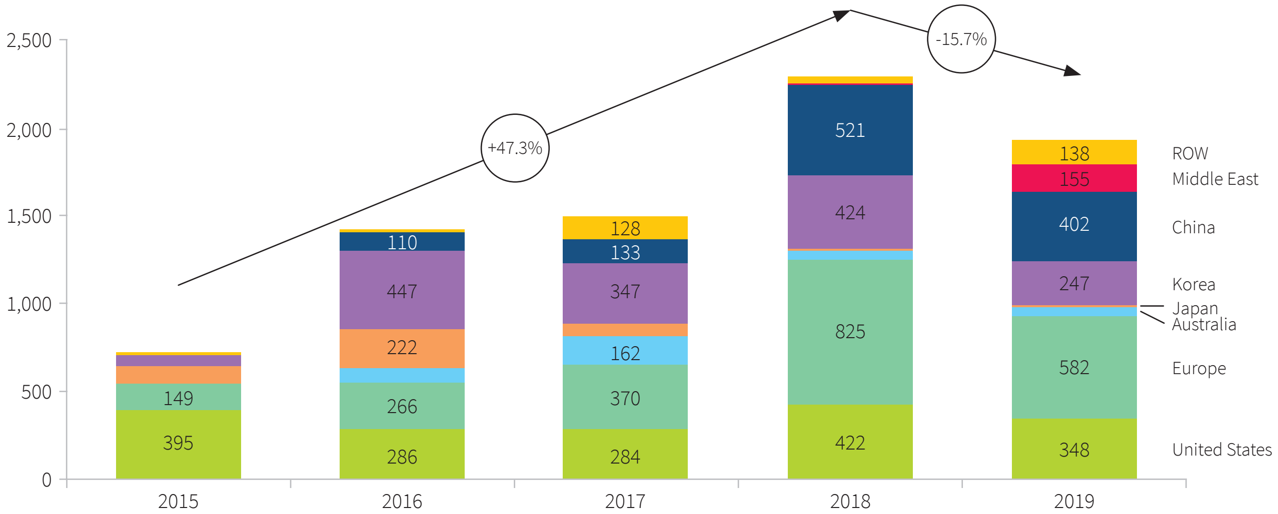


Source: Board decision, decision sequence No. 3519/52

According to its technology, meters are classified either as mechanical or electronic. Mechanical meters are still widely used in Turkey and although their use has begun to increase, the number of smart meters remains limited. Due to the limited availability of smart meters, the need for human resources continues to collect user data. According to Electricity Distribution Services Association (ELDER), meters in Turkey do not have the ability to communicate data to a centre via any communication channel and data may only be collected once a month manually. They also claimed that replacing approximately 38 million residential meters with smart meters will cost around 3.5 billion euros (Şengül, 2018). As a result of the financial difficulties and budgetary constraints, a gradual transformation is required. A system managed by human resources also poses a risk for the reliability and quality of the data since errors may arise. Manual meter reading can result in unbilled energy, as well as disputed and incorrect bills. The failure of energy measurement and the creation of an hourly billing profile prevent the establishment of billing infrastructure, which in turn prevents the adoption of the P2P model. In April 2020, Energy Market Regulatory Authority made a statement that within the scope of preventions against COVID-19, the on-site meter reading will not be realized for three months in cases where the employees won't be able to maintain their social distance. The energy bills were calculated based on the averages of the preceding two years' same month invoices. If the use of smart meters were widespread, remote meter reading would be possible without any disruption in operations and an error-free, precise invoice could be issued by accurately measuring the consumption of consumers.

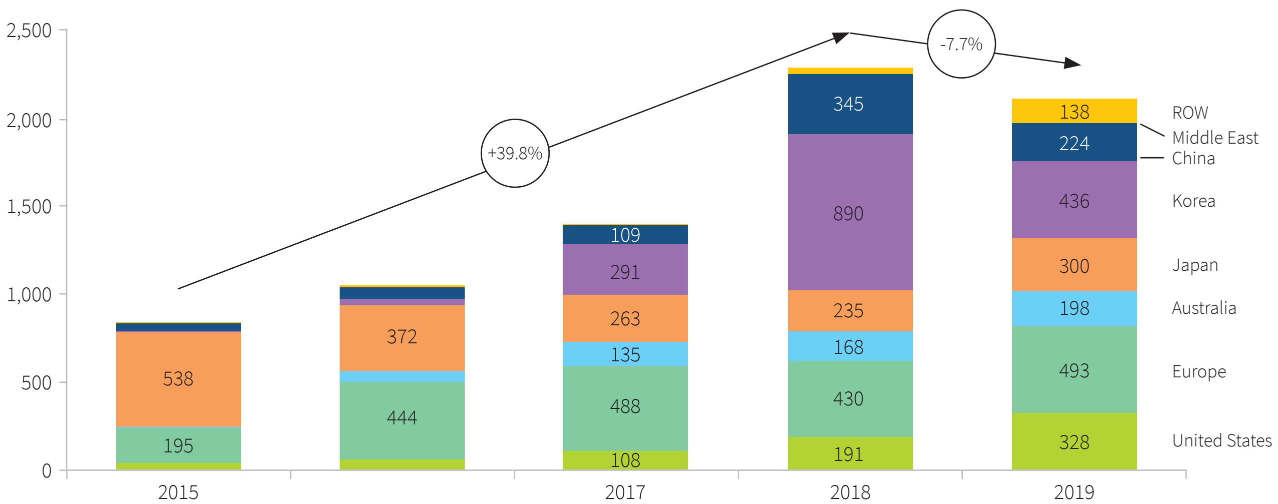
While new business models encourage consumers to use their battery systems for cost optimization purposes, consumer-level behind-the-meter and grid-scale batteries are available on a limited basis. Worldwide battery storage investments declined for the first time in 2019 and continued falling in 2020, owing to market uncertainty and the lack of stable policies, but they remained above 4 billion US dollars. Investments in grid-scale batteries experienced a drastic fall of around 16%, while investments in behind-the-meter storage fell by more than 7%. Except for Australia and the Middle East, every region's grid-scale storage spending declined in 2019. However, the US, Europe, Australia, and Japan increased their behind-the-meter investments in the same year (IEA, 2020). Energy storage applications are considered to be in the early stages of commercialisation and are facing economic challenges. Although costs have started to decrease, behind-the-meter batteries remain almost twice as expensive as grid-scale batteries.

Figure 46: *Investment in grid-scale battery storage, 2015-2019, million*



Source: IEA, World Energy Investment, 2020

Figure 47: *Investment in behind-the-meter battery storage, 2015-2019, million*



Source: IEA, World Energy Investment, 2020

Aggreko, a multinational power solutions company based in Scotland, installed a 500 kW lithium-ion battery storage system in Alaca, Turkey to help local grid infrastructure deliver reliable electricity by balancing peaks in supply and demand. This project becomes a pioneer and expects to accelerate the deployment of battery storage in the country (aggreko, 2021). To increase the usage of battery storage systems, the regulatory environment should be transparent and, policies structuring the role of storage in networks as well as ownership issues should be developed. In 2021, the Spanish government announced an energy storage strategy in which the expected storage in capacity by 2030 was identified as 20 GW, and measures for the deployment were shared (IEA, 2021). The Turkish government is also working on regulations to allow storage applications in the market. With the secondary legislation introduced in May 2021, distribution companies were permitted to establish a storage facility, only for grid balancing purposes, by proving that it is cost-effective. Universities and technology development regions were also allowed to establish storage facilities. However, power limitations prevent smaller consumers from participating in the market. All-inclusive regulations will pave the way for the prevalence of storage applications.

6.5.2 Software

In terms of software, two major barriers are preventing Turkey from adopting innovative business models. To begin with, there is a lack of a data collection system that will preserve the data in a singularized and standardized structure and industry players must rely on old methods, each of which is unique to them. Furthermore, a common platform that allows for data sharing, analysis, and modelling is required. Although there are concerns about possible conflicts with the Personal Data Protection Law (PDPL), these platforms will begin to gain recognition in the market as new generation technology proliferate.

Firstly, the supply and demand of energy resources must be kept in balance through continuous monitoring and control by a standardised data-sharing infrastructure, which is missing in Turkey. Currently, in general data collection is over manual spreadsheets, and a platform for data and information sharing does not exist. AES Colombia, a subsidiary of the AES Corporation and a Fortune 500 company that generates and distributes electrical power, used standard methods in handling large volumes of data on independent and disorganized spreadsheets. Manual work later resulted in the generation of errors and inconsistencies. As a result, the firm was reassured that a digital transformation was a must to follow data management processes via modern tools (Giraldo, la Rotta, Nieto-Londono, Vasquez, & Escudero-Atehortua, 2021) . In Turkey, the different data infrastructures of companies in each step of the value chain cause inefficiencies and difficulty in controlling based on regulators. Moreover, the fact that the goals and strategies of companies in terms of digitalisation are different also differentiates the technological infrastructure regionally.

Secondly, in addition to the lack of data standards and protocols for sharing, the current legislative framework hinders the realization of joint data management in Turkey. While energy companies necessitate to carry out their activities over the cloud, the PDPL prevents data sharing resulting in the loss of benchmarking opportunities. For instance, in the Aggregator model, data collection, management, and sharing rules for DSOs might be contradicting with the PDPL. This law also prevents the implementation of cloud-based control and management software for the PAYG model. Moreover, due to the confidentiality of some industrial processes and company information, “in-house” solutions may be preferred instead of ESCO. In Turkey, there is a need for a common and standard platform fostering AI that will enable the management of components such as EV, smart home appliances, electronic products, and PV energy management systems through the same protocol. A European standard, called SAREF, for smart appliances, has been developed in Europe by the European Commission with the cooperation of the industry and ETSI (European Commission, 2019). The standard creates a reference language for energy-related data, which will be used by devices and will allow them to exchange information.

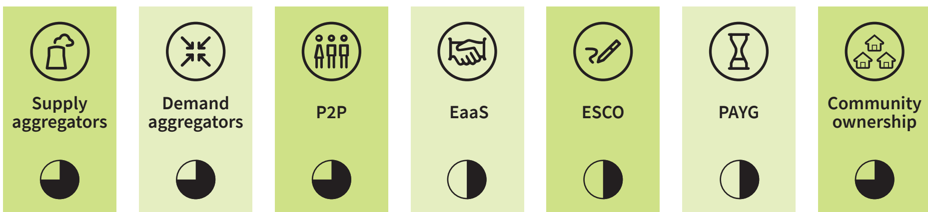
The applications of data modelling and optimisation are limited in Turkey and are still in the planning stage. The Turkish energy sector necessitates various software for on-grid optimisation purposes, for battery systems and electric vehicles, and the establishment of a reliable trading platform for the P2P model. Moreover, artificial intelligence technologies could play a role in reducing the need for alternative mechanisms that emerge as a result of weather conditions by allowing for early detection of energy demand and management of renewable output changes. Stem, a US-based firm founded in 2009, created “Athena” by combining the power of artificial intelligence and energy storage to optimize the timing of energy use. The Athena software uses AI to improve the batteries, accurately predicts the energy demand and the amount of energy in the grid, makes economic calculations when determining how much energy to distribute or store. With these calculations, it understands the complexity in the market and provides the highest economic value for customers. Another firm, Verdigris Technologies, a SaaS-based platform provider, combines IoT and AI to gain insight into energy consumption in large facilities. By mapping the entire energy consumption of the building, operators can identify where the highest consumption is and the location of faults in the system (Lugo, 2020).

6.5.3 Communication protocols

Communication protocols need to be developed to ensure coordination between system operators, network operators, producers, consumers, and prosumers. In IoT, the wireless communication protocol is a set of rules for exchanging data between sensors and electronic devices. Wi-Fi, Bluetooth, ZigBee, and cellular technology such as LTE-4G and 5G networks are examples of these technologies. Different energy applications necessitate the employment of the right communication protocols based on range, power consumption, and bandwidth requirements. EV charging infrastructure providers in Turkey should be able to increase their communication with the distribution network through protocols and manage the concurrency factor and even dynamic pricing in the network. Since this cannot be achieved independently of the network, the communication protocols between the DSO and service providers need to be determined.

At the same time, telecom operators and their investments are developing in Turkey. For instance, Türk Telekom, which has invested 6.7 billion Turkish liras in 2020, has determined its 2021 investment forecast as approximately 7.7 billion TL. Especially the COVID-19 pandemic with the transition of many companies to remote working and the continuation of education in the virtual environment brought the need for strong infrastructure and uninterrupted service. Turkish companies, which have already started 5G investments before COVID-19, are expected to continue their efforts. It would be beneficial for these investments to play a role in the integration of the telecom and energy sectors.

Figure 48: *Extent of technological infrastructure barrier on business models*



The supply aggregator and P2P operator models are the most negatively affected business models by the technological infrastructure in Turkey. This could be due to the fact that the P2P model necessitates a blockchain-based platform that allows energy trading between parties; however, such a platform/software is still in its planning phase in Turkey. Moreover, supply aggregators, also known as virtual power plants, combine different energy supplies through a centralized IT system, a system consisting of all of the components of the technological infrastructure, such as smart meters and energy storage systems for hardware and analytic tools for software. Demand aggregators benefit from IoT and AI technology for energy optimisation purposes. Although the community ownership model enables the purchase of community-shared battery systems, along with other energy-related assets, and the need for better data management, the technological infrastructure in Turkey does not pose a severe challenge for the model's adoption.

6.6 Grid planning and infrastructure

6.6.1 Grid planning approach

Power system planning has become a challenging exercise that requires new methodologies and tools to help utilities prioritize grid investments. Technology is transforming the edge of distribution systems, where customers are no longer seen as "static loads" with predictable growths; instead, they make individual decisions that affect the distribution grid, for example by actively changing their loads, reacting to prices and tariffs, or adopting PV and storage technologies. In addition, the electrification of important sectors of the economy and society (government, health, information, industry, etc.) has made power distribution vital for our communities, requiring the grid to be reliable and resilient in many uncertain scenarios (Berkeley Lab Grid Integration Group, 2021a).

In Turkey, with increasing use of distributed energy sources and electrification trends, discussions have begun on whether the grid infrastructure can tolerate this change. As solar and wind power add larger shares to Turkey's electricity mix and with higher integration of EVs, grid management and planning will become more important than ever. Currently in Turkey, electricity networks are relatively old and mostly above ground. Also, maintenance and operation of the grids are not optimized with a holistic approach and with a tight planning of how to manage the calendar, posing a risk of power outages. Scope of the distribution network planning should be made to include distributed generation, new forms of demand, and flexibility options. Grid development plans, prepared biennially, should provide transparency on the medium- and long-term flexibility services needed, and outline planned investments for the next five to ten years. Emphasis is placed on the need for a new distribution infrastructure to connect new loads with new generation capacity, including charging points for electric vehicles. The grid development plan should also include the use of demand-side participation, energy efficiency, energy storage facilities or other resources that the distribution system operator would use as an alternative to system expansion (SHURA, 2021b).

6.6.2 Improvement of distribution and transmission network cooperation

Fundamental questions about the future role of distribution companies and their relationship with the transmission system operator relate to the shift of generation capacity from the transmission to the distribution grid and the increased reliance on services generated through distributed generation resources and local markets.

Congestion management schemes have traditionally been treated in the transmission system level. But with the widespread use of DERs and expected severe loading conditions, the management procedure will have to be applied in the distribution network as well. Therefore, it is critical to determine the cooperation between TSOs and DSOs with the regulations and to define the tasks such as administrative processes, product features and cost sharing issues. The congestion management can be managed jointly between the distribution company and the transmission system operator with different approaches. No matter which, the biggest advantage here is the fact that the transmission system operator and distribution company can jointly optimize the congestion-related requirements and thus ensure a competitive market for the flexibility providers by reducing the total cost.

6.6.3 Lack of smart-grid approach

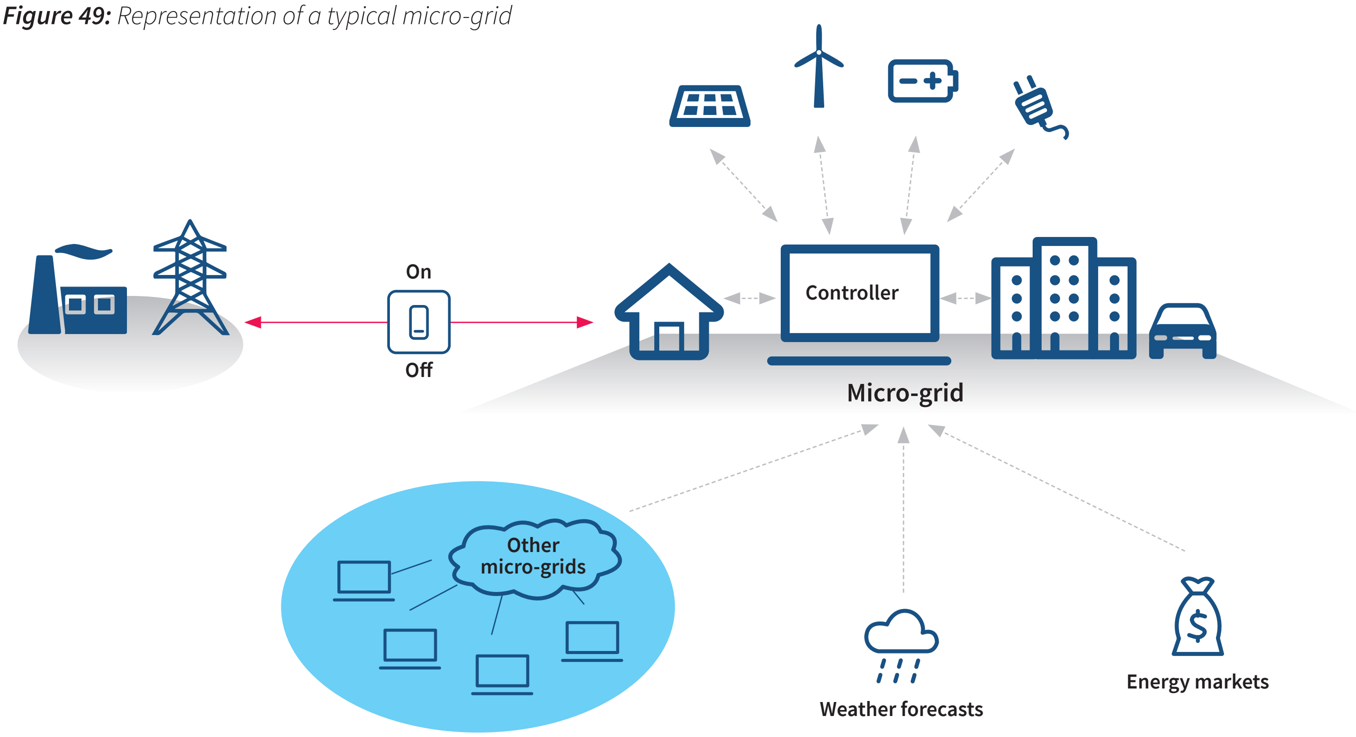
Successful transition to actively managed grids will be possible if distribution companies attach importance to digitalisation for both grid management and market operations. Firstly, investing in smart grids would adapt the grid to the diverse generation landscape and ensure reliable and secure energy grid functioning at all times. Moreover, market participants would build their business model on the functionalities of smart grids, which also endorses the role of the market-facilitating network operators. In the end, end-consumers are the real beneficiaries of the smart grids due to a reliable, affordable network and the possibility of profiting from various energy products and services from different market parties (CEDEC).

To realise the benefits of smart grids for different parties of the energy system, requirements include installation of smart meters, consumer access to consumption data, and common sensor and big data analytics applications for real-time monitoring of the network and transparency of network capacity and constraints through market platforms. In this manner, distribution companies need advanced monitoring and data supply processes for instant surveillance, control of network assets and smart management of the supply process. However, despite the widespread use of sensor technologies in Turkey, the smart grid approach is still not at an adequate level. Thus, the innovative solutions such as energy management activities of Aggregators and EaaS companies, smart contracts involved in P2P models, V2G solutions/smart charging of EVs or the offerings using dynamic tariffs -demand response- encounter a bottleneck in the process.

6.6.4 Lack of alternative grid approaches

Micro-grids are local and autonomous electricity distribution networks made up of Distributed Energy Resources (DER), including storage assets and loads. Projects today range from a few kW to hundreds of MW. In a rapidly evolving energy environment, micro-grids are the right solution to bring local and decentralized generation into a large, centralized grid, and also to create self-contained electrical networks.

Figure 49: *Representation of a typical micro-grid*



Source: Berkeley Lab Grid Integration Group

For Electrical Services, investing in the micro-grid makes sense for multiple reasons:

- Electrification of an off-grid area
- Prioritizing local and green generation for environmental reasons
- Political reasons such as ensuring continuity of service in areas exposed to attacks on the main grid

Micro-grid projects differ mainly in their size or main objectives:

1) Micro-grids connected to the main energy grid

If it is connected to the mains, the micro-grid does not need to consider the frequency and voltage regulation. Therefore, the micro-grid controller will only have to deal with Energy Management System (EMS), including energy issues and optimization.

Among more than 400 micro-grids announced around the world, some can be categorised under connected micro-grid model. Examples are Tesla micro-grid aiming to optimize the behaviour of a 1.4 MW solar farm in American Samoa with 6 MWh batteries, or California micro-grids aiming to relieve very congested transmission lines with large projects such as 10 megawatts (Energy Pool, 2020).

2) Island micro-grids

In island micro-grids, distributed generators should manage the stability of frequency and voltage control. In fact, unlike connected mode, distributed resources will no longer operate in grid-connected mode but in stand-alone mode. In the stand-alone mode, a micro-grid is isolated from the main grid, so they have to create the voltage wave.

Island micro-grid projects with no connection to the main grid are mainly located in Africa and the islands. Examples of these grids are "Hybrid Solutions Deliver Energy and Cost Savings for Mauritania" with 1,300 kW solar power and 5,000 kW diesel and gas power, or "La Palme Canary islands micro-grid" which aims to promote renewable energy integration instead of diesel generator set (Energy Pool, 2020).

Given all the benefits and examples in the globe, micro-grid approach is not common in Turkey. One of the main reasons is that there is no legislation that will allow micro-grids to be implemented. An example of micro-grid initiative can be shown in Philippines. The Electric Power Industry Reform Act passed in 2001 contained provisions specifically intended to allow mini grids to operate in unserved parts of the country. However, it took until 2006 for the regulator to issue the necessary rules to implement this provision. These rules included requirements for designation of unserved areas by the authorities, followed by public hearings and a commission decision to allow a mini utility to operate. In the five years since the rules were promulgated, only one company (Power Source) has managed to negotiate the regulatory red tape and become legally qualified to serve the market. The other micro-grids remain illegal. As a result, they cannot access finance, nor can they grow or formalize their operations, for fear of attracting attention from the authorities. In Kenya, the Energy Act 2006 provides that energy undertakings with a capacity of less than 3 MW do not need licenses, only permits. This is presumably intended to facilitate mini grids. But the rest of the act makes little distinction between licenses and permits in terms of requirements or procedure (International Finance Corporation, 2013).

6.6.5 Voltage regulation

Due to the passive nature of distributed generation, it can present technical difficulties after a certain level of proliferation, both in the distribution grid and in the overall electricity system. Being one of the most important technical issues, with the amount of distributed generation increasing at the LV (low voltage) level, energy flows become two-way, that is when local generation at a feeder exceeds demand, the energy flow will be towards higher voltage grid elements/transformers. These distribution transformers are the connection points that are calibrated with respect to the minimum and maximum old load, and they cannot be easily adapt to the additional fluctuations created by renewable energy generation (SHURA, 2021b). That is, there used to be a transformer structure that only supported consumption in the past. With the energy transition, transformers may not be able to handle it in places where there will be a lot of small generation because DERs, causing an increase in voltage, might violate the limits of the maximum voltage that the grid can accommodate.

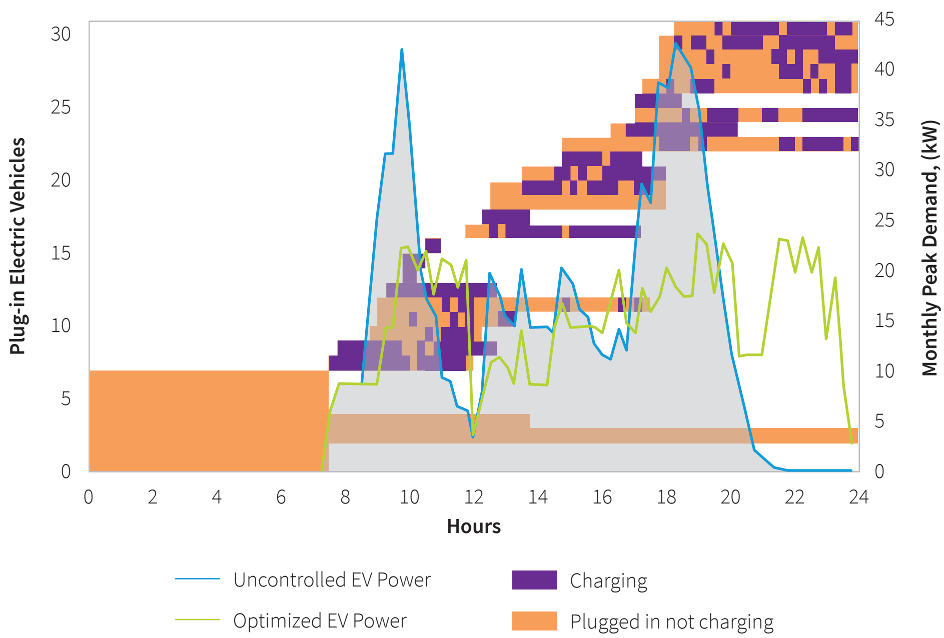
When the above-mentioned reasons are considered, with DERs, some areas may require serious replacement of transformers. By replacing transformers, the grid is aimed to be flexible enough to see both the highest voltages and the lowest voltages. Many countries have encountered problems of continuing to operate with DERs for voltage and frequency balancing during emergencies and have begun to modify their new solar PV installations accordingly. To illustrate, the USA changed the connection standard (IEEE 1547) in 2018. This change has since become a national requirement that applies to all DERs connected at typical primary or secondary distribution voltage levels (except California and Hawaii) (Nagarajan, 2018).

6.6.6 Load increase in the system with EVs

In the near future, with the further increase of electrification (use of electric vehicles, etc.) in addition to distributed generation, distribution networks need to take a more active role, acting as neutral market provider and facilitator, in the development, management and operation of networks. In order to reduce the investment requirements arising from the increase in the peak load in the grid that comes with the electrification in the transportation sector, distribution companies should encourage demand aggregators and/or direct electric vehicle owners to create demand-side flexibility and shift peak demand through the use of smart charging. Also, emphasis should be placed on the need for a new distribution infrastructure to connect new loads with new generation capacity, including charging points for electric vehicles (SHURA, 2021b).

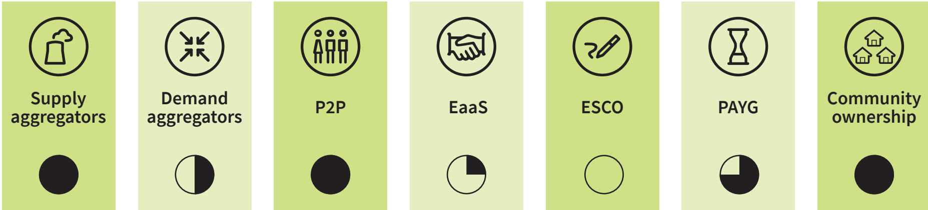
Beyond minimizing the impact of electrified transport on the grid, EVs can benefit the grid by providing needed grid services and demand response (DR) resources. The uncertain impact that REs and EVs will have on net loads (i.e., the "duck" curve) requires automated control of DR resources. Among the plenty of research on the issue, Grid Integration Group of Berkeley Lab focuses on EVs as storage and vehicle to grid integration, EV smart charging and DR, Automated DR technologies, tools, and standards. In one of their works, the smart charging control system was applied to a fleet of approximately 50 EVs owned by Alameda County and to charging stations that are used both by Alameda County vehicles and by the public including a DC fast charging station capable of charging at up to 50 kW. The project supplements Alameda County's existing infrastructure investments by adding systems for intelligent optimization of EV charging rates and schedules, simple EV owner engagement, and control algorithms to create a flexible, modular, and scalable solution for smart charging of existing and future fleet and public EVs. The demonstration below leverages the inherent flexibility in the time and rate of EV charging to decrease utility electric costs of EV charging (Berkeley Lab Grid Integration Group , 2021).

Figure 50: *Monthly peak demand created by smart charging vs. uncontrolled charging, kW*



Source: Berkeley Lab Grid Integration Group (2021)

Figure 51: *Extent of grid planning and infrastructure barrier on business models*



Supply aggregators, P2P operators and community ownership models are the most affected business models by the grid planning and infrastructure in Turkey. Especially the need for smart grids and micro-grids approach arises for these models to enable trading among peers and to add a value to the system. Furthermore, the voltage regulation comes to the forefront as being the most potential risk of DERs, which form the basis of these models at the distribution level. On the other hand, for EaaS model adoption, involving individual energy solutions for end-consumers, the grid planning and infrastructure does not pose a severe challenge in Turkey.

6.7 Urban development

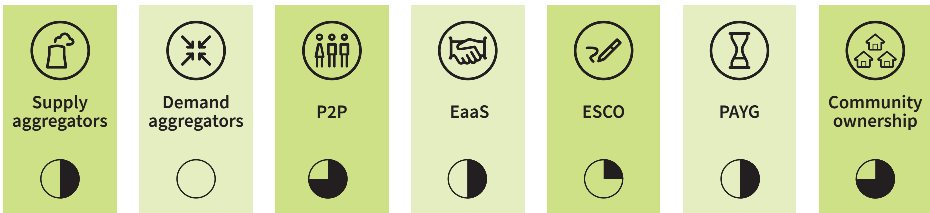
Important global trends such as the growing population, especially in the middle-class, and the demand for comfortable lives have increased the migration to urban areas. As inhabitants of rural areas pursue the same path towards greater urbanisation, their per capita energy consumption is rising substantially with increased demand for energy services, including heating, cooling, lighting, power, and transportation (Reuters , 2019). To meet the increased demand in urban areas, increasing energy resource capacities or efficient use of existing energy resources have gained importance. Provided that electrification trends are in place, meeting the required energy generation from renewable energy sources instead of fossil fuels is indispensable for global decarbonisation targets.

To electrify the urban areas and meet the increased energy demand with greener energy resources, proliferation of renewable energy and electrification trends (e.g., heat pumps and EVs) are highly dependent on building the required infrastructure. However, in Turkey, a country with a lot of urban transformation projects, innovative energy projects may be interrupted due to the increase in vertical structuring, and the fact that urban transformation projects are not planned in a way that regards the installation of renewable energy, and infrastructure requirements. In an example to urban planning considering the energy projects, the collected experiences of horizontal planning in Sweden have been put into action by Sweden Green Building Council through the development of CITYLAB. CITYLAB does not replace existing planning systems in municipalities but rather supports the cooperation and experience exchange between different actors and projects. For this purpose, a guideline has been developed. CITYLAB primarily supports urban development projects in formulating sustainability targets and ensuring that those targets are achieved within the urban planning process. Considering all the areas, “Energy” comes to the forefront as a focus area to be handled in CITYLAB GUIDE (Wennersten, 2018). Such practices regarding energy transition involvement in urban transformation planning should be a priority in Turkey as well, for both achieving maximum efficiency from distributed energy sources such as solar PV proliferation and for electrification targets including widespread use of EV charging stations and heat pumps.

As another result of increased urbanisation, unbalanced population distribution in Turkey is prevailing. The population concentrated in certain regions, especially in Istanbul and Ankara, triggers unplanned urbanisation and have negative consequences in the implementation of energy projects. Considering the construction, geographical conditions, and consumer habits in Turkey, the allocation of necessary areas for renewable energy and electric vehicle charging stations happens to be inadequate for the implementation of these projects. In the current situation in Turkey, most of the households generally prefer apartments to live in, where the common areas are limited. As a result, even though all requirements are satisfied, the limited space for asset installation in the urban areas constitutes a barrier to the innovative business models.

Considering the roof-top solar energy systems in Turkey, assuming that 15% of the total housing stock was compatible with roof-top PV systems 10 years ago, 1 out of every 4 residential buildings can be used for solar PV installation today. Despite the increase, it is revealed that the existing buildings are insufficient to meet the space requirement, considering that the majority of the residential buildings are apartments. Currently, only about 15% (0.9 GW) of the 6 GW solar capacity of Turkey is provided by rooftop PV systems, mostly in commercial, public, and industrial buildings (SHURA, 2020b). Given the facts, the share of rooftop PV in the total solar energy generation is expected to increase in the future, especially with the contribution of residential installations with a proper urbanisation planning.

Figure 52: *Extent of urban development barrier on business models*



When the urbanisation effects on the innovative business models are considered, it is suggested that community-owned projects may experience the most harm due to its large space requirement for renewable installations. Therefore, community ownership model is likely to be seen in rural areas which is suitable both for energy asset installations and for energy deliveries to rural communities. The urbanisation and the area insufficiency for the energy trends would also hinder the potential of EaaS model that can play a role in residential energy management including the energy generated by roof-top PV solar panels. Moreover, ESCO projects that support unlicensed energy generation of especially large energy consumers, and P2P model in which solar PV energy generation and electric vehicles can play a role in peer-to-peer trade might be highly affected by increased urbanisation.

7. Conclusion

In line with technological advancement in energy industry around the globe, a significant transformation is being experienced, driven also by the ambition to respond to climate change. Turkey, as one of the fastest rates of growth in energy consumption and GHS emissions, is also part of this transformation. The components leading energy transformation particularly include energy efficiency, rapid scale-up of renewable energy resources and electrification. Information and communication technologies, digitalization, innovative policies, market instruments and financing models are among the other factors that support this transformation.

Concurrently with the transformation in energy systems, digitalization initiatives and digital technologies facilitating transformation in the electricity sector value chain are also becoming more widespread. The widespread adoption of digital technologies in the energy sector leads to a transformation in the internal operations of enterprises themselves, while also increasing the value creation potential and allowing the creation of new business opportunities.

Innovative business models focused on digital technologies, which are comprehensively discussed in this report, are viewed as a solution to take advantage of the opportunities brought about by energy transformation and to deal with potential difficulties. The facilitating effects offered by digitalization allow for the emergence of new business models that will accelerate the energy transformation. Although the business models introduced newly at the global scale offer the opportunity to improve the energy system in many ways, they are either not implemented at all or implemented at a limited extent or fail to realize their full potential due to certain obstacles. As a result of the research conducted and stakeholder meetings held during the preparation of the report; potential obstacles that could arise in the introduction of new business models in Turkish energy sector were analysed specifically with regard to existing market structure, legislation, socio-cultural conditions, financial conditions, technological infrastructure, grid planning and infrastructure, and urban development. In order to develop recommendations for the elimination of potential difficulties identified, these obstacles have been analysed in detail and conclusions have been presented comprehensively.

Although it is possible to argue that potential obstacles affect almost all business models, it appears that the extent or impact of these obstacles could be different in each business model. The P2P model stands out as the most affected one, therefore being the most difficult to implement in Turkey, having the highest level in each category, except urban development, when compared to other models. This is because this model requires a structure supported by both technological and grid infrastructure and related regulations, in which market participation is ensured and consumers are allowed to consciously sell/buy the energy obtained from smart grids on a platform. This is due to the fact that this model necessitates a structure supported by relevant regulations and both the technological and grid infrastructure where market participation is enabled, and consumers are allowed to sell/purchase energy derived from smart grids deliberately on a platform. Consumer participation also requires a certain level of awareness and recognition of the benefits offered by the business model. However, as in the case of P2P operators, EaaS and ESCOs are also the most affected by socio-cultural conditions since these models necessitate efforts and active participation of consumers. On the other hand, the EaaS model, involving individual energy solutions for end-consumers, is believed to offer the most potential for implementation, with legislation and grid planning being the least influential barriers and having a below average impact. Furthermore, it is seen that the extent of urban development barrier is the lowest when compared to other barriers, but it poses a significant threat to the community ownership model. The vertical structuring in Turkey prevents the installation of smaller renewable energy sources, which is the key requirement of the C-O model. Moreover, although there are differences between the categories, it is understood that the supply and demand aggregators are affected at the same rate when considered collectively. It is understood that these models have difficulties in becoming widespread since they are not defined in the legislation which prevents them from participating in the market by trading activities to support balancing activities. In addition, the low predictability of the market and subsidised electricity prices hinder the creation of potential value to the industry. Moreover, aggregators are the most negatively affected business models by the technological infrastructure since the needed technologies are still not fully adopted in Turkey. Supply aggregators benefit from a centralized IT system consisting of all the components of the technological infrastructure, while demand aggregators benefit from IoT and AI technology, highlighting the importance of software.

The detailed analysis of the obstacles to the implementation of new business models gives a comprehensive idea on how to overcome these obstacles. Complementary to the views discussed here, steps that can accelerate the integration of new business models brought about by energy transformation in Turkey into the energy sector are discussed below.

Existing market structure

The effective functioning of any business model depends on the correct functioning of each the dynamics making up the market individually (especially the aspects affecting competition). In a highly regulated sector such as the energy sector, it is critical to ensure that competitiveness and market surveillance aspects function efficiently, while regulated areas to not negatively affect competition on the other hand. Recommendations for addressing the barriers relating to existing market structure discussed in Section 6.1 are presented below.

- It should be essential that energy prices are determined in a manner that covers all costs. Subsidies provided to end consumer prices should be avoided to the extent possible, and direct support should be provided to vulnerable consumer groups who are in need of support.
- It should be ensured that the prices formed in the wholesale markets are determined according to the supply-demand balance that will occur under actual conditions,value of lost load calculations should be taken as a basis in setting the price caps that will negatively affect price predictability, while avoiding other price interventions.
- With regard to the continuity of the support provided for rapidly developing technologies (such as renewable energy resources) in case the cost reductions in these technologies reach competitive levels in the market, they should be competitively placed in the markets. It should be considered that the direct incentives provided may create an obstacle to new business models after the need for incentives does not exist anymore.
- The imbalance penalties incurred by market players should reflect the actual cost of imbalance. Deterring imbalance costs that will encourage market participants to reduce their own imbalances, will pave the way for innovative business models.

- It should be ensured that energy commodity prices are determined competitively, and it should be essential that regulated tariffs are minimized. Time of Use and dynamic tariff options may be offered if regulated retail tariffs are applied.
- Instantaneous generation/consumption requirements cannot be taken into account in the monthly net metering practice, which is currently used in unlicensed electricity generation, hence there exists no incentive for eliminating imbalances. After some distributed generation integration, the monthly net metering practice may be replaced by different methods that will take into account the actual costs of the system.
- The costs of energy surveillance devices, smart meters and other equipment required to maximize the value offered by new business models could be allowed to be reflected in tariffs.
- Legislative amendments should be introduced so that consumers can become active players in the market.
- Although it is important to provide reserve capacity for system reliability and implement a capacity mechanism to assure this, the capacity mechanism should be re-visited in a way that highlights flexible resources and should have a structure that does not create inefficiencies.
- The Intraday Market is particularly important in terms of the effective functioning of all wholesale markets and the reduction of imbalances in renewable resources among them, so that new business models can be operationalized. If the transactions in this market take place in time periods closer to the real time, it will be possible to trade the imbalances that occur, which will enhance the accuracy of generation forecasts decrease imbalances in the market. In this context, the gate closure times of trades in organized wholesale markets should be reduced to a level close to real time.
- Although the practice of Balance Responsible Group (BRG) is a good instrument for managing financial imbalances, it can have negative consequences in terms of physical balancing and inflict additional costs on the system operator. The definition of BRG could be revised and obligations could be introduced in terms of physical balancing.
- As organized industrial zones have the right to establish and operate distribution facilities in their own regions, to distribute electrical energy and to perform other related services, the success in the implementation of innovative business models in these regions could be limited to the success of OIZs in that area. The constraints and benefits related to this issue should be re-evaluated in the future.
- Generator companies should be allowed to become active market players in electricity trade executed through distributed generation method.
- The legislative work to pave the way for the use of battery technologies at the grid scale and behind the meter should be completed and incentives should be provided to support this technology, which is not yet competitive.

Legislation

Since the energy sector is highly regulated, relative to many other sectors, most of the activities in this sector are carried out in compliance with the provisions of the legislation. There is a need to develop new legislation in order to implement some of the new business models discussed in this report. Furthermore, along with definition of new areas, it will also be necessary to ensure alignment with the legislation in force and/or improve its enforcement. The steps that need to be taken in the field of legislation, for the implementation of new business models, are summarized below.

- It is important to review and harmonize the regulations that cause inefficiencies in the current legislation, not only for the introduction and effective functioning of new business models, but also for the effective functioning of existing practices in the energy sector. This will also allow the regulator to identify responsible parties and improve their communication and coordination.
- Undertaking the investments to pave the way for new business models in the energy sector are subject to bureaucratic processes. In particular, there is a need to simplify the defined bureaucratic processes for implementing unlicensed solar power plant investments. Simplifying the existing 9-step lengthy bureaucratic process for getting permits for establishment of solar power plants, which tales 4 months, would also be useful in increasing the motivation of consumers to adopt new practices regarding energy.
- The implementation of new business models will require the creation of many new concepts, the development of necessary regulations relating to them, and the development of practices that will make sure that these new regulations will be enforced on the ground.
- Definition of new concepts and a framework of responsibilities will facilitate the dissemination of these models; aggregators and the build-operate-transfer model should be clearly defined in the regulations, the regulations on energy storage activities should be improved to include small participants and to allow the sharing of excess energy. Finally, although the term ESCO has already been defined, the mechanisms such as the arbitration mechanism required by this model should also be incorporated into the regulations.
- Digitalization applications in energy require significant technical infrastructure and implementation. Rapid adoption and reliable operation of value-added systems require establishment of the technical standards of such systems and the authorization of third parties to supervise these systems. Certification of EPCs with qualification prerequisites to ensure institutionalization after the relevant training and testing will also secure the success of energy projects and will help ease the burden of auditing each EPC application of distribution companies.

Socio-cultural conditions

Even if technological facilities are offered, the widespread implementation of business models will only be possible if energy system users believe in the benefits of energy transformation and demand new services. For the energy transition to be fully adopted in Turkey, it will be critical for consumers, industry players and public institutions in the market to reach a certain level of awareness. This could be achieved by providing trainings on digital literacy skills, the energy transformation itself, and the potential benefits of new business models. Moreover, collaboration of industry players to develop user-friendly solutions minimizing the operational effort required by end-consumers is of high importance. This would also allow cooperation between new and existing industry players, improving the competitive environment of the market. The endeavor of the public sector is also believed to be crucial; development of a consistent and long-term roadmap for the industry and its transparent sharing would motivate new models to emerge. The examination of global cases and applications could be advantageous during the preparation of the roadmap. Lastly, the acquisition and retention of qualified workforce is significant for the industry to progress, and measures must be taken to achieve this.

The actions recommended in the sociocultural field are listed below:

- Programs should be developed to increase the digital literacy levels of energy consumers.
- Programs should be implemented to increase the level of public awareness on energy transformation.
- It is crucial to raise awareness among commercial and industrial consumers about the benefits offered by energy transformation.
- Due to the leading role of the public sector in the energy industry, roadmaps with clear objectives regarding energy transformation and the application of new digital technologies in the energy sector should be developed, shared with the public and their implementation should be followed up closely.
- In order to improve the competencies of employees in the sector, training programs should be delivered on professional subjects, particularly including software development.
- Importance should be attached to retaining the labor force and supports and incentives should be provided to ensure that all human resources, especially R&D personnel, are satisfied with their work.

Financial conditions

The implementation of any investment and its supporting business models requires a proper set-up of financial conditions. The obstacles brought by the financial difficulties in the energy sector delay the implementation of new business models and increase the need for new solutions. Innovative models that include technical/credit risk hedging mechanisms would be crucial in the spread of business models, especially for ESCO companies. To alleviate the financial and performance-based risks of these projects, a guarantee and insurance mechanism can take place, which ultimately would reduce the amount of collateral the banks collect from project-owners. Moreover, the financial incentives are of high importance for potential investors who struggle with high upfront costs of energy assets, infrastructure, or technology, as well as currency pressure and limited budgets.

The recommendations for improvement of financial conditions, one of the most critical areas in implementing new business models, are presented below:

- Providing the financial conditions required for the realization of new business models will only be possible if basic parameters such as inflation, exchange rates and commodity prices are predictable.
- Incentives for potential investments should be defined due to the high initial investment costs of new facilities and infrastructures that will enable new business models. However, as mentioned earlier, it is also important to terminate obsolete incentive mechanisms in a timely manner.
- It could be considered to provide the necessary budgets for the installation of critical technological infrastructures required for digitalization applications in energy, in the tariffs.
- Coordination should be ensured between the banking and energy sectors to provide the financing opportunities needed by the energy transformation.

Technological infrastructure

Transformation of the energy sector and digitalization of the sector require a substantial technological transformation. the following steps should be taken to make this technological transformation possible:

- Dissemination of three technological applications that will support the transformation in the energy sector –i.e., internet of things, smart meter infrastructure and battery storage– should be supported.
- In order to determine the standard meter requirements and implement pilot applications, the roadmap created for smart meters in the "Smart Grid Roadmap of Turkey" should be followed.
- The minimum limit for the installation of AMRS should be reduced to increase adoption of remote metering applications.
- Necessary steps should be taken towards regulatory adjustments for the determination of the energy storage systems' role in networks as well as their ownership rights as well as the establishment of an all-inclusive environment where the power limitations of smaller consumers are reduced.
- Standards and reference-language should be determined for software and data sharing; processes for data validation and quality control should be developed and supported by changes in regulations to resolve conflicts with the Personal Data Protection Law.

Grid planning and infrastructure

In Turkey, with increasing use of distributed energy sources and electrification trends, discussions have begun on how the grid infrastructure will transform. Going forward, it is clear that the scope of distribution grid planning should include distributed generation, new forms of demand and flexibility options. The steps required to be taken so that the grid infrastructure develops in a manner that supports new business models are listed below:

- Grid development plan should include demand-side participation, energy efficiency, energy storage facilities or other resources that the distribution system operator will use as an alternative to system expansion.
- Distribution and transmission system operators should increase their cooperation and coordination for grid development planning purposes.
- Holistic plans should be prepared, and implemented, for smart grid development. In this context, practices like smart meter installation, consumer access to consumption data, real-time monitoring of the grid, common sensor, and big data analytics applications, and addressing of grid capacity and restrictions through market platforms should be handled under the smart grid umbrella.

Urban development

Finally, to electrify the urban areas and meet the increased energy demand with greener energy resources, proliferation of renewable energy and electrification trends (e.g., heat pumps and EVs) are highly dependent on building the required infrastructure. Provided that Turkey is a country with a lot of urban transformation projects, authorities should consider the energy transition involvement in these projects for both achieving maximum efficiency from distributed energy sources such as solar PV proliferation and for electrification targets including widespread use of EV charging stations and heat pumps. Consequently, the compatibility of new constructions with the application of technologies such as rooftop solar PVs, battery systems, electric vehicle charging stations and heat pumps will pave the way for the widespread dissemination of these innovations.

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NOTES

About Istanbul Policy Center at the Sabancı University

Istanbul Policy Center (IPC) is a global policy research institution that specializes in key social and political issues ranging from democratization to climate change, transatlantic relations to conflict resolution and mediation. IPC conducts its research activities under three main clusters: IPC-Sabancı University-Stiftung Mercator Initiative, Democratization and Institutional Reform, Conflict Resolution and Mediation. Since 2001, IPC has provided decision makers, opinion leaders, and other major stakeholders with objective analyses and innovative policy recommendations on matters relevant to its field of expertise.

About European Climate Foundation

The European Climate Foundation (ECF) was established to help Europe become a low-carbon community and to play a strong international leadership role in climate change response. ECF focuses on "how" the transition to a low carbon society will take place, by staying away from all kinds of ideologies. As part of its collaboration with its partners, ECF aims to contribute to these discussions by revealing the pathways that will play a key role in this transition and the results of different alternatives.

About Agora Energiewende

Agora Energiewende develops data-driven and politically feasible strategies to facilitate a successful transition to clean energy all around the world, particularly in Germany and Europe. As a think-tank and policy laboratory, Agora ensures a constructive exchange of ideas, while also aiming to share its knowledge with stakeholders from the world of politics, business and academia. As a non-profit and donor-financed organization, Agora is dedicated to climate change response, rather than corporate and political interests.

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