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THE IMPACT OF REMOTE WORKING ON TÜRKİYE'S ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS: LEARNING FROM THE EXPERIENCES OF COVID-19 ERA

Master's Thesis

Mustafa KAYA

ENERGY ECONOMICS AND MANAGEMENT

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UZAKTAN ÇALIŞMANIN TÜRKİYE'NİN ENERJİ TÜKETİMİNE VE SERA GAZI EMİSYONLARINA ETKİSİ: COVID-19 DÖNEMİNDEN DENEYİMLER

ÖZET

Türkiye'de ilk Covid-19 vakası 11 Mart 2020'de açıklanmıştır. Hastalığın küresel bir salgına dönüşmesi iş yapma biçimini köklü şekilde değiştirmiştir. Uzaktan çalışma, ofisten çalışmaya önemli bir alternatif olarak ortaya çıkmıştır. Bu dönüşüm kapsamında Türkiye'de 2020 ve 2021 yıllarının belirli aylarında uzaktan çalışmanın hayata geçirilmesi, enerji tüketiminde ciddi düşüşlere neden olmuştur. Bu çalışmanın ilk amacı tüm ülke potansiyelinin kullanıldığı durumunda, uzaktan çalışmanın Türkiye'de otomobil yakıt tüketimi (motorin, benzin, LPG) ve elektrik tüketimi açısından sağlayacağı enerji tasarrufunu tespit etmektir. İkinci amaç ise enerji tüketimindeki bu düşüşün, Türkiye'nin sera gazı emisyonlarını azaltmadaki katkısını ortaya koymaktır. Üçüncü amaç ise, salgın bittiğinde uzaktan çalışmanın kalıcı olarak uygulanması için olası itici güçleri belirlemektir. Uzaktan çalışma sonucunda otomobil yakıt tüketiminde bir düşüş beklemek tahmin edilebilir olsa da, bu çalışma uzaktan çalışmanın elektrik tüketimini de azalttığını ortaya koymuştur. Sonuçlara göre Türkiye tüm potansiyelini kullanması durumunda, uzaktan çalışma ile ülke toplam enerji tüketiminin %1,66'sına tekabül eden 1,8 milyon ton petrol eşdeğeri enerji tüketimini azaltma imkanına sahiptir. Bu tutar ekonomik olarak 2019 fiyatlarına göre 1.4 milyar ABD dolarına karşılık gelmektedir. Toplam 7,73 milyon ton karbondioksit eşdeğeri sera gazı emisyonu azaltımı ile Türkiye, ulaşım kaynaklı emisyonlarını %3,2, elektrik kaynaklı emisyonlarını ise %3,79 oranında azaltabilecektir. Bu nedenle, Türkiye'nin net fosil yakıt ithalatçısı ve Paris Anlaşmasına taraf bir ülke olduğu göz önünde bulundurulduğunda, uzaktan ve hibrit çalışmanın tamamlayıcı bir enerji verimliliği ve iklim değişikliği politikası olarak teşvik edilmesinde fayda görülmektedir. Bu çalışma pandemi dönemi tecrübelerinden faydalanarak normal koşullar altında uzaktan çalışmanın rafine edilmiş petrol ürünleri ve elektrik tüketimini azaltmadaki faydasını ortaya koymayı amaçlarken, gelecek çalışmalarda, uzaktan çalışmanın Rusya-Ukrayna Savaşı gibi enerji krizi dönemlerinde doğalgaz da dâhil olmak üzere enerji tüketimi üzerindeki etkilerinin araştırılmasında fayda görülmektedir.

Anahtar kelimeler: Covid-19, Uzaktan Çalışma, Esnek Çalışma, Yakıt Tüketimi, Elektrik Tüketimi

THE IMPACT OF REMOTE WORKING ON TÜRKIYE'S ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS: LEARNING FROM THE EXPERIENCES OF COVID-19 ERA

ABSTRACT

The first Covid-19 case was announced on March 11, 2020 in Türkiye. The transformation of the disease into a global epidemic has radically changed the way of doing business. Remote working emerged as an important alternative to office working. As part of this transformation, Türkiye put in force this practice in certain months of 2020 and 2021, which led to serious decline in energy consumption. The first aim of this study is to find out the contribution of remote working on reducing Türkiye's energy consumption in car fuel (diesel, gasoline, LPG) and electricity in case the country's whole potential is used. The second aim is to reveal the contribution of this decline in energy consumption on reducing Türkiye's greenhouse gas emissions. The third aim is to determine the possible drivers for the permanent implementation of remote working when the outbreak is over. Although it is presumable to expect a fall in car fuel consumption as a result of remote working, this study revealed that it also decreased electricity consumption. According to the results, in a scenario where Türkiye's remote working potential is fully utilized, the country can reduce 1.8 million tons of oil equivalent of it's energy consumption which corresponds to 1.66% of the total energy consumption and 1.4 billion USD dollars with 2019 prices. With a total of 7.73 million tons carbon dioxide equivalent GHG emission mitigation, Türkiye will be able to reduce its transport related emissions by 3.2% and electricity related emissions by 3.79%. Therefore, considering that Türkiye is a net fossil fuel importer country and a party to the Paris Agreement, it is necessary to promote remote and hybrid working as a complementary energy efficiency and climate change policy. While this study aims to reveal the benefits of working remotely in reducing the consumption of refined petroleum products and electricity under normal conditions by making use of the experiences of the pandemic period, it is beneficial to investigate the effect of remote working on energy consumption, including natural gas, during energy crises such as the Russia-Ukraine War in future studies.

Key Words: Covid-19, Remote Working, Flexible Working, Fuel Consumption, Electricity Consumption

ACRONYMS

CAD: Current Account Deficit

CIPD: Chartered Institute of Personnel and Development

CH_4: Methane

CO_2: Carbon Dioxide

CRF: Common Reporting Format

EMRA: Turkish Energy Market Regulatory Authority

EPA: U.S. Environmental Protection Agency

GDP: Gross Domestic Product

GHG: Greenhouse Gas

Gt: Gigaton

GWh: Gigawatt Hours

GWP: Global Warming Potential

ICT: Information and Communications Technologies

IEA: International Energy Agency

IPCC: Intergovernmental Panel on Climate Change

Km: Kilometer

KWh: Kilowatt Hours

LPG: Liquefied Petroleum Gas

MENR: Ministry of Environment and Natural Resources

MT: Million ton

MTOE: Million Ton of Oil Equivalent

MWh: Megawatt Hours

N_2O: Nitrous Oxide

OECD: Organization for Economic Co-operation and Development

OPEC: Organization of the Petroleum Exporting Countries

Ppm: Parts per Million

TEIAS: Turkish Electricity Transmission Corporation

TOE: Ton of Oil Equivalent

TURKSTAT: Turkish Statistical Institute

TWh: Terawatt Hours

WHO: World Health Organization

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CHAPTER 1

1. INTRODUCTION

1.1. BACKGROUND

The first Covid-19 case in the world appeared in the city of Wuhan, China in December 2019. Due to its easy transmission, the virus has spread all over the world. On March 11, 2020, the World Health Organization (WHO) declared that Covid-19 is a pandemic (WHO, 2020). As of September 12, 2022, 609 million people have been infected by the virus and approximately 6.5 million people have died globally (WHO, 2022). In order to prevent the spread of the virus, many countries put in force strict lock down measures. Many facilities and businesses such as schools, restaurants and fitness centers were shut down where people could have intensive face-to-face interaction. Due to their dense and large population, big cities have been more affected by the pandemic (Stier et al., 2020). Although the vaccines were developed against the virus and they were met with huge hope at first, over time it has been realized that they do not prevent patients getting sick but experiencing fewer and milder symptoms. While vaccines are widely available in developed countries, vaccination rates remains limited in many developing countries. The emergence of variants such as delta and omicron has brought along the continuation of the pandemic. Many scientists predict that the Covid-19 pandemic will turn into an endemic over time, affecting people less and the process to be managed more easily (Herrero & Madzokere, 2021).

The spread of the outbreak and the lock down measures affected the human mobility and economic activities substantially. The energy sector, which is directly related to mobility and manufacturing, has also been affected by this unexpected transformation. According to the International Energy Agency (IEA), the global energy demand declined by 3.8% in the first quarter of 2020 compared to 2019 (IEA, 2020). At the beginning of the outbreak, strict lockdown measures reduced mobility, resulting in a drastic drop in oil demand. Besides OPEC-Russia disagreement on the production amount caused the decline of the crude oil price significantly. However, due to having the ability to travel individually, road transportation was less effected by the outbreak compared to public transport such as aviation (Gürbüz et al., 2021). In addition, there was a decline in electricity demand by 2.5% (IEA, 2020). Besides, fall in manufacturing decreased the coal demand (IEA, 2020).

Despite all its negative economic and social effects, the Covid-19 pandemic has revealed important opportunities for the environmental sustainability (Kylili et al., 2020). Since energy is an emission-intensive sector, the decline in energy consumption and industrial production caused reduction in greenhouse gas emissions (GHG) and atmospheric pollutants. In fact, Uludag, a famous mountain in the city of Bursa in Türkiye, became visible from Istanbul for the first time after years, due to the improvement in air quality.

The outbreak has also shown how certain behaviors and practices can change under special circumstances instantly (Lambrecht et al., 2021). This transformation has contributed to the widespread implementation of new ways of doing business such as flexible working. During Covid-19 outbreak, remote working, which is a type of flexible working, has been applied out of necessity and put in force more widely than ever before globally. This process provided an excellent opportunity to measure the impact of remote working on different areas and the effectiveness of this work arrangement.

As an energy import dependent country, any measure and policy to reduce energy consumption without compromising from the economic output is critical for Türkiye. This study wants to reveal whether remote working can be one of these policies. In addition, soaring natural gas and oil prices due to the Russia-Ukraine War have increased the importance of researching such policies to determine their contribution to reduce fossil fuel consumption.

1.2. PROBLEM

The Covid-19 outbreak has caused one of the biggest shocks of the modernization process that has been going on since the industrial revolution. This process can be considered as a driver for the transformation of national economies. Even though remote working was applied extensively and successfully by public and private entities during the beginning of the pandemic, many organizations, businesses and public entities went back to the old way of full time office working. This situation brings with it the risk of reverting to a way of doing business that will be economically inefficient, make employees unhappy, and pollute the environment, by choosing not to take advantage of an important opportunity while all infrastructure and facilities are available.

1.3. RESEARCH QUESTION

The research questions of this study are as follows:

- "How can remote working impact energy consumption in the context of car driving and electricity consumption in Türkiye?"
- "How can remote working impact greenhouse gas emissions in the context of car driving and electricity consumption in Türkiye?"
- "What are the possible drivers for the permanent implementation of remote working when the outbreak is over?"

1.4. OBJECTIVE OF THE STUDY

This study aims to reveal how remote working can impact Türkiye's energy consumption in car fuel and electricity in a scenario where the country utilizes her full remote working potential. In addition, calculating the amount of reduction in greenhouse gas (GHG) emissions that may arise due to a decline in fuel consumption is another aim of the study. Lastly, possible drivers for the permanent implementation of remote working will be discussed.

1.5. SIGNIFICANCY OF THE STUDY

In the literature there is no study identified that assesses the impact of remote working on reducing Türkiye's energy consumption and greenhouse gas emissions and this study wants to fill this gap by creating a scenario where Türkiye puts in force her full remote working potential. This way the study will contribute to the policy makers for considering remote working as an effective energy efficiency and climate policy.

It is also worth mentioning that this study assessed the impact of remote working on energy and greenhouse gas emissions by making use of the daily mobility data published by Google and Apple, which track and publish the movement of their users through cell phone applications.

1.6. SCOPE OF THE STUDY

Remote working has the potential to affect a wide variety of energy areas. As an example, widely usage of online meetings reduced international and national business trips resulting in a significant drop in aviation fuel demand and airline travels. The focus of this study is the effect of remote working on car fuel (diesel, gasoline, LPG) and electricity consumption. Other potential areas that might be affected by remote working, such as public transport (railway, air, maritime) are outside the scope of the study. In addition, electric-hybrid cars were not included in the study due to their low share in the total number of cars.

In terms of emission reduction, three main greenhouse gases namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions are considered. F-gases are not included in the study because they have the lowest share in total greenhouse emissions and are not reported sectorally by the Ministry of Environment, Urbanization and Climate Change.

1.7. STRUCTURE OF THE STUDY

In this study, firstly the literature review is presented. The third section describes a conceptual framework on the relationship between energy consumption and climate change, impact of the pandemic on energy consumption and flexible working. The fourth section describes the method and materials used in this study. The fifth section presents the findings. The discussion section focuses on the drivers for the permanent implementation of remote working. This section is followed by the conclusion.

CHAPTER 2

2. LITERATURE REVIEW

2.1. IMPACT OF COVID-19 ON ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS

In the literature there are studies assessing the impact of Covid-19 pandemic on oil price, consumption and production. Camp et al. (2020) researched the impact of the Covid-19 outbreak on the price of crude oil and refined petroleum products. They found that from January to April 2020 the price of oil has declined due to fall in demand and OPEC-Russia disagreement on production and the price began to recover from April to July with ending of the dispute and easing in lockdown measures. Some of the studies on the impact of Covid-19 on energy are listed in Table 1. Aydin and Ari (2020) analyzed how the negative economic impacts of Covid-19 on non-recoverable sectors (e.g. tourism, transportation) can be compensated by the fall of the oil price in Türkiye considering it's high oil dependency. Results suggest that the decline of the GDP by 1.16% due to the outbreak can be compensated by the decline of oil imports and under different scenarios, where the price of oil declines by 25% and 50% can increase the GDP by 0.72% and 1.56% respectively. Tvalchrelidze and Silagadze (2020) focused on the impact of Covid-19 outbreak on the international oil markets. According to the results, there was a strong negative correlation between the oil price and the number of infections at the beginning of the outbreak and after April 2020, the mortality rate began to influence the oil price. In addition, the decline in the mortality rate resulted in a revival of the oil markets and stability in the markets is expected if the death rate does not increase in the future. Gürbüz et al. (2021) looked at the impact of Covid-19 outbreak and especially the lock down measures on Türkiye's energy consumption and GHG emissions in road transportation sector. The study also focuses on the impact of GHG emissions on enviro-economic indicators. According to the results; the energy consumption, GHG emissions and their social cost values have decreased in April and May 2020 in Türkiye.

Table 1: Studies in the Literature on the Impact of Covid-19 on Energy

Title	**Author (s)**	**Year**	**Method**	**Key Findings**
From the barrel to the pump: the impact of the COVID-19 pandemic on prices for petroleum products	Kevin M. Camp, David Mead, Stephen B. Reed, Christopher Sitter	2020	The price change of oil products during Covid-19 outbreak was assessed.	- From January to April 2020 the price of oil declined due to decline in demand and OPEC-Russia disagreement on production. - The price began to recover from April to July with the end of disagreement and easing in lockdown measures
The impact of Covid-19 on Turkey's non-recoverable economic sectors compensating with falling crude oil prices: A computable general equilibrium analysis	Levent Aydin, Izzet Ari	2020	ORANI-G as a multi-sectoral computable general equilibrium model was used.	- The decline of the GDP by 1.16% due to the outbreak can be compensated by the decline of oil imports. - Decline in the oil price by 25% and 50% can increase the GDP by 0.72% and 1.56% respectively.
Influence of COVID-19 coronavirus pandemic on international oil markets	Alexander G. Tvalchrelidze, Avtandil Silagadze	2020	A regression model was developed between oil price and Covid-19 world mortality rate	- Strong negative correlation between the oil price and the number of infections at the beginning of the outbreak and after April 2020 - Decline in the mortality rate resulted in a revival of the oil markets. - Stability in the markets is expected if the death rate does not increase in the future.
Evaluating effects of the Covid-19 pandemic period	Habib Gürbüz, Yasin	2021	The impact of Covid-19 outbreak (the lock down period) on	- Decrease in energy consumption, GHG emissions and their social cost

on energy consumption and enviro-economic indicators of Turkish road transportation	Şöhret, Selçuk Ekici		Türkiye's energy consumption and GHG emissions in road transportation sector was calculated. The impact of GHG emissions on enviro-economic indicators was found.	values in April and May 2020 in Türkiye

2.2. IMPACT OF FLEXIBLE/REMOTE WORKING ON ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS

The subject of flexible or remote working was considered before the Covid-19 pandemic. Regarding the effect of flexible working on fuel consumption, Ott et al. (1980) researched the implantation of flexible working in a government facility in the USA by providing the employees two alternative working schedules. Results suggests that flexi-time provided 5.8% fuel saving. Besides workers' journey time declined and people could have a better work-life balance. Crow and Millot (2020) analyzed the impact of flexible working on fuel consumption and CO_2 emissions by implementing a scenario where people work from home once a week globally. According to the results, the savings from remote working are four times the energy consumption of working from home. Additionally, one day remote working has the potential to reduce the global oil consumption in road related passenger transport by 1% annually (11.9 mtoe). After taking into account the increase in energy demand by the households, working from home for 1 day a week can provide an annual saving of 8.5 mtoe and a reduction of 24 million tons CO_2 emissions.

Concerning the impact of flexible working on solely climate change and environment, Nanda (2019) researched the effect of reducing workings days from five to four on emissions in the UK. According to the results, four-day workweek causes people to drive 558 miles less weekly, which leads cars to drive 9% less miles. However, there might be a rebound effect.

By having three days weekend, people can take more vacations leading to an increase in emissions. In a similar study conducted by Knight and others (2012) on OECD countries, it was determined that 10% reduction in working time leads to a 12.1% reduction in ecological footprint, 14.6% in carbon footprint and 4.2% in carbon dioxide emissions.

In the literature, there are several studies assessing the impact of remote working using a calculation based method, as used in this study. Lambrecht et al. (2021) focused on the impact of home-office working on reducing transport related greenhouse gas emissions in Germany. By researching the transport sector, the study presents how much remote working would reduce greenhouse gas emissions in two different scenarios in the short and long term. In the scenarios, the country's remote working potential is taken as 20% (conservative scenario) and 40% (optimistic scenario) for the short term and 40% (conservative scenario) and 55% (optimistic scenario) for the long term (2030). Results suggest that Germany can reduce 1.9 mt CO_2 emissions (conservative scenario) and 5.8 mt CO_2 emissions (optimistic scenario) in the short term and 2.5 mt CO_2 emissions (conservative scenario) and 4.1 mt CO_2 emissions (optimistic scenario) in the long term. The outcomes of Lambrecht's study supports the results of this study and both of which benefit from the remote working potential of countries in calculating the reduction of energy consumption and GHG emissions as a result of remote working. In addition, Fuhr & Pociask (2011) researched how the widespread provision of internet services and this way the increase in remote working practices can reduce GHG emissions in the USA. At the time of the study, remote working was applied to 10% of the employed. The study looks at the impact of increasing this ratio to 20%. The scope of the study is limited with car driving. Therefore, public transport is not included. While there were 146 million employees in the USA in 2006, 91% (132.9 million people) went to work by individual car. Assuming 3 people go to work in 1 car, 127.5 million cars get 132.9 people to work. The average employee spent 15 miles and 26.4 minutes for commuting. Based on this, it has been calculated that increasing remote working to 20% could result in savings of 96.5 billion dollars. The study also reveals that working remotely can reduce 588.2 tons of GHG emissions for the next 10 years in the USA. Even though Fuhr's study has many similarities with this study in terms of the method, many circumstances between USA and

Türkiye are different. Fuhr has taken 48 kilometers as one day distance to and from the work. However according to some researches, people in Türkiye drive in average 40 kilometers each day, which was taken in this study. In addition, due to widespread usage of heavy and large motor cars in the USA, the fuel consumption is much higher (around 11.2 liters per 100 km taken in the study) in comparison to Türkiye.

There are also other studies considering the experiences of the Covid-19 era (Table 2). Kylili et al. (2020) used a case study for the staff of a university. By developing 3 different working scenarios (working from home, collaborating, going to work) they examined the impact of remote working on energy consumption and climate using the location-allocation modeling. According to the results, 4 liters of transportation fuel savings and 7.4 kilograms of carbon dioxide emission reduction can be achieved per hour for 100 employees by working remotely. Coutellier et al. (2021) investigated the impact of homeworking on energy consumption during the curfews in the UK by focusing on transport related fuel, electricity and natural gas consumption. The fuel consumption was measured my conducting a survey with 452 people. Using smart meter data from 1,164 households from a company, the change in electricity and natural gas consumption was determined. Meter data showed that working at home shifts electricity demand from the high carbon peak to lower carbon density. According to the results, during the period of the curfew, weekly electricity consumption increased by 10.4% on average. However, there has been a significant decline in emissions per household due to the change in transportation. Emissions decreased by 33% and they offset the increase in emissions from electricity in the same period.

Table 2: Studies in the Literature on the Impact of Flexible/Remote Working on Energy Consumption and GHG Emissions

Title	**Author (s)**	**Year**	**Method**	**Key Findings**
Behavioral Impacts of Flexible Working Hours	Marian Ott, Howard Slavin, Donald Ward	1980	Flexible working was applied in a building where 600 people were employed and the results were analyzed by conducting	5.8% car fuel saving for employees who drive to work

			surveys and using employee data (e.g. entry and exit times, flexible working preferences).	
Working from home can save energy and reduce emissions. But how much?	Daniel Crow, Ariane Millot	2020	Effect of one day home office working is calculated by using commuter trends and labor market data.	- Global saving of 11.9 mtoe (1% of the global oil consumption in road related passenger transport) - Considering the increase in residential energy demand, 8.5 mtoe energy saving (24 mt CO_2 emission mitigation)
Work less to save the planet? How to make sure a four-day week actually cuts emissions	Anupam Nanda	2019	A survey was conducted to find out how working four days would affect commuting habits.	- 558 miles (around 900 km) less driving weekly - 9% less car driving
Reducing Growth to Achieve Environmental Sustainability: The Role of Work Hours	Kyle Knight, Eugene A. Rosa, Juliet B. Schor	2012	Data from 29 OECD member countries between 1970 and 2007 were used. The effect of working hours (independent variable) on ecological footprint, carbon footprint and CO_2 emissions (dependent variables) was calculated.	10% reduction in working time leads to a 12.1% reduction in ecological footprint, 14.6% reduction in carbon footprint and 4.2% reduction in carbon dioxide emissions.
THG-Minderungspotenziale einer erweiterten Homeoffice-Nutzung	Udo Lambrecht, Jan Kräck, Frank Dünnebeil	2021	The effect of home office working on reducing Germany's GHG emissions is found by making calculations and driving a	- 1.9 mt CO_2 emission (conservative scenario) mitigation and 5.8 mt CO_2 emission (optimistic

			conservative and optimistic scenarios.	scenario) mitigation in the short term - 2.5 mt CO_2 emission mitigation (conservative scenario) and 4.1 mt CO_2 emission mitigation (optimistic scenario) in the long term
Broadband and Telecommuting: Helping the U.S. Environment and the Economy	Joseph P. Fuhr, Stephen Pociask	2011	Impact of increasing remote working from 10% to 20% over ten years is estimated for the USA by making calculations. The scope is limited with the impact on car driving.	- 96.5 billion dollars saving annually - 588.2 tons GHG emission mitigation for the next 10 years
The role of Remote Working in smart cities: lessons learnt from COVID-19 pandemic	Angeliki Kylili, Nicholas Afxentiou, Loucas Georgiou, Christiana Panteli, Phoebe-Zoe Morsink-Georgalli, Andri Panayidou, Constantinos Papouis & Paris A. Fokaides	2020	Impact of remote working on energy consumption and climate is examined by using location-allocation modeling.	- 4 liters of transportation fuel savings and 7.4 kilograms of carbon dioxide emission reduction per hour for 100 employees by working remotely
Homeworking can be Net Positive, Evidence from the UK Lockdown during COVID-19	Quentin Coutellier, Jeffrey Hardy, Ralf Martin, Mirabelle Muûls	2021	Impact of homeworking on energy consumption during the curfews in the UK is assessed by conducting a survey with 452 people on	- Shift in electricity demand from the high carbon peak to lower carbon density

			transport related fuel consumption and using smart meter data from 1,164 households on electricity and natural gas consumption.	- During the period of the curfew, weekly electricity consumption increased by 10.4% on average - Emissions decreased by 33% in total

2.3. OTHER STUDIES ON REMOTE WORKING

Regarding other studies on remote working (Table 3), Dingel and Neiman (2020) researched the rate of jobs that can be done at home for 86 countries. Additionally, the study looked at the relation between wage level and share of home workable jobs. According to the results, the rise in income increases the rate of jobs that can be done at home. By this way, there are more home workable jobs in high income countries compared to the developing ones. Results also show that 37% of jobs in USA are home workable which represent 46% of all wages in the country. In addition, 23% of the jobs in Türkiye can be done from home.

Loia & Adinolfi (2021) assessed the public perception on remote working by analyzing 11.000 tweets for six months. It was determined that there was no awareness about the effect of remote working on the environment, despite the increasing ecological sensitivity during the pandemic period.

Its seems that this study will be one of the first in the field of assessing the impact of remote working on reducing Türkiye’s energy consumption in car driving and electricity by using the experiences of the Covid-19 era.

Table 3: Other Studies on Remote Working

Title	Author (s)	Year	Method	Key Findings
How Many Jobs can be done at Home?	Jonathan I. Dingel, Brent Neiman	2020	Survey results from O*NET, which are from pre-pandemic period, are used regarding jobs and workforce. To determine the relation between income and share of jobs that can be done at home, employment data from ILO and GDP per capita (purchasing power parity) are used.	Rise in income increases the rate of home workable jobs, 37% of jobs in USA are home workable, low-income countries have lower rate of home working jobs.
Teleworking as an Eco-Innovation for Sustainable Development: Assessing Collective Perceptions during COVID-19	Francesca Loia, Paola Adinolfi	2021	11.000 tweets are analyzed for 6 months	There is no awareness about the effect of remote working on environment.

CHAPTER 3

3. CONCEPTUAL FRAMEWORK

3.1. ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS

According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change is the variation in the structure of the atmosphere directly or indirectly due to human activities in addition to naturally occurring changes (United Nations, 1992). With the Industrial Revolution, industrialization has led to the increase in fossil fuel use, change in land use and reduction of forests and concentration of greenhouse gases (GHG) such as carbon dioxide (CO_2) in the atmosphere (Ata, 2010). At the same time, with the improvement of health conditions, the rising world population has increased the demand for energy and the use of conventional energy resources, which caused more emissions. The increase in the density of these gases in the atmosphere has caused global warming and melting of the glaciers and rise of the ocean water level. The solution to this global problem is to mitigate the amount of GHG emissions in the atmosphere (United Nations, 2021). According to the climatologists, the temperature rise should be limited to 2 degrees Celsius above pre-industrial levels (maximum CO_2 concentration of 450 parts per million (ppm)) so that the effects of climate change can be tolerable (Oesterwind, 2011). CO_2 concentration in the atmosphere was 414.72 ppm in 2021 (Lindsey, 2022).

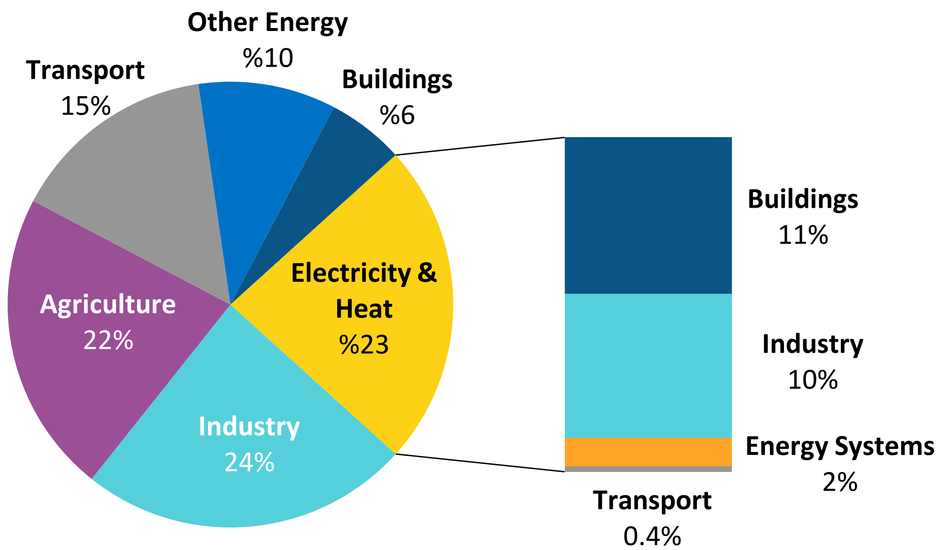

Figure 1: Sectoral Distribution of Global Greenhouse Gas Emissions in 2019.

(Source: Prepared by the author based on information from IPCC (2022))

Global GHG emissions were 59 GtCO_2eq in 2019 (IPCC, 2022). As seen in Figure 1, energy (electricity and heat production, transport and other energy) had the highest share in global greenhouse gas emissions with around 48% in 2019 and was followed by industry with 24% and agriculture, forestry and land use with 22% (IPCC, 2022). Because of the fact that energy has a significant share in global GHG emissions, it is seen as one of the major areas to combat climate change. Within the energy sector, majority of the emissions occur due to electricity and heat production (IPCC, 2022). Next, transport sector comes with 15% of the total GHG emissions. Road transport accounts for around 10% of the global GHG emissions (IPCC, 2022).

3.1.1. Global Emissions by Gas Type

According to the United Nations, six main greenhouse gases are handled as greenhouse gas: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. As it can be seen from

Figure 2, carbon dioxide accounted for 75% of the global greenhouse gas emissions and the majority of this amount comes from fossil fuels and industrial processes (IPCC, 2022). This gas was followed by methane with 18%, nitrous oxide with 4% and fluorinated gases with 2% (IPCC, 2022).

One of the biggest problems in combating the climate change is the rising trend of GHG emissions. According to the IPCC (2021), CO_2 concentration in the atmosphere was recorded as the highest in the last at least 2 million years in 2019. In addition, the methane and nitrous oxide concentrations were measured as the highest in at least the last 800,000 years (IPCC, 2021).

In this study, the effect of remote working on carbon dioxide, methane and nitrous oxide emissions is examined. These three gases accounted for 98% of global GHG emissions.

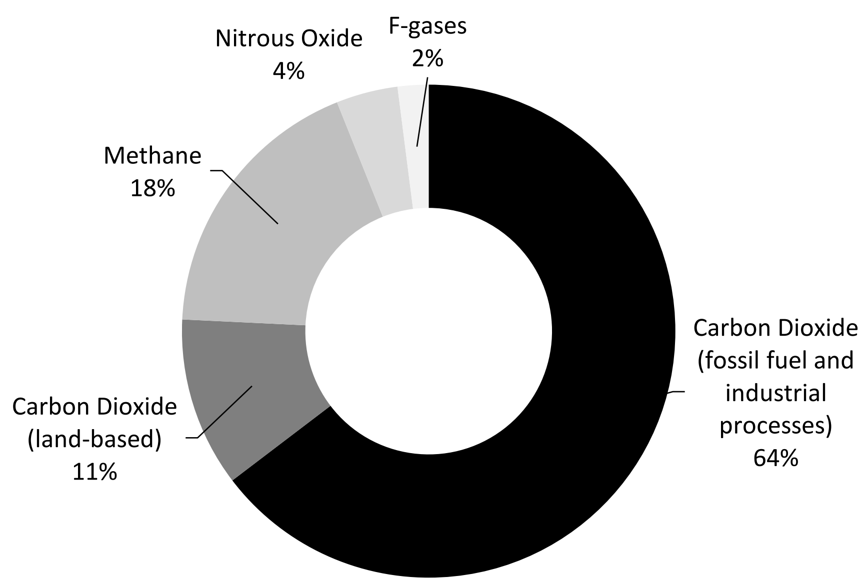

Figure 2: Global Greenhouses Gas Emissions According to the Gas Type, 2019

(Source: Prepared by the author based on information from IPCC (2022))

However, each greenhouse gas has a different warming potential per same amount. Some gases such as nitrous oxide and methane, have much higher impact on global warming compared to carbon dioxide. Global warming potential (GWP) is the criterion used to make the greenhouse gases comparable by expressing these gases in carbon dioxide equivalent values according to their impact on global warming. The higher the GWP of a gas, the more that gas warms the earth (EPA, 2021b). Mostly 100 years is taken as the time horizon in calculations and this horizon was used in this study (EPA, 2021b). Table 4 shows GWP values for the gases under review.

Table 4: Global Warming Potential of the GHG Gases under Review for 100 Years

	CO_2	CH_4	N_2O
GWP	1	25	298

(Source: IPCC (2007), Gürbüz et al. (2021))

3.1.2. Greenhouse Gas Emissions in Türkiye

Türkiye's GHG emissions were 506.1 mt CO_2e in 2019 (TURKSTAT, 2021b). Considering that the global GHG emissions were 59 GtCO_2eq, the country accounted for around 0.9% of the global emissions in 2019. As seen in Figure 3, majority of Türkiye's GHG emissions occurred due to energy consumption by 72% of the total emissions. Energy is followed by agriculture with 14% and industrial processes and product use with 11%. Surprisingly, even though economic activity contracted in 2020, Türkiye's GHG emissions increased by 3.1% to 523.9 mt CO_2e in 2020 (TURKSTAT, 2022a). This was mainly due to the rise in year-on-year emissions in industrial processes and product use with 14% and agriculture with 7.5% (TURKSTAT, 2022a).

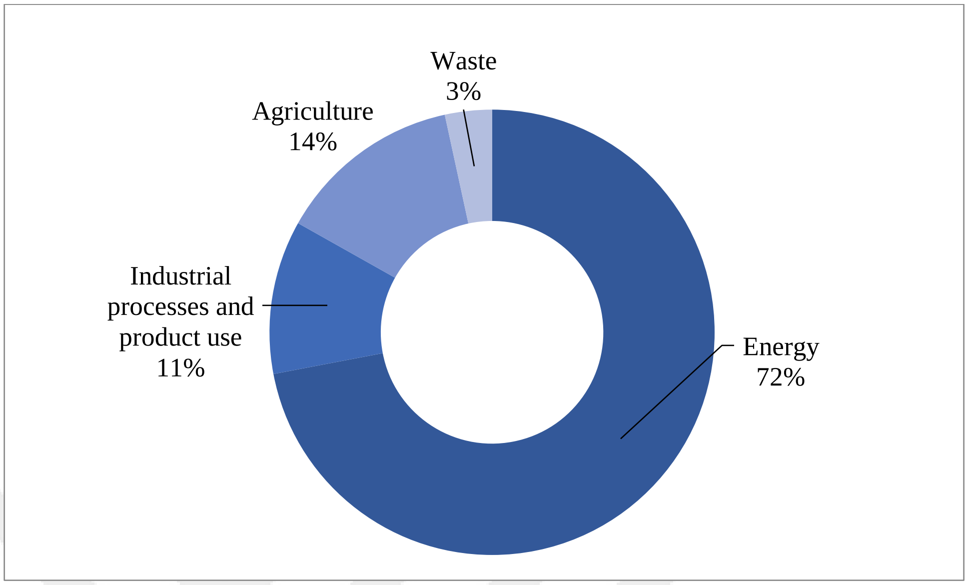

Figure 3: Sectoral Distribution of Greenhouse Gas Emissions in Türkiye, 2019.

(Source: Prepared by the author based on information from TURKSTAT (2021b))

The Figure 4 shows the development of Türkiye's real GDP and GHG emissions over the years and there has been a directly proportional relationship between the two variables. Since 2017, Türkiye’s real GDP is in a declining trend. As a result, the pace of annual CO_2 emissions began slowing down since that year.

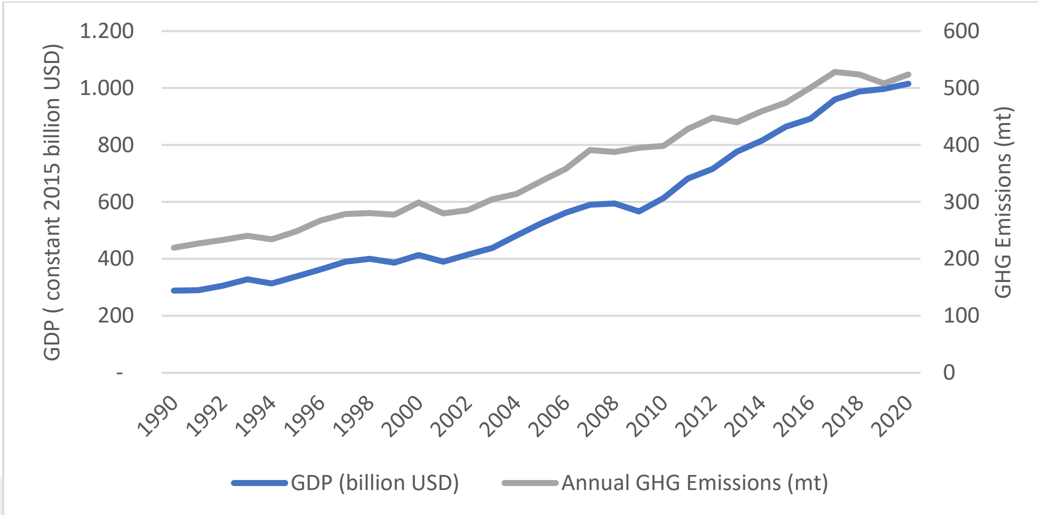

Figure 4: Real GDP and Annual GHG Emissions in Türkiye, 1990-2020.

(Source: Prepared by the author based on information from World Bank (2022), TURKSTAT (2022b))

According to the data provided by Ministry of Environment, Urbanization and Climate Change (UNFCCC, 2021), energy sector emitted 364.4 mt CO_2e emissions in 2019. Within the energy sector, energy industries were responsible for 148.5 mt CO_2e emissions, most of which consists of electricity and heat production with 139.1 mt CO_2e. This sub-sector is followed by transport with 82.4 mt CO_2e and manufacturing industries and construction with 54.5 mt CO_2e emissions. Within the transport, road transportation caused 76.7 mt CO_2e emissions. All together, electricity and road transport, which are the sub-sectors under review in this study, were responsible for 215.8 mt CO_2e emissions in 2019 representing 42.6% of the total GHG emissions in Türkiye.

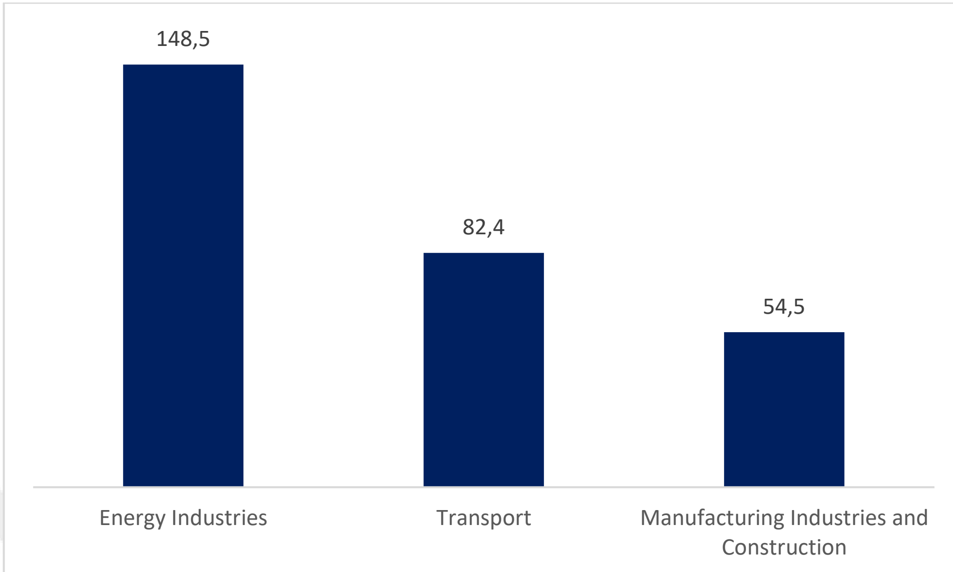

Figure 5: Türkiye's GHG Emissions mt CO2 eq. from Fuel Combustion Activities in 2019

(Source: Prepared by the author based on information from UNFCCC (2021))

Türkiye signed the Paris Agreement on April 22, 2016 and officially became a party to the agreement on November 10, 2021 (Anadolu Agency, 2021). In addition, the country declared its goal of achieving net zero emissions by 2053 (Anadolu Agency, 2021). For this reason, it is indispensable for Türkiye to develop emission reduction policies in a way that will not adversely affect its economy.

3.1.3. Car Driving and Electricity Consumption in Türkiye

According to TURKSTAT (2021c), there were 12,451,438 passenger cars in Türkiye in 2019. Diesel cars came first, constituting 38% of the total cars, followed by LPG with 37% and gasoline with 24%. The rest (1%) consists of electric-hybrid cars and unknown. It is worth mentioning that electric-hybrid cars have a very low share in the total number of cars.

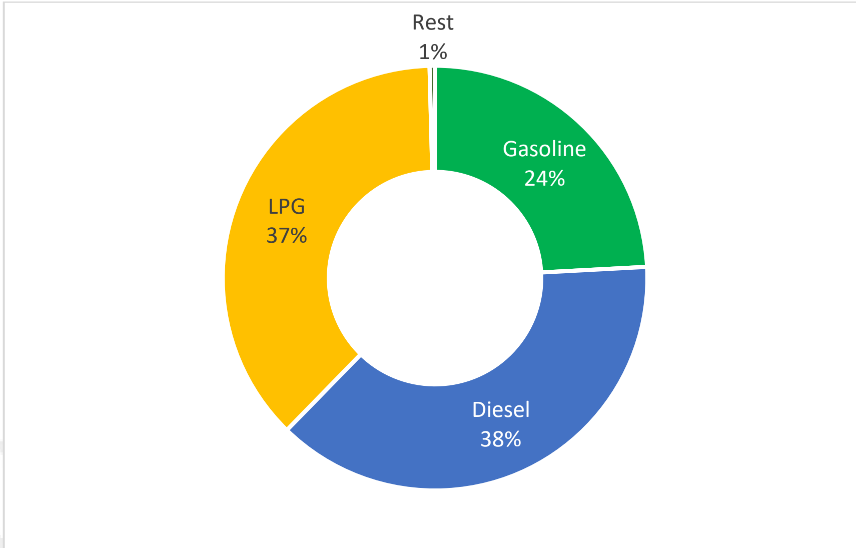

Figure 6: Distribution of Cars According to Fuel Type in Türkiye, 2019

(Source: Prepared by the author based on information from TURKSTAT (2021c))

Emissions of cars vary according to their fuel type. As seen in Table 5, diesel cars have the highest CO_2 emissions and it is followed by gasoline and LPG. Even though diesel cars emit higher emissions per gallon and liter compared to other types, they emit lower emissions in 100 kilometers (14.8 kg/100 km) compared to gasoline cars (16.2 kg/100 km) due to efficiency of diesel motors. Diesel cars consume the lowest amount of fuel per kilometer compared to gasoline and LPG.

Table 5: CO_2 Emissions by Fuel Type

	CO_2 Emissions (kg/gallon)	**CO_2 Emissions (kg/ lt)**	**Fuel Consumption in 100 km (lt)**	**CO_2 Emissions in 100 km (kg)**
Gasoline	8.78	2.3	7.0	16.2
Diesel	10.21	2.7	5.5	14.8
LPG	5.68	2.0	9.0	13.5

(Source: Prepared by the author based on information from EPA (2021a), Otostil (2017))

Figure 7 illustrates Türkiye’s electricity generation by source in 2019. Renewable energy came first, providing 44% of the total energy production. The vast majority of this amount comes from hydroelectricity. Renewables are followed by coal with 37% and natural gas with 19%. The high share of coal in electricity generation shows that policies that will reduce electricity consumption will make a significant contribution to the mitigation of emissions.

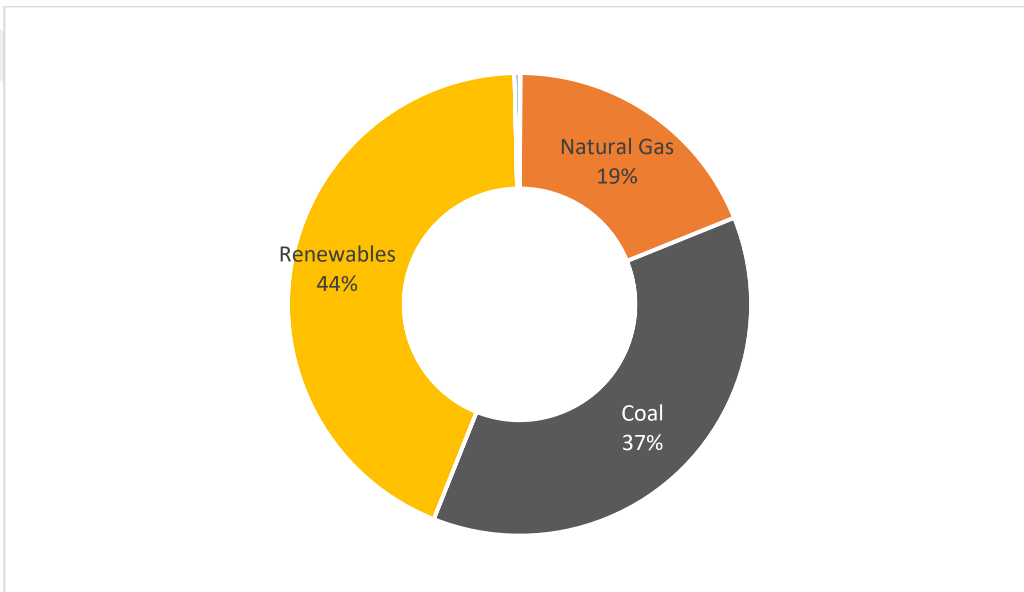

Figure 7: Electricity Generation by Source in Türkiye, 2019

(Source: Prepared by the author based on information from BP (2020))

In conclusion, almost all of the cars consume refined petroleum products and around one fifth of electricity is generated by natural gas in Türkiye. Considering that the country's imports it's 93% of its oil and 99% of its natural gas consumption, any policy to decrease fossil fuel consumption will help the country to reduce its current account deficit as well (IEA, 2021).

3.2. COVID-19 OUTBREAK AND ITS'S IMPACT ON ENERGY AND EMISSIONS

The first Covid-19 case emerged in December 2019 globally. With the spread of the virus, the WHO declared Covid-19 as a pandemic on March 11, 2020 (WHO, 2020). As a result, containment measures were particularly put in force intensively by many countries in March and April months of 2020 (IEA, 2020). Nevertheless, each country has carried out a different policy response. At the beginning of the outbreak, China, Italy, USA and France imposed massive lock down measures (Jae Moon et al., 2021). On the other hand, the UK let the virus spread aiming to ensure herd immunity for it's citizens (Rosen, 2021). However, this policy is now seen as a failure due having caused high death tolls and pressure on the public health system (Ellyatt, 2021). Additionally, Japan and South Korea didn't impose large scale lock downs but they focused on testing and treatment (Jae Moon et al., 2021). In addition, Australia put in force strict social distancing rules which limited the Covid-19 cases and death tolls but in 2022 many rules were lifted (Mcguirk, 2022). China has maintained its zero Covid-19 strategy for a long time, although it was implemented in a limited number of countries worldwide.

This variety in policies has also caused the energy demand of each country to be different. According to the IEA (2020), in countries where full lockdown measure were implemented, the energy demand declined by 25% each week in April. On the other hand, countries that put in force limited lockdown measures saw 18% decline in energy demand (IEA, 2020). In the first quarter of 2020, the energy demand fall by 3.8% globally (IEA, 2020).

Many countries lifted most of the restrictions for economic recovery in February-March 2022, despite increasing Covid-19 cases (Sevencan, 2022). Figure 8 shows the global primary energy consumption in the last ten years. Due to the pandemic, the energy consumption declined by 4% in 2020 year on year and this was the only fall within the period. As the most of the lockdown measures are lifted for economic recovery, the energy consumption increased around 5.5% year on year in 2021. In the meantime, the global carbon dioxide emissions from energy and industrial processes changed in correlation to the level of energy consumption.

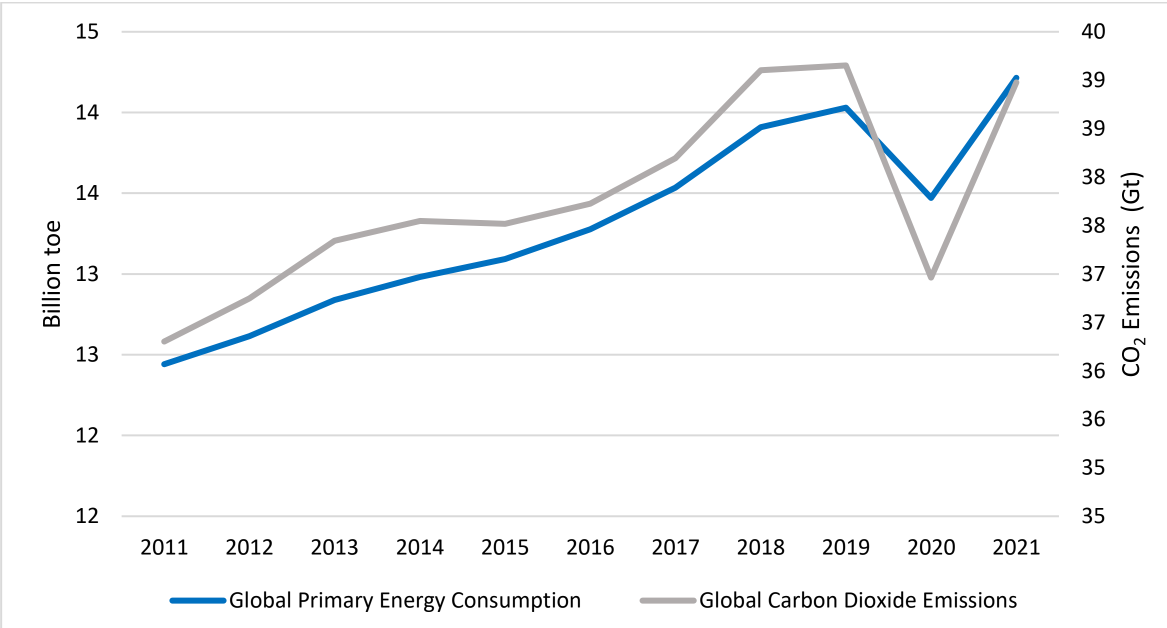

Figure 8: Global Primary Energy Consumption and Carbon Dioxide Emissions, 2011-2021[1]

(Source: Prepared by the author based on information from BP (2022))

3.2.1. Impact of Covid-19 on Türkiye's Energy Consumption and Emissions

Similar to the global trends, the disease spread rapidly throughout Türkiye and the Turkish government has implemented restriction policies to limit the mobility of the foreigners and it's citizens. From 27th March 2020, all international flights were prohibited (Directorate General for Civil Aviation, 2020). From March 28, 2020 on all intercity bus and air travels required permission (Ministry of Interior, 2020a). In additional, all intercity train travels were ceased (Turizm Günlüğü, 2020). In addition, as of March 30, 2020, a limit has been imposed on the number of taxis in traffic (Ministry of Interior, 2020b). Besides; cafes, restaurants and shopping malls were closed down temporarily (Turizm Gazetesi, 2021). In

[1] The original data is converted from exajoules to billion tons of oil equivalent by multiplying with 0.0239

addition, schools were shut down and distance education put in force. On March 23, 2020, distance education began and it was applied until the end of the school term, which was June 19, 2020 (Ministry of National Education, 2020c). Figure 9 shows the traffic density index between February 2020-June 2020 in Istanbul. A remarkable point is that there was a serious decline in total traffic density after Covid-19 in March. With the implementation of precautionary measures, traffic density decreased significantly in April and May. In addition, weekend curfews were implemented in April and May, which decreased the traffic density in the weekends further. As of June 1, many measures were lifted. For this reason, the traffic density was higher in June compared to the months when Covid-19 measures were applied strictly.

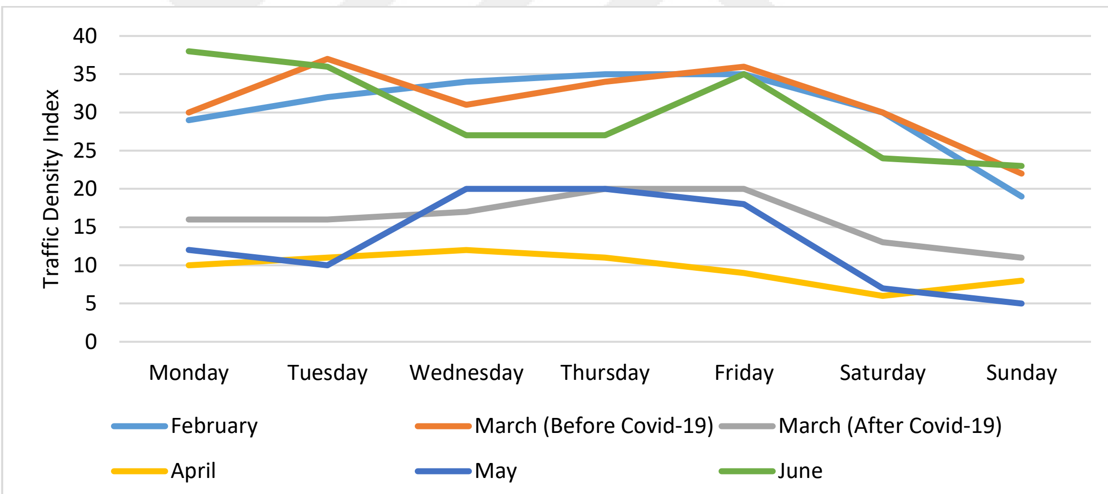

Figure 9: Istanbul's Traffic Intensity Index by Days of the Week, 2020

(Source: Prepared by the author based on information from Istanbul Metropolitan Municipality (2020))

For the education term 2021-2022, distance education began on August 31, 2021 and on September 21, 2021 face to face education began only for pre-school classes and the first class limited with 2 days (Ministry of National Education, 2020a, 2020b). All of these restrictions limited the mobility resulting in a drop in transport related energy consumption. As shown in Figure 10, Türkiye's primary energy consumption fall 2.5% while emissions fall 1% year-on-year in 2020. Since restrictions were lifted for the majority of 2021, the primary energy consumption increased 6% and carbon dioxide emissions rose 7.9% in the year.

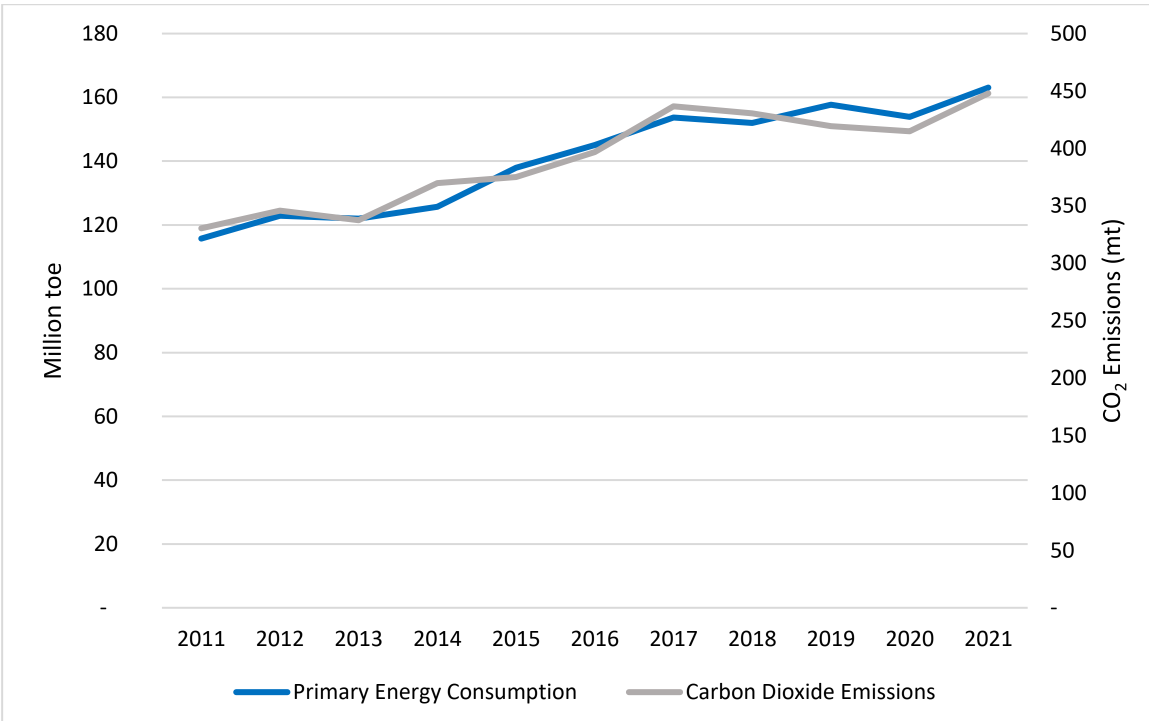

Figure 10: Türkiye's Primary Energy Consumption and Carbon Dioxide Emissions, 2011-2021[2]

(Source: Prepared by the author based on information from BP (2022))

3.3. FLEXIBLE WORKING

With the emergence of modern factories and workplaces, Industrial Revolution was the starting point of the working life as known today (Ören & Yüksel, 2012). Typically, workdays are from Monday to Friday from 9 AM to 5 PM or 6 PM (Dale, 2020). The workplace has been the place where the work was performed and the place to go to perform the tasks (Dale, 2020). With the shift of economies from industry to the service sector and the development of the information and communications technologies (ICT), the situation of

[2] The original data is converted from exajoules to million tons of oil equivalent by multiplying with 23.8846

going to the workplace has begun to change (Dale, 2020). For example now, more than 50% of the employees in the ICT sector work remotely in the UK (CIPD, 2021b).

The fact that many people go to the workplace at the same time causes environmental pollution due to vehicles, loss of time due to traffic and stress for people (Dale, 2020). In many offices, work is carried out by using tools that can be used anywhere (Dale, 2020). This situation allows the implementation of flexible working practices in many areas. According to Chartered Institute of Personnel and Development (CIPD, 2021a), flexible working is a working method that provides a certain level of flexibility in the duration, location and timing of a work performed by an employee. On the contrary to the traditional 9 to 5 working, with flexible working employees can have more control over their working arrangement (Dale, 2020). By having the locational flexibility, employees can work at the different places including in offices, homes, co-working spaces, cafes and even trains (Dale, 2020).

Of course, some works have to be performed in certain places such as healthcare or military service. However, many workplaces can obtain significant opportunities by shifting to flexible working practices.

3.3.1. Types of Flexible Working

According to Dale (2020), there are many types of flexible working such as:

- Part-time working
- Remote working
- Flexi-time
- Hybrid working
- Job-share
- Compressed hours
- Nine-day fortnight
- Annualized hours
- Staggered hours

- Self-rostering
- Zero-hours contracts
- Career breaks
- Phased retirement

The most common types of flexible working are part-time working, remote working, flexi-time and hybrid working. According to the OECD (2022b), part time working is defined as working less than 30 hours per week. It is the most common flexible working method (Dale, 2020). In 2021, 9% of the employed worked in part-time jobs in Türkiye (OECD, 2022b). Flexi-time gives employees the opportunity to decide when to begin and end a work under determined conditions (CIPD, 2021a). Hybrid working is a type of work method that allows both working from home and workplace on certain days of the week.

3.3.2. Remote Working

Remote working (teleworking, e-working) is a working method in which work is carried out partially or completely away from the workplace using technological communication tools (Felstead & Henseke, 2017; Hardill & Green, 2003; Kylili et al., 2020). Remote working can be done in many places, such as from home, cafe or co-working spaces (NoHQ, 2022). On the other hand, home working is doing work from home (Cultrix, 2020). Therefore, remote working includes home working (Cultrix, 2020). Since almost all remote workers worked from home during the pandemic and some scholars such as Gemma Dale use remote working and homeworking as synonyms, the two concepts were used interchangeably in this study. According to Nickson & Siddons (2012), home office working is defined as working from home at least two days of a week.

According to a research conducted in the UK on home working, the proportion of workers that work from home peaks at the middle age (CIPD, 2021b). At the same time, it can be seen in Figure 11 that working from home permanently increases with aging. The fact that young employees work mostly from the office is related to the fact that it is difficult for them to have a separate office at home and they are willing to be in contact with other employees in the office (CIPD, 2021b).

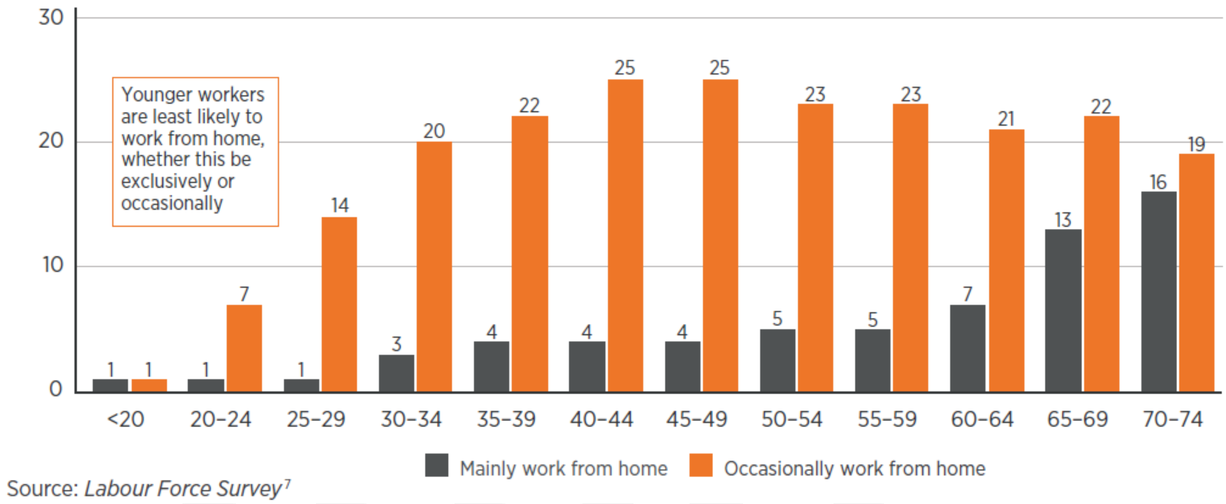

Figure 11: Proportion of Employees Working from Home by Age Group in the UK, April-June 2014

(Source: CIPD (2021b))

Figure 12 illustrates the proportion of remote workers by occupational group in 2014. It can be clearly seen that the rise in skill level, increases the proportion of workers working from home. Remote working has been most widely practiced among senior managers and professional occupations. At the beginner level, remote working was rarely applied.

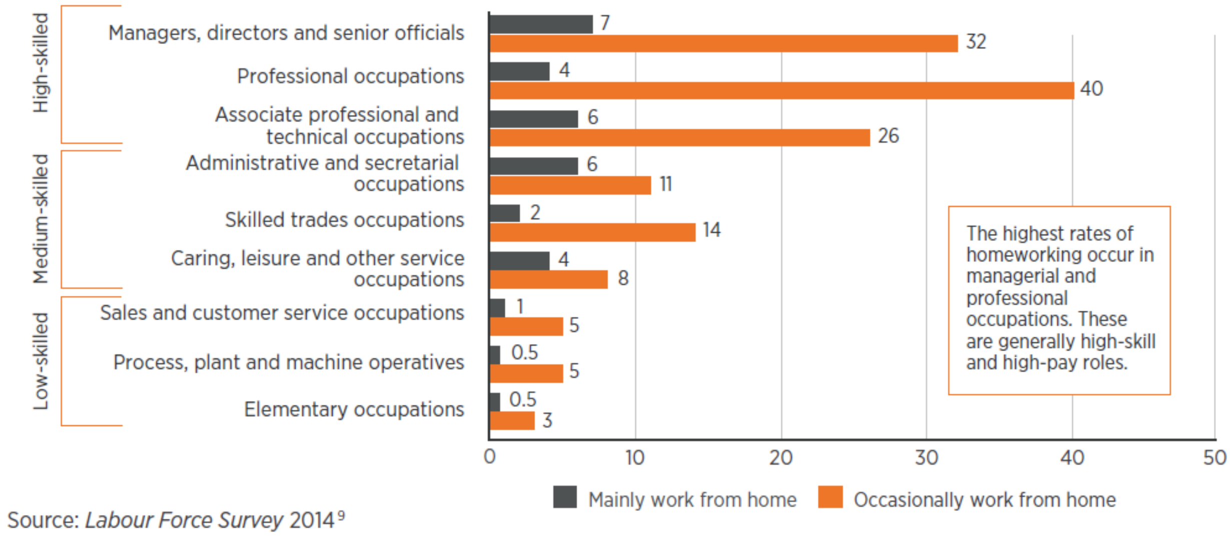

Figure 12: Proportion of Employees Working from Home by Occupational Group in the UK, April-June 2014

(Source: CIPD (2021b))

Figure 13 shows the proportion of employees working from home by industry in the UK. According to the results, ICT has the highest share with 51% of the employees and it is followed by scientific-technical activities with 44% and education with 39%. However, industries such as transport, food and drink and retail have the lowest proportion of remote workers (CIPD, 2021b).

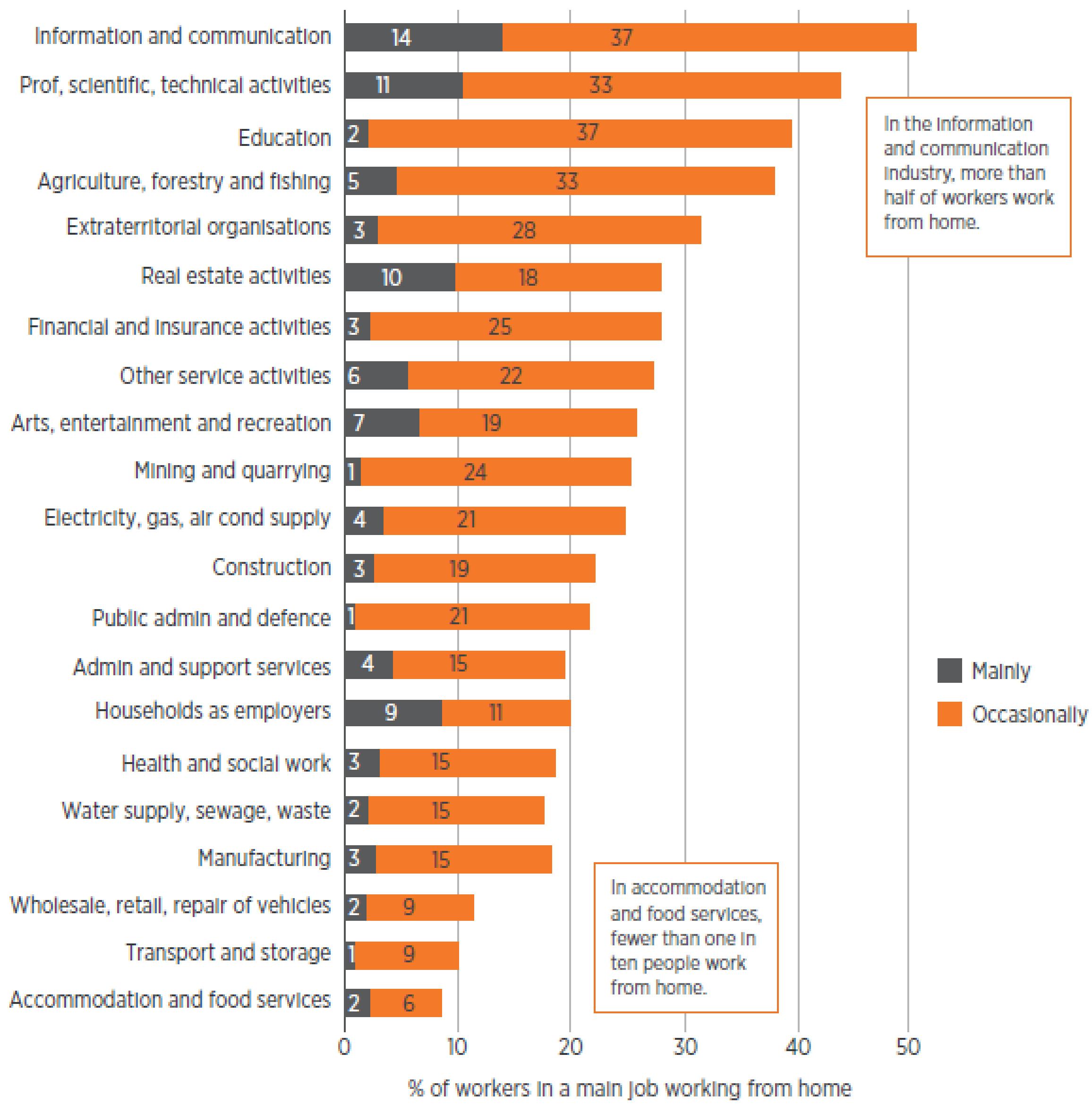

Figure 13: Proportion of Employees Working Remotely by Industry in the UK, April-June 2014

(Source: CIPD (2021b))

3.3.3. Advantages and Disadvantages of Remote Working

Flexible working and in particular remote working can have many economic, social and environmental benefits.

In terms of economic benefits, remote working helps employers to save money from office space (CIPD, 2021a). By this way employers can move to smaller offices and pay less rent and utility bills. Flexible working also contributes to fewer sick leaves, helping employees better manage their health and this way reducing absence of employees (CIPD, 2021a). According to a study conducted at the U.S. Department of Transportation, implementation of flexi-time decreased the usage of sick leave and short term annual leave by employees (Ott et al., 1980). In addition, by providing remote working opportunity, employers can attract high quality employees to work for them (Özkan, 2021). According to Özkan (2021), not providing the opportunity to work remotely causes brain drain.

From social point of view, remote working provides better work-life balance (CIPD, 2021a). As reported by a research, employees save in average 2 hours daily by not commuting to the office and by this way, they can use this time to have a better work-life balance (AGI Global, 2020). According to a study conducted on the companies in the UK, flexible working employees (remote working and reduced hours working) have a higher level of job satisfaction and dedication towards their jobs compared to office working employees (Kelliher & Anderson, 2010).

Figure 14 illustrates employees' opinion on the difficulty of working from home by age group in the UK. Majority of the employees (59%) don’t find home working difficult. On the other hand, 40% of the employees find it challenging. However, with the decreasing age of the employees, higher number of employees found it difficult to work from home. This shows that experienced employees are more suitable for home working.

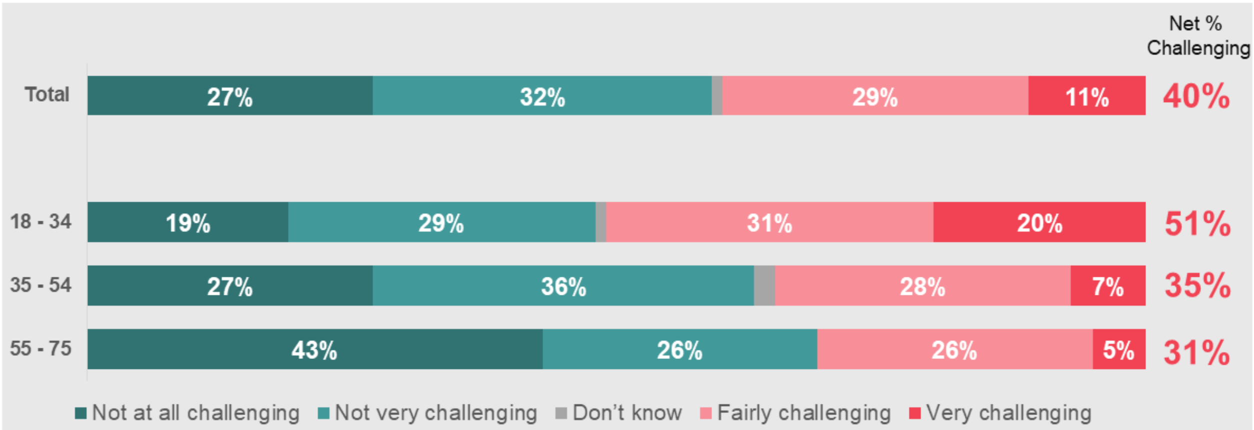

Figure 14: Employees' Opinion on the Difficulty of Working from Home by Age Group in the UK, 2020

(Source: Ipsos (2020))

As shown in Figure 15, "lack of suitable workplace" was cited as the biggest barrier to working from home with 38% of the employees finding home working challenging. Second barrier is mentioned as "missing face-to-face meeting and working with colleagues" with 36%. Afterwards comes "difficulty to maintain work-life balance" with 34%. The other reasons are mostly related to the conditions of home working such as the quality of technological equipment or distraction by other people/children at home.

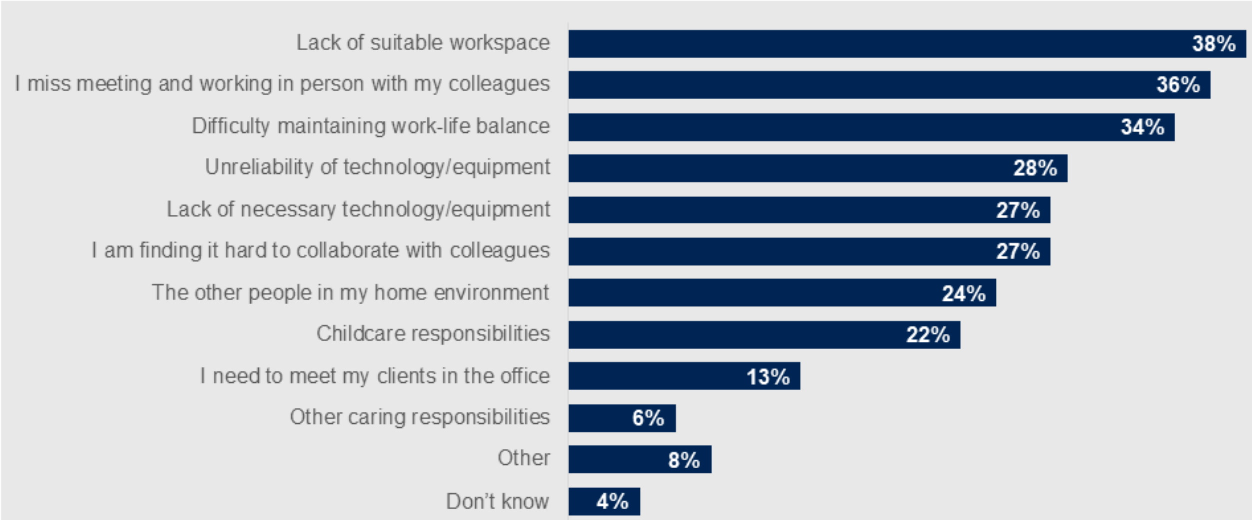

Figure 15: Reasons for the Challenges of Home Working in the UK, 2020

(Source: Ipsos (2020))

The fact that senior employees can financially afford a separate working room contributes to overcoming many of the difficulties mentioned by employees (The Economist, 2021a). As a result, young employees don't have such flexibility as they are in the early stage of their career.

3.3.4. Remote Working during Covid-19 Outbreak

Remote work has been applied globally more widely than ever before during the Covid-19 pandemic. In this way, the health of the employees was protected, the work was continued and the pandemic was kept under control (CIPD, 2021a). This also helped employees to avoid long commuting hours (CIPD, 2021a). By this way, four out of ten employees in Europe worked remotely (ILO, 2020). This rate differed from country to country. As shown in Figure 16, While 60% of the employees in Finland worked from home, this rate was 50% in the Netherlands and 40% in Italy (ILO, 2020).

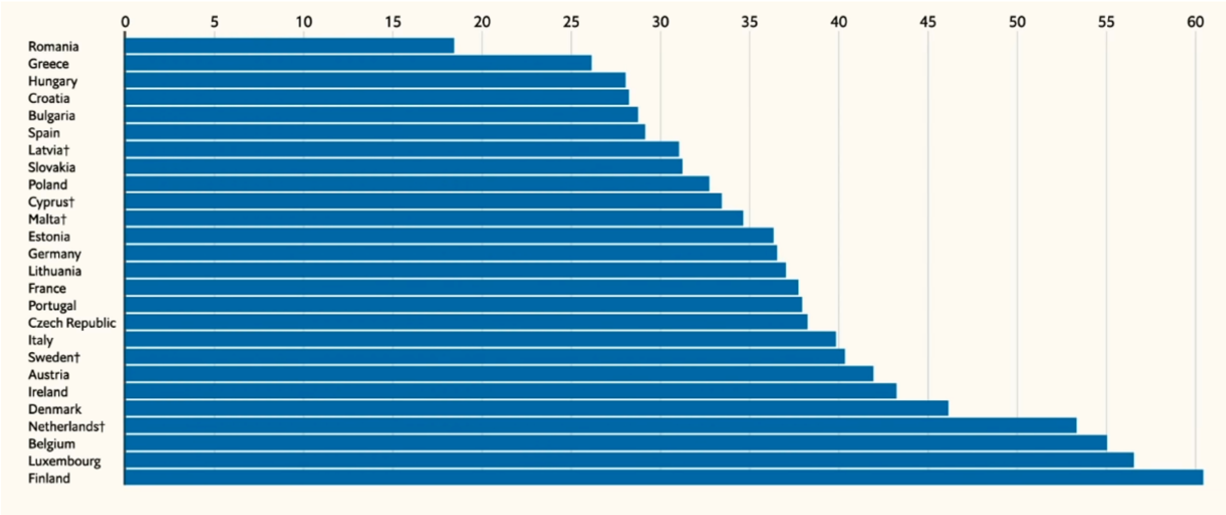

Figure 16: Ratio of Adults that began Working from Home as a Result of Covid-19, %

(Prepared by the Economist (2021b) based on the information from Eurofound (2020))

According to the research conducted by EBRD on efficiency of remote working, the number of employees who think remote working is more productive is much higher than those who think it is less productive. As it can be seen in Figure 17, 40% of the Turkish employees believe that they are more efficient while remote working and 40% of the Turkish employees think that remote working and office working are equally productive. Only 20% of the employees believe that they are less productive by working remotely.

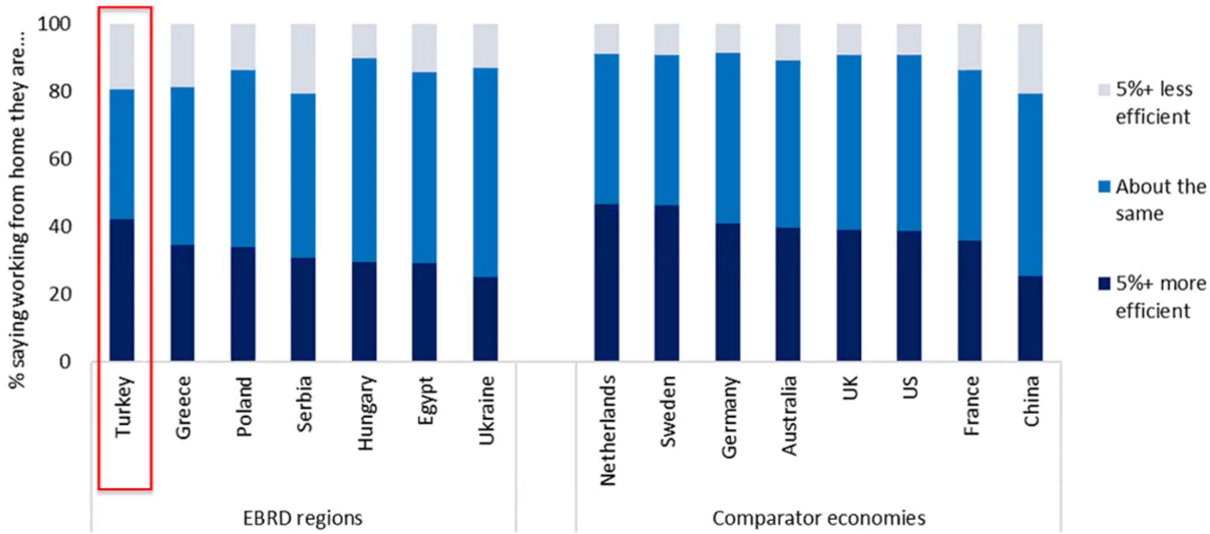

Figure 17: The Efficiency of Home Working Employees during Covid-19 Pandemic

(Source: EBRD (2021))

Figure 18 illustrates the number of working days employers and employees desire to work remotely. In all countries in the study, it is seen that employers are distant to remote working compared to employees. In Türkiye employers are willing to work around 2 days of the week remotely while employers are willing to allow them 1 day per week. Female employees are more willing to work remotely compared to male employees. In addition, female employers have a much higher desire to allow remote working compared to male employers in the country.

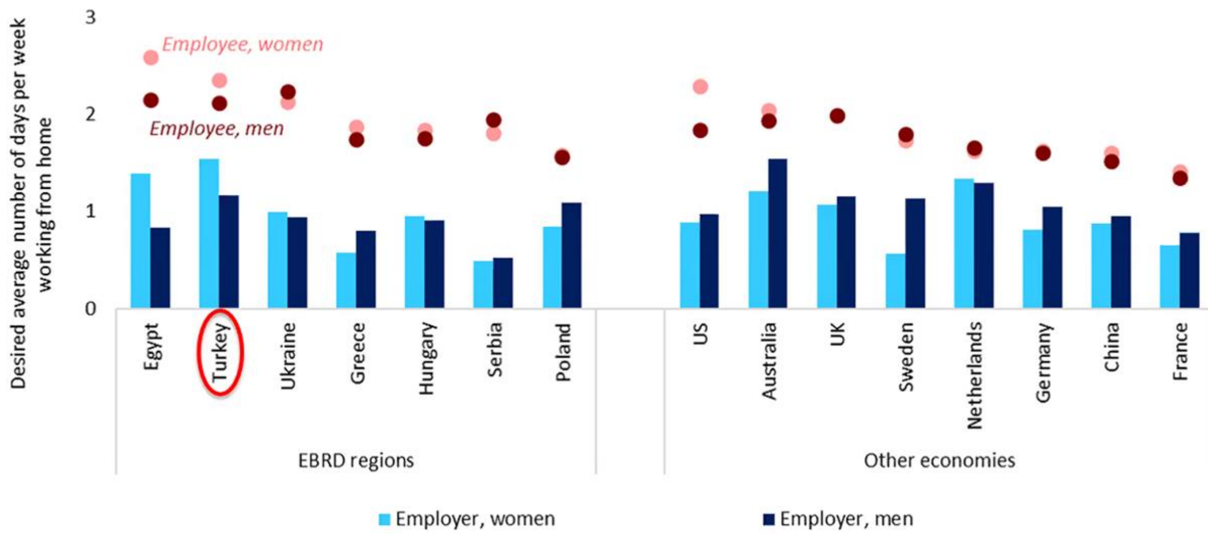

Figure 18: Desired Number of Home Working Days by Employers and Employees

(Source: EBRD (2021))

3.3.5. Remote Working Potential

It is also not possible to apply remote working practices in certain areas such as agriculture, forestry, construction (Lambrecht et al., 2021). For example, less than one in ten employees in accommodation and food services have the ability to work remotely (CIPD, 2021b). However, the potential is very high especially for insurance and some services sectors (Lambrecht et al., 2021).

Each country has a different remote working potential. According to some studies, there is a positive correlation between remote working potential and GDP per capita (Crow & Millot, 2020; Dingel & Neiman, 2020). Figure 19 illustrates remote working potential of countries versus GDP per capita. In general, the higher the GDP per capita, the higher the potential for remote working. According to the results of Dingel & Neiman (2020), Türkiye's remote working potential is 23% of the total jobs. Benefiting from this study, Crow & Millot (2020) takes Türkiye's remote working potential as 23% as well. This can be confirmed by the EBRD (2021), which predicts Türkiye's remote working potential between 20-25% of the total jobs.

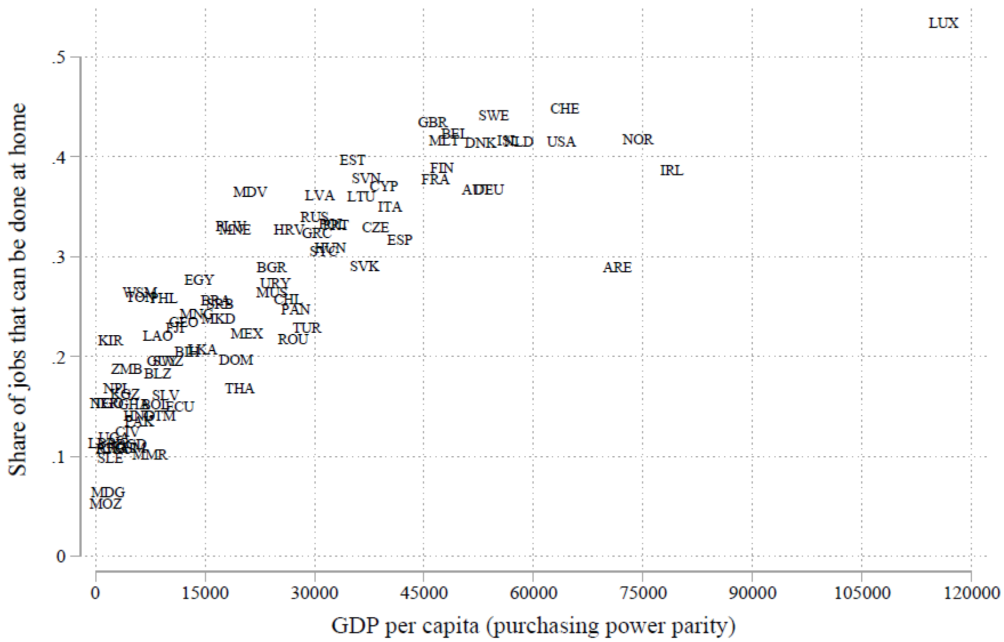

Figure 19: The Share of Jobs that can be done from Home vs. GDP per Capita

(Source: Dingel & Neiman (2020))

As a result, remote working potential of a countries depends on factors such as economic development, infrastructure and digital readiness (Crow & Millot, 2020). With the increase in GDP per capita, digitalization and technological improvements, the potential of remote working will increase further (Lambrecht et al., 2021). This shows that the potential for energy savings and emission reductions that can occur with remote working will gradually increase.

According to a study by OECD (2020), remote working potential between and within countries differs significantly. As shown in Figure 20, remote working potential for the city of Van in Türkiye was less than 15% of the total jobs in 2018. However, the potential was around 30% for Istanbul. Big cities have higher share of remote workable jobs compared to small ones (OECD, 2020). In addition, it has been determined that the remote working potential of most capital cities is 9% above the country average (OECD, 2020).

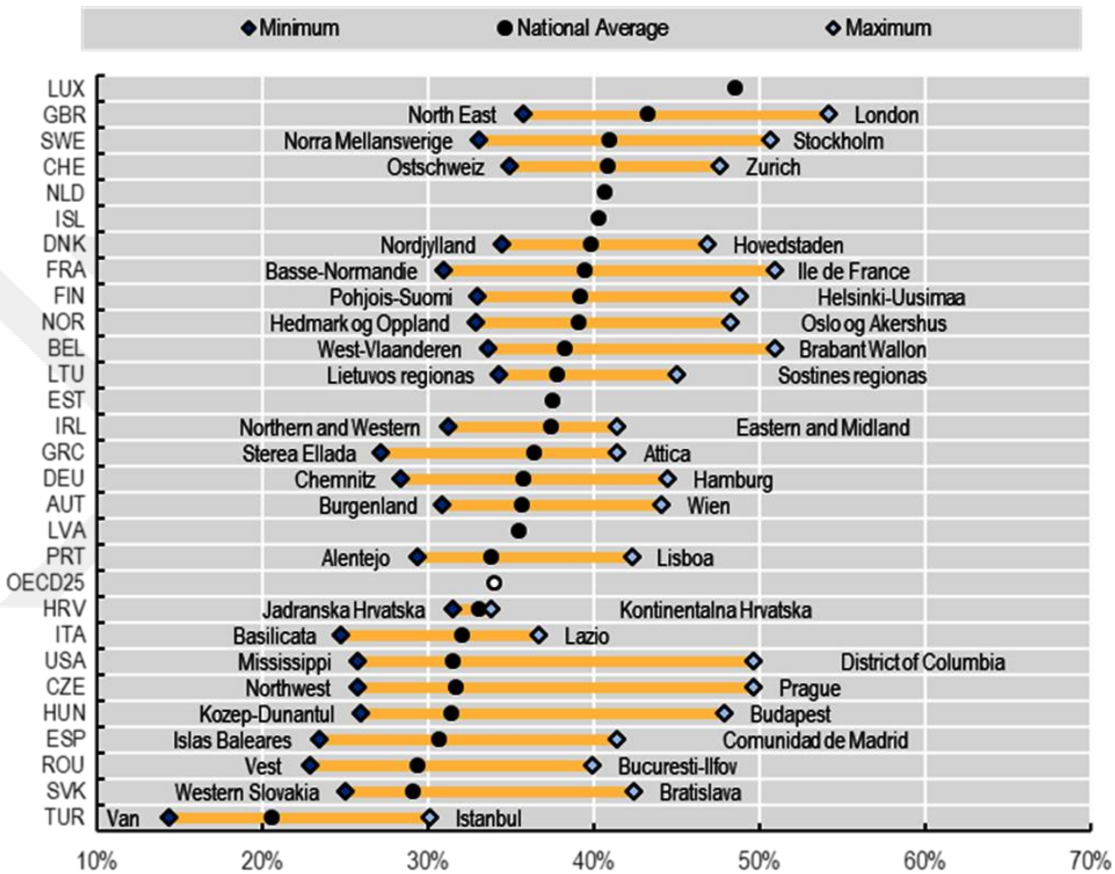

Figure 20: Remote Working Potential between and within Countries, 2018

(Source: Prepared by OECD (2020) based on the information from European Labor Force Survey, American Community Survey, Turkish Household Labor Force Survey and Occupational Information Network data)

Figure 21 shows the share of remote workable jobs and employees with tertiary education and there is a positive relation between the two variables. One point worth noting is that Türkiye remains below the trend line (OECD, 2020). This result shows that the share of jobs remote workable are lower than the expected considering the share of employees with tertiary education (OECD, 2020).

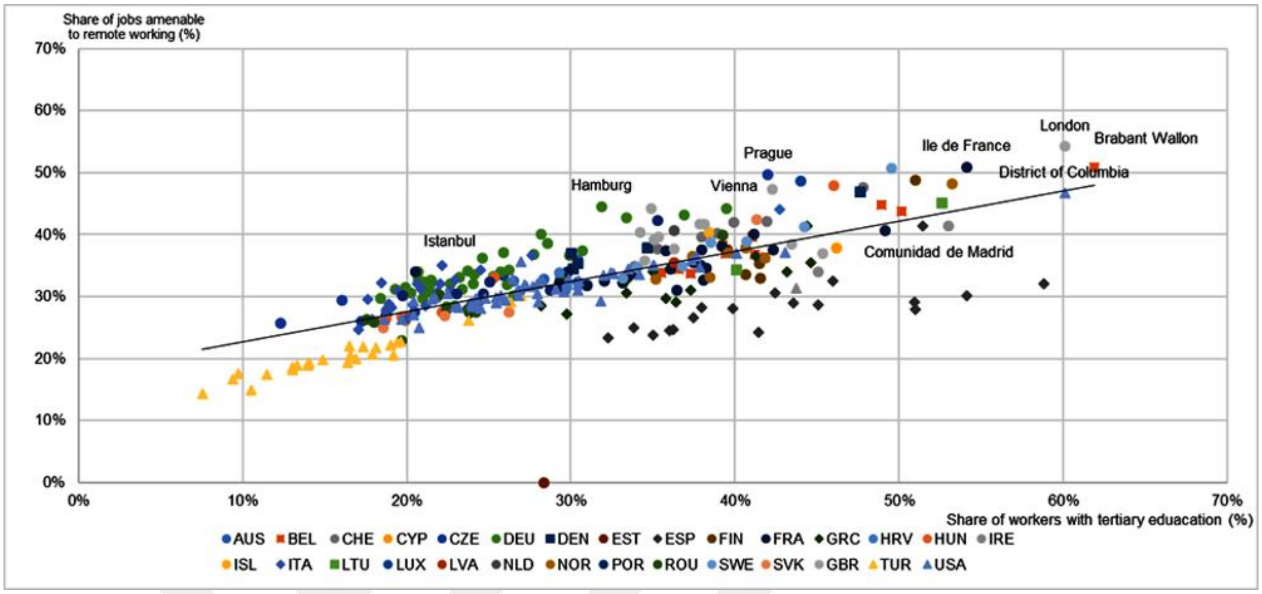

Figure 21: The Share of Remote Workable Jobs (%) and Employees with Tertiary Education (%), 2018

(Source: Prepared by OECD (2020) based on the information from European Labor Force Survey, American Community Survey, Turkish Household Labor Force Survey and Occupational Information Network data)

3.3.6. Türkiye's Remote Working Policy during Covid-19 Outbreak

The first Covid-19 case was announce on March 11th, 2020 in Türkiye (TRT Haber, 2020). As shown in **Hata! Başvuru kaynağı bulunamadı.**, remote working put into force i n three periods in the country. First, On March 22, 2020, a Presidential Circular was announced which enabled public institutions to apply flexible working practices such as remote working and shift working for public employees and it became valid until 1st of June 2020 (Resmi Gazete, 2020b). Between 1st of June to 25th of August 2020, public employees began working from office (Anadolu Agency, 2020). With a new circular on 26th of August 2020, flexible work arrangements put into force again which continued until 1st of March 2021 (Resmi Gazete, 2020a, 2021b). Afterwards, office working took place between 2nd of March and 13th of April 2021 (Resmi Gazete, 2021c, 2021b). Due to the significant increase in the number of Covid-19 cases and death tolls, with a new Presidential Circular, public employees had the opportunity to work from home again between April 14 and June 30, 2021 (Resmi Gazete, 2021c). In addition with this circular, the working hours of public employees were shortened and became between 10.00 AM and 16.00 PM (Resmi Gazete, 2021c).

Finally, As of July 1, 2021, remote working has been terminated and employees have been working from the office within regular working hours as of this date (Resmi Gazete, 2021a).

Figure 22 also shows workplace mobility in 2020 and 2021. During the periods when flexible working was introduced, there was a decrease in workplace mobility. It can also be seen that flexible working was applied stricter in the first period compared to the other two. It is also worth mentioning that workplace mobility is not only affected by the enforcement of flexible working practices by the government. Many employees are on vacation especially in the summer months.

Figure 22: Türkiye's Workplace Mobility and Flexible Working Periods in the Working Days of 2020 and 2021

(Source: Prepared by the author based on information from Google (2022a), Anadolu Agency (2020), Resmi Gazete (2020a, 2020b, 2021b, 2021c, 2021a))

CHAPTER 4

4. METHOD AND MATERIALS

The scope of the study covers the effect of remote working on car fuel (gasoline, diesel and LPG) and electricity consumption. Therefore, other oil products and energy sources are beyond the scope of this study.

While calculating the potential effect of remote working on car fuel and electricity consumption, Covid-19 period of 2020 and 2021 was taken as the basis. However, when calculating the concrete output of this potential (such as fuel saving amount or GHG emission mitigation), data for the year 2019, which did not experience extraordinary events such as pandemics or global energy crisis, was used. However, it should also be noted that carbon intensity in Türkiye increased above the average in 2019. Table 6 shows the data used in the study.

Table 6: Data used in the Study

Data	Unit	Source
Workplace mobility	Workplace mobility index	Google (2022a)
Residential mobility	Residential mobility index	Google (2022a)
Car driving	Car driving index	Apple (2022)
Cars by fuel type	Number of cars	TURKSAT (2021c)
Fuel consumption per 100 km	Liters	Otostil (2017)
Cost of fuel type	Turkish Lira	EMRA (2020b, 2020d)
Annual Turkish Lira to USD exchange rate	USD	OECD (2022)
CO_2 Emissions	kg per gallon	EPA (2021)
CH_4 Emissions	kg per gallon	EPA (2021)
N_2O Emissions	kg per gallon	EPA (2021)
GWP of CH_4	CO_2e	IPCC (2007)

GWP of N_2O	CO_2e	IPCC (2007)
Working days	Number of working days	Hakedis (2022)
Remote working potential	Share of jobs that can be done at home	Dingel & Neiman (2020)
Türkiye's public electricity and heat production emissions	kilo tons	UNFCCC (2021)
Türkiye's road transportation emissions	kilo tons	UNFCCC (2021)
Türkiye's national emissions	Million tons of CO_2e	TURKSTAT (2021b)
Türkiye's hourly electricity consumption	MWh	EPIAS (2022)
Electricity cost (energy and network cost) in the price	Percentage	EMRA (2020a)
Price of electricity	Kuruş/kWh	TURKSTAT (2021a)
Türkiye's total energy consumption	Thousand toe	MENR (2021)

In order to determine the effect of workplace mobility on car driving, the correlation relationship between the daily car driving index published by Apple and the daily workplace mobility data published by Google in solely working days (excluding non-working and exceptional days) from February 17th 2020 to 31st December 2021 was examined. Apple and Google began to publish mobility data of their users collected from smart phones to help policy makers and scientists make use of real-time data to prevent the spread of the virus (Google, 2022a). Google collects mobility data from the users which turned on their Location History (Google, 2022b). The company reports mobility in five categories: Retail and recreation, grocery and pharmacy, parks, transit stations, workplaces and residential (Google, 2022b). The company set the median values of the dates between 3rd of January and 6th of February 2020 which represent the period where the outbreak has not widely spread (Google, 2022b). The data tracks how their user's mobility in five categories change compared to the median values of the basis dates (Google, 2022b). Besides, Apple has a similar approach and set 13th of January 2020 as basis (Apple, 2022). The company tracks data on three categories: Walking, car driving and public transport (Apple, 2022). However, for some countries such as Türkiye, the company doesn't publicize the public transport data. Apple published the relative volume of direction requests in comparison to the basis date (Apple, 2022). As of April 2022, Apple stopped publishing mobility data publicly and Google does not publish new mobility data since October 15, 2022.

As seen in Figure 23, there has been a strong positive relation between car driving and workplace mobility in working days since the beginning of the pandemic. After the first case seen in Türkiye on March 11th 2020 and the announcement of the Presidential Circular on flexible working, there was a sudden decline in workplace mobility and car driving. In general, workplace mobility and car driving changed simultaneously. However, as it can be seen in the figure, the correlation became negative in three periods. The two of these occurred in the summer months of 2020 and 2021. In summer, most employees are on vacation and they don't go to the workplace. That's why the workplace mobility decreases compared to other months. However, due to the increase of travels to other cities, car driving rises. The third exception was the period in between 15-19 November 2021, the school holiday for primary and secondary school students. Many parents were also on vacation, which increased car driving but decreased workplace mobility.

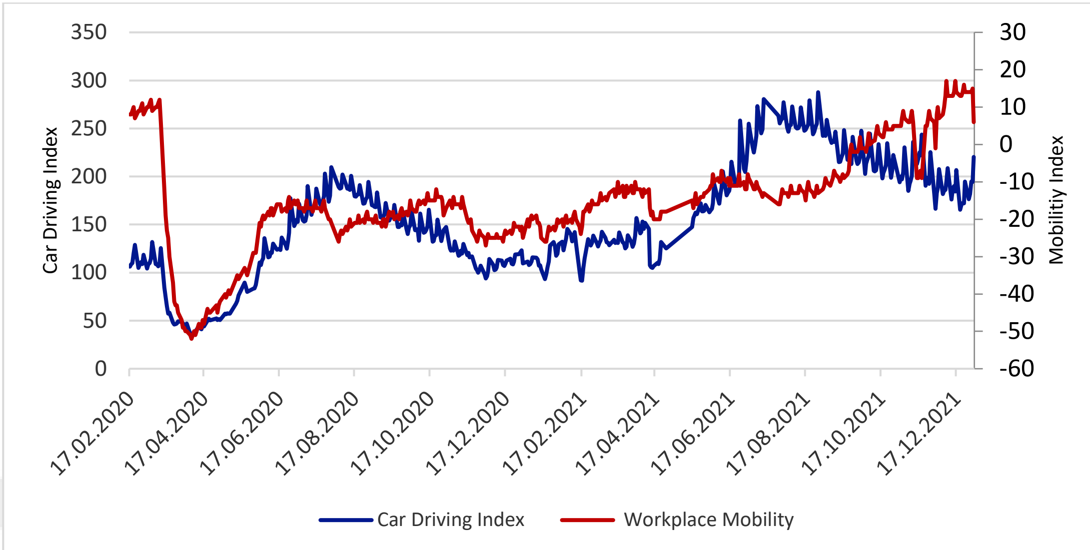

Figure 23: The Daily Relationship between Car Driving and Workplace Mobility in Working Days in Türkiye

(Source: Prepared by the author based on information from Apple (2022), Google (2022a))

Table 7 shows the correlation between car driving and workplace mobility in working days, which is around 0.59.

Table 7: Correlation between Car Driving and Workplace Mobility in Working Days in Türkiye

	Column 1	*Column 2*
Column 1	1	
Column 2	0.587311	1

After determining the correlation, Dingel & Neiman's (2020) and Crow & Millot's (2020) findings on Türkiye's remote working potential (23% of the total jobs) were used. In order to realize this potential, the Covid-19 process has become a trial and test period.

In the light of the available data, an empirical potential of 13.51% (23% of 59%) was calculated as a result of the 0.59 correlation between workplace mobility and car driving. This result shows that car driving during working days can be reduced by 13.51% if Türkiye takes advantage of its full remote working potential.

Number of cars by fuel type is taken from the TURKSTAT for 2019 (2021c). Each car consumes fuel according to it's fuel type. As stated in some researches, people in Türkiye drive in average 40 kilometers each day (Haberturk, 2013; Otostil, 2017). Based on this, the amount of fuel consumed by cars in 40 kilometers was calculated according to the fuel types. The cost of fuel types is published by the Turkish Energy Market Regulatory Authority's (EMRA) in Turkish Liras and OECD's annual average exchange rates were used to convert Turkish Liras to US Dollars (EMRA, 2020b, 2020c; OECD, 2022a). In this study the cost of the fuel is taken into account instead of the price because the price also includes taxes which have a beneficial role for the public. This way, the study wants to focus on the burden aspect of the energy for the economy. As a result of these calculations, one-day total cost of driving cars in a working day is calculated for the Turkish economy. By taking 13.51% of this one-day total fuel cost, the potential daily saving with remote working was calculated. The annual savings amount is determined by multiplying this amount by the number of working days in 2019. The number of working days in 2019 was found by using an online calculation portal (Hakedis, 2022).

Concerning the impact of this reduction in fuel consumption on greenhouse gas emissions, three main greenhouse gases were taken into consideration: Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The amount of emissions that the vehicles will cause by driving 40 kilometers has been calculated by using the emission figures of the U.S. Environmental Protection Agency (EPA) for each fuel type (EPA, 2021a). Global warming potential (GWP) calculated by Intergovernmental Panel on Climate Change (IPCC) for 100 years is used to convert methane and nitrous oxide emissions to carbon dioxide equivalent (IPCC, 2007). By using these data, daily emissions for each gas type was estimated. By taking 13.51% of this emission amount, the emission reduction that can occur with remote working has been calculated. To find the yearly mitigation, one-day emission reduction amount is multiplied by the number of working days in 2019. In order to find the share of this potential mitigation in total emissions, TURKSAT data on national emissions was used (TURKSTAT, 2021b). In addition, Türkiye's 2019 CRF table was used to calculate the share of the potential mitigation with remote working in the related sectors, which are "public electricity and heat production" and "road transportation" (UNFCCC, 2021).

For the purpose of finding the impact of remote working on electricity consumption, first the hourly electricity consumption data published by Energy Exchange Istanbul (EPIAS) between 17th of February 2020 and 31st of December 2021 was used (EPIAS, 2022). EPIAS receives the electricity consumption data from Turkish Electricity Transmission Corporation (TEIAS). Non-working days (weekends, public holidays, exceptional days) were excluded from this data set, and only the electricity consumption data during working hours (from 08:00 AM to 18:00 PM) were taken into account.

Figure 24 shows the relationship between electricity consumption and residential mobility. The inverse relationship can be obviously seen. In the beginning of the outbreak, many employed began working from home, which raised the level of residential mobility to a higher level than ever before. The correlation between the adjusted electricity consumption in working days and the daily residential mobility data for the same dates published by Google was calculated and found to be -0.63. According to this result, an increase in residential mobility by 100 units reduces electricity consumption by 63 units.

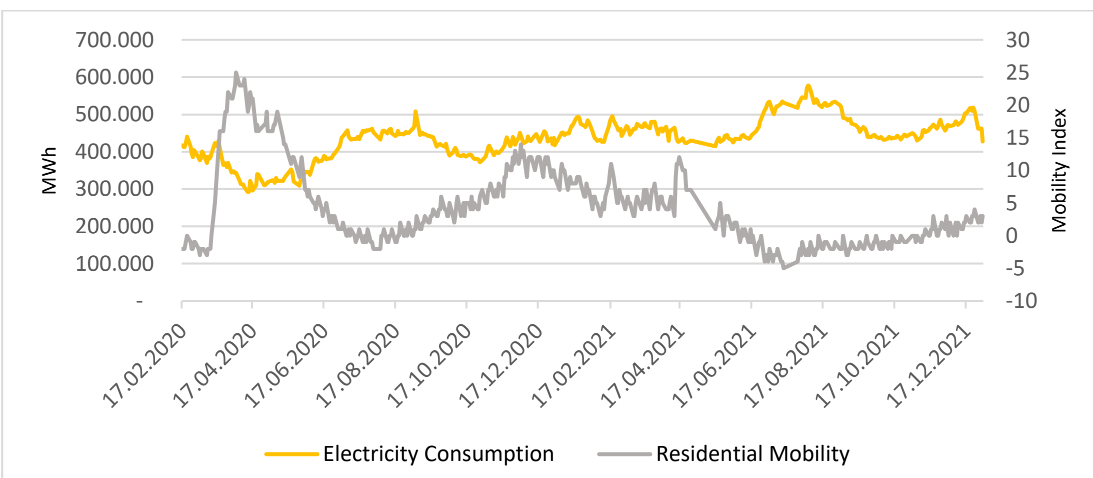

Figure 24: The Daily Relation between Electricity Consumption and Residential Mobility in Working Days in Türkiye

(Source: Prepared by the author based on information from EPIAS (2022), Google (2022a))

However, not all residential mobility is related to the workplace mobility. Figure 25 illustrates the relationship between residential mobility and workplace mobility. The two variables have almost a symmetric relationship. Their correlation was calculated for the working days and found as -0.76. This means that the negative relationship between workplace and residential mobility is 76%. The rest of the residential mobility is related to the citizens, which are not employed.

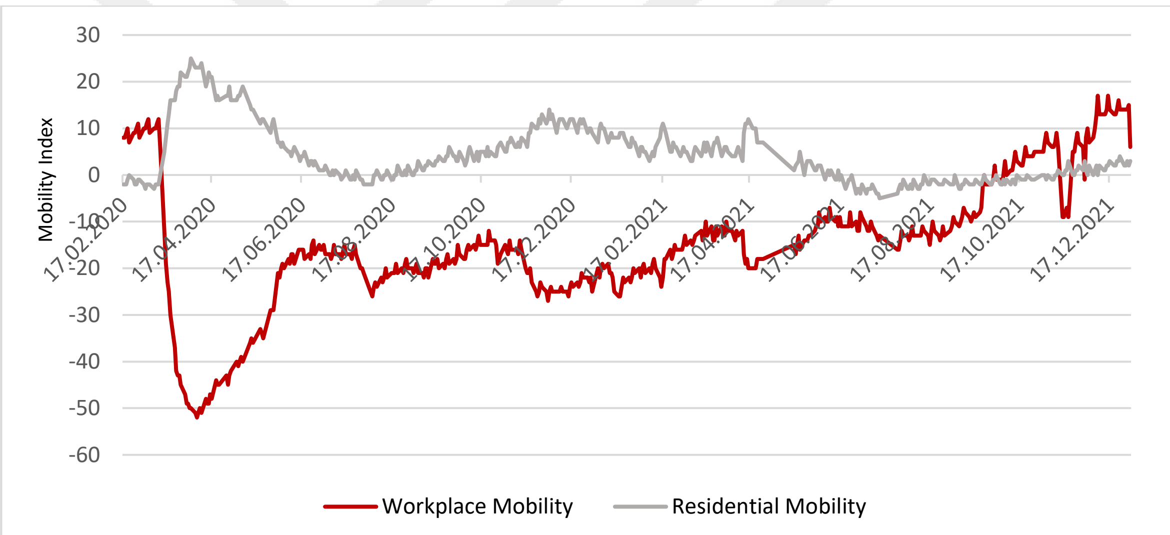

Figure 25: The Daily Relation between Workplace Mobility and Residential Mobility in Working Days in Türkiye

(Source: Prepared by the author based on information from Google (2022a))

When these two results are combined, the relationship between electricity consumption and employee-driven residential mobility is found. In this case, if remote working could be applied for the all employed, electricity consumption would decrease 48% (76% of 63) in working hours. The same result can also be found by looking at the relationship between electricity consumption and workplace mobility, which can be seen in Figure 26. The correlation between the two data sets is 0.48.

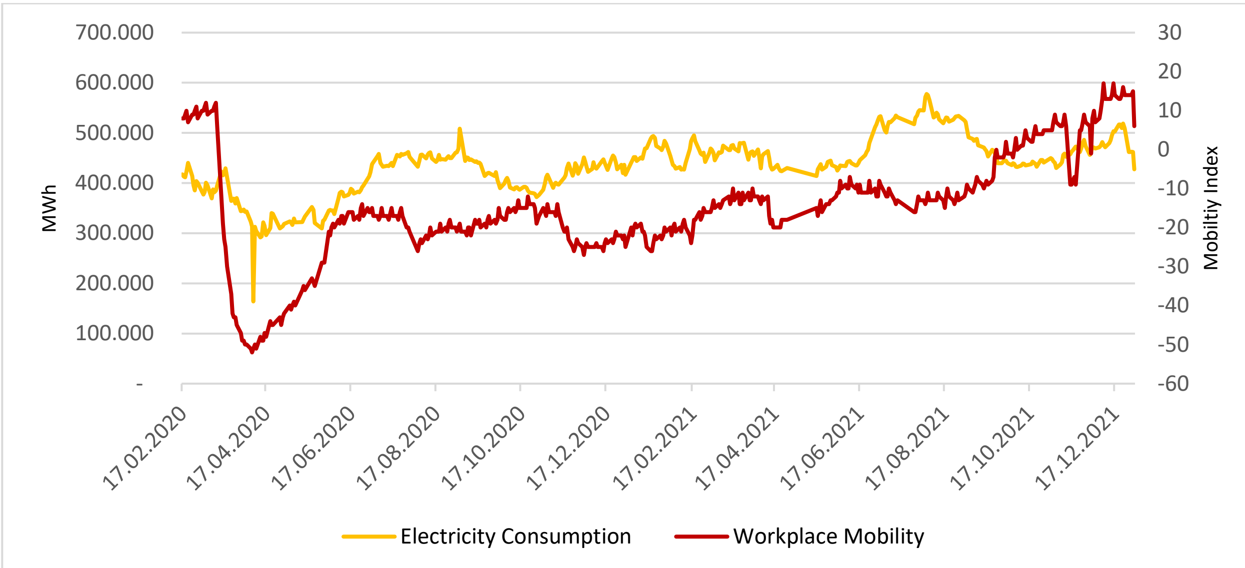

Figure 26: The Daily Relation between Electricity Consumption and Workplace Mobility in Working Days in Türkiye

(Source: Prepared by the author based on information from EPIAS (2022), Google (2022a))

However, it is not possible to reduce the electricity consumption by 48% during working hours because remote working can't be applied to all workers but to 23% of the jobs in Türkiye. In this case, if Türkiye utilizes her full remote working potential, the country can reduce the electricity consumption by 10.94% (23% of 48) during working hours.

Based on this result, the amount of saving and greenhouse gas emission reduction potential was estimated by using electricity consumption and GHG emissions data for 2019. In this way, the potential annual contribution of remote working was calculated using the data of 2019, which was an ordinary year. All weekends and public holidays were excluded as only working days were taken into account. In this way, 10.94% of the total electricity consumption between 8.00 AM and 18.00 PM on working days was calculated and the electricity savings that could be achieved by remote working was determined. EMRA publishes the cost share (energy and network cost) in the electricity prices annually (EMRA, 2020a). In additional TURKSAT shares the semiannual electricity prices for households

(TURKSTAT, 2021a). As in the calculation made for car driving, the cost of electricity was taken as the basis for calculating the contribution of remote working to the Turkish economy. The cost of electricity was calculated by taking the average of the semiannual electricity prices and using the cost ratio within the electricity prices. Similar to the calculations made for car driving, OECD's annual average exchange rates were used to convert the cost of electricity from Turkish Liras to US Dollars.

In order to calculate the emission reduction that remote working can provide in the electricity sector, the amount of emissions originating from electricity generation was used in the 2019 CRF table. By using the ratio between the amount of electricity saving with remote working and the total amount of electricity consumed in 2019 published by EPIAS, it has been determined how much electricity-related emissions could be reduced. Thus, the contribution of remote working to the reduction of both electricity sector emissions and nationwide emissions has been calculated.

Lastly, after calculating the oil equivalent value of the total savings achieved by remote working, the share of this amount in Türkiye's total energy consumption in 2019 was calculated. Türkiye's total energy consumption data is published by the Ministry of Energy and Natural Resources (MENR, 2021). In this way, the effect of remote working savings in terms of total energy consumption has been revealed.

CHAPTER 5

5. RESULTS

5.1. SAVING DUE TO REDUCED CAR DRIVING

For calculating the correlation between car driving and workplace mobility, 448 working days of data were used. Although the study examined the working days between 17.02.2020 and 31.12.2021, Apple did not release data for 3 working days[3] during this period globally. Therefore, these three days were not used in the study. As part of focusing solely on working days, all weekends, national holidays[4] and exceptional days were excluded. The exceptional days are administrative leave[5], days between two holidays[6], the full lockdown in 2021[7] and days prior to the full lockdown[8]. As a result, correlation between workplace mobility and car driving was found as 0.59 for working days. This result shows that car driving can decrease by 59% if all employees don't go to work on working days. However, according to the researches by Dingel & Neiman (2020) and Crow & Millot (2020), 23% of the employees can work remotely in Türkiye. Therefore, 23% of 59 is taken (13.51%) to determine the reduction in car driving in case Türkiye utilizes her full remote working potential. This way, full implementation of remote working have an empirical potential of reducing car driving by 13.51% in working days.

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[3] These dates are: 11.05.2020, 12.05.2020, 12.03.2021

[4] The excluded national holidays in working days are: 23.04.2020 (National Sovereignty and Children's Day), 01.05.2020 (Labor and Solidarity Day), 19.05.2020 (Commemoration of Ataturk, Youth and Sports Day), 25.05.2020-26.05.2020 (Ramadan Feast), 15.07.2020 (Democracy and National Unity Day), 30.07.2020-03.08.2020 (Sacrifice Feast), 29.10.2020 (Republic Day), 01.01.2021 (New Year's Day), 23.04.2021 (National Sovereignty and Children's Day), 19.05.2021 (Commemoration of Ataturk, Youth and Sports Day), 15.07.2021 (Democracy and National Unity Day), 19.07.2021-23.07.2021 (Sacrifice Feast), 30.08.2021 (Victory Day), 28.10.2021-29.10.2021 (Republic Day).

[5] Administrative leave for public workers days are: 24.04.2020, 18.05.2020,

[6] 16.07.2021 is a date between Democracy and National Unity Day (15.07.2021) and Sacrifice Feast (19.07.2021-23.07.2021). Therefore many employees took a day off.

[7] Full lockdown dates are: 30.04.2021-14.05.2021, these dates also include Ramandan Feast

[8] Between 27.04.2021-29.04.2021, many people went to countryside and coastal towns before the full lockdown (30.04.2021-14.05.2021).

Since 2019 was the year closest to the current conditions and without major extraordinary events, this year was used as the basis for calculating the amount of saving. Table 8 illustrates the daily cost of car driving in Türkiye for 2019.

Table 8: Daily Cost of Car Driving in Türkiye, 2019

Type of Fuel	Number of Cars (2019)	Consumption in 100 km	Consumption in 40 km	Cost per Liter in 2019 (USD)	Daily Cost (USD)
Gasoline	3,020,017	7	2.8	0.46	3,877,799.76
Diesel	4,769,714	5.5	2.2	0.51	5,315,112.39
LPG	4,661,707	9	3.6	0.22	3,703,074.69
Total					12,895,986.84

(Source: Prepared by the author based on information from TURKSTAT (2021c), Otostil (2017), EMRA (2020b), EMRA (2020c), OECD (2022a))

Number of cars according to their fuel type data is taken from TURKSTAT for 2019 (2021c). The amount of fuel consumed by each car varies according to the type of fuel (in average gasoline: 7 LT/100 km, diesel fuel: 5.5 LT/100 km, LPG: 9 LT/100 km) (Otostil, 2017). As stated in some researches, people in Türkiye drive in average 40 kilometers each day (Haberturk, 2013; Otostil, 2017). In this way, the consumption of cars according to their fuel type in 40 kilometers was calculated. The cost of fuel type is published by the Turkish Energy Market Regulatory Authority's (EMRA) in Turkish Liras and OECD's annual average exchange rates were used to convert Turkish Liras to US Dollars for 2019 (EMRA, 2020c, 2020b). The price of car fuel also includes taxes, which is an important source of income for the public. However, since this study focuses on the burden of car fuel consumption on economy, the cost is taken as the basis. By multiplying the number of cars with consumption per 40 km and cost per liter, daily cost of car driving in Türkiye was calculated, which was 12.9 million dollars. By taking 13.51% (remote working' empirical potential to reduce car driving) of the daily cost, daily saving with remote working was found as 1.7 million dollars. By multiplying this number with the number of working days in 2019 (248 days), the annual fuel saving can be found as 432.1 million dollars. As a result, Türkiye has the potential to save 432.1 million dollars annually due to the reduction in car driving with remote working. Figure 27 show how the calculations are made.

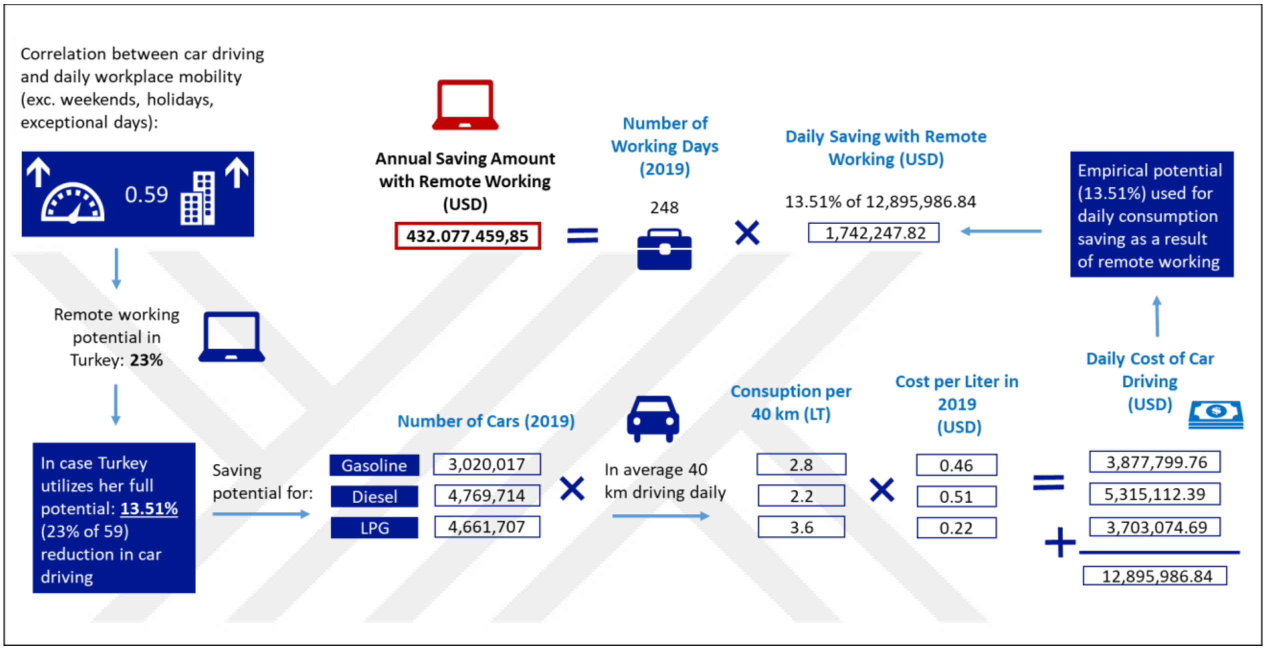

Figure 27: Calculation of the Potential Annual Saving due to Reduced Car Driving with Remote Working

(Source: Prepared by the author based on information from Apple (2022), Google (2022a), Dingel & Neiman (2020), Crow & Millot (2020), TURKSTAT (2021c), Otostil (2017), EMRA (2020b), EMRA (2020c), OECD (2022a), Hakedis (2022))

5.2. SAVING DUE TO REDUCED ELECTRICITY CONSUMPTION

Similar to the calculation made for car driving, data for 448 working days (17.02.2020-31.12.2021) were used to determine the correlation between electricity consumption and remote working (Figure 28). In order to take into account only working days, the non-working days mentioned in the previous section were excluded from the study. Hourly electricity consumption data are published by EPIAS. Since the working hours are mostly between 8:00 AM and 18:00 PM, daily electricity consumption for working days was obtained by summing the electricity consumption between these hours.

Residential mobility data is published by the Google. A correlation of -0.63 was found between electricity consumption and residential mobility. This result shows that increase in residential mobility decreases electricity consumption. However, not all residential mobility is related to the workplace mobility. People that do not participate in the labor force (e.g. retired, children, disabled) or who are unemployed can be given as an example to this group of people. For this reason, the correlation between workplace and residential mobility for working days was calculated and found as -0.76. This shows that residential mobility increases by 76% in case all employees do not go to the workplace. When these two relations are combined, that is, in case remote working could be applied to all employees, electricity consumption could be reduced by 48% (76% of 63) during working hours.

This result was also confirmed by finding the correlation between electricity consumption and workplace mobility for the same dates and the result was found as 0.48.

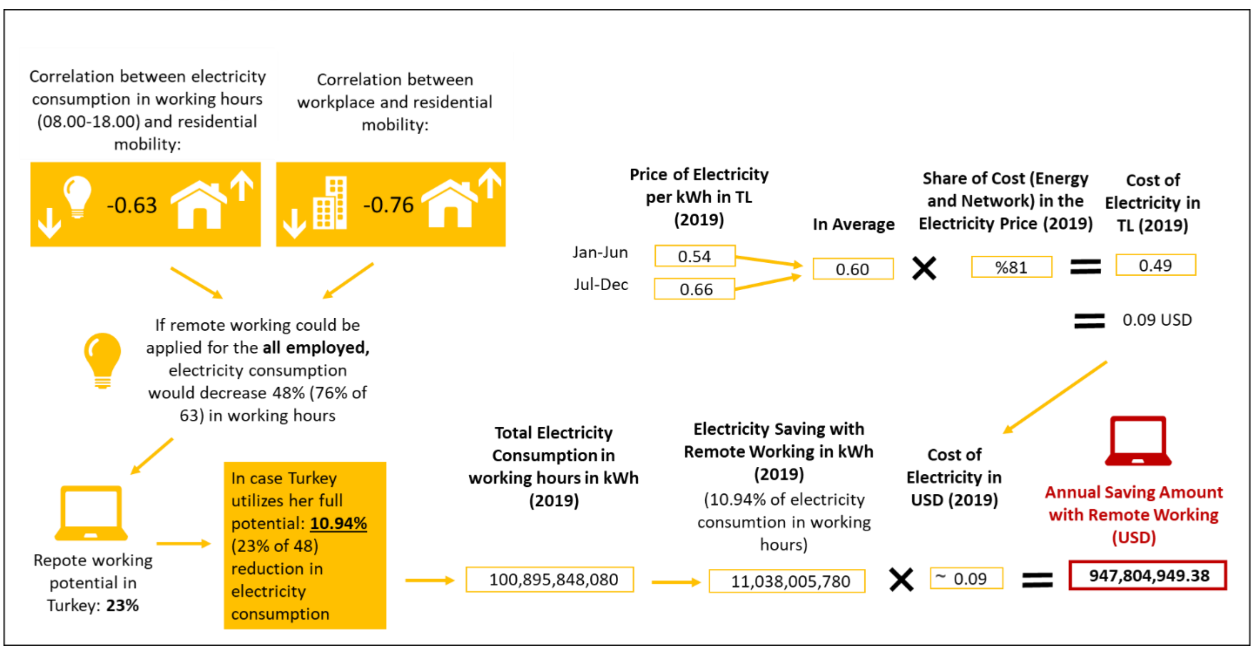

Figure 28: Calculation of the Potential Annual Saving due to Reduced Electricity Consumption with Remote Working

(Source: Prepared by the author based on information from Google (2022a), EPIAS (2022), Dingel & Neiman (2020), Crow & Millot (2020), TURKSTAT (2021a), EMRA (2020a), OECD (2022a))

However, considering that remote working can be applied to 23% of the total employees in Türkiye, remote working can reduce electricity consumption by 10.94% (23% of 48) during working days.

It is thought that the reason why people consume less electricity by working from home is that individuals are more careful about consumption because they pay their electricity bills themselves rather than their workplaces.

Table 9: Annual Saving Amount with Remote Working

Annual Electricity Consumption During Work Hours in 2019 (kWh)	Electricity Saving with Remote Working (kWh)	Average Electricity Price in 2019 (kurus/kWh)	Average Electricity Cost in 2019 (kurus/kWh)	Average Electricity Cost in 2019 (cents/kWh)	Annual Saving Amount with Remote Working (USD)
100,895,848,080	11,038,005,780	0.60	0.49	0.09	947,804,949.38

(Source: Prepared by the author based on information from EPIAS (2022), TURKSTAT (2021a), EMRA (2020a), OECD (2022a))

Table 9 shows annual saving amount with remote working. Türkiye's electricity consumption between 8:00 AM and 18:00 PM on working days in 2019 was found as 101 TWh using EPIAS data. By taking 10.94% of this electricity consumption, the saving with remote working was found to be 11 TWh. Electricity prices are published by TUKSTAT semiannually. Therefore, the average of the semiannual prices for 2019 were taken which was 0.6 TL. According to EMRA, 81% of the electricity price (0.49 TL) consists of energy and network costs. This cost is converted to USD using annual average USD/Lira currency for 2019 and found as 0.09 USD. As a result, total electricity saving with remote working was multiplied by the cost of electricity. In this way, it has been calculated that remote working can save 948 million dollars annually from reduction in electricity consumption.

5.3. ANNUAL COST OF CAR DRIVING AND ELECTRICITY CONSUMPTION

Table 10 shows how fuel cost of car driving is calculated in Türkiye. According to TURKSTAT (2021c), passenger cars travelled 166,605 million kilometers in 2019. Diesel cars drove 48.4% of this total distance and it was followed by LGP cars with 33.3% and gasoline cars with 18.3%. By using total distance and the share of each car type, distance travelled by each car type was calculated. Total fuel consumption by fuel type was calculated by dividing distance travelled by each type of car with their consumption in 100 km. By multiplying the result with the cost per liter for 2019, total fuel cost of driving is found as 4.3 billion dollars. As explained in section 5.1, annual fuel saving with remote working was found as 432.1 million dollars. This means that remote working has the potential to decrease the total cost of car driving by 10% annually.

Table 10: Fuel Cost of Car Driving in Türkiye, 2019

Type of Car	Distribution of Distance Travelled by Cars (%)	Vehicle-km (thousand km)	Consumption in 100 km	Total Fuel Consumption (lt)	Cost per lt in 2019 (USD)	Fuel Cost in 2019 (USD)
Gasoline	18.3	30,488,715,000	7.0	2,134,210,050	0.46	978,712,469.18
Diesel	48.4	80,636,820,000	5.5	4,435,025,100	0.51	2,246,433,228.30
LPG	33.3	55,479,465,000	9.0	4,993,151,850	0.22	1,101,767,027.88
						4,326,912,725.36

(Source: Prepared by the author based on information from TURKSTAT (2021c), Otostil (2017), EMRA (2020b), EMRA (2020c), OECD (2022a))

According to EPIAS (2022), Türkiye consumed 291,069.03 GWh of electricity in 2019. As found in section 5.2, the cost of electricity was around 0.09 USD per kWh in 2019. This means that the total cost of electricity was around 25 billion dollars for the Turkish economy in 2019. As calculated in section 5.2, remote working has the potential to decrease electricity cost 948 million dollars annually. This means that remote working has the potential to decrease the annual cost of electricity by 3.79%.

5.4. GREENHOUSE GAS EMISSION MITIGATION DUE TO REDUCED CAR DRIVING

5.4.1. Carbon Dioxide Emission Mitigation due to Reduced Car Driving

In calculating the carbon dioxide mitigation that can occur due to the decrease in car driving, firstly, the number of cars according to fuel types is multiplied by the amount of consumption per 40 kilometers. As unit, consumption in gallons was used in this study as EPA publicizes kilograms of emissions per gallon to calculate emissions by fuel type. Next, the total consumption amount that will occur in 40 kilometers according to the fuel types was multiplied by the carbon dioxide emissions per gallon. The result was divided by 1000 to find the amount in tons. Then, the daily total CO_2 emissions was found as 73,049.86 tons which corresponds to 0.07 million tons (mt). Table 11 demonstrates the daily CO_2 emissions as a result of car driving.

Table 11: Daily CO_2 Emissions as Result of Car Driving

Car Type	Number of Cars (2019)	Consumption in 40 km per Car (gallon)	Total Consumption in 40 km (gallon)	CO_2 Emissions (kg/gallon)	Daily Total CO_2 Emissions (kg)	Daily CO_2 Emissions (ton)
Gasoline	3,020,017	0.74	2,232,396.57	8.78	19,600,441.85	19,600.44
Diesel	4,769,714	0.58	2,770,249.89	10.21	28,284,251.39	28,284.25
LPG	4,661,707	0.95	4,430,486.33	5.68	25,165,162.37	25,165.16
					73,049,855.61	73,049.86

(Source: Prepared by the author based on information from TURKSTAT (2021c), Otostil (2017), EPA (2021a))

By using empirical potential of 13.51% reduction in car driving with remote working, 13.51% of 0.07 is taken to find the daily CO_2 emission reduction. Finally, by multiplying this result by the number of working days in 2019 (248 days), annual CO_2 mitigation was found. According to the results, remote working has the potential to reduce 2.45 mt CO_2 as a consequence of reduced car driving. The calculations can be seen in Figure 29.

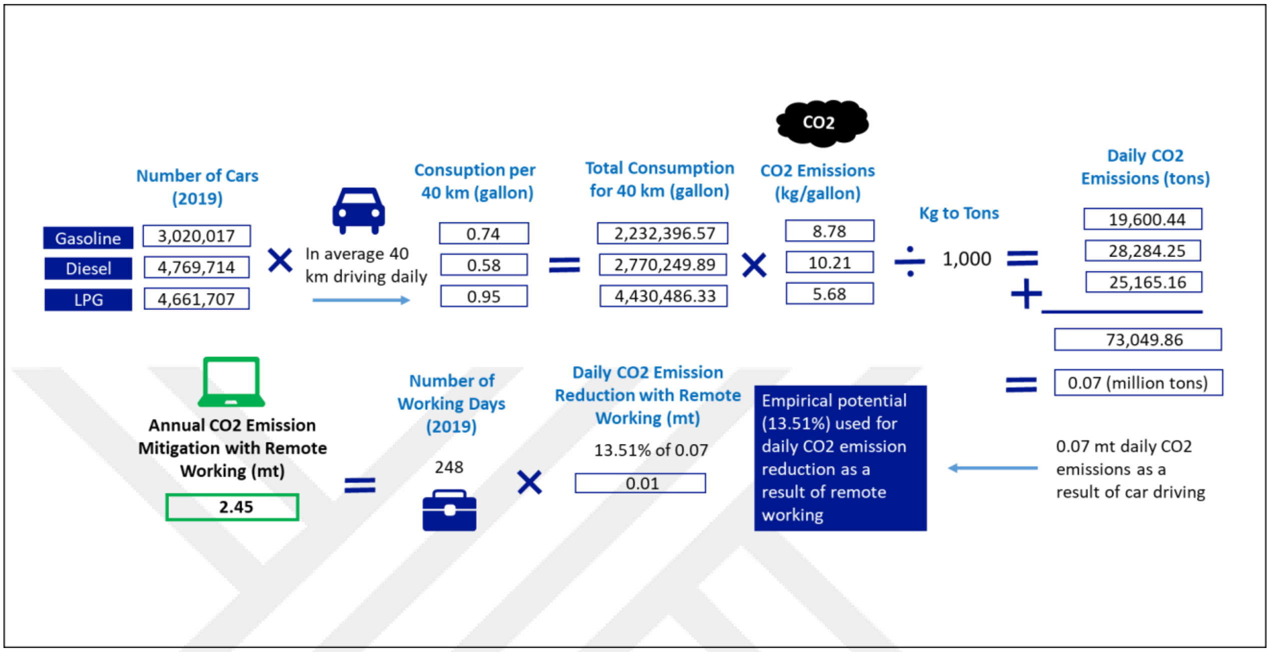

Figure 29: Calculation of the Annual Carbon Dioxide Emission Mitigation due to Reduced Car Driving with Remote Working

(Source: Prepared by the author based on information from Apple (2022), Google (2022a), Dingel & Neiman (2020), Crow & Millot (2020), TURKSTAT (2021c), Otostil (2017), Hakedis (2022), EPA (2021a))

5.4.2. Methane Emission Mitigation due to Reduced Car Driving

As in the calculation made for carbon dioxide mitigation, the total consumption per 40 kilometers by fuel type is multiplied by the methane emissions by fuel type. The results were divided by 1000 to convert kilograms to tons. Then the results were multiplied by 25 to convert methane emissions to carbon dioxide equivalent. This way all greenhouse gas emissions became comparable. GWP calculated by Intergovernmental Panel on Climate Change (IPCC) for 100 years was used to convert methane emissions to carbon dioxide equivalent (IPCC, 2007). The total amount of methane emissions for each fuel type was added up and according to the result 80.6 tons of CO_2e of methane emissions per day occur due to car driving, which is equal to 0.0008 mt CO_2e. Table 12 illustrates the calculation of daily CH_4 emissions as a result of car driving.

Table 12: Daily CH_4 Emissions as Result of Car Driving

Car Type	Number of Cars (2019)	Consumption in 40 km per Car (gallon)	Total Consumption in 40 km (gallon)	CH_4 Emissions (kg/gallon)	Daily Total CH_4 Emissions (kg)	Daily CH_4 Emissions (ton)	Daily CH_4 Emissions (ton) (CO_2e)
Gasoline	3,020,017	0.74	2,232,396.57	0.00038	848.31	0.85	21.21
Diesel	4,769,714	0.58	2,770,249.89	0.00041	1,135.80	1.14	28.40
LPG	4,661,707	0.95	4,430,486.33	0.00028	1,240.54	1.24	31.01
					3,224.65	3.22	80.62

(Source: Prepared by the author based on information from TURKSTAT (2021c), Otostil (2017), EPA (2021a), IPCC (2007))

Considering the empirical potential of 13.51%, daily CH_4 emission mitigation with remote working was calculated as 0.00001 mt CO_2e. The result was multiplied by the number of working days. Finally, annual CH_4 emission mitigation of 0.003 mt CO_2e was found as a result of reduced car driving. The calculations can be seen in Figure 30.

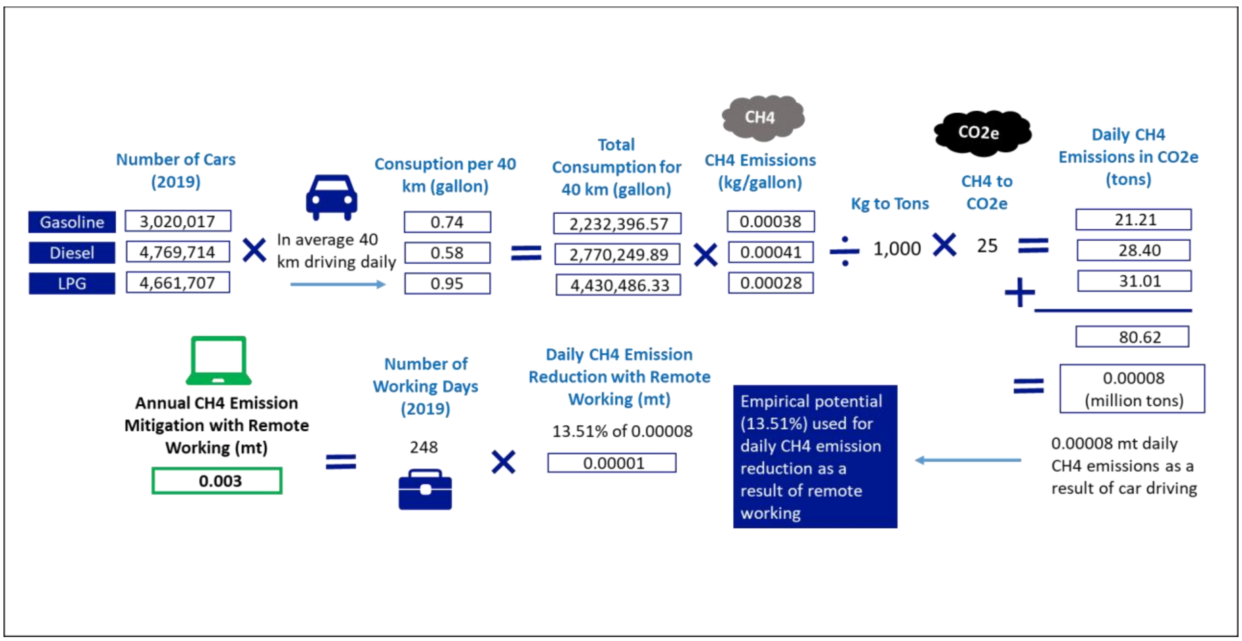

Figure 30: Calculation of the Annual Methane Emission Mitigation due to Reduced Car Driving with Remote Working

(Source: Prepared by the author based on information from Apple (2022), Google (2022a), Dingel & Neiman (2020), Crow & Millot (2020), TURKSTAT (2021c), Otostil (2017), Hakedis (2022), EPA (2021a), IPCC (2007))

5.4.3. Nitrous Oxide Emission Mitigation due to Reduced Car Driving

Similar to the calculation made for methane emissions, nitrous oxide emission mitigation was calculated by multiplying the total fuel consumption per 40 km by N_2O emissions per gallon for each fuel type. Next, the result is converted to tons by dividing with 1,000 and to carbon dioxide equivalent by multiplying with 298, which is the GWP calculated by the IPCC for 100 years. The daily N_2O emissions was found as 198.48 tons of CO_2e, which is 0.0002 mt CO_2e. This means that 0.0002 million tons of CO_2e nitrous oxide emissions occur daily because of car driving in Türkiye. Table 13 shows the calculation of the daily N_2O emissions.

Table 13: Daily N_2O Emissions as Result of Car Driving

Car Type	Number of Cars (2019)	Consumption in 40 km per Car (gallon)	Total Consumption in 40 km (gallon)	N_2O Emissions (kg/gallon)	Daily Total N_2O Emissions (kg)	Daily N_2O Emissions (ton)	Daily N_2O Emissions (ton) (CO_2e)
Gasoline	3,020,017	0.74	2,232,396.57	0.00008	178.59	0.18	53.22
Diesel	4,769,714	0.58	2,770,249.89	0.00008	221.62	0.22	66.04
LPG	4,661,707	0.95	4,430,486.33	0.00006	265.83	0.27	79.22
					666.04	0.67	198.48

(Source: Prepared by the author based on information from TURKSTAT (2021c), Otostil (2017), EPA (2021a), IPCC (2007))

Benefitting from the empirical potential, 13.51% of 0.0002 mt CO_2e emissions (0.00003 mt CO_2e) can be reduced daily with the implementation of remote working. This result was multiplied by the number of working days in 2019 which was 248 days. Finally, the annual N_2O emission mitigation with the implementation of remote working was calculated as 0.01 mt CO_2e. The calculations can be seen in Figure 31.

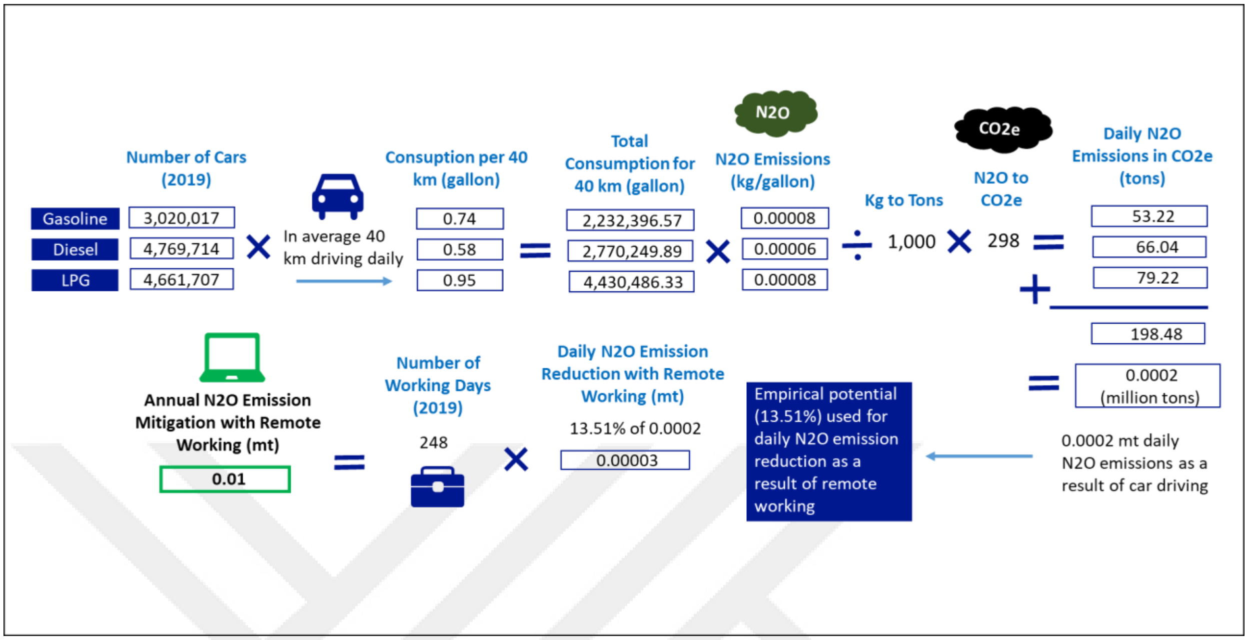

Figure 31: Calculation of the Annual Nitrogen Dioxide Emission Mitigation due to Reduced Car Driving with Remote Working

(Source: Prepared by the author based on information from Apple (2022), Google (2022a), Dingel & Neiman (2020), Crow & Millot (2020), TURKSTAT (2021c), Otostil (2017), Hakedis (2022), EPA (2021a), IPCC (2007))

5.4.4. Total GHG Emission Mitigation due to Reduced Car Driving

Türkiye's Ministry of Environment, Urbanization and Climate Change shares the country's GHG emissions for each sector in the form of Common Reporting Format (CRF) Tables. As shown in Table 14, Türkiye's emissions in transport sector for each gas type in 2019 were converted to carbon dioxide equivalent values and million tons to make the results comparable. As a result, transport sector in Türkiye was responsible for 76.72 mt CO_2e GHG emissions in 2019.

Table 14: GHG Emissions in Türkiye's Transport Sector (2019)

GHG Type	Transport Sector Emissions in kt (2019)	CO_2e	kt to mt
CO_2	75,130.61	75,130.61	75.13
CH_4	15.83	395.76	0.40
N_2O	4.01	1,194.98	1.19
TOTAL			76.72

(Source: Prepared by the author based on information from UNFCCC (2021), IPCC (2007))

By adding all of the mitigation potential of the greenhouse gases (carbon dioxide, methane and nitrous oxide), 2.46 mt CO2e can be found as a result of less car driving (Table 15).

Table 15: GHG Emission Mitigation Potential of Remote Working as a Result of the Reduced Car Driving

	Mitigation Potential (mt CO_2e)
CO_2	2.45
CH_4	0.003
N_2O	0.01
TOTAL	2.46

The mitigation potential corresponds to 3.2% of the total emissions in the transport sector in 2019. This result is illustrated in Figure 32.

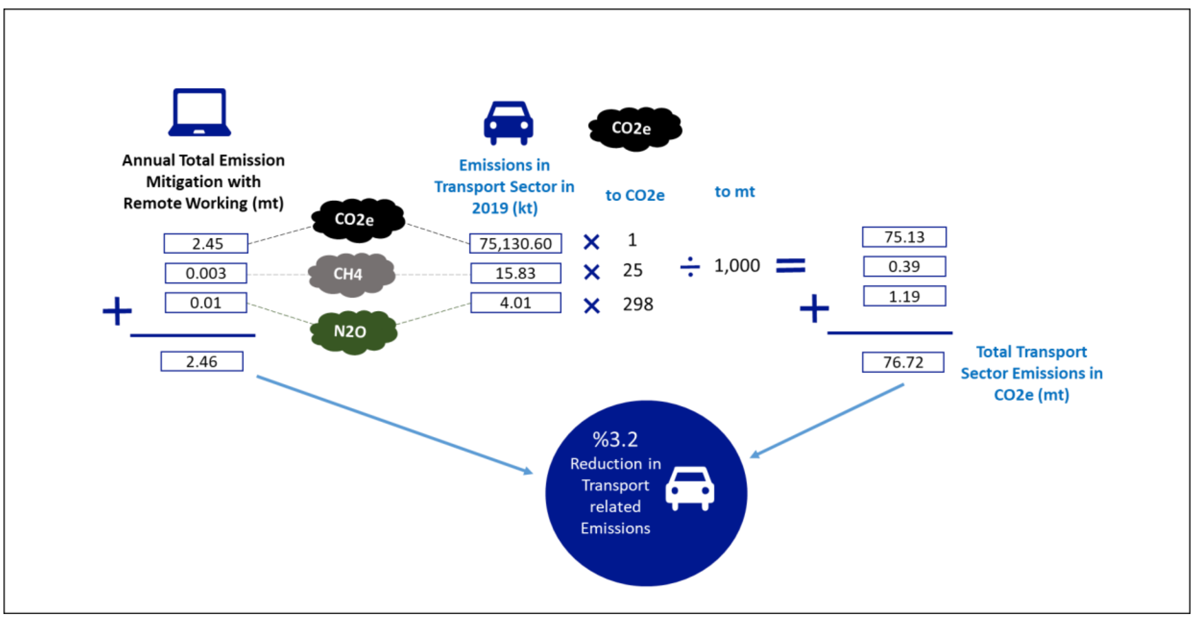

Figure 32: Calculation of the Annual GHG Emission Mitigation due to Reduced Car Driving with Remote Working and it's Share in the Total Transport Related GHG Emissions

(Source: Prepared by the author based on information from Apple (2022), Google (2022a), Dingel & Neiman (2020), Crow & Millot (2020), TURKSTAT (2021c), Otostil (2017), Hakedis (2022), EPA (2021a), IPCC (2007), UNFCCC (2021))

5.5. GREENHOUSE GAS EMISSION MITIGATION DUE TO REDUCED ELECTRICITY CONSUMPTION

Türkiye's total electricity consumption for 2019 was taken from EPIAS by summing all the hourly electricity consumption, which was 291,069 GWh. As calculated in the section 5.2, remote working has an empirical potential for reducing 11,038 GWh of electricity consumption in Türkiye, which corresponds to %3.79 of the total electricity consumption in 2019. Thus, it is assumed that each GHG emission from electricity generation can be decreased by 3.79% by putting in force remote working practices.

By adding CO_2, CH_4 and N_2O emission mitigation potentials with remote working, in total 5.3 mt CO_2e can be found. The calculations be seen both in Table 16 and Figure 33. This means that remote working has the potential to decrease 5.3 mt CO_2e GHG emissions annually as a result of reduced electricity consumption.

Table 16: GHG Emission Mitigation as Result of Lower Electricity Consumption with Remote Working

	Türkiye's 2019 Emissions	**Emission Mitigation with Remote Working**
CO_2 Emissions from Electricity Generation (kt)	138,272.87	5,243.62
CO_2 Emissions from Electricity Generation (mt)	*138.27*	*5.24*
CH_4 Emissions from Electricity Generation (kt)	1.66	0.06
CH_4 Emissions from Electricity Generation (mt)	0.002	0.0001
CH_4 Emissions from Electricity Generation in CO_2e (mt)	*0.04*	*0.002*
N_2O Emissions from Electricity Generation (kt)	2.69	0.10
N_2O Emissions from Electricity Generation (mt)	0.003	0.0001
N_2O Emissions from Electricity Generation in CO_2e (mt)	*0.80*	*0.03*
Total Emissions from Electricity Generation in CO_2e (mt)		**5.3**

(Source: Prepared by the author based on information from EPIAS (2022), UNFCCC (2021), IPCC (2007))

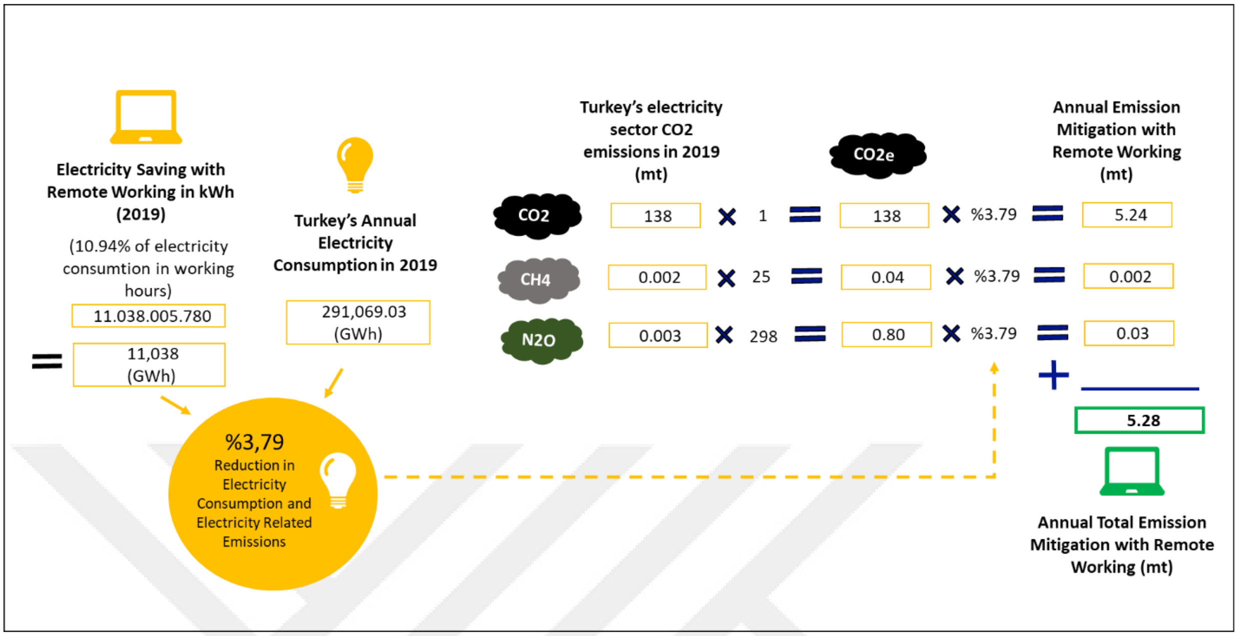

Figure 33: Calculation of the Annual GHG Emission Mitigations due to Reduced Electricity Consumption with Remote Working and it's Share in the Total Electricity Related GHG Emissions

(Source: Prepared by the author based on information from Google (2022a), EPIAS (2022), Dingel & Neiman (2020), Crow & Millot (2020), UNFCCC (2021), IPCC (2007))

5.6. CONTRIBUTION OF REMOTE WORKING ON REDUCING TÜRKİYE'S TOTAL ENERGY CONSUMPTION

When calculating the effect of remote working on Türkiye's total energy consumption, first of all, the energy saving that can occur as a result of the decline in car driving was found in ton of oil equivalent (toe) (Table 17).

Table 17: Annual Fuel Saving as a Result of Less Car Driving with Remote Working

Car Type	The Number of Cars * Fuel Consumption in 40 km	Daily Fuel Consumption (lt)	Daily Fuel Saving (lt)	Annual Fuel Saving (lt)	Kiloliter to Tons Conversion (density)	Tons to TOE Conversion	Annual Fuel Saving (toe)
Gasoline	3,020,017 * 2.8	8,456,048	1,142,412	283,318,184	0.753	1.07	228,272
Diesel	4,769,714 * 2.2	10,493,371	1,417,654	351,578,290	0.843	1.04	306,754
LPG	4,661,707 * 3.6	16,782,145	2,267,268	562,282,418	0.541	1.13	343,740

TOTAL							878,766

(Source: Prepared by the author based on information from TURKSTAT (2021c), Otostil (2017), Hakedis (2022), BP (2021), Statistics Canada (2012))

Figure 34 shows how the annual fuel saving in toe is calculated as a result of the decline in car driving with remote working. As the first step, the number of cars in 2019 was multiplied by the consumption per 40 kilometers (in liters) according to the fuel type. This way daily fuel consumption for each fuel type was calculated. Next, benefitting from the empirical potential between remote working and car driving, 13.51% of daily fuel consumption for each fuel type was taken.

Afterwards, the result is multiplied by the number of working days in 2019. This way, the annual fuel saving with remote working was calculated in liters. Next annual fuel saving is converted to toe by the conversion factors of IEA (Statistics Canada, 2012). As a result, 878,766 toe of energy can be saved as a result of reduced car driving with remote working.

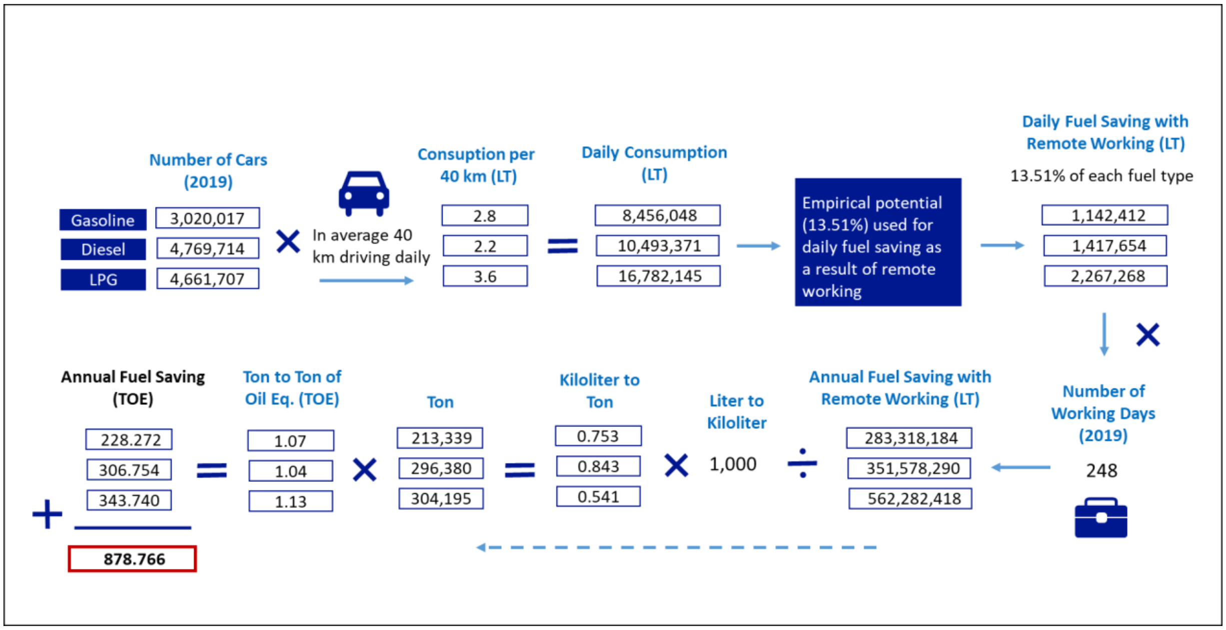

Figure 34: Calculation of the Annual Fuel Saving due to Reduced Car Driving with Remote Working

(Source: Prepared by the author based on information from TURKSTAT (2021c), Otostil (2017), Hakedis (2022), BP (2021), Statistics Canada (2012)).

In order to find the effect of the reduction in electricity consumption on total energy consumption, the amount of savings that can be achieved by remote working was converted from GWh to toe (Extra Conversion, 2022). The annual electricity saving with remote working was found as 11 TWh, which corresponds to 961,036 toe.

Table 18: Annual Fuel Saving with Remote Working in TOE

	Annual Fuel Saving with Remote Working (toe)
Electricity Consumption	961,036
Car Driving	878,766
TOTAL	1,839,802

As shown in Table 18, by adding the savings from reduced car driving and electricity consumption, the annual total saving with remote working is found as 1.8 million toe. Türkiye's total primary energy consumption was around 110.6 million toe in 2019 (MENR, 2021). This means that remote working has the potential to decrease Türkiye's total energy consumption by 1.66% (Figure 35). This way remote working can help the Turkish economy to reduce its energy intensity.

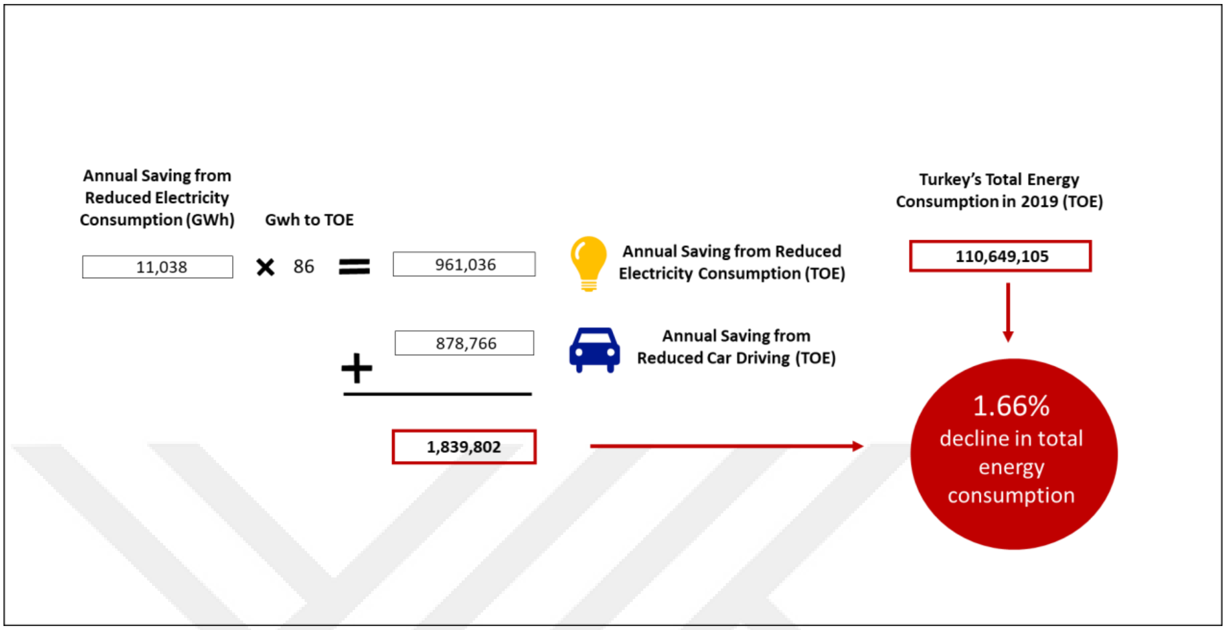

Figure 35: Calculation of the Contribution of Remote Working on Reducing Türkiye's Total Energy Consumption

(Source: Prepared by the author based on information from Extra Conversion (2022), MENR (2021))

DISCUSSION

Understanding the economic, environmental and social benefits of remote working is essential for its permanent implementation.

Due to its nature, some jobs cannot be done remotely. However, for some jobs remote working increases the efficiency. According to an experiment done in a travel agency company, home working increased the performance of call center employees by 13% while increasing work satisfaction and decreasing the turnover (Bloom et al., 2015). After the success, the company has enabled remote working to all employees. As a result, with most of its employees switching to remote working, there has been a 22% increase in employee performance (Bloom et al., 2015).

First of all, computer and internet services became a precondition for remote working (CIPD, 2021b). Therefore, it is important employers to provide these technological tools for their employees. However, even though all the internet infrastructure and technological facilities are available, Türkiye went back to office working for public employees since 1st of July 2021. For this reason, it has been understood that technology is not the only factor to bring remote working permanently and there is a need for new norms and change in the work culture (CIPD, 2021b).

Having realized the gains of remote working during the Covid-19 pandemic, many tech companies such as Twitter, Spotify and Square announced that they are going to implement remote working permanently (Bursztynsky, 2021). On the other hand, many Wall Street Banks such as Goldman Sachs insist that remote working was applied temporarily (Colvin, 2022). Despite this approach, Deutsche Bank declared that the company will allow remote working up to three days a week because it provides the opportunity to reduce real estate cost while not compromising from work productivity (Black & Schaefer, 2021). According to the regular way of doing business, employers mostly evaluate the performance of their employees according to the time spent in the workplace rather than the output (CIPD, 2021b). However, it is much more productive for both employees and employers to create a culture of trust by looking at the outputs of the employees (CIPD, 2021b). Moreover, while some companies advertise that they offer flexible working opportunities through their websites or other media, in practice they do the opposite (Dale, 2020). This situation is expressed as "flexwashing" and causes damage to the trust between the employee and the employer (Timewise, 2019).

Remote Working Regulation entered into force on March 10, 2022 in Türkiye, which set framework of the main principles and processes of the working method (Resmi Gazete, 2021d). Even though it was a necessary step to protect employee and employer rights, the legislation lacks incentives to promote remote working. According to a research by Aon on multinational and local companies in Türkiye, only 3% of companies provide full scale remote working arrangements for their employees after the Covid-19 normalization period (Dunya Gazetesi, 2022). Considering that 23% of jobs can be done remotely in Türkiye, it is important the Turkish government to promote flexible working, in particular remote working and hybrid working practices, in the "new normal" era for private workplaces. In addition, it is important the Turkish government to make use of flexible working in public institutions permanently, as this study confirms its benefits as an effective energy efficiency and climate change policy.

As Dingel and Neiman's research (2020) shows, remote working potential rises as countries' GDP per capita increases. For this reason, if Turkish economy could maintain stable and high growth, this will raise the country's remote working potential to the level of developed countries in the future. In addition, the development of technological and digital infrastructure are other factors that increase the potential (Lambrecht et al., 2021). Therefore, increasing investments in these areas will enable Türkiye to benefit more from remote working opportunities.

In this study, while calculating the effect of remote working on car driving, the daily savings were multiplied by the number of working days. However, the number of working days of each country varies according to cultural and social factors such as public holidays. For this reason, potential energy saving or GHG emission mitigation by remote working can also be influenced by the cultural and social factors. In Türkiye, tax revenues are obtained from car fuel sales as well. Therefore, implementation of remote working may cause a slight reduction in public revenues.

Electric-hybrid cars were not included in the study due to their negligible share (less than 1%) in the total number of cars in Türkiye. However, it is expected the electric cars to replace internal combustion engine cars in the near future. Therefore, it would be beneficial to include them in future studies. In this case, especially when the environmental effects are researched, the sources of electricity generation will gain more importance. Additionally, even though this study focuses on greenhouse gas emissions, atmospheric pollutants can also be studied in future studies. In addition, although this study looked at the effect of remote working on energy consumption, other potential areas that might be affect by this work arrangement, including labor market and labor productivity, can be explored in other studies. Lastly, comparisons can be made between Türkiye and countries with similar remote working potential.

CONCLUSION

The Covid-19 pandemic has been an important testing period for measuring the wide-ranging effects of remote working.

According to the findings of this study, with the full utilization of remote working potential, Türkiye can save annually 432 million dollars due to the reduction in car driving and 948 million dollars from the decline in electricity consumption with 2019 prices. The savings due to the decrease in car driving corresponds to 10% of the annual amount Türkiye spends on car fuel. In addition, the total saving amount was found to be roughly 1.4 billion dollars with 2019 prices. By this way, remote working has the potential to reduce Türkiye's energy intensity.

Although it is expected that working remotely will lead to a decrease in car driving, this study revealed that remote working also contributes to the reduction of electricity consumption. Less electricity consumption due to remote working might have occurred as individuals are more careful about their electricity consumption when they pay the bills by themselves. This subject can also be a research area for further studies.

In terms of GHG emissions, Türkiye can mitigate 2.46 mt CO_2e GHG emissions from reduced car driving which corresponds to 3.2% of the annual emissions in the transport sector. In addition, remote working has the potential to decrease 5.28 mt CO_2e GHG emissions annually as a result of reduced electricity consumption and this represents 3.79% of the electricity-related emissions in Türkiye. As a result, a total of 7.73 mt of CO_2e emission mitigation potential was found. This corresponds to 1.53% of the total GHG emissions in Türkiye. As a party to the Paris Agreement, Türkiye has to decrease it's GHG emissions and plans to reach net zero emissions by 2053. As the findings of the study show, remote and hybrid working can also be implemented as a complementary climate change policy to decrease the country's GHG emissions without compromising from economic growth.

The total energy saving (car driving and electricity consumption) that can be achieved by remote working was found to be 1.8 mtoe. Türkiye's total energy consumption was 110.6

mtoe in 2019. Consequently, remote working has the potential to reduce Türkiye's total energy consumption by 1.66%.

For the permanent implementation of remote and hybrid working, it is important that the economic, social and environmental benefits of this work arrangement are well understood by the policy makers and the society. Besides, it is necessary the Turkish government to put in force flexible working practices in public institutions and promote such working arrangements for private work places. While this study reveals the benefits of working remotely under normal conditions in terms of petroleum products and electricity consumption, the contribution of remote working during energy crises such as the Russia-Ukraine War should be investigated in future studies especially for energy import dependent countries such as Türkiye.

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