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Abstract

Technology is considered to be one of the core building blocks in solving the problem of climate change. Current studies on climate change demonstrate the increasing importance of scientific and technological trends that will shape the future of the world. Energy system technologies, in particular, are of great importance as they lie at the very heart of the climate change problem.

On the other hand, to achieve the net-zero emission targets announced by many countries, including our country, it is necessary to ensure the dissemination of existing clean technologies, develop and introduce new technologies to the market and provide technical and financial support to developing countries to reduce emissions. Delaying the dissemination of these technologies will cause economies to continue their carbon-intensive growth paths despite the climate crisis. This situation will make it difficult to achieve emission reduction targets over time.

Accelerating R&D and investment activities in clean technology right after Türkiye became a party to the Paris Agreement and announced its net-zero emission target emerges as a economic and environmental priorities.

Times of crisis are also times of opportunity. Climate change, which has been defined as a crisis recently, is critical not only for the development of clean technologies but also for a radical change in production and consumption processes. In this context, risks and opportunities related to the climate crisis should be addressed in a holistic way and the process should adopt a win-win approach with effective and inclusive policies.

It is necessary to move beyond the existing policies on low-carbon technologies in order to minimize the impact of green transition in our country and use the process as an opportunity. Such technologies should be supported under all subheadings and throughout the entire technology cycle, and in order to do this, effective mechanisms including financial ones, should be created and activities with concrete indicators in line with designated targets should be carried. In this context, the very first step to take is to set a technology roadmap regarding the transition that will take place within the framework of the 2053 net-zero emission vision. In addition, it is essential to improve national and international cooperation on technology. The participation of the private sector in R&D efforts and improve the public-university-private sector cooperation in these areas should be increased. Lastly, it is of utmost importance that international financing is mobilised in a stronger way for the dissemination of technology efforts.

Türkiye has made significant advances in technology in the green transition process, which is seen as a solution to the climate change problem. It is needed to identify the related strategies and policies required by these change with all institutions. The development and dissemination of these technologies will provide an opportunity not only for the fight against climate change but also green transition of our country.

Keywords

Clean technology, Climate change, Net-zero emission, Green transition, Low-carbon technologies

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1. Introduction

1.1. The Role of Technology in the Fight Against Climate Change

The climate change problem is not like any other environmental problem both because of its scale and being related to the future. One of the points making the fight against climate change harder is that a naturally global problem cannot be solved with local precautions and implementations, thus requires global cooperation, and the other point is that the problem covers many topics such as energy, trade, industry, development, investment, and education. In this context, the greatest indication that the climate change problem is recognized globally and the global will to solve this problem is created is the adoption of the Paris Agreement in one day with the approval of all countries and the announcement of the net-zero emission target of more than 140 countries today.

Technology is considered to be one of the core building blocks in solving the problem whether it is the mitigation of greenhouse gas emissions that cause climate change or the climate change adaptation. Current studies on climate change demonstrate the increasing importance of scientific and technological trends that will shape the future of the world. Energy system technologies, in particular, are of great importance as they lie at the very heart of the climate change problem.

Technology simultaneously serves the 3 pillars of the concept of sustainability: the environment, economy and social matters. In recent years, governments have considered technological innovations as the solution to environmental pollution and a way of increasing the competitiveness of national economies (Montalvo, 2008). Countries attach great importance to clean technologies for reasons such as achieving green development, transforming carbon-intensive production structures, and keeping environmental pollution under control (Lapercheve et al., 2012).

The transition from energy-intensive industry to technology and information-intensive industry increases the importance of technology even further. Furthermore, as countries move to high-income groups, the manufacturing industry (especially chemistry, metal, and plastics) increases its emission performance. As transited to cleaner technologies, the emission rates per added value of these sectors get closer to those that are less polluting, such as machinery and motor vehicles (UNIDO, 2015; Dinçbaş, 2017).

With environmental policies, there is a flow from polluting to less polluting or non-polluting technology within the scope of technological change (Vollebergha and Kemfert, 2005). In many parts of the world, adapting new technologies has resulted in a notable improvement in natural environment (Dinçbaş ve Yiğitbaşıolu, 2017). The potential of technological change to produce new solutions to today's economic and environmental problems is obvious. For example, when alternative technologies are introduced, the increasing energy demand will be met with less carbon or carbon-free with new technologies (Bretschger, 2005).

In order to achieve the necessary emission reduction towards net-zero emission, it is necessary to ensure the dissemination of existing clean technologies, introduce new technologies to the market and support developing countries technically and financially in this regard in order to achieve the necessary emission reduction. Delaying the dissemination of these technologies will cause economies to continue carbon-intensive growth despite the climate crisis. This situation will make it difficult to achieve the emission reduction target over time (WBCDS, 2009).

According to the Intergovernmental Panel on Climate Change (IPCC), annual average emissions reached the highest level in human history between 2010-2019, but the rate of emission growth has started to slow down. Unless deep emission reductions are achieved globally and in all sectors immediately, the 1.5°C target remains far from reach (IPCC, 2022).

According to the International Energy Agency, a reduction of 35 $GtCO_2e$, which is 70% of the amount of emission that need to be reduced by 2050, can be achieved through existing technologies. 30% of the needed emission reduction depends on new technologies such as carbon capture and storage and reduction costs per unit ton of CO_2 are quite high (WBCDS, 2009; Dinçbaş, 2017). It has been calculated that there is an emission reduction potential of 3.8 $GtCO_2eq$ with the use of wind energy and 4.5 $GtCO_2eq$ with the use of solar energy by 2030. The unit cost of more than half of this reduction amount is less than $\$20/tCO_2eq$. According to the IPCC, the unit costs of low emission technologies such as wind, solar energy and batteries have decreased by approximately 85% since 2010 and this makes the transition to the low emission energy sector possible by 2030. 2 $GtCO_2eq$ reduction with fuel conversion technologies, 3.5 $GtCO_2eq$ reduction with carbon sequestration in the agriculture sector and 4 $GtCO_2eq$ reduction with preventing forest and ecosystem destruction, all of which have a unit reduction cost between $\$20\text{-}200/GtCO_2eq$, can be achieved. On the other hand, it is possible to reduce 40% of methane emissions from fossil fuels with the help of existing technologies in a way to be less than $\$50/GtCO_2eq$ unit cost (IPCC, 2022; Dinçbaş, 2021).

Clean technologies develop and mature at different paces and speeds like other technologies as well. An explosion has been observed especially in information processing technologies, environmental and energy technologies since 2005. According to the OECD, the percentages of the developed environmental innovations by country are as follows: 28% by the EU, 21,1% by the USA, 21% by Korea, 15,5% by Japan, 12,6% by Germany and 3,9% by China (OECD, 2022a). The USA, Japan and Korea, which are among the largest economies, led to the rapid development of these technologies between 2010-1012. Although it varies by field, these three countries have 40-80% of all patents. China is the only developing country among all developed economies that dominate this field (Dinçbaş, ve Yiğitbaşıoğlu, 2017). Germany, on the other hand, draws attention especially with patents in the fields related to emission reduction technologies (OECD, 2015).

Considering the shares of environmental technologies patents in total patents in 2019, as seen in Figure 1, while this rate was 5.9% in our country, it was 8.8% in the USA, 8.7% in China, 12.9% in the EU (27) and 10.4% in the OECD (OECD, 2022b).

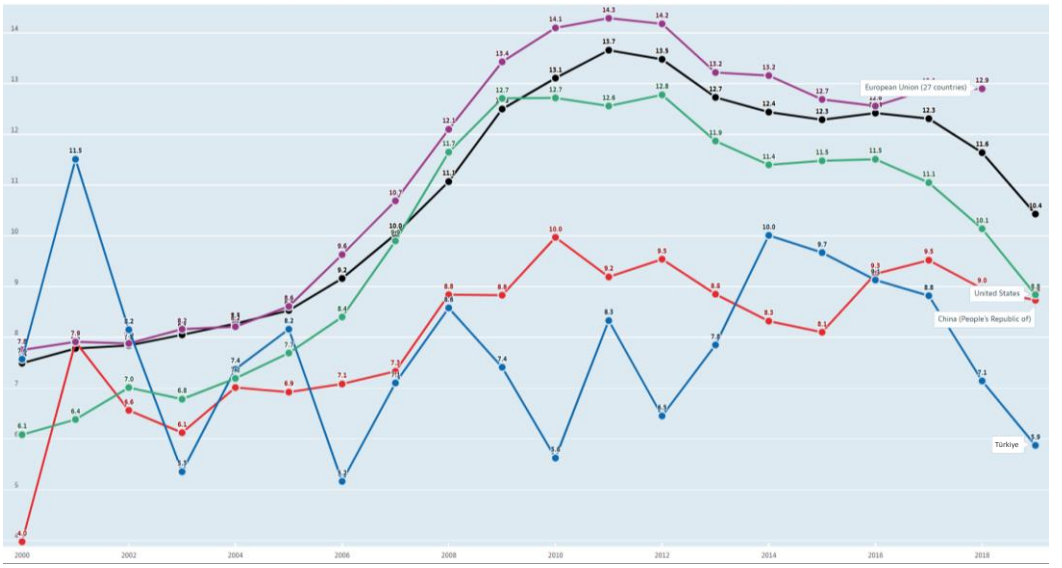


Figure 1. *Percentages of patents in environment technologies (2000-2019)*

1.2. Technology Development and Transfer Agenda in International Climate Change Negotiations

Considering that existing technologies can ensure a substantial amount of the necessary emission reduction and have a great potential impact on emission reduction in this regard, spreading the use of these technologies in production processes is a critical matter in the fight against climate change. Global protocols and agreements signed around the world have had various impacts on developing and dissemination of clean technologies. Renewable energy technologies with the Kyoto Protocol and technologies for reducing the substances that deplete the ozone layer with the Montreal Protocol have been developed and disseminated (Goldlieb, 2003; Dinçbaş, 2017).

The United Nations Framework Convention on Climate Change (UNFCCC), which entered into force on March 21, 1994, is the most important building block constituting the corporate infrastructure on climate change. In this context, parties to this Convention are liable to develop programs, policies and measures for fighting against climate change and adapting to its impacts, and to make national announcements about their efforts in this sense. The Kyoto Protocol, which was adopted at the 3rd Conference of the Parties of the UNFCCC in 1997, entered into force on February 16, 2005, as the first concrete step designed for the Convention to achieve its ultimate aim. Today, global climate change negotiations are sustained at an accelerated pace with the entry into force of the Paris Agreement in 2016. With the Paris Agreement, it is aimed at making efforts to limit the warming caused by greenhouse gas emissions from industrial processes, transportation, agriculture, buildings, land use and forestry, and waste to 2°C, which is the critical warming level, and keeping it below 1.5°C (Dinçbaş and Yiğitbaşıoğlu, 2017).

"Technology development and transfer" is addressed as a fundamental topic both in the negotiations and in the efforts to fight against climate change within the scope of the UNFCCC and efforts are made to encourage the development and spread of environmentally friendly technologies in developing countries. The important milestones of the UNFCCC in terms of technology are summarized in Table 1 (UNFCCC, 2022; Dinçbaş, 2017).

Table 1. *Technology Development and Transfer in UNFCCC Negotiations*

1992: Rio Conference
Agenda 21 and 3 Rio conventions, including UNFCCC, were adopted. Agenda 21 - Chapter 34 focuses on environmentally sound technologies, technological cooperation and capacity-building.
1992: United Nations Framework Convention on Climate Change
Technology is addressed in paragraphs 1(c), 3, 5 and 7 of Article 4.
2001: Marrakesh Accords
The Marrakesh Accords adopted at the 7th Conference of the Parties include a framework for the implementation of paragraph 5 of Article 4 of the UNFCCC, and it is called the technology transfer framework.
2007: Bali Action Plan
The Bali Action Plan, adopted at the 13th Conference of the Parties, includes the matter of long-term cooperation involving technology transfer.
2008: Poznan Programme
The Poznan Strategic Programme of the Global Environment Facility (GEF) on Technology Transfer was adopted at the 14th Conference of the Parties. The programme aims to increase the level of investment in the transfer of climate technologies.
2010: Cancun Agreement
The technology mechanism consisting of TEC (Technology Executive Committee) and CTCN (Climate Technology Centre and Network) was established with the Cancun Agreement adopted at the 16th Conference of the Parties.
2012: Doha Climate Gateway
The 18th Conference of the Parties selected a consortium led by the UNEP to host the CTCN. The parties worked on the CTCN's advisory board and made the TEC fully operational. Policies of developing countries on the development and transfer of climate technologies are supported by the TEC and their practices are supported by the CTCN.
2015: Paris Agreement
Article 10 of the Paris Agreement, adopted at the 21st Conference of the Parties, is about technology. According to the agreement, all parties share a long-term vision on the importance of technology development and transfer, a new technology framework is established, international cooperation shall be strengthened, technological support, including financial support, shall be provided to developing countries, and the Technology Mechanism shall serve the Agreement. In addition, an important decision on the relation between technology and finance mechanism was taken at the Conference. The article emphasizes that encouraging technological innovations is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development.

2. Prominent Technologies in The Fight Against Climate Change and Clean Technology Activities in Türkiye

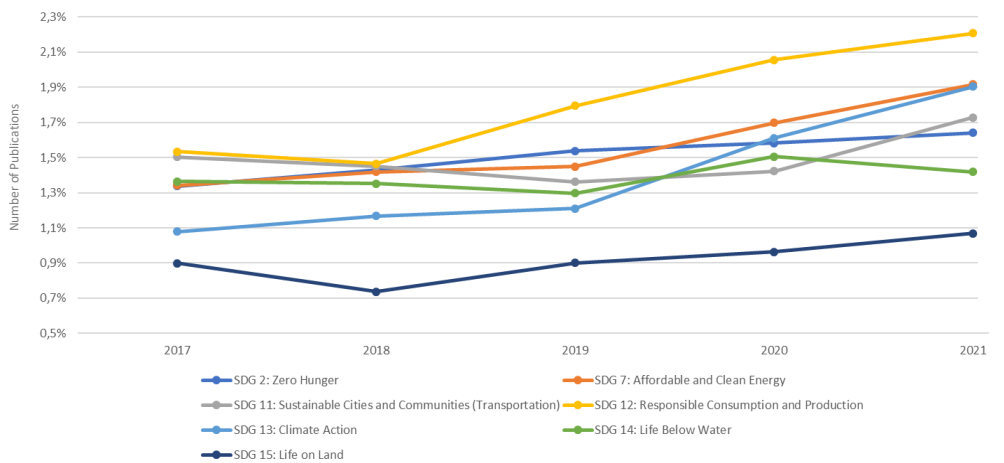
The 2053 Net-Zero Emission Target of our country was announced by H.E. President Recep Tayyip Erdoğan on September 27, 2021. With the signing of the Paris Agreement and the announcement of the net-zero emission target, which is defined as the green development revolution, Türkiye has entered an important period towards green transformation and growth. In order to realize this transformation, it is important to develop and transfer technologies in many fields and to develop infrastructure and policies in this regard.

R&D and innovation fields for fighting against and adapting to climate change include renewable energy technologies, energy storage, carbon capture and storage, environmentally sensitive agriculture, ecosystem restoration, urban planning technologies, electrification, green infrastructure and solutions for bio-based raw materials. It is highly critical to activate the R&D and innovation ecosystem in order to make progress in these fields and to ensure transformation in line with the net-zero target in our country.

The field of technology was emphasized in article 2.2.1. of the Green Deal Action Plan about "compliance with the EU Green Deal, identification of the prominent technologies that will support green production through technology needs analysis and carrying out efforts for the development/dissemination/transfer of the identified technologies", published on July 16, 2021. In this context, the first thing to do in our country is to carry out a detailed technology needs assessment at a national scale in line with the net-zero target, and then to draw an inclusive roadmap that includes matters such as the development, transfer, financing and support mechanisms of these technologies.

At Türkiye's first Climate Council held on February 21-25, 2022, the topic of technology was discussed with the studies carried out under the Science and Technology Committee, chaired and coordinated by TÜBİTAK (The Scientific and Technological Research Council of Türkiye). In line with our country's 2053 net-zero emission target and green development policy, groundbreaking R&D and innovation-based solutions and technology-based actions have been developed under 5 main themes as "Climate Change, Environment and Biodiversity", "Clean and Circular Economy", "Clean, Accessible and Safe Energy Supply", "Green and Sustainable Agriculture" and "Sustainable Smart Transportation" in order to fight against and adapt to climate change. A total of 34 Policies and 262 Actions were developed within the scope of the 5 themes and horizontal policy fields as the output of the Committee studies.

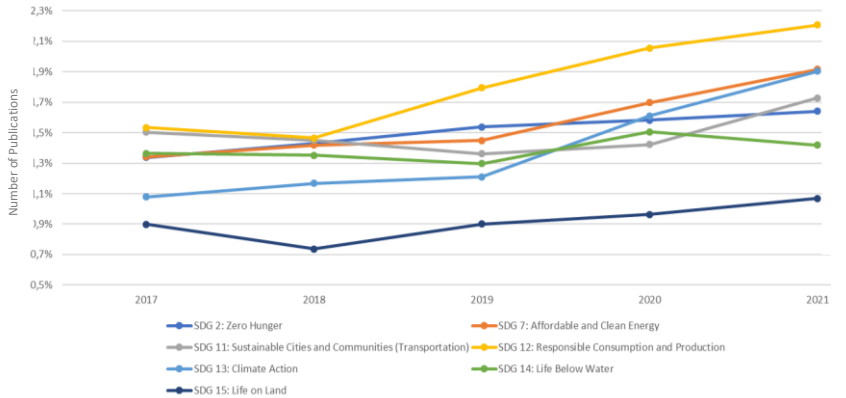
During the Committee studies, international academic publication accumulation and patent accumulation analyses were carried out regarding the situation in the world and our country in key scientific and technological fields that serve to fight against and adapt to climate change. When the number of international academic publications from Türkiye is considered, it is seen that most of the articles and compilations are under the theme of "Clean, Accessible and Safe Energy Supply". This theme has rates far above the publication volume of other themes. The energy theme is followed by the themes of "Climate Change, Environment and Biodiversity" and "Clean and Circular Economy" (Figure 2) (CCO, 2022).



Source: The SCOPUS Database, International Indexed Publications (Article and Review); Data for SDG11 are limited to the word

Figure 2. *Number of publications by years in Türkiye on research that serve to fight against and adapt to climate change*

It is seen that the ratio of the number of publications under the theme of "Clean, Accessible and Safe Energy Supply" to all publications in Türkiye is 4.1% in 2020 and 2021. It is considered that Türkiye is currently focusing on this field and is in a good position in terms of capacity. Considering the ratio of the total number of publications under other themes in our country, it is seen that the number of publications in all themes except "Sustainable Smart Transportation" is around 1% of the number of publications in Türkiye. When the ratio of publications from Türkiye to the world on fighting against and adapting to climate change is analysed, it is seen that the theme of "Clean and Circular Economy" stands out in terms of contribution to the global publication volume (Figure 3). These publications in 2021 constitute 2.2% of the publications in the world in this field. This theme is followed by the themes of "Clean, Accessible and Safe Energy Supply" and "Climate Change, Environment and Biodiversity". The contribution of publications from our country under all themes after 2018 to the global publication volume has been consistently increasing. This is evaluated as increasing academic accumulation and potential in our country (CCO, 2022).



Source: The SCOPUS Database, International Indexed Publications (Article and Review); Data for SDG11 are limited to the word "Transportation"

Figure 3. *The ratio of publications from Türkiye to the number of publications in the world by years on research that serve to fight against and adapt to climate change*

According to the "Field-Weighted Citation Impact (FWCI)", which allows for quality assessment by using the citation scores of the publications, the FWCI for all publications in Türkiye between 2017-2021 was calculated as 0.99. This score is interpreted as that all the publications made from our country in these years were cited almost at the same rate when compared to the world average. The FWCI score of the publications in our country in the field of "Green and Sustainable Agriculture" has a relatively lower score than the world score. The FWCI scores of the publications in our country on the themes of "Sustainable Smart Transportation", "Clean, Accessible and Safe Energy Supply" and "Clean and Circular Economy" are above the average world scores, especially in the last 2 years (CCO, 2022).

The main policies and measures that come to the fore in the field of mitigation in the fight against climate change concentrate in the energy, transportation, industrial processes, buildings, agriculture, waste and land use and forestry sectors. The IPCC brings the transformation in these fields together in 4 main axes for a climate-neutral world: 1. Land and ecosystem 2. Energy system 3. Urban and infrastructure 4. Industrial systems.

The highlights of the progress that our country has made in the field of climate change and that we are proud of are summarized below:

Our country has made significant developments both in terms of solar energy source and current experience and knowledge in this technology. Photovoltaic research in Türkiye is carried out in national research centres, centres affiliated with universities and a few private sector research centres. With the Turkish Photovoltaic Technologies Platform (TFTP), it is aimed to develop high efficiency and cost-effective solar cell technologies, including new generation solar energy technologies, and transfer them to the industry. With TFTP, it is also aimed to establish the technological infrastructure that will increase the domestic rate of Solar Power Plant (SPP) technologies, which is expected to play an important role in Türkiye's near future, from 25% to 80%.

Karapınar YEKA-1 SPP facility in the Karapınar district of Konya is Türkiye's largest Solar Power Plant. Kalyon PV brand photovoltaic solar panel was used in the SPP. Within the scope of Karapınar SPP works, the largest and first integrated solar panel production factory of Türkiye and the region was established in the Başkent Organized Industrial Zone with a capacity of 500 MWp/year. All of the silicon ingot, wafer, solar cell and solar module productions are carried out in the factory, and the total domestic contribution rate of the produced photovoltaic solar modules is 76.42%. R&D activities on solar energy technologies will be carried out in the R&D Centre established in an integrated manner with the factory (Energy Atlas, 2022).

Within the scope of the Development of Domestic Solar Power Plant Technologies for Electricity Generation (MILGES) project supported by TÜBİTAK, a 6 MW SPP, where local cells, panels and power electronics systems are produced, was installed in the Ceylanpınar district of Şanlıurfa in partnership with TÜBİTAK MAM (Marmara Research Centre), Middle East Technical University Solar Energy Application and Research Centre (TÜBİTAK, 2013).

In order to further strengthen the photovoltaic industry in our country, efforts on the development of new generation thin-film and tandem solar cells should be increased. Additionally, installation works of thermal solar energy systems for industrial processes in Türkiye should continue increasingly. It is anticipated that photovoltaic panels will be more common in buildings, vehicles and agricultural lands in the near future. These new fields should be included in R&D studies and focused on.

The greatest obstacle to the spread of renewable energy is known to be the storage problem. In this context, battery systems that are 20% lighter, have a 25% shorter charge time, and have higher life cycle performance are developed in the ALBATROSS (Advanced light-weight battery systems optimized for fast charging, safety, and second-life applications) project coordinated by our country within the scope of Horizon 2020. The potential of such efforts to be a solution to the storage problem is very high (Horizon Europe, 2022).

It is foreseen that the first vehicle to be produced by Türkiye's Automobile Enterprise Group Industry and Trade Inc. (Togg) will come off the line by the end of 2022. Air quality in cities will be improved and emissions from transportation will be reduced with the widespread use of Togg. The call for "mobility" was opened for applications within the scope of the Technology Oriented Industry Move Programme. In addition to electric and autonomous vehicle technologies, a contribution will be made to infrastructure for fighting against climate change under 5 innovative technology headlines (Autonomous or Semi-Autonomous Concept Vehicles, Driver Assistance and Security Technologies, Advanced

Material Technologies, Battery and Energy Management Technologies, Next Generation Advanced Wireless and Mobile Technologies) within the scope of the support of the "Mobility" call (Technology Oriented Industry Move, 2022).

Electrification of public transportation in cities is of great importance for emission control in the transportation sector. In this context, 6 companies in our country have the infrastructure to produce electric buses, and the first 100% domestic electric bus of the Turkish automotive industry, developed in cooperation with TEMSA - ASELSAN, has been completed and even started to be exported. It is important that these and similar electric vehicles produced in our country become widespread across our country and contribute to global transformation activities by increasing their exportation.

In many sectors, advanced material technologies are needed for the development of more environmentally friendly, light and low-cost materials, and platforms have been established in our country in these areas within the scope of the High Technology Platform Programme (TÜBİTAK, 2022a). Works that we will perform on advanced materials will contribute greatly both to the fight against climate change and our green transformation process.

One of the most important elements that can increase efficiency in the transportation sector is weight reduction. This weight reduction is possible with the development of new generation materials with a high strength/density ratio. Therefore, the development of relevant material technologies is one of the most effective approaches for reducing fuel consumption, especially in the transportation sector. On the other hand, environmentally friendly materials are very critical for the emission management of the buildings sector as well. The "Newton-Katip Çelebi Fund Research Project" supported by Türkiye and the United Kingdom, which focuses on green concrete technology, won the 2020 Newton Prize. Under the project, a new low-cost green concrete technology was developed based on recycled construction waste in order to reduce carbon dioxide emissions (TÜBA, 2020).

Within the scope of the Urban Transformation Law, risky buildings are being transformed and it is foreseen that the number of transformed buildings will be increased exponentially in the coming years. At this point, geopolymerization technology is important in order to convert the construction and demolition waste to advanced materials with added value. This practice is important in creating a completely waste-based green building materials-based circular economy. Although successful results have been obtained in the efforts carried out in our country in this regard, the need to improve existing technologies for the wastes specific to our country continues.

It is considered that the demand for hydrogen, which is the new fuel type that comes to the forefront in the long-term strategies of countries targeting 2050, will increase even more. It is estimated that this will be due to the need for more stringent product specifications in oil refineries in the medium-term and hydrogen being an important energy carrier in the long-term, and that new hydrogen purification technologies under development are the only way to reduce hydrogen production costs. In this context, it is known that TÜBİTAK MAM Energy Institute conducts research in the field of clean and renewable energy technologies, including hydrogen production technologies, and the topic emerges as one of the fields that should be addressed as a priority in green transformation.

In terms of biomass, it is seen that it has the potential to accelerate hydrogen to be the main fuel of the future. Under the TÜBİTAK project titled "Technology for Hydrogen Production by Gasification of Biomass (BioH2)", carried out in our country between 2016-2020, it was aimed to develop a technology for producing hydrogen from biomass through

gasification to be used in the energy and transportation sectors and to implement the results on a pilot system. With the project, a pilot-scale facility was established with hydrogen production technology developed entirely with domestic resources and means (TÜBİTAK, 2022b). It is extremely critical to carry out this and similar projects, and ultimately to commercialize the developed technology by increasing the TRL (Technology Readiness Level).

Wastes and waste sludge applications are important as they cause methane emissions. Within the scope of the "Regulation on Sanitary Landfilling of Wastes", it is foreseen that 35% of biodegradable wastes will be accepted into sanitary landfills for 2025. In other words, 65% of the biological sludge generated in 2025 will not be sent to the sanitary landfill. In order for the sludge to be incinerated in incineration plants and used in agricultural areas, it must have a certain dryness rate. It has been identified that a thermal value of 60 thousand GJ, equivalent to approximately 600 thousand tons of oil per year, can be obtained with 80% efficiency with the implementation of domestic integrated sludge digesters, in which the treatment sludge can be converted into biogas and liquid fertilizer using biological methods, and that the liquid fertilizer to be obtained will provide significant benefits to our agricultural activities. Therefore, it is of great importance to develop Domestic Integrated Sludge Digesting Reactors that produce biogas with high biogas efficiency and low sulphur rate (CCO, 2022).

On the other hand, it is known that there is an average of 50% loss-leakage rate in drinking water network systems in our country. With the rehabilitation of existing systems, water-saving will increase significantly. In this regard, domestic companies in our country are in the market with their own products and they are in partnership with our municipalities.

It is also important to note that TÜBİTAK Polar Research Institute, which contributes to the science of climate change with its polar research, has also succeeded important technology collaborations.

In line with the global emission reduction requirements and efforts, the interest in "carbon capture and storage" (CCS) technologies has increased and countries have begun to create and announce their roadmaps on the subject. CCS involves the capture of CO_2 from major industrial sources in the electricity and manufacturing industries. CO_2 can also be captured directly from the atmosphere. Some of the captured CO_2 is used to produce economically valuable products or services. Research on alternative use of captured CO_2 continues. Because it is stated in the last IPCC report that the world's carbon storage capacity is less than the carbon that needs to be captured (IPCC, 2022). Therefore, increasing R&D on CCS and alternative uses of captured carbon through international cooperation will be of vital importance for managing hard to abate emissions by deployment of these technologies in the long term.

Digital technologies will make a significant contribution to reducing emissions and achieving the Sustainable Development Goals. For example, sensors, internet of things and artificial intelligence will improve energy management in every sector, increase energy efficiency and support the spread of many low-carbon technologies. Digitalization is estimated to significantly reduce the vulnerability of the sectors, in which it is implemented, during a crisis as well as ensure savings up to 20% in greenhouse gas emissions (CCO, 2022). As an example, energy and carbon efficiency will increase and 1.3. GT CO_2eq reduction will be achieved as a result of the use of the internet of things in the industrial sector and the optimization of processes and activities. Additionally, it is calculated that a

reduction in energy used between 2-4% is possible as a result of only improving feedback and information management in houses and buildings on a global basis (IPCC, 2022). Although there are projects carried out in our country in the field of digital technologies, especially in the housing and buildings sector, such efforts should be boosted immediately.

5. Conclusion

Accelerating R&D and investment activities in the clean technology field in Türkiye emerges as an essential topic in terms of both economic and environmental priorities.

The current ecological opportunity that has emerged with the fight against climate change, which has recently been defined as a crisis, and the solution to the problem is critical not only for the development of clean technologies but also for a radical change in people's lifestyles (transportation, education, social relations, consumption, etc.). In this context, risks and opportunities related to the climate crisis should be addressed in a holistic way in the solution process and the process should be turned into a win-win approach with effective and inclusive policies.

Unless the topic of technology is managed well in the upcoming transformation process, the gap between countries with and without clean technologies could widen and countries without clean technologies could be stuck with carbon-intensive technologies. When we look at the world, it is observed that these technologies are not widespread enough in developing countries despite all efforts. In this context, if the current situation continues, the gap between developed and developing countries will gradually widen instead of closing. The risk for fast-growing countries, like our country, is the foreign dependency on technology due to the intense need for technology in many sectors. The sole way to prevent this is to develop and spread our technology, especially in critical fields.

In this context, TÜBİTAK currently supports R&D projects in areas such as the protection of natural ecosystems from climate change, circular economy opportunities, sustainable agriculture, net-zero carbon production solutions, industrial symbiosis opportunities, clean, accessible and safe energy supply and sustainable smart transportation within the scope of various programmes. Supporting such R&D efforts on fighting against and adapting to climate change is of the utmost value.

However, it is necessary to move far beyond the existing policies on low-carbon technologies in order for our country to be affected by the green transformation process as minimum as possible and turn the process into an opportunity for our economy.

Such technologies should be supported under all subheadings and throughout the entire technology cycle, and in order to do this, effective mechanisms including finance should be established and activities should be followed with concrete indicators in line with the designated targets.

In this context, the very first step to take is to set a technology roadmap regarding the transformation that will take place within the framework of the 2053 net-zero emission vision. Prioritizing technologies in terms of R&D and transfer in this roadmap is a significant point as well. We have taken the first step of this roadmap with the climate council.

Besides, it is essential to improve national and international cooperation about technology. It is necessary to increase the participation of the private sector in R&D efforts and improve the public-university-private sector cooperation in these areas.

Finance is also a crucial point within the scope of international efforts. It is necessary that international financing is mobilised in a stronger way for needed technology efforts.

While our country transfers clean technology in certain areas, it also should be a country that exports clean technology in certain areas. Our clean technology export will also play an important role in achieving our country's target of becoming the regional leader in the field of climate, within the scope of south-south cooperation.

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