# CURRENT STATUS AND THE FUTURE PROJECTIONS OF THE TURKISH PELLET FUEL INDUSTRY: A SURVEY STUDY

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NEŞET KUTAY KARACA

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submitted by **NEŞET KUTAY KARACA** in partial fulfillment of the requirements for the degree of **Master in Business Administration, the Graduate School of Social Sciences of Middle East Technical University** by,

Prof. Dr. Yaşar KONDAKÇI
Dean
Graduate School of Social Sciences _____

Prof. Dr. Zehra Nuray GÜNER
Head of Department
Department of Business Administration _____

Prof. Dr. Özlem ÖZDEMİR
Supervisor
Department of Business Administration _____

**Examining Committee Members:**

Assoc. Prof. Dr. Eminegül KARABABA (Head of the Examining Committee)
Middle East Technical University
Department of Business Administration _____

Prof. Dr. Özlem ÖZDEMİR (Supervisor)
Middle East Technical University
Department of Business Administration _____

Prof. Dr. İlkay DELLAL
Ankara University
Department of Agricultural Economics _____

**I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.**

**Name, Last Name:** NEŞET KUTAY KARACA

**Signature:**

## ABSTRACT

CURRENT STATUS AND THE FUTURE PROJECTIONS OF THE TURKISH PELLET FUEL INDUSTRY: A SURVEY STUDY

KARACA, Neşet Kutay
M.B.A., The Department of Business Administration
Supervisor: Prof. Dr. Özlem ÖZDEMİR

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As of 2019, Turkey has 22 million 740 thousand hectares forest assets nationwide and ranks at 31st worldwide; which positions Turkey as a potential large volume pellet fuel producer. Turkey has the potential to become a more important producer and consumer on global pellet fuel markets if certain strategic actions be taken. This thesis study aims to elaborate the current status of the Turkish pellet fuel industry and to explore the main opportunities and challenges facing the industry's future development which is a developed industry especially in Europe, and in its early life cycle stage in Turkey and has a strategic potential for the country in line with the renewable energy action plan, renewable energy targets and its high biomass potential. A survey study is conducted with 64 people who are accepted as experts in the fields of biofuels and pellet fuel. The purpose of the survey is to identify the challenges and barriers the industry is currently facing and to understand the expectations and views of experts on the future of the industry. The challenges in matters regarding policy support, raw materials, European Union harmonization process, logistics, environmental factors, competition with other solid fuels etc. are

focused on, the expectations of the experts about these matters and the future of the industry determined and the possible patterns pointed out by the survey are tried to be revealed. These patterns provided a framework for the industry, general problems and barriers, and the resources on which they depend, and will help us understand the areas that require improvements for the future of the industry.

**Keywords**: Forestry Industry, Pellet Fuel, Renewable Energy, Strategic Analysis, Survey Research

# ÖZ


TÜRKİYE PELET YAKITI SEKTÖRÜNÜN MEVCUT DURUMU VE GELECEK ÖNGÖRÜLERİ: BİR ANKET ÇALIŞMASI

KARACA, Neşet Kutay
Yüksek Lisans, İşletme Bölümü
Tez Yöneticisi: Prof. Dr. Özlem ÖZDEMİR

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2019 yılı itibarıyla ülke genelinde 22 milyon 740 bin hektar orman varlığına sahip olan Türkiye, dünya genelinde 31. sıradadır. Türkiye, belirli stratejik adımların atılması halinde küresel pelet yakıtı pazarlarında daha önemli bir üretici ve tüketici olma potansiyeline sahiptir. Bu tez çalışması, Türkiye pelet yakıtı endüstrisinin mevcut durumunu detaylandırmayı ve özellikle Avrupa'da gelişmiş bir endüstri olan ve Türkiye'de erken yaşam döngüsü aşamasında olan ve stratejik bir öneme sahip olan endüstrinin gelecekteki gelişiminin önündeki temel fırsatları ve zorlukları araştırmayı amaçlamaktadır. Ulusal yenilenebilir enerji eylem planı, yenilenebilir enerji hedefleri ve yüksek biyokütle potansiyeli doğrultusunda pelet yakıtı endüstrisi ülke için yüksek potansiyele sahiptir. Biyoyakıt ve pelet yakıtı alanlarında uzman olarak kabul edilen 64 kişi ile anket çalışması yapılmıştır. Anketin amacı, sektörün şu anda karşı karşıya olduğu zorlukları ve engelleri belirlemek ve uzmanların sektörün geleceğine ilişkin beklenti ve görüşlerini anlamaktır. Politika desteği, hammadde, Avrupa Birliği uyum süreci, lojistik, çevresel faktörler, diğer katı yakıtlar ile rekabet vb. konulardaki zorluklara odaklanılmakta, bu konularda uzmanların beklentileri ve

sektörün gelecek perspektifi çizilmekte ve olası senaryolar belirlenmektedir. Bu kalıplar, endüstri, genel sorunlar ve engeller ile bunların bağımlı oldukları kaynaklar için bir çerçeve sağlayarak endüstrinin geleceği için iyileştirme gerektiren alanları anlamamıza yardımcı olacaktır.

**Anahtar Kelimeler**: Ormancılık Endüstrisi, Pelet Yakıtı, Yenilenebilir Enerji, Stratejik Analiz, Anket Araştırması

*For My Family*

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# CHAPTER 1

## INTRODUCTION

Turkey is the world's 19th and Europe’s 7th largest economy by Gross Domestic Product as of 2019 [1]. Energy demand in the country is enhancing rapidly as its economy and population are continuously growing, thus government prioritized the security of supply for energy sources. The country’s energy needs are mainly met through imported energy with fossil fuels represents the majority of consumption; while oil is the leader in final energy consumption with 35%, natural gas ranks second. Turkey meets more than 90% of its oil and more than 99% of its natural gas needs through imports. These situations are seen among the important reasons behind the increase in the country’s foreign trade deficit [2]. The country’s energy mix as of the year 2018 is given in the Fig. 1 below. The distribution that illustrates the foreign dependency of the Turkey’s energy needs is given in the Fig. 2 below, and the dominance of the fossil resources of the country’s energy supply is shown in the Fig. 3 below.

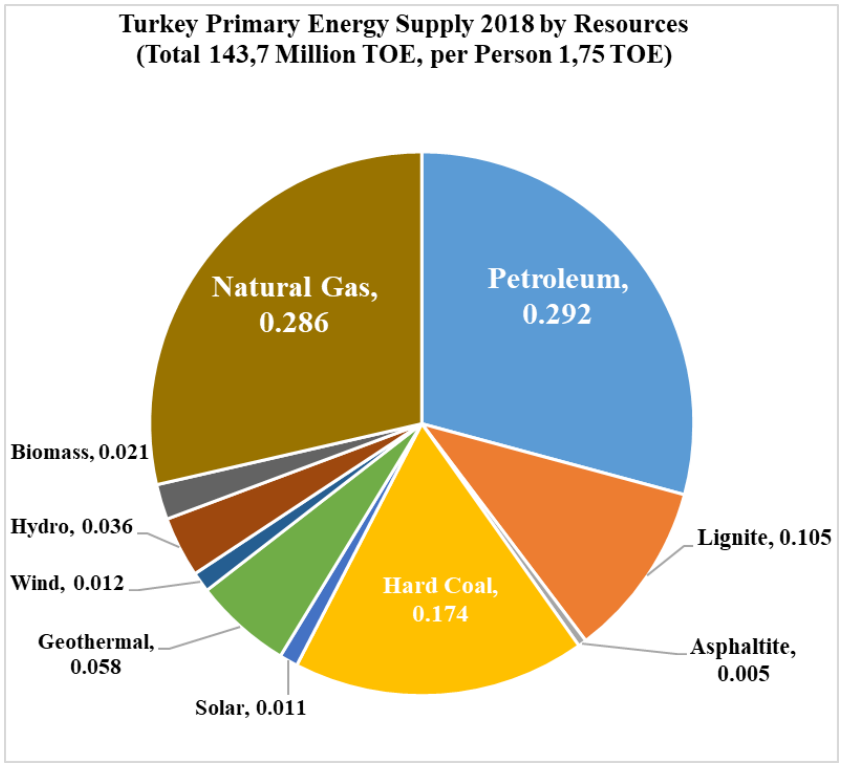



**Figure 1.** Turkey's Primary Energy Sources by the Year 2018 [3]

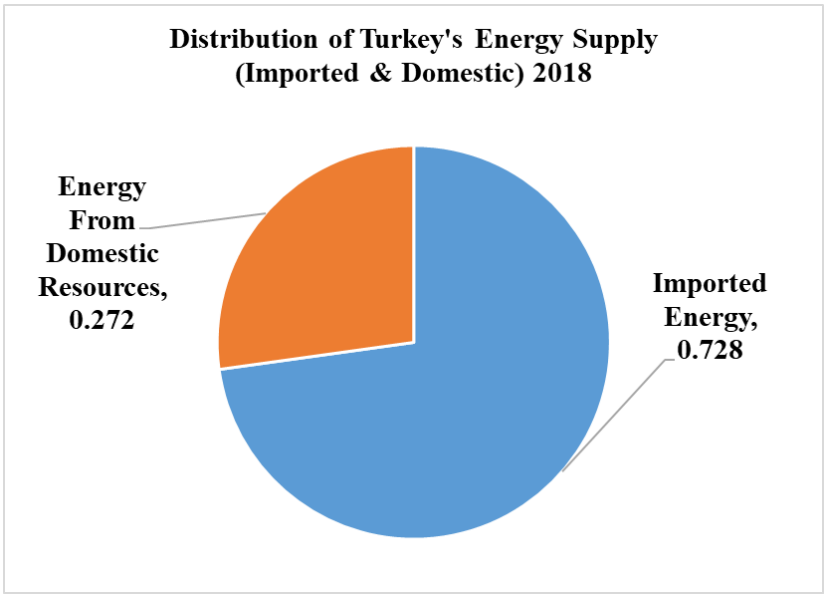



**Figure 2.** Distribution of Turkey's Energy Supply (Imported & Domestic) by the Year 2018 [3]

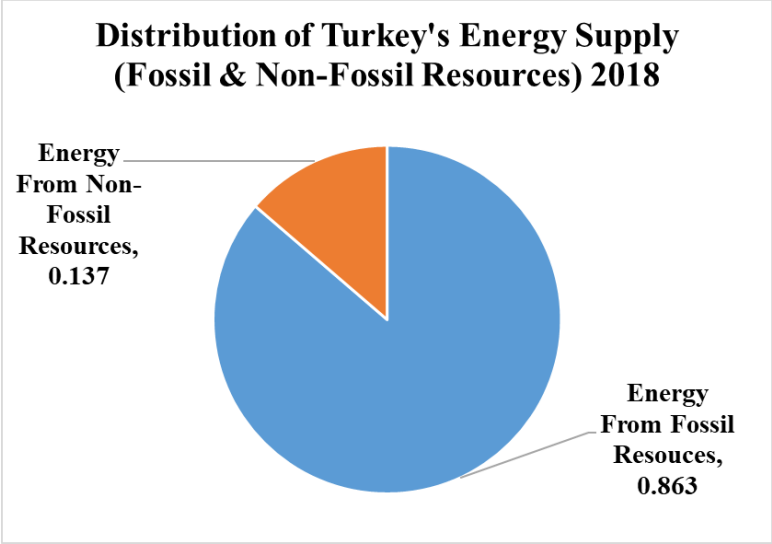



**Figure 3.** Distribution of Turkey's Energy Supply (Fossil & Non-Fossil Resources) by the Year 2018 [3]

Industrial consumption is leading the energy consumption of Turkey while conversion and energy sector came in second. Transportation and household energy consumption are the other major consumers of energy in Turkey. Sectoral distribution of energy consumption is illustrated in the Fig. 4 below. Economically, in the energy sector, the supply is occurring naturally based on the demand and the country's primary energy demand according to the sources are given in the Fig. 5 below.

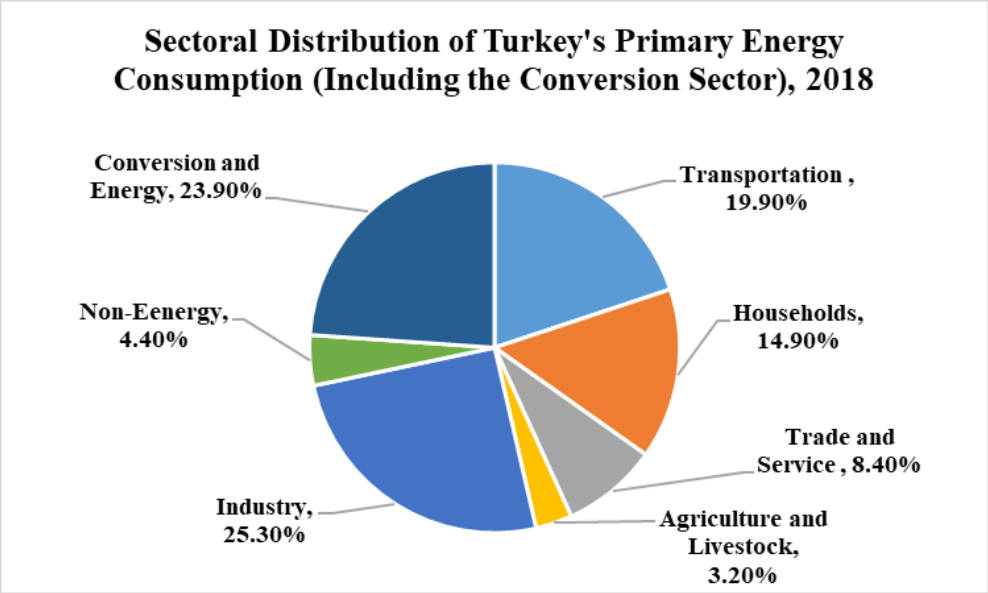



**Figure 4.** Sectoral Distribution of Turkey's Primary Energy Consumption (Including the Conversion Sector) by the Year 2018 [3]

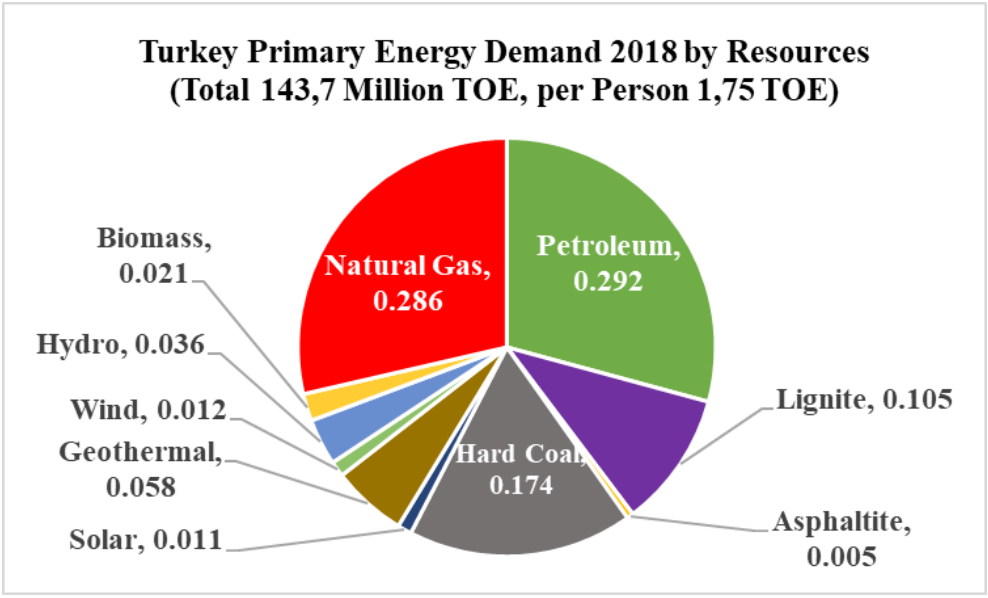



**Figure 5.** Turkey's Primary Energy Demand by Sources for the Year 2018 [3]

Turkey applied to the European Union for a full membership in 1987 and EU accepted Turkey as a candidate state in 1999. Turkey and EU officially started the negotiation process in 2005 for the country's full membership [4]. The country puts a great importance on its action plans towards constructing a flawless path to comply with the EU's requirements and acquis where energy is being considered as a highly crucial chapter. The European Parliament's Directive 2009/28/EC on the Promotion of the Use of Energy from Renewable Sources requires every of its members to prepare and execute a National Renewable Energy Action Plan (NREAP) for the 2011-2020 period including a perspective to comply with the Directive. There are aggressive and strict targets including 20% of the total energy generated will be obtained from renewable sources in addition to 10% share of renewable energy is targeted for the transportation sector by the year 2020 [5]. Turkey prepared its own NREAP for the 2013-2023 period and established the strategies in line with the directive.

As an energy importing country, utilization of renewable resources to generate energy is a very crucial matter for Turkey. Given its 22.933.000 ha forest and wooded land as of 2020, Turkey has a significant amount of forest assets [6]. Combined with its solar power, wind, thermal and other natural renewable energy resources, Turkey has a great potential to utilize renewable energy, yet it has not reached its full potential. Given its forest assets and biomass resources potential, pellet fuel produced from biomass resources especially wood, is a highly crucial energy source for Turkey, both in terms of reaching its energy mix goals and to develop a potentially profitable market to become competitive in the international arena in the future.

This thesis study aims to elaborate the current status of the Turkish pellet fuel industry and to explore the main opportunities and challenges facing the industry's future development which is a developed industry especially in Europe, and in its early life cycle stage in Turkey and has a strategic potential for

the country in line with the renewable energy action plan, renewable energy targets and its high biomass potential.

Survey research, one of the quantitative research methods, employed by this study, which aims to present the current status of the pellet fuel industry in Turkey and to reveal the main opportunities and difficulties that the development of the industry faces. This survey is conducted with people who are accepted as experts in the fields of biofuels and pellet fuel. The purpose of the survey will be to identify the challenges and barriers the industry is currently facing and to understand the expectations and views of experts on the future of the industry.

The challenges in matters regarding policy support, raw materials, European Union harmonization process, logistics, environmental factors, competition with other solid fuels etc. will be focused on, the expectations of the experts about these matters and the future of the industry will be determined and the possible patterns pointed out by the survey will be tried to be revealed. These patterns will provide a framework for the industry, general problems and barriers, and the resources on which they depend, and will help us understand the areas that require improvements for the future of the industry. It is aimed to present suggestions regarding the future of the industry with the findings within the context of policy regulations and applications.

The study on this developing industry will have an integrity as academia, public, private sector and consumers, and will guide the strategic management studies to be carried out in biomass fuels and other renewable energy sub-branches.

# CHAPTER 2

# OVERVIEW OF THE PELLET FUEL INDUSTRY

## 2.1. Evolution of the Pellet Fuel

All ligno-cellulosic materials, including wood, hay, paper, and many vegetable fibers, offer an important source of energy. The main issue with these materials stems from their high volume-to-weight ratio, which adds difficulty and cost to their processing, storage, and handling. In order to solve this problem, these materials may be dried and then compressed under extreme pressure into pellet fuels. Pellet fuels will have a higher density (more than 2 times the initial density) and a high calorific value than the initial material. The dictionary defines a pellet as a lump, a spool, a tablet, or a ball. In terminological sense, however, a pellet refers to a type of compressed fuel, of small cylindrical form generally with a diameter of 6 to 10 mm and a length of 10 to 50 mm, produced with natural products and wastes including wood shavings, barks, agricultural products, stalks of agricultural crops, and shells of hazelnuts, almonds, and walnuts [7]. Fig. 6 shows 8 mm wood pellet fuel below.

**Figure 6.** Wood Pellet Fuel (8 mm) [8]

Wood pellet fuels represent a type of fuelwood usually produced with compressed sawdust. Pellet fuel produces energy (4200-5000 kcal/kg) at an extremely high combustion efficiency (80%) owing to their improved density and small percentage of moisture (0.3-0.6%). Thanks to wood pellet fuel's compact storage, it allows convenient and cheap transport over long distances. In terms of ash content, pellet fuels appear to offer a much higher advantage (0.3-0.6%) when compared with burning coal (between 3% and 20%) and agricultural plants, weeds, and waste (between 3% and 10% or more). All types of wood can be used to produce pellet fuels. However, softer types of wood (e.g. coniferous trees) are more suitable for pellet fuel production, because these softer types of wood contain more lignin than harder types of wood (leaf trees). Lignin is a component of wood that acts as a natural adhesive and contributes to pellet fuel production as a binding agent, thus leaving no need for additives in pellet fuel production [9].

The white wood (trunk wood) used in pellet fuel production as the raw material is sourced from bark and timbering waste. However, it is predicted to make economic sense to use an entire tree in pellet fuel production. These white woodchips are preferred due to their use for Premium, i.e., superior pellet fuels with very low ash content (less than 1%). They additionally reduce drying costs. On the other hand, standard pellet fuels produced with bark wood vary between 1% and 3% in terms of their ash content. Premium pellet fuels are used in heating stoves, while standard pellet fuels are combined with coal in boilers and heating plants [10].

In most developed countries, the use of pellet fuels is a matter of cost with implications for sustainability in fuel supply and reduction of environmental pollution. In a country endowed with limited resources of oil, gas, or coal, but dependent on ligno-cellulosic resources, it does not appear to make sense not to reduce the use of conventional fuels. Turkey produces approximately 65 million tons of agricultural waste and 10 million m3 of tree waste every year and since

this great ligno-cellulosic potential cannot be converted into electrical and heat energy in biomass power plants, the country suffers from an ever increasing dependency on imported oil, natural gas, and coal. The growth of national economy and industry, as well as the continued generation of electricity and heat at the great quantities that are necessary for industrial processes, require maximum utilization of local resources of biomass.

Agricultural wastes can reach ease of transportation, storage and use only if compressed into pellet form. Pellet fuels are equivalent to half the oil energy in weight and one-third of the same in volume. This factor balances out the price difference in transport over long distances. Woodchips, on the other hand, generate 18 times less energy in volume when compared to oil. As higher-quality wood fuels, wood pellet fuels are produced through the drying and compression of such materials as sawdust, planer dust, chips, and barks that are natural products of various processes, as well as whole trees and timbers.

The most important characteristics of this production process are as follows [9]:

- The energy value of waste is improved, preparing the product for immediate use or for further thermochemical conversions (combustion, gasification, pyrolysis, and carbonization);
- Pellet fuels reduce storage volume;
- Handling and transport are facilitated, and relevant costs reduced;
- Energy density/volume ratio is increased; and
- The product is free from the loss of substance arising from fermentation.

The use of wood pellet fuels as a renewable source of energy reduces the climate-changing emissions from fossil fuels, thus slowing down global warming. More importantly, they offer long-term energy security thanks to their competitiveness with high oil and gas prices that threaten the economy. Wood is the first fuel for humanity and wood pellet fuels, produced through chipping, drying, and compression, are the renewable fuels of the 21st Century by the

reasons of its high energy content and low emission levels. Wood pellet fuels are favored strongly in global trade with their ease of transport in bulk on vessels, trains, and trucks; multifaceted use for electricity and heat generation; and position as an environmentally friendly renewable source of energy.

Wood pellet fuels represent a clean, renewable fuel produced through pressing milled woodchips and sawdust under high pressure. Pellet fuel production with solid biomass is a technology that allows for the conversion of biomass into an efficient energy transporter. In this process, biomass is milled, dried, and compressed, the result being a homogenous solid fuel offering a higher energy density. Their high energy content and affordable transport and storage allow wood pellet fuels to stand out as the ideal fuel to replace coal, fuel-oil, and natural gas. European countries promote technologies that support increased use of renewable biomass rather than fossil fuels in heat and electricity generation.

One of the advantages of pellet fuels in energy generation is its low impact on the environment during production, transport (zero harm to the environment upon spillage), and use. Modern pellet-burning plants cause only low levels of air pollution. Pellet fuels contain much lower quantities of Sulphur (acid rain) when compared to oil or coal. Impeccably controlled pellet burning processes allow small quantities of dust containing inorganic salt to dissolve in water, posing a much lower risk to health when compared with other types of dust.

Moreover, pellet fuels offer quite an effective element to reduce CO2 emissions. Modern pellet boilers enjoy an efficiency higher than 90%, allowing pellet fuels to replace fuel-oil and natural gas for the most part. Pellet fuels, when used instead of coal in suitable combined heat-and-power (CHP) plants, will offer high rates of greenhouse gas savings. The amount of CO2 released as a result of burning biomass explains how carbon accumulated in a forest as its origin (closed carbon cycle) returns to the atmosphere. However, it does not increase the amount of CO2 in the atmosphere (carbon neutrality).

The European Constitution requires that energy generation from renewable sources of energy be promoted and in this sense, renewable sources of energy should represent 20% of gross energy consumption and 10% of liquid fuels by 2020 [5]. Numerous countries notably including Italy and Sweden imposed additional taxes on the use of fossil fuels in order to promote renewable sources of energy and to protect the atmosphere. The EU, with its policy on the matter, supports the efforts to increase the market share of biomass in both heating and electricity generation industries, because wood pellet fuels not only contribute to climate and environment goals, but also revitalizes local economies by reducing dependency on imported fossil fuels. Other political initiatives of relevance include the European Biomass Action Plan-COM (2005) 628-final and the amended Directive on the energy performance of buildings. Biomass assumes a strategic role in the efforts of the EU to achieve its renewable energy goals and wood pellet fuels are key to these goals [7, 11].

Wood pellet fuels are produced under high pressure without any additional chemical binding agents, and they carry heat energy at a quantity of approximately 5 kWh. Therefore, a 1-kg wood pellet has a capacity that is equivalent to the energy value of around half a liter fuel-oil. The use of wood pellet fuel is CO2 -neutral for the most part, contrary to sources of fossil energy. The quantity of CO2 arising from the burning of wood pellet fuels is equal to the quantity received by a tree during its growth (closed CO2 cycle). The CO2 that is released after the burning of sources of fossil energy has been stored for millions of years. The amount of CO2 that is released as a result of combustion increases the CO2 content in the atmosphere and is largely responsible for anthropogenic greenhouse effect. Whoever uses pellet fuels instead of fossil fuels will reduce not only the quantity of CO2 released, but also the quantity of SO2 arising from the process. The latter gas creates acid rain and is held responsible for “dead forests”, i.e., extensive damage to individual forests, while burning wood pellet fuels contributes significantly to the protection of forests. When one family replaces fuel-oil or natural gas with wood pellet fuels for

household heating, their release of CO2 will be reduced by 5 tons/year or by 2.5 tons/year, respectively. Either switch will result in a significant reduction in the greenhouse effect.

## 2.2. Production of the Wood Pellet Fuel

Wood pellet fuels are clean, environmentally friendly fuels produced through pressing sawdust and shavings and wood waste in a cylindrical form. Pellet fuels are produced with a diameter of 6 mm and a length of 10 to 40 mm in line with DIN standards. Natural wood or other agricultural biomass (i.e. olive pomace) raw materials can be used in pellet fuel production in order to avoid harmful emissions. The energy contained in a wood pellet fuel is equivalent to ½ liter of fuel-oil with a calorific value of approximately 5 kWh/kg. They offer quite a high energy density along with rather a small storage volume.

Switching to wood pellet fuels in heating will ensure that;

- Greenhouse gas emissions are reduced;
- Renewable energy goals are achieved;
- Employment opportunities are created in rural areas and in forest industries;
- The national budget for importing costs relating to fossil fuels is reduced; and
- Household heating will be more affordable [12].

### 2.2.1. Global Overview of the Pellet Fuel

Wood and tree waste collected from forests and energy forests are converted into wood pellet fuels to generate heat for houses and buildings or burnt in biomass power plants to offer central heating to surrounding buildings or co-burnt with coal in thermal power plants to generate heat and electrical energy. European Union countries burnt approximately 4.5 million tons of biomass along with coal in the year of 2010 [13]. To this end, 430 pellet fuel production plants around the

world produced 15 million tons of wood pellet fuels in 2009. On the other hand, the total annual generation capacity of 627 pellet fuel production plants around the world reached 30.6 million tons of pellet fuels = 144 TWh/year = 14 million m3 oil in 2011 [13]. According to EU-27 Biofuels Annual Report 2013, the European Biomass Association estimates that the demand for wood pellet fuels in the 27 countries of the European Union in the year 2020 may reach 50-80 million tons, 20-32 million tons of oil equivalent (Mtoe). The Great Britain was the top country in Europe in terms of pellet fuel production with 4.5 million tons of production in 2013, followed by Denmark with 2.5 million tons and the Netherlands with 2 million tons. Sweden, Germany, and Belgium were the other countries that ranked high in the ranking of top pellet fuel producers. Germany ranked the first in Europe in 2013, producing 2 million wood pellet fuels, followed by Sweden with 1.25 million tons and Austria with 950.000 tons [14]. If continued and reliable supply of raw materials is secured, annual quantity of pellet fuel production is expected to exceed 100 million tons along with new pellet fuel production plants in the year 2020. The Fig. 7 shows the breakdown of the pellet fuel production plants by country as of year 2017 [15]. The Fig. 8 illustrates the global pellet fuel production between 2000 and 2018 [16].


**Figure 7.** Breakdown of Pellet Fuel Production Plants by Country as of 2017 [15]

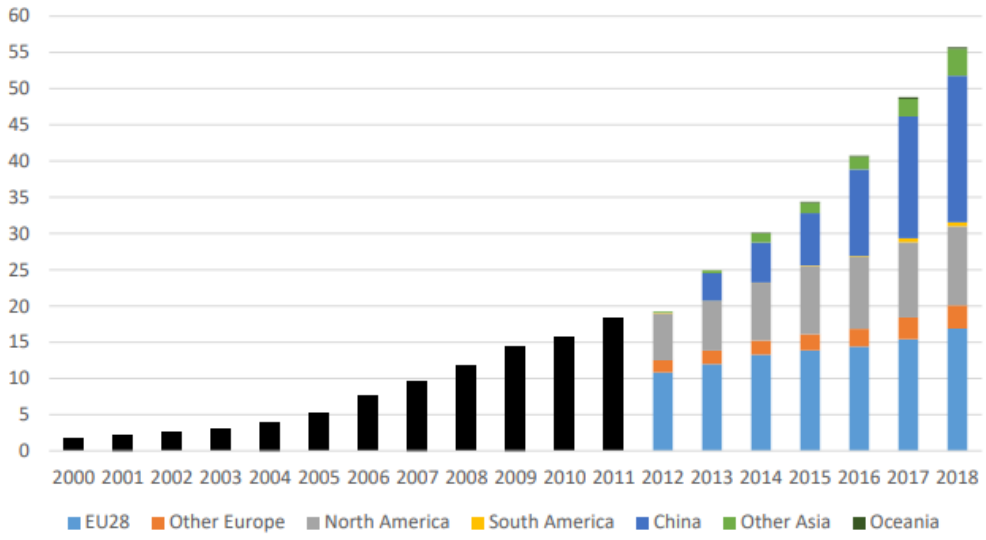



**Figure 8.** 2000-2018 World Pellet Fuel Production Overview (million tons) [16]

| | 2017 | | | 2018 | | |
|---|---|---|---|---|---|---|
| | Number of operating production plants | Production capacity (tonnes) | Actual production (tonnes) | Number of operating production plants | Production capacity (tonnes) | Actual production (tonnes) |
| **EU28** | **707** | **22.860.771** | **15.401.127** | **719** | **23.352.903** | **16.879.382** |
| AT | 43 | 1.600.000 | 1.225.000 | 42 | 1.630.000 | 1.345.000 |
| BE | 12 | 760.000 | 550.000 | 12 | 760.000 | 660.000 |
| BG | 56 | 285.000 | 144.000 | 59 | 302.000 | 162.000 |
| CY | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| CZ | 26 | 450.000 | 366.000 | 28 | 480.000 | 385.000 |
| DE | 55 | 3.400.000 | 2.250.000 | 55 | 3.750.000 | 2.415.000 |
| DK | 5 | 300.000 | 180.000 | 5 | 300.000 | 195.000 |
| EE | 23 | 1.612.000 | 1.173.000 | 23 | 1.612.000 | 1.290.300 |
| EL | 18 | 130.000 | 35.000 | 24 | 135.000 | 40.000 |
| ES | 89 | 1.747.000 | 529.000 | 80 | 1.760.000 | 593.000 |
| FI | 29 | 630.000 | 324.000 | 28 | 630.000 | 385.000 |
| FR | 52 | 1.800.000 | 1.350.000 | 52 | 1.800.000 | 1.500.000 |
| HR | 18 | 352.000 | 287.000 | 21 | 370.000 | 305.000 |
| HU | 3 | 122.000 | 5.191 | n.a. | n.a. | 11.490 |
| IE | 1 | 40.000 | 28.100 | 1 | 40.000 | 30.600 |
| IT | 30 | 450.000 | 400.000 | 30 | 450.000 | 400.000 |
| LT | 17 | 400.000 | 350.000 | 19 | 480.000 | 400.000 |
| LU | 1 | 50.000 | n.a. | 1 | 50.000 | n.a. |
| LV | 27 | 1.950.000 | 1.466.000 | 27 | 1.950.000 | 1.577.100 |
| MT | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| NL | 4 | 350.000 | 264.300 | 4 | 350.000 | 290.000 |
| PL | 55 | 1.200.000 | 1.000.000 | 63 | 1.400.000 | 1.200.000 |
| PT | 23 | 1.159.000 | 700.000 | 26 | 1.300.000 | 782.906 |
| RO | 22 | 1.030.150 | 500.000 | 20 | 800.000 | 500.000 |
| SE | 64 | 2.300.000 | 1.678.929 | 64 | 2.300.000 | 1.834.736 |
| SI | 17 | 145.000 | 110.000 | 18 | 150.000 | 110.000 |
| SK | 10 | 250.000 | 150.000 | 11 | 250.000 | 160.000 |
| UK | 7 | 348.621 | 286.957 | 6 | 303.903 | 258.600 |
| **Other Europe** | **538** | **3.555.000** | **3.005.933** | **547** | **3.578.000** | **3.222.889** |
| AL | 10 | 45.000 | 32.000 | 11 | 52.000 | 44.200 |
| BA | 32 | 360.000 | 283.400 | 32 | 360.000 | 305.000 |
| BY | 0 | 0 | 220.000 | 0 | 0 | 220.000 |
| CH | 24 | 280.000 | 210.000 | 24 | 280.000 | 227.000 |
| ME | 7 | 65.000 | 48.000 | 7 | 65.000 | 42.400 |
| NO | 4 | 105.000 | 57.368 | 4 | 105.000 | 57.368 |
| RS | 61 | 525.000 | 327.165 | 69 | 541.000 | 324.086 |
| RU | 87 | 2.175.000 | 1.438.000 | 87 | 2.175.000 | 1.612.835 |
| UA | 313 | n.a. | 390.000 | 313 | n.a. | 390.000 |

**Figure 9.** Pellet Fuel Production Comparison Between 2017 and 2018 in Europe [16]

As a renewable source of energy, pellet fuels can be co-fired with coal to contribute to reduced CO2 emissions. Pellet fuels offer a very relevant quality in allowing the energy output to be controlled by energy producers in a manner dissimilar to solar and wind energy. This quality is an important factor that explains our strong faith in pellet fuels.

Until now, Europe has been the largest pellet market around the world and half of the needed energy is for household heating. However, the actual increase in the demand for pellet fuels around the world mainly comes from electricity generation [17]. Fig. 10 shows the pellet fuel consumption comparison between 2017 and 2018 in Europe based on consumption categories.

| | 2017 | | | | 2018 | | | |
|---|---|---|---|---|---|---|---|---|
| | Residential | Commercial | 2/3 CHP | Total | Residential | Commercial | 2/3 CHP | Total |
| **EU28** | **9.840.520** | **3.327.039** | **1.958.804** | **15.126.363** | **10.297.645** | **3.557.046** | **1.926.256** | **15.780.947** |
| AT | 800.000 | 160.000 | 0 | 960.000 | 790.000 | 170.000 | 0 | 960.000 |
| BE | 346.500 | 8.800 | 13.333 | 368.633 | 381.150 | 9.680 | 13.333 | 404.163 |
| BG | 140.071 | 1.227 | n.a. | n.a. | 157.775 | 1.384 | 0 | 159.159 |
| CY | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| CZ | 65.000 | 32.000 | 0 | 97.000 | 68.000 | 34.000 | 0 | 102.000 |
| DE | 1.425.000 | 615.000 | 40.000 | 2.080.000 | 1.485.000 | 640.000 | 43.333 | 2.168.333 |
| DK | 800.000 | 160.000 | 1.466.667 | 2.426.667 | 800.000 | 150.000 | 1.416.667 | 2.366.667 |
| EE | 30.000 | 10.000 | 0 | 40.000 | 30.000 | 10.000 | 0 | 40.000 |
| EL | 73.000 | 15.000 | 0 | 88.000 | 75.000 | 15.000 | 0 | 90.000 |
| ES | 326.000 | 203.000 | 0 | 529.000 | 355.000 | 218.000 | 0 | 573.000 |
| FI | 62.000 | 247.000 | 42.667 | 351.667 | 62.000 | 351.000 | 15.333 | 428.333 |
| FR | 1.240.000 | 160.000 | 0 | 1.400.000 | 1.380.000 | 180.000 | 0 | 1.560.000 |
| HR | 19.000 | 9.000 | 0 | 28.000 | 22.000 | 11.000 | 0 | 33.000 |
| HU | n.a. | n.a. | n.a. | n.a. | 0 | 0 | 0 | 0 |
| IE | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| IT | 3.150.000 | 300.000 | 0 | 3.450.000 | 3.042.749 | 253.256 | n.a. | 3.296.005 |
| LT | 47.500 | 12.500 | n.a. | n.a. | 47.500 | 12.500 | n.a. | 60.000 |
| LU | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| LV | 129.000 | 9.000 | 0 | 138.000 | 129.000 | 9.000 | 0 | 138.000 |
| MT | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| NL | 60.000 | 130.000 | 0 | 190.000 | 70.000 | 150.000 | 0 | 220.000 |
| PL | 233.000 | 50.000 | 20.000 | 303.000 | 280.000 | 60.000 | 20.000 | 360.000 |
| PT | 100.000 | 150.000 | 0 | 250.000 | 160.000 | 150.000 | 0 | 310.000 |
| RO | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| SE | 538.849 | 455.212 | 356.071 | 1.350.132 | 691.774 | 482.834 | 392.845 | 1.567.453 |
| SI | 95.000 | 40.000 | 6.667 | 141.667 | 98.000 | 37.000 | 10.000 | 145.000 |
| SK | 40.000 | 30.000 | 0 | 70.000 | 40.000 | 30.000 | 0 | 70.000 |
| UK | 120.600 | 529.300 | 13.400 | 663.300 | 132.697 | 582.392 | 14.744 | 729.833 |
| **Other Europe** | **726.441** | **181.286** | **0** | **907.727** | **755.151** | **204.640** | **20.000** | **979.791** |
| AL | 27.700 | 2.800 | 0 | 30.500 | 26.200 | 3.300 | 0 | 29.500 |
| BA | 169.090 | 23.000 | 0 | 192.090 | 188.340 | 34.200 | 0 | 222.540 |
| BY | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| CH | 185.250 | 99.750 | 0 | 285.000 | 198.250 | 106.750 | 0 | 305.000 |
| ME | 10.200 | 1.550 | 0 | 11.750 | 18.200 | 2.200 | 0 | 20.400 |
| NO | 46.180 | 24.866 | 0 | 71.046 | 46.180 | 24.866 | 0 | 71.046 |
| RS | 277.521 | 4.820 | 0 | 282.341 | 232.481 | 8.824 | 0 | 241.305 |
| RU | 10.500 | 24.500 | 0 | 35.000 | 45.500 | 24.500 | 20.000 | 90.000 |
| UA | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |

**Figure 10.** Pellet Fuel Consumption Comparison Between 2017 and 2018 in Europe Based on Categories [16]

| | Jan-18 | Feb-18 | Mar-18 | Apr-18 | May-18 | Jun-18 | Jul-18 | Aug-18 | Sep-18 | Oct-18 | Nov-18 | Dec-18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AL | 185 | 180 | 177 | 175 | 180 | 180 | 180 | 180 | 185 | 190 | 192 | 197 |
| AT | 272 | 271 | 272 | 270 | 261 | 264 | 262 | 264 | 268 | 270 | 274 | 275 |
| BA | 180 | 180 | 175 | 160 | 155 | 155 | 155 | 155 | 160 | 170 | 170 | 175 |
| BE | 266 | 264 | 265 | 265 | 263 | 265 | 267 | 270 | 273 | 277 | 277 | 280 |
| CZ | 248 | 248 | 248 | 242 | 232 | 232 | 232 | 232 | 238 | 238 | 246 | 250 |
| DE | 297 | 296 | 299 | 297 | 285 | 287 | 286 | 289 | 292 | 299 | 313 | 311 |
| DK | 280 | 280 | 280 | 280 | 280 | 280 | 280 | 285 | 295 | 298 | 302 | 305 |
| EL | 305 | 305 | 295 | 285 | 265 | 260 | 260 | 270 | 270 | 280 | 290 | 295 |
| ES | 264 | 264 | 264 | 264 | 264 | 264 | 267 | 267 | 267 | 276 | 276 | 276 |
| FR | 276 | 276 | 276 | 277 | 277 | 277 | 278 | 278 | 278 | 283 | 283 | 283 |
| HR | 260 | 260 | 240 | 230 | 230 | 220 | 220 | 220 | 230 | 240 | 260 | 270 |
| IT | 310 | | | 295 | | | 295 | | | 332 | | 315 |
| LT | 195 | 195 | 195 | 170 | 170 | 170 | 170 | 170 | 180 | 180 | 180 | 180 |
| ME | 180 | 175 | 170 | 165 | 165 | 165 | 165 | 165 | 170 | 170 | 180 | 185 |
| PL | 200 | 200 | 200 | 200 | 200 | 190 | 190 | 190 | 200 | 210 | 220 | 220 |
| PT | 270 | | | | | | 230 | 230 | 250 | 250 | 270 | 270 |
| RO | 280 | 280 | 280 | 260 | 260 | 260 | 260 | 260 | 280 | 280 | 280 | 280 |
| RS | 204 | 201 | 197 | 185 | 185 | 185 | 187 | 196 | 203 | 208 | 209 | 210 |
| SE | 257 | 260 | 261 | 259 | 263 | 263 | 271 | 275 | 286 | 286 | 291 | 294 |

**Figure 11.** Pellet Fuel Prices for The Year 2018 in Europe (VAT Included Retail Price EUR/Ton) [16]

There is a rapid increasing trend in the investments in pellet fuel production around the world. The Figure 7 shows the breakdown of pellet fuel production plants by country as of 2017 [15]. The number of pellet fuel production plants with an annual quantity of production exceeding 10.000 tons reached 627 and the global pellet fuel production capacity reached 30 million tons of pellet fuels or an energy value of 144 TWh/year in the year 2011. The generation capacity of 81 pellet fuel production plants exceeding 100.000 tons in annual pellet fuel production capacity reached 13 million tons. These plants include Vyborgskaya Cell with an annual pellet fuel production capacity of 1 million tons; Georgia Biomass with 750.000 tons; Green Circle with 500.000 tons; Biowood with 450.000 tons; and Pinnacle Pellet with 400.000 tons. On the other hand, the annual pellet fuel production capacity of 515 pellet fuel production plants that rate below 100.000 tons in annual pellet fuel production capacity is 17.6 million tons of pellet fuels or 114 million MWh = 144 TWh electrical energy, i.e., approximately 14 million m3 of oil [18].

RWE Innogy, with its biomass combined heat-and-power plants in Germany offering a generation capacity of 99 MWelectricity/683 MWheat, is currently building biomass power plants of 72 MWelectricity in capacity in the UK and Italy. RWE Innogy is also planning to convert Lynemouth coal thermal power plant of 400 MW in capacity in Northumberland, UK to render it compatible with biomass use. This move of the company was promoted by the Department of Energy and Climate Change of the UK Government as an exemplary initiative and was thus included in the nine projects to be supported with various incentive mechanisms. In addition, RWE Innogy is constructing a biomass power plant with a generation capacity of 49.9 MW electricity in Markinch, Scotland. Moreover, the pellet fuel production plant situated in Georgia, USA produces 750.000 tons of industrial pellet fuels in a year [19].

Scotia Atlantic Biomass Company Ltd., located in Vancouver, Canada, exported its first batch of wood pellet fuels of 25.000 tons to the harbor in Ghent, Belgium on February 5th, 2014 after a voyage of 9 days. The chief financial officer of the company, Michele Rebiere, stated that its annual production of 120.000 tons of pellet fuels would replace coal in the biomass power plants in Europe; wood pellet fuels were a much cleaner option when compared to coal; and therefore, the company focused primarily on wood pellet fuels. Rebiere also indicated that 25.000 tons of wood pellet fuels would supply one hour of electricity to 8.25 million households [20]. The Fig. 9 illustrates the pellet fuel production comparison between 2017 and 2018 in Europe, including the capacities [16].

The European Union governments agreed that the demand for wood pellet fuels for use in electricity generation for green energy resources would reach three times the current value by 2020. According to Reuters' report, wood pellet fuels, as a perfect alternative to coal in electricity generation as a preliminary environment policy, does not release any net carbon emissions as a result of combustion when compared to fossil fuels. Consequently, Brazil and Canada export increasing amounts of wood pellet fuels. Biomass is an attractive option

in comparison with intermittent renewable energy resources that generate electricity with a fixed base load such as wind and solar in the green energy mix. Europe needed 8 million tons of wood pellet fuels in 2010 and this amount is estimated to potentially reach 29 million tons by 2020. According to analysts, the majority of the current deficiency of biomass in Europe, i.e., approximately 66% or 19 million tons, can be met specifically through imports from North America, Russia, and Brazil [21].

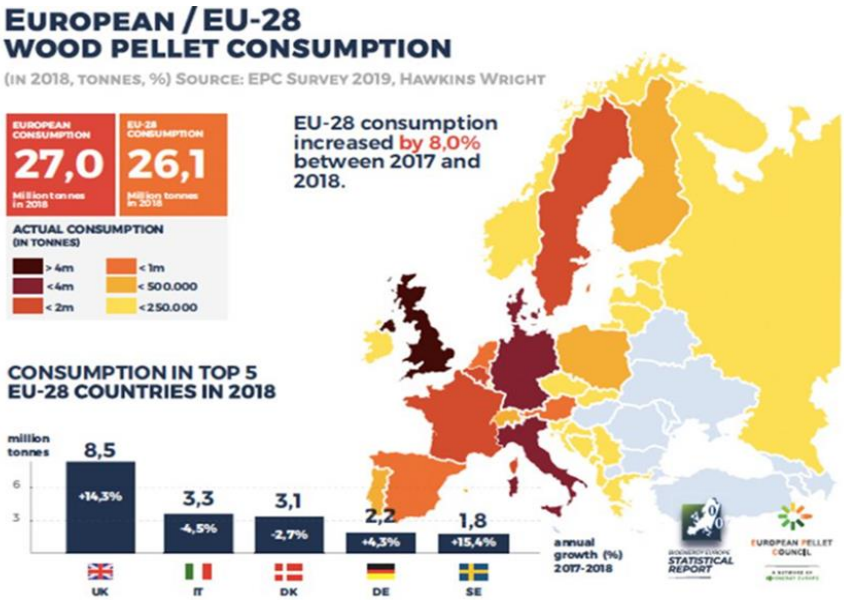



**Figure 12.** Wood Pellet Fuel Consumption in Europe for the year 2018 [16]

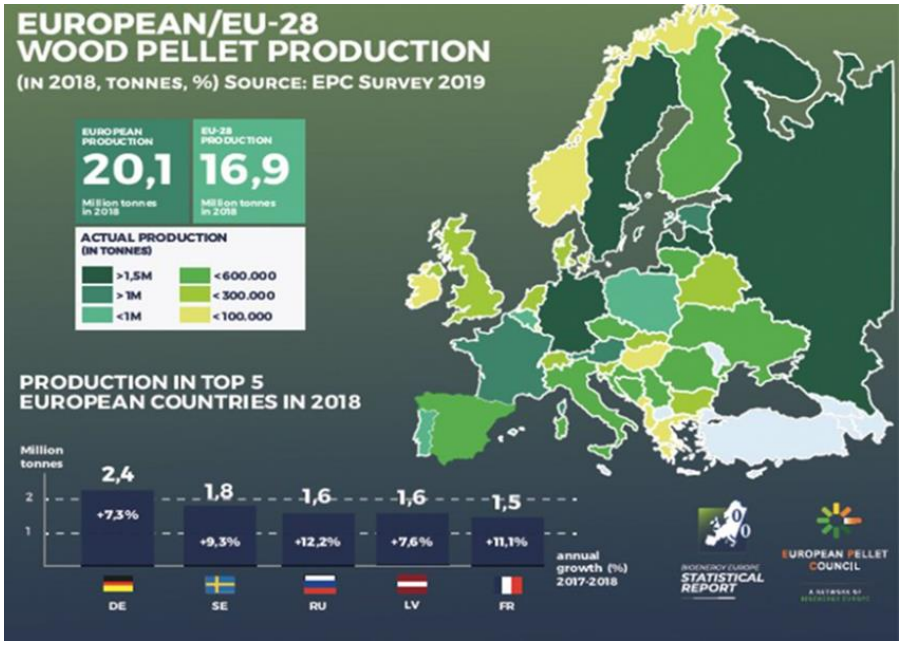



**Figure 13.** Wood Pellet Fuel Production in Europe for the year 2018 [16]

## 2.3. Superior Features of the Pellet Fuel

1. 1 liter of fuel-oil, once burnt, will release 2.9 kg of fossil CO2, while 1 m3 of natural gas, once burnt, releases 1.9 kg of fossil CO2 to the atmosphere. The burning of wood pellet fuels is, however, neutral in terms of climate change (The amount of CO2 released by fired pellet fuels is equal to that stored by a tree through photosynthesis during natural growth).
2. A new fuel-oil installation provided for a family will produce approximately 6.700 kg of fossil CO2 in a year. In its economic life, the installation will release 133.000 kg of fossil CO2 to the atmosphere. The resulting damage to the environment (e.g., forests drying up due to acid rain, excessive precipitation and droughts, human and animal health problems, and disruptions to the natural balance) are not taken into consideration in the pricing of fuel-oil and natural gas.
3. The use of wood as fuel offers a distinct advantage in terms of its added value to regional economies and the resulting job creation when compared to fuel-oil and natural gas.

4. A comparison of pellet fuels, fuel-oil, natural gas, and electricity used in heating in terms of the CO2 emissions released to the atmosphere indicates that pellet fuels release 68 kg/MW CO2; natural gas 228 kg/MW CO2; fuel-oil 342 CO2; and electricity 681 kg/MW CO2. In summary, the generation of 1 MWh of energy with natural gas results in 3 times, with fuel-oil in 5 times, and with electricity 10 times the CO2 released to the environment through the use of pellet fuels in heating (Figure 14). Considering these values, the use of pellet fuels for energy generation and for other purposes will be able to contribute greatly to the carbon quota of our country [9].

The following list specifies the results to be obtained with the use of wood pellet fuels as an alternative source of energy [9]:

- Wood pellet fuels are affordable as they are produced entirely of waste materials. They are cheaper than fossil fuels.
- They offer a renewable source of energy. They are sourced from our own domestic materials.
- Heating systems using wood pellet fuels are ozone-friendly and fare well below the acceptable threshold values for CO2 emissions as designated in Kyoto Protocol. Pellet burning systems offer the cleanest burning among solid fuel systems.
- Wood pellet fuels are quite easy to transport. They can be bought in packages or ordered in tankers for central heating systems, both to be placed in a warehouse through piping.
- No trees need to be cut for commercial pellet fuel production. Pellet fuels allow for the use of forest waste. As a result, with the collection of inflammable forest waste, forests are also protected against fires.
- New-technology pellet burning systems are equipped with automatic fuel supply, which means low operating costs and better comfort.
- Wood pellet fuels, when not sourced through importing, are immune to fluctuations in foreign economies and exchange rates and will not suffer spontaneous increases in their production costs.

- Wood pellet fuels burn at exceedingly high temperatures, thus resulting in only small quantities of solid or gaseous waste. An 18 kg bag of pellet fuels will only produce 85 grams of ash.
- Pellet fuels require relatively smaller storage space than wood.
- Pellet fuels contain less than 10% of moisture, which more than doubles the combustion efficiency in comparison with wood.
- Conventional solid fuel systems produce significant amounts of creosote in stacks, while almost no such creosote appears in pellet fuel systems and this feature allows the fume to be exhausted out without a stack (as is the case with hermetic boilers).
- Pellet fuel allows for the use of 95% of combustion energy, eliminating energy loss.
- Pellet fuels have very little ash content at 0.5%, allowing for clean and practical use. This content varies between 10 and 15% for other fuels, which increases their resulting energy loss.
- Pellet fuels pose no poisoning risk as they do not give out any poisonous gas upon combustion.
- 1 kg of pellet fuels equals to 5 kw of energy, while 2 kg of pellet fuels produce energy in equivalence to 1 liter of liquid fuel at one-third the price.
- Pellet fuels represent an environmentally friendly and clean source of energy that releases 4 times less CO2 than natural gas and 5 times less CO2 than fuel oil.
- The use of pellet fuels in the industry will significantly reduce air pollution and eliminate the high costs associated with stack filter systems. These features will offer economic advantages to producers.
- Once biomass is densified through pellet fuel production, storage and transport become less costly and more affordable.

Table 1 compares kombi boilers and pellet boilers for a family of 5 living in an apartment of 130 $m^2$. The use of a pellet boiler results in energy savings of 46%

leading to a decrease of TRY 1.246 in heating costs. Moreover, the amount of carbon monoxide produced through the use of energy is reduced by up to 93%.

**Table 1.** Comparison of Kombi Boilers and Pellet Boilers [22]

| **Heating System** | **Kombi Boiler** | **Pellet Boiler / Room Heater** |
|---|---|---|
| **Type of Fuel** | Natural Gas | Pellet fuels |
| **Model** | 2009 | 2009 |
| **Hot water** | Yes | Yes |
| **Number of people** | 5 | 5 |
| **Photovoltaic** | No | No |
| **Energy power** | 26 kW = 22360 kcal | 11 kW = 9455 kcal |
| **Energy spent** | 2200 MJ of natural gas | 3.7 tons of pellet fuels |
| **Total annual spending** | TRY 2.541 | TRY 1.295 |

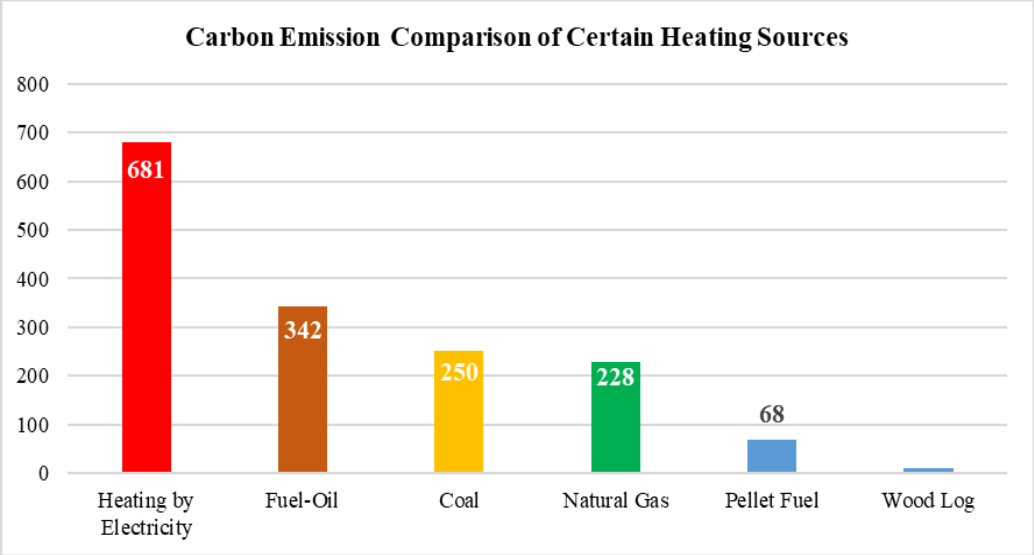



**Figure 14.** Carbon Emission Comparison of Certain Heating Sources [23]

### 2.3.1. Superior Characteristics of the Pellet Fuels to Other Bio-Fuels

Pellet fuels offer characteristics significantly superior to not only sources of fossil energy, but also split wood and woodchips [9].

1. Storage superiority: Wood pellet fuels require smaller storage spaces than other biological fuels when considered in terms of their material and energy

density, allowing wood pellet fuels to rate superior in affordability and savings in storage space for certain warm-up time.

2. Transport superiority: The standardized dimensions of pellet fuels allow for simple and convenient supply and transport and subsequent use in fully-automated transmission systems. Wood pellet fuels are transported in tankers (tank wagons), pumped into a warehouse, and transmitted to the boiler from there in a fully-automated system.
3. Emissions Superiority: Burning wood pellet fuels in pellet stoves and pellet boilers in central heating systems will produce fewer CO2 and nitrous oxide emissions and less dust when compared to split wood and woodchips.
4. Material properties: Wood pellet fuels contain approximately 0.5% ash and less than 10% residual moisture. These values are lower than those with the other biological fuels. Pellet fuels feature a significantly high calorific value in every weight and volume unit. The small quantity of residual moisture also allows for continued and smooth pellet fuel storage. Dryness and ventilation in a warehouse will also contribute to storage time.
5. Economic superiority: Pellet fuels are affordable as they are produced entirely from biomass wastes. Pellet fuel allows for the use of 95% of combustion energy, eliminating energy loss. 1 kg of pellet fuels equals to 5 kw of energy, while 2 kg of pellet fuels produce energy in equivalence to 1 liter of liquid fuel at one-third the price. The use of pellet fuels in the industry will significantly reduce air pollution and eliminate the high costs associated with stack filter systems. These features will offer economic advantages to producers.

All ligno-cellulosic materials, including wood, hay, paper, and many vegetable fibers, offer an important source of energy. The main issue with these materials stems from their high volume-to-weight ratio, which adds difficulty and cost to their processing, storage, and handling. In order to solve this problem, these materials may be dried and then compressed under extreme pressure into pellet

fuels. These resulting products will have a higher density (more than 2 times the initial density) and a high calorific value.

In most developed countries, the use of pellet fuels is a matter of cost with implications for sustainability in fuel supply and reduction of environmental pollution. In a country endowed with limited resources of oil, gas, or coal, but dependent on ligno-cellulosic resources, it does not appear to make sense not to reduce the use of conventional fuels.

Turkey produces approximately 65 million tons of agricultural waste and 10 million m3 of tree waste every year and since this great ligno-cellulosic potential cannot be converted into electrical and heat energy in biomass power plants, the country suffers from an ever increasing dependency on imported oil, natural gas, and coal. The growth of national economy and industry, as well as the continued generation of electricity and heat at the great quantities that are necessary for industrial processes, require maximum utilization of local resources of biomass.

Agricultural waste can enjoy ease of transport, storage, and use only if compressed into the pellet form. Pellet fuels are equivalent to half the oil energy in weight and one-third of the same in volume. This factor balances out the price difference in transport over long distances. Woodchips, on the other hand, generate 18 times less energy in volume when compared to oil.

As improved-quality wood fuels, wood pellet fuels are produced through the drying and compression of such materials as sawdust, planer dust, chips, and barks that are natural products of various processes, as well as whole trees and timbers. The most important characteristics of this production process are as follows:

- The energy value of waste is improved, preparing the product for immediate use or for further thermochemical conversions (combustion, gasification, pyrolysis, and carbonization);

- Pellet fuels reduce storage volume;
- Handling and transport are facilitated, and relevant costs reduced;
- Energy density/volume ratio is increased; and
- The product is free from the loss of substance arising from fermentation.

According to a study conducted in Finland [24], the stages involved in pellet fuel production are raw material storage, drying, milling, pressing, cooling, screening, and packing/end product storage.

*Drying:* Sawdust or planer dust, when used as raw materials for pellet fuel production, will not require drying. However, damp sawdust for pellet fuel production should be dried in a drum drier before milling.

*Milling:* In general, the raw material will be hammer-milled to a homogenous size, e.g., to the size of a wheat grain, for subsequent pressing. If the process requires drying, milling and drying may be performed at the same time. Milling greatly facilitates the drying process by achieving a uniform size and relatively similar moisture content in all particles. A homogenous moisture content in every particle will ensure better durability for pellet fuels. Drying is usually carried out in a hot gas generator. The burner in this mechanism will burn excess sawdust from the production process. The resulting gas essentially contains carbon dioxide, water, and nitrogen.

Pressing: Pellet fuels are pressed flat or vertically into a mold. Normally, the pressing of wood pellet fuels will not involve any binding agent. Pellet particles bind onto the internal surfaces of fiber particles through cohesion (retention, attachment) and adhesion arising from the softening of lignin due to the heat of compression. Pellet molds are always chosen on a case-by-case basis in line with their quality (hardness, moisture, mixture).

*Cooling:* Cooling is an important stage in pellet fuel production. Once pressed, pellet fuels usually reach approximately 90°C in temperature. Pressing will eliminate any remaining moisture along with the increase in heat. Cooling, on the other hand, balances the pellet fuels, hardens the melted lignin on pellet surfaces, and thus, fixes the pellet shape.

*Screening:* Screening filters out any raw material dust left among pellet fuels and sends these back to the initial pellet fuel production stage. Screening is generally carried out with a moving screen and produces homogenous pellet fuels that will not pose a problem to conveyor belts and combustion equipment.

*Packing/End Product Storage:* Pellet fuels are sent to a silo or filled into large (500-1000 kg) or small (15-20 kg) plastic bags to be shipped to buyers [24].

The pellet fuel production machine is the most important part of the system. It is extremely suitable for the processing of various waste materials. Such waste materials include dehydrated activated sludge used in water processing plants as a waste product; biological and chemical fertilizers; pulp and slag obtained through industrial processes; shells of grains and cereals; outer leaves of ears of corn; dry stalks of grains; plant stalks; plant growth waste; biological content in municipal and industrial solid waste; fertilizers mixed with rotten leaves, etc. (compost); paper and carton; factory waste; woodchips and sawdust; forest waste; plastic materials; and chemical products suitable for pellet fuel production, etc.

Turkey does possess the raw material potential required to produce pellet fuels, even though it is not home to as large a forested area as in Canada, a country that is known to use pellet fuels widely. The most important proof for such potential lies in the forested areas in the country amounting to 27% and in agricultural areas representing 34% of its territory. The total forested area in Turkey amounts to 21.2 million hectares and agricultural land to 26.4 million hectares. Cultivated

areas represent 38.4% of all agricultural land and forested areas in the country, while forested areas and fallow land and growing fields amount to 44.1% and 10.4%, respectively. The waste produced through maize and cotton cultivation reaches 50-65 million tons. Moreover, considering the significant number and size of industrial plants processing forestry products, the waste products that will be sourced from these plants will play an important role in meeting the need for raw materials in pellet fuel production.

National and international transport of pellet fuel production raw materials to relevant plants does not encounter difficulties in Turkey, a country boasting a developed road transport network, however, transportation as a challenge against the Turkish pellet fuel industry is elaborated in the second part of this study. The most important problem facing pellet fuel production in Turkey concerns the difficulties in finding markets for end products. The industry suffers from a marketing problem due to the additional installations required for the use of pellet fuels especially in space heating systems, as well as the lack of public awareness on its properties. The new pellet fuel production plants established by domestic and foreign companies in the country are willing to solve this problem soon [22].

The production and use of pellet fuels originated from North America in the 1970s, while Sweden, Denmark, Austria, and later other European countries joined in with their pellet fuel production efforts in the 1990s. The recent few years witnessed the establishment of a number of high-capacity plants around the world and a boom in pellet fuel production in North America. With Canada and Russia standing out as prominent pellet fuel exporters, Denmark, Italy, Belgium, and the Netherlands have become significant pellet fuel importers. Today, pellet fuels offer an advantageous source of heat that can compete with heating systems using oil or electricity for single-family homes. More than 800.000 homes in the U.S. and more than 700.000 homes in Italy use pellet-fueled systems. Moreover, the use of pellet fuels constitutes a feasible option for regional heating stations

(central heating systems) and even power plants. Table 2 shows cost and energy input values for unit applications in pellet fuel production.

**Table 2.** Cost and Energy Inputs in Pellet Fuel Production [25]

| **Unit applications** | **Cost ($/ton)** | | **Energy Input (MJ/ton)** | |
|---|---|---|---|---|
| | **Min.** | **Max.** | **Min.** | **Max.** |
| **Raw materials** | 10 | 60 | 100 | 150 |
| **Chipping** | 2 | 10 | 100 | 350 |
| **Drying** | 5 | 25 | 1000 | 2500 |
| **Milling (hammer-milling)** | 2 | 6 | 70 | 175 |
| **Pressing (pellet fuel production)** | 3 | 7 | 175 | 210 |
| **Storage** | 1 | 5 | 34 | 35 |
| **Transport** | 25 | 50 | 1000 | 5000 |
| **Transfer of materials** | 1 | 2 | 2 | 100 |
| **Total** | 49 | 165 | 2481 | 8520 |

Logistics and drying represent the two most important factors in reducing pellet fuel costs and energy input (Table 3).

**Table 3.** Improvement of Pellet Systems [25]

| **Cost** | | **Energy** | |
|---|---|---|---|
| 1. Transport | 35% | 1. Transport | 55% |
| 2. Raw materials | 33% | 2. Raw materials | 32% |
| 3. Drying | 14% | 3. Drying | 4% |
| 4. Chipping | 5% | 4. Chipping | 3% |
| 5. Pressing (pellet fuel production) | 5% | 5. Pressing (pellet fuel production) | 2% |
| 6. Milling | 4% | 6. Milling | 3% |
| 7. Storage | 3% | 7. Storage | 1% |
| 8. Transfer of materials | 1% | 8. Transfer of materials | 1% |

The waste arising from the production processes (cutting, timbering, and extraction) of wood-derived biomass in the harvesting of round wood and other forestry applications is left in the forest in an unusable form. Forest waste including small-scale wood, branches, end pieces of trees, roots, and logs up to 40% of harvested wood biomass, can be utilized effectively in energy generation. Quantities of production waste varies depending on specific forestry

applications used. Initial spacing essentially produces small-scale wood reaching a relatively small total quantity. Further down the line, partial production or total clear-cutting will provide waste in the form of branches, needles, and partially rotten timbers.

The amount of production waste generated in one setting depends on the type and quantity of the trees involved, as well as the quality and number of branches and the presence of rotten parts. Spruce forests will produce two times the production waste available with pine or birch forests. Higher quantities of production waste allow for better utilization. Production waste can be collected wet immediately after harvesting or left on site to dry, shedding leaves and needles, and leaving nutrients in soil. If such waste is left on site for a few months in the summer, the moisture content will decrease by 20-30%. This will double the solid wood content, but the amount of collectible waste will decrease by 20-30%, leading the same amount to reach 55% in comparison with the wet weight of forest waste. Forestry guidance indicates that *leaving one-third of waste and some logs on site will add sustainability to the utilization of forest waste* [26].

## 2.4. Competitive Advantages of the Pellet Fuel

### 2.4.1. Economic Advantages of the Pellet Fuel

The use of domestic wood and wood waste in wood pellet fuel production creates a large number of circles of trade in industries, technical professions, forestry, and agricultural businesses. They, therefore, play a particularly important role in strengthening rural social structure and value-added operations. The price of pellet fuels is largely independent of the prices of natural gas and oil. Considering sources of fossil energy and the global climate change problems associated with them, the prices of fuel-oil and natural gas are bound to increase significantly in the future. In terms of fuel prices, wood pellet fuels are an

affordable alternative to fossil fuels even today. The current price of wood pellet fuels is significantly lower than that of fuel oil or natural gas when considered in combination with their calorific value. The price of wood pellet fuels does not follow the price fluctuations observed with fuel-oil and natural gas and has remained relatively stable in the last five years. For instance, the delivery of 5 tons of wood pellet fuels to a home that is 50 km away costs approximately EUR200/ton, the price being inclusive of all relevant expenses (Fig. 11).

#### 2.4.1.1. Price Advantage of the Pellet Fuel

The use of local wood and wood waste in wood pellet fuel production creates a large number of circles of trade in industries, technical professions, forestry, and agricultural businesses. They, therefore, play a particularly important role in strengthening rural social structure and value-added operations. The price of pellet fuels is largely independent of the prices of natural gas and oil. Considering sources of fossil energy and the global climate change problems associated with them, the prices of fuel-oil and natural gas are bound to increase significantly in the future. In terms of fuel prices, wood pellet fuels are an affordable alternative to fossil fuels even today. The current price of wood pellet fuels is significantly lower than that of fuel oil or natural gas when considered in combination with their calorific value. The price of wood pellet fuels does not follow the price fluctuations observed with fuel-oil and natural gas and has remained relatively stable in the last five years. The price of pellet fuels increased from 3.7 cent/euro in January 2002 to 3.8 cent/euro in January 2006, while the price of natural gas rose from 4.4 cent/euro to 5.7 cent/euro and the price of fuel-oil rose from 3.2 cent/euro to 5.7 cent/euro in the same period [27]. Trend of bagged and bulk pellet fuel prices in the European countries which offer the lowest prices between January 2016 and October 2018 are given in the Figures 15 and 16 respectively.

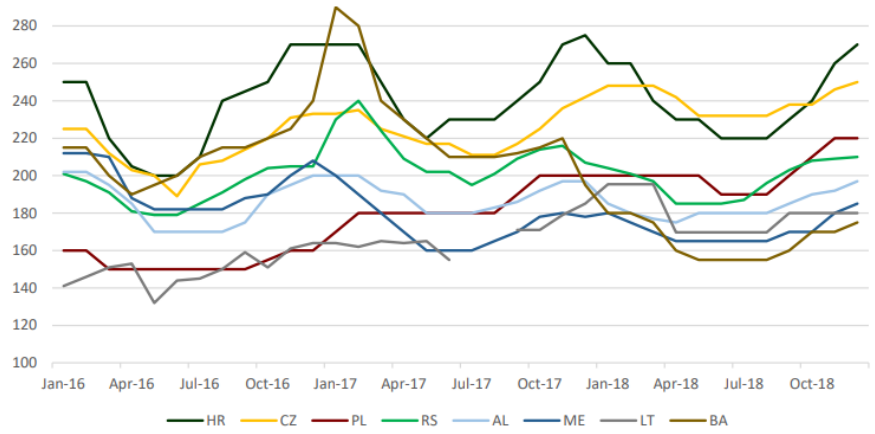



**Figure 15.** Trend of The Bagged Pellet Fuel Prices in European Countries with The Lowest Pellet Fuel Prices Between 2016-2018 (VAT Included EUR/Ton) [16]

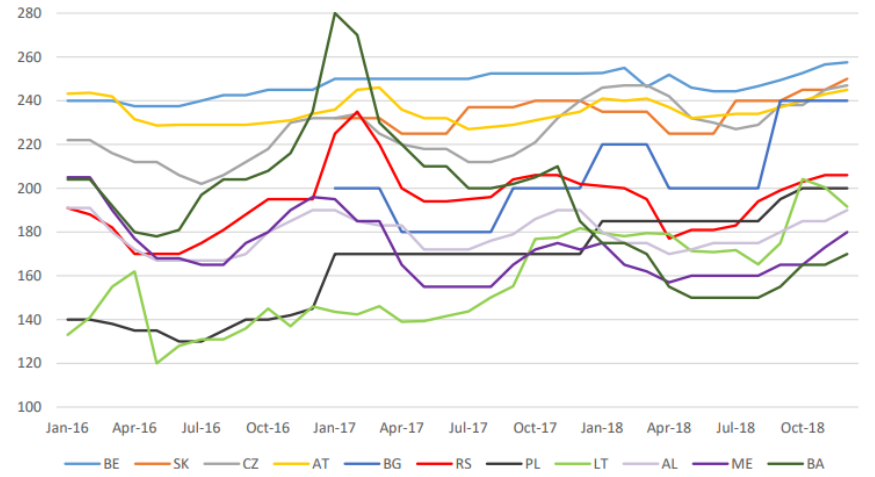



**Figure 16.** Trend of The Bulk Pellet Fuel Prices in European Countries with The Lowest Pellet Fuel Prices Between 2016-2018 (VAT Included EUR/Ton) [16]

#### 2.4.1.2. Security of Supply of the Pellet Fuel

Wood is a regenerating, durable, and widely available fuel. Approximately 2/3 of all trees in Turkey are used as wood. This fact is of significance for the use of wood as fuel improving the security of fuel supply and alleviating dependence

on fuel-oil and natural gas. Resources for the sake of the Turkish pellet fuel industry are further elaborated in the following sections.

#### 2.4.1.3. Fewer Transport and Storage Risks of the Pellet Fuel

Frequent environmental disasters including tanker accidents and pipe leakage should be taken into consideration for the use of fuel-oil and natural gas specifically for the heating of living spaces. However, the use of wood pellet fuels as fuel will rarely pose any transport risks. Hazards associated with the storage of fossil fuels such as oil and natural gas including explosions, fires, and groundwater pollution are much rarer and generally non-existent with wood pellet fuels.

#### 2.4.1.4. Possibilities for Regional Circles of Trade for the Pellet Fuel

The use of domestic wood and wood waste in wood pellet fuel production creates a large number of circles of trade in industries, technical professions, forestry, and agricultural businesses. They, therefore, contribute the value and safety of rural social structures. Global pellet fuel trade stream with volume of trade is illustrated in the Fig. 17 below.

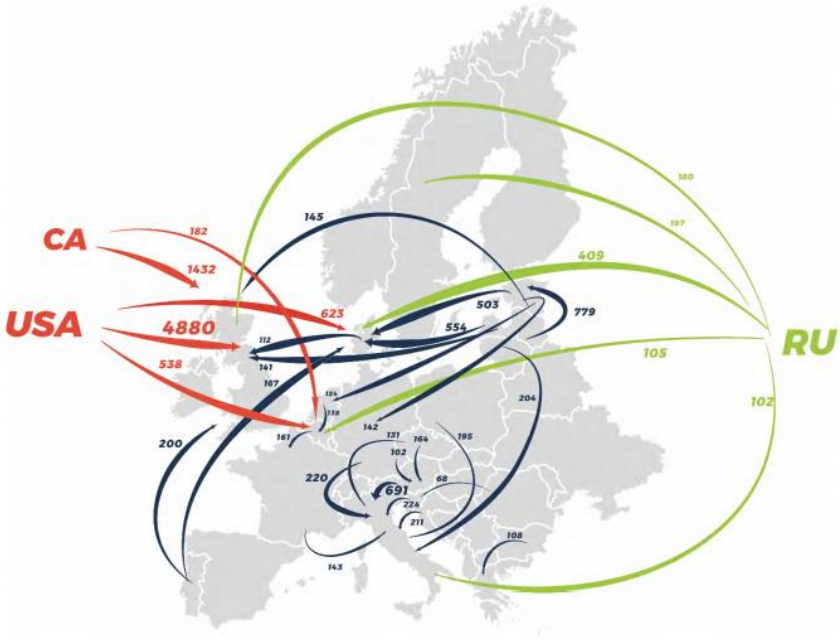



**Figure 17.** Global Pellet Fuel Trade Stream for The Year 2018 (>100 ktons), (ktons) [16]

### 2.4.2. Ecological Advantages of the Pellet Fuel

#### 2.4.2.1. Climate Protection

The use of wood pellet fuel is CO2-neutral for the most part, contrary to sources of fossil energy. The quantity of CO2 arising from the burning of wood pellet fuels is equal to the quantity received by a tree during its growth (closed CO2 cycle). The CO2 that is released after the burning of sources of fossil energy has been stored for millions of years. The amount of CO2 that is released as a result of combustion increases the CO2 content in the atmosphere and is largely responsible for anthropogenic greenhouse effect. When one family replaces fuel-oil or natural gas with wood pellet fuels for household heating, their release of CO2 will be reduced by 5 tons/year or by 2.5 tons/year, respectively. Either switch will result in a significant reduction in the greenhouse effect.

#### 2.4.2.2. Acid Rain Reduction

Whoever uses pellet fuels instead of fossil fuels will reduce not only the quantity of CO2 released, but also the quantity of SO2 arising from the process. The latter gas creates acid rain and is held responsible for “dead forests”, i.e., extensive damage to individual forests, while burning wood pellet fuels contributes significantly to the protection of forests.

### 2.4.3. Advantages of the Pellet Fuel to the Other Bio-Fuels

Pellet fuels offer characteristics significantly superior to not only sources of fossil energy, but also in comparison with other solid fuels such as split wood and woodchips. Wood pellet fuels require smaller storage spaces than other biological fuels when considered in terms of their material and energy density, allowing wood pellet fuels to rate superior in affordability and savings in storage space for certain heat generation time. The standardized dimensions of pellet fuels allow for simple and convenient supply and transport and subsequent use in fully-automated transmission systems. Wood pellet fuels are transported in tankers (tank wagons), pumped into a warehouse, and transmitted to the boiler from there in a fully-automated system. Heating a space with wood pellet fuels is at least as practical and comfortable as heating with oil and gas except for the normal requirement of ash collection, which is highly minimized compared to coal or to a wood log.

Burning wood pellet fuels in pellet stoves and pellet boilers in central heating systems will produce fewer emissions. Emission thresholds were significantly restricted for modern pellet boilers with “States-Emissions-Protection Act [28]”. Wood pellet fuels contain approximately 0.5% ash and less than 10% residual moisture. These values are lower than those with the other biological fuels. Pellet fuels feature a significantly high calorific value in every weight and volume unit. The small quantity of residual moisture also allows for continued and smooth

pellet fuel storage. These advantages will be much more visible specifically in dry and sufficiently ventilated spaces [29].

## 2.5. Turkish Pellet Fuel Industry's Characteristics

Pellet fuel is a relatively new product and a renewable energy source for Turkey. Certain features of the Turkish Pellet Fuel Industry will be elaborated in the following subsections. A summary of industry's strength, weaknesses, opportunities and threats are given in the Appendix-A.

### 2.5.1. Number of Firms

There are a small number of producers – approximately 30- operating officially in Turkey as pellet fuel producers. These firms often utilize wood -usually pine tree but also other kinds of trees- to produce pellet fuel however especially in the Aegean and Mediterranean Regions there are producers who are using olive pomace as a raw material. Fig. 18 illustrates the distribution of density of the producers according to regions in Turkey.


**Figure 18.** Distribution of the Pellet Fuel Producers Based on Turkish Cities

Producers based their location according to closeness to the sources of raw material and transportation routes. For instance, in Ankara, there are a large number of wood processing factories such as pallet producers, furniture makers and saw mills. Similarly, the Black Sea Region is rich in terms of forest assets thus providing a significant resource to produce pellet fuels. Aegean and Mediterranean regions have a large number of olive trees and olive oil factories, thus providing a vast amount of olive pomace, a raw material source for pellet fuel. In addition to official pellet fuel producers, there are a substantial quantity of illegal pellet fuel producers in Turkey's almost every region. These illegal producers often mix MDF and chipboard shavings with wood dust to produce pellet fuel. MDF and chipboards have cost advantages comparing to the wood and other biomass sources however they contain adhesive and glue, which are making them hazardous when burnt. This situation is causing damage to the reputation of the Turkish pellet fuel industry.

### 2.5.2. Type of the Industry

The type of the Turkish pellet fuel industry can be best defined as a monopolistic competition, where a large number of firms are producing a similar product – however not identical substitutes for each other- consumed by a vast amount of consumers while actions of a producer does not have a direct effect on its rivals [30]. There are both official and non-official pellet fuel producers in Turkey's almost every region. Similarly, the amount of consumers is also substantial. The products produced by different producers are almost identical, differing in convenience, size, and raw material mix but the raw material is generally sourced from wood or other agricultural biomass. The pellet fuel's raw material mix differ only based on region. As told in 2.5.1, in some regions there are a vast amount of olive trees and producers located in those regions utilize olive pomace to produce pellet fuel, thus consumers in these regions logically prefer to purchase pomace pellet fuel. With respect to new producers entering to the industry, there are almost no barriers. Along with the necessary machinery and

equipment, any firm can produce pellet fuel. Each of the producers sell their products which is accounted to a relatively small share in the industry thus the producers' sales actions do not affect the market price. Transportation and raw material costs are the primary inputs affecting the sales price. As mentioned in the 2.5.1, Turkey has a substantial amount of illegal pellet fuel producers and their sales are non-official. Thus they can compete with other producers through selling their product without a Value Added Tax (VAT), enabling them to sell the product with a so called discount by avoiding tax. However, it is known that during the high season the illegal producers tend to prefer the official price to sell their product to obtain the VAT value for themselves.

### 2.5.3. Characteristics of Products

The characteristics of the pellet fuel are mentioned in the sections 2.2, 2.3. and 2.4. Producers are offering very similar however not yet standardized products to the market. An important feature of the product is the convenience. As it can be seen in the Fig. 18, the producers are located in certain limited locations in Turkey, and this causes an advantage for the merchants of this product. Merchants are bringing this product to regions without any production activities and they are charging above market prices because they are supplying convenience to the consumers in those regions. For other regions with production activities, consumers have advantage in terms of price negotiations.

### 2.5.4. Characteristics of Consumers

Pellet fuel has two types of consumers which are industrial consumers and household consumers. Industrial consumers are using pellet fuel in power plants to obtain energy. Household consumers are burning pellet fuels for heating purposes. In Turkey there are currently no power plants using pellet fuel for power generation. Pellet fuels are used by consumers for heating concerns. In Turkey, pellet fuel consumers are divided into two categories, household users

and corporate users. Both are consuming pellet fuel to heat their houses or companies/facilities/offices. The main difference between them is their consumption volume. Household consumers tend to consume a substantially lesser amount than a corporate consumer. As mentioned in the 2.5.2, the industry can be defined as a monopolistic competition where each firm's products are similar for one another but not direct substitutes, and there are a vast quantity of producers operating in the market. Demand is highly elastic and is subject to change with regards to price fluctuations. The producers have a level of control over the price however competition limits this situation. Consumers can easily substitute to a similar solid fuel in case of price increases. The primary feature of the pellet fuel which is affecting the consumers is its size and dimension. Heating systems and devices are set to burn a certain sized solid fuel. Some of them can burn pellet fuel with a 6 mm diameter while another system can burn 8 to 10 mm's. In general, heating devices for small household usage prefer smaller caliber pellet fuels while bigger heating systems operate better with larger sized pellet fuels. As given in the 2.5.2, different producers can use different sources of raw materials but in the end there is no difference between pellet fuels produced from biomass. However, illegal producers usually use MDF and/or chipboard shavings to produce pellet fuel and it is hazardous to burn it, yet some large scale corporate consumers prefer to burn them in their facilities because of their cost advantage.

### 2.5.5. Entry/Exit Barriers

Referring back to the sub-section 2.5.2, Turkish pellet fuel industry can be classified as a monopolistic competition, with low entry/exit barriers. Pellet fuel is relatively a highly standardized product. It requires certain machinery and equipment, with certain biomass raw materials primarily wood. Apart from the initial capital necessary to begin production, the process needs basic inputs such as blue collar workers, electricity and etc.

### 2.5.6. Resources

Given its 22.933.000 ha forest and wooded land as of 2020, Turkey has a significant amount of forest assets [6]. Perhaps the most important resource that can meet the ever-increasing energy requirement of the world with the increasing population and industrialization without polluting the environment and sustainably is biomass energy. Biomass is an inexhaustible source of energy, as the cultivation of plants will continue as long as the sun is present. It is seen as an appropriate and important source of energy, as it can be grown anywhere and helps socio-economic developments, especially for rural areas [31]. Of the biomass energy currently being obtained; Forest and wood wastes, 64% of which are fine materials from forest maintenance and production, sawdust and chips formed in the forest industry, unused (scrap) wood, 24% from municipal solid wastes (garbage), 5% agricultural plants and their residues are produced from agricultural wastes such as hard fruit shells (olive seed and pulp, nuts, etc.) and 5% from landfill gas [32]. Studies on energy forests have been initiated in our country with a principle included in the 5th Five-Year Development Plan and have been developed and reached today. In the inventory studies carried out, it has been determined that there are approximately 5 million hectares of forest land suitable for establishing an energy forest in our country. 2.6 million hectares of this is fertile forest connected to the cutting system, and the remaining 2.4 million hectares is degraded forest. OGM has established a total of 562.513 hectares of energy forest from the first 5030 hectares of energy forest establishment in 1978 to 2008 [32]. Degraded coppice forest areas make no contribution to the country's economy with the current situation. If energy forests are established in these areas, they will contribute to the economy of the country by making their habitats productive, and also, a large amount of job opportunities will be created. With the energy forest projects initiated by the General Directorate of Forestry in 1978 in the Eastern, Southeastern, Central Anatolia and Thrace regions in order to meet the fuel wood requirement of our country (average 28 million m3 / year) and to reduce the negative effects of

grazing and branch utilization on forests, a classical energy forest has been established on an area of 536,000 hectares [33]. Turkey's forest area covers 20.7 million hectares with a ratio of 27%. Not all of the forest areas are in the nature of fertile forest, and the forest area that can yield fruit is 9.9 million hectares (48%). The remaining 10.8 million hectares (52%) of forest area consists of low yield forests or completely inefficient degraded scrub and scrubland. The area of 6.4 million hectares corresponding to 31% of forest assets in our country is coppice (normal, degraded, highly degraded) forest. It can be said that this 4 million hectares of very degraded coppice forest area may be subject to energy forestry [34]. According to the Turkish Forest Inventory, the tree wealth of our forests will be 1.2 billion cubic meters, its annual increment will be 34 million cubic meters, and the amount that can be cut annually (felling) will be 18 million cubic meters. In 2020, our annual wood product requirement will be 43 million cubic meters. If the difference between production and consumption is to be covered by imports, approximately 6.4 billion USD will be paid. In closing this gap, both the establishment of modern energy forests in a suitable part of the areas that need to be afforested in the state forests and the encouragement of the citizens to establish energy forests with fast growing tree species such as poplar, willow, acacia, eucalyptus, alder, and additional wood production to be produced in energy forests is an important will be able to play a role [35]. In addition to the annual volume of 18 million m³ trees cut by the General Directorate of Forestry from the forests of Turkey, the volume of trees illegally cut from the state forests by the citizens living in and around the forest, as well as the annual average tree volume cut from the private forests in the deed lands is 10 million m3, in addition it is estimated that the annual volume of trees cut from private forests is 28 million m3. Considering that approximately 25% of a tree consists of branches, trunk bark and the remaining parts after cutting, it is known that approximately 7 million m3 of wood waste stays in the forest every year in the forests of Turkey and a large proportion of it is left to rot in the forest because it does not cover transportation costs. In addition to this vast amount of wood wastes decomposed in the forests, if approximately 56 million tons of plant

stalks and wastes of agricultural production used in energy production every year, our country will also benefit from bioenergy, similar to the countries that generate energy from biomass wastes [36]. Although 50-65 MTEP (million tons of oil equivalent) agricultural waste and 11.05 MTEP animal waste are produced annually in Turkey, only 60% of these wastes can be used for energy production. It is known that the energy to be obtained from these agricultural and animal wastes is equal to 22-27% of the annual energy consumption of Turkey [37]. Nevertheless, instead of turning to renewable energy resources and developing technologies in energy policies in our country, it is preferred to meet the energy needs through imports.

A family with a heat requirement of 15 kW can use 6000 kg of wood pellet fuels instead of 3000 liters of fuel oil per year. The use of pellet fuels as fuel for homes; It provides similar usage comfort like natural gas and fuel oil. Compared to the fact that fuel-oil and natural gas ignite, explosion, pollute the environment and soil, emit intensive CO2, SO2 and NOx into the atmosphere, these negativities are little or no in wood pellet fuels. The amount of ash formed after burning from wood pellet fuels is approximately 0.5% and since it does not contain heavy metals, it can be used as a natural fertilizer for flower growing, greenhouses and forests [33]. With 56 million tons of agricultural product waste and 10 million m3 of wood waste per year, this huge ligno-cellulosic potential cannot be converted to electricity and heat energy in biomass power plants and to pellet fuels in pellet fuel production facilities, so dependency on imported oil, natural gas and coal is constantly increasing. In the growth of the country's economy and industry, it is necessary to utilize the local biomass resources at the highest level in the production of the large amount of electricity and heat required in industrial processes [36].

## 2.6. Literature Review

This thesis study aims to present the latest status of the Turkish pellet fuel industry and further elaborate the challenges against its development and perspectives regarding its future, thus will reveal recommendations on actual matters concerning policy and industrial applications. Pellet fuel industry is a highly developed industry in western countries and it bears a great potential for Turkey in terms of economic success and reaching a higher proportion of renewable energy sources in its energy mix. Since it's a hot topic especially in the western world, the academia gave a great importance to this matter.

One study carried out in Canada scrutinized the present-day status and future of the pellet fuel market with predicting the cost of Canadian torrefied pellet fuels, then comparing it to the cost of traditional pellet fuels. It showed that the pellet fuel industry is on the rise because of the Europe's incentives to the renewable energy and increasing fossil fuel costs [38].

A comparative study on economically sustainable production of pellet fuel between the countries of Norway, U.S, Sweden, Germany and Finland was carried out. The study compared small scale pellet fuel production plant which utilizes dry wood residues and large scale pellet fuel production plant which uses both dry and wet woody residues in terms of production inputs. The study reached that the future of the pellet fuel production will depend on wet feedstock for instance round wood and wet sawdust [39].

Another study in Austria has highlighted the character of the European pellet fuel market, reveal a market model for pellet fuels in Austria, predicted supply and demand price elasticities, and reached that demand for pellet fuels is inelastic while supply for pellet fuels is elastic for the short-term. Further, policies to stimulate the demand will cause a rise in pellet fuel prices and raw material costs [40].

A detailed study about wood pellet fuel industry's current overview, the primary opportunities and challenges facing for its future development was accomplished for Finland back in 2017. The study collected and elaborated data through a detailed survey study of approximately 60 pellet fuel experts. As a result, absence of policy support and deficiency in appropriate regulations are the primary factors against the development of the Finnish pellet fuel industry. Nevertheless, the industry can be developed if challenges such as raw material costs and rivalry with other solid fuels are given weight to. Effective policy supports and practical framework for regulations are essential to achieve a competitive edge against other industries [41].

For the Turkish case, a research study regarding the pellet fuel industry's current overview and parameters its future development was not carried out. Studies regarding pellet fuel were done within the scope of its technical characteristics, production techniques and methods regarding the recycle of wood and agricultural biomass into pellet fuels [42, 43]. As mentioned above, peer studies were carried out especially in western countries. In addition, detailed industry reports and industry trends are periodically published by unions, associations and research institutions in the western countries regarding the pellet fuel industry. There is a lack of studies and research in this regard in Turkey. This study aims to fill this gap for Turkey in line with its European counterparts in this field.

# CHAPTER 3

# STRATEGIES TO BE IMPLEMENTED

## 3.1. Method and the Data

### 3.1.1. Method

The analysis for this thesis study was conducted through utilizing a qualitative method. The thesis study is built on the Turkish pellet fuel industry's current situation through literature reviews merged with the results of a survey regarding perspectives of the pellet fuel specialists. The objective of the survey was to gather data on the existing condition and future development of the Turkish pellet fuel industry. The survey was done using the Internet by the means of the Google Docs tool and it was sent to specialists representing different occupations which are highly associated with the Turkish pellet fuel industry.

The main drivers were uncovered through exploring the factors that are encouraging or hindering the development of the industry, investigating who derives the most profits out of this industry (producers, consumers or the traders), and what are the perspectives for the future of the Turkish pellet fuel industry. The sending of the survey to the participants started on March 26th 2021 and the survey was active until April 17th, 2021. The total number of specialists who received and viewed the survey is 64, the whom are including Turkish pellet producers, consumers, traders, academicians, researchers and NGO members. The survey was specifically prepared the for Turkish specialists. The survey consisted of four different parts and thirty-seven questions including three open ended questions. Participants were asked to specify which institution/organization are they from along with the city they are living and

working in however besides these they were opt to remain anonymous but still the majority left their contact information as they are willing to remain in contact for further inquiries and the results of this thesis study thus indicating their interest regarding the future of the Turkish pellet fuel industry. Hence, the results of the survey study constitute the opinions of sixty-four Turkish pellet fuel specialists. Figure 19 briefly demonstrates the main contents and the structure of the survey.

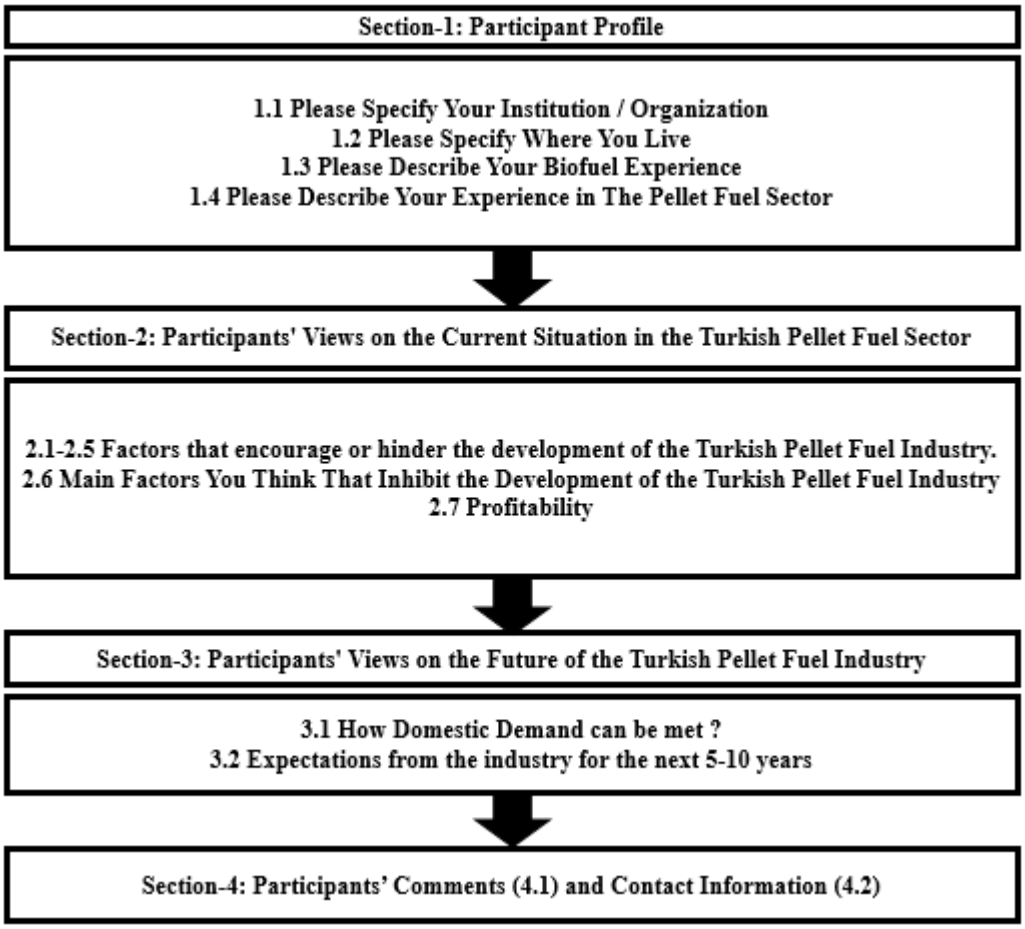



**Figure 19.** Main Contents and the Structure of the Survey Study

This particular survey provided a number of benefits to the thesis study. Primarily, participants were chosen only among the people who are highly familiar with the Turkish pellet fuel industry thus they hold genuine information which is cannot be found from reports, literature or other sources. Moreover, the

responds of the participants are covering the latest status of the industry which provides the study with an accurate visualization of the situation. Lastly, since the participants are from diversified backgrounds, for instance they are from different organizations with different levels of experience in the industry, enable the survey study to illustrate divergent opinions and be highly comprehensive. The outputs of the survey are largely given in the form of percentiles.

For survey method applications, since the evaluation of the outputs and the drawing of the results are insignificant, it means that the validity, reliability and generalizability of the relevant results cannot always be easily established [44]. In order to enhance the dependability of the thesis research, the survey is initially started with a section that contains questions about the participants' profile; the institution or organization which they are working for, the city they are living in and their level of experience in biofuel and pellet fuel industry. Receiving these insights about the participants assisted the validity of the responds. In addition, all of the survey's questions were required to be answered by the participants which prevented missing responds. As mentioned before, the study utilized reliable and accurate online Google Docs tool.

There are a small number of downsides of the survey approach. First of all, although the questions deal with general matters and concentrate on perspectives, business ethics may limit honest responds. There are a number of participants from companies operating in the industry, and so they may have felt uncomfortable about sharing crucial and confidential corporate insights. Nearly half of the participants were either producers, traders or consumers of pellet fuel thus having worries regarding competition may have been a problem about the survey. In addition, the participants may not have grasped the significance of the survey research, and the effect of its outputs. Participants were provided with a briefing explaining the scope and the aims of the survey research in order to minimize potential misconceptions.

Furthermore, the response options of the questions can lead to ambiguous output since some response options may be perceived differently by the dissimilar participants. For instance, the "slightly agree" response option may be associated with different matters when its mentioning different topics thus having its own signification for each participant. The survey contains different question types and analogous questions of different kinds regarding the same subjects in order to prevent the aforementioned issues. Every question is prepared with regards to as it is a compact edition of the survey whilst stability is estimated in that purpose in order to make sure accuracy. Eventually list of questions are gathered to reveal a depiction of an elaborate idea regarding the Turkish pellet fuel industry.

Moreover, the timing is a crucial actor for survey approach. The study concentrates on the year 2021 however recent updates such as the COVID-19 Outbreak is not taken into consideration. As mentioned above, the sending of the survey to the participants started on March 26th 2021 and the survey was active until April 17th, 2021, it can be stated that there was a time constraint which affected the total number of participants. However, the distribution of the participants was rather balanced and they represent their professions and area of origins well. Another setback is the anonymity of some of the participants. Within the context of the data analysis, the anonymity prevents to illuminate some of the suspicious responds which are open to different interpretations, especially for the open questions. In order to prevent this, the data was controlled via reports and literature. As a result, the responses from the participants were factual which were supported by sources of industry reports and literature.

In addition, the difference between the perspectives of the participants who opt to participate and who did not opt to participate to the survey research which is leading to bias. It is rather burdensome to assess the participation rate since the survey was sent to participants directly through e-mail as well as it was shared on certain digital platforms so some portion of the participants were self-decided.

Participants were provided with a briefing stated that the ones who give their contact information will be kept informed with the output of the research. The human factor is a farther troublesome side of the survey method. Participants' views on the future of the Turkish pellet fuel industry is subject to change depending of the morals of the participants while they are responding. Participants may be more pessimistic on the day they provided responds which leads them giving responds accordingly or vice versa. Participants might have limited time to provide their perspectives due to their heavy schedule resulting in incomplete expression of their opinions and/or they might have misunderstood the response options. The survey was provided in Turkish language and all of the participants were native Turkish speakers, so mistakes arisen from language difficulties were not the case for this survey research.

Prior to the actual survey study a pilot study has been conducted with twenty-nine participants. In this pilot study first responds of the twenty-nine participants were collected and afterwards reliability and validity analysis were carried out using the SPSS 26.0 (IBM Corp., 2019) software. This information of participants was collected through an online survey which was constructed on Google Docs. The measurement types of coded items in the survey study is given in the Table 4.

**Table 4.** Measurement types of the coded items in the survey study

| Survey Headlines | Question Headlines | Codes | |
|---|---|---|---|
| Section 1: Participant Profile | BioFuel Experience Level | Pro | Pro_Bio |
| | Pellet Fuel Experience Level | | Pro_Pel |
| Section 2: Industry's Development | Industry's Development | Id | Id |
| 2.1: Environmental Dimension | Environmental Dimension | Id_Env | Id_Env |
| 2.2: Competition with Other Fuels | Competition with Domestic Coal | Id_Comp | Id_Comp_Dom |
| | Competition with Imported Coal | | Id_Comp_Imp |
| | Competition with Other | | Id_Comp_Ren |
| 2.3: Policies and Standards | Pellet Fuel Standards | Id_Pol | Id_Pol_Std |
| | EU Renewable Energy Plan | | Id_Pol_EU |
| | Government Subsidy | | Id_Pol_Sub |
| | International Pellet Fuel Market | | Id_Pol_Int |
| 2.4: Domestic Raw Material and Market Price | Production Cost TR vs EU | Id_Pri | Id_Pri_Dif |
| | Biomass Potential and Reality | | Id_Pri_Bio |
| 2.5: Pellet Fuel Logistics and International Cooperation | International Cooperation | Id_Log | Id_Log_Co |
| | Foreign Currenct Appreciation | | Id_Log_Cur |
| | Lack of Cooperative Prevents | | Id_Log_Cop |
| | Lack of Logistics Infrastructure | | Id_Log_Log |
| 2.6 The Main Factors That Prevent the Development of the Turkish Pellet Fuel Industry | Lack of Policy and Regulation | Id_Pre | Id_Pre_Pol |
| | Competition with other Biofuels | | Id_Pre_Com |
| | Lack Of Investment | | Id_Pre_Inv |
| | Lack Of Raw Material | | Id_Pre_Raw |
| | Lack Of R&D | | Id_Pre_Rd |
| | Domestic Coal Industry | | Id_Pre_Dom |
| | Lack Of Heating Systems | | Id_Pre_Hs |
| | Environmental Factors | | Id_Pre_Env |
| | Other Factors | | Id_Pre_Oth |
| 2.7 Opinions regarding the profitability of the Turkish Pellet Fuel Industry | Large Scale Corporate | Id_Pro | Id_Pro_Lar |
| | Small Scale Corporate | | Id_Pro_Sm |
| | Household Consumers | | Id_Pro_Hh |
| | Merchants and Tradesman | | Id_Pro_Mer |
| | Small Scale Producers | | Id_Pro_Sp |
| | Small Scale Producers | | Id_Pro_Lp |
| Section 3: Future Perspectives | Domestic Demand meeting options for the next 5-10 years. | Fut | Fut_Dem |
| | Opinions on the industry's growty | | Fut_Gro |

According to Reliability Analysis, Cronbach's Alpha is our measurement statistic for internal consistency. When reliability estimate is .7 or higher, this suggests good reliability but also reliability between .6 and .7 may be acceptable if the other indicators of a model's construct validity are good [45]. For Pro and Id scales Cronbach's Alpha were higher than .8 which means that they are

internally consistent (Tables 5-6). For Fut scale items, Cronbach's Alpha were approximately .6 and this is acceptable (Table 7).

**Table 5.** Reliability Statistics for Pro Scale

| **Reliability Statistics** | | |
|---|---|---|
| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
| .875 | .879 | 2 |

**Table 6.** Reliability Statistics for Id Scale

| **Reliability Statistics** | | |
|---|---|---|
| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
| .843 | .865 | 29 |

**Table 7.** Reliability Statistics for Fut Scale

| **Reliability Statistics** | | |
|---|---|---|
| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
| .556 | .564 | 2 |

A validity analysis has been done which aimed to explain how well the data gathered includes the true zone of research [46]. Validity essentially refers to "measure what is intended to be measured" [47]. For this pilot study the Pearson's *r* correlation coefficient method was utilized for determining the validity. According to this method, the correlation is stronger when the Pearson's

r correlation coefficient is near to absolute value of 1 while it should be higher than .60 to be considered as valid [48, 49]. Within this context the validity analysis was conducted using the Pearson's r correlation coefficient on SPSS 26.0 (IBM Corp., 2019) software for the sub items listed under the main coded items of Pro, Fut and Id. As a result, the majority of the Pearson's r correlation coefficient has been founded as greater than .60 for the items which reflects that the pilot study is valid. The results are given in the Tables 8-15.

**Table 8.** Correlation for the Pro Scale

| **Correlations** | | | | |
|---|---|---|---|---|
| | | Pro_Bio | Pro_Pel | Tot_Pro |
| Pro_Bio | Pearson Correlation | 1 | .784** | .951** |
| | Sig. (2-tailed) | | .000 | .000 |
| | N | 29 | 29 | 29 |
| Pro_Pel | Pearson Correlation | .784** | 1 | .937** |
| | Sig. (2-tailed) | .000 | | .000 |
| | N | 29 | 29 | 29 |
| Tot_Pro | Pearson Correlation | .951** | .937** | 1 |
| | Sig. (2-tailed) | .000 | .000 | |
| | N | 29 | 29 | 29 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | |

**Table 9.** Correlation for the Fut Scale

| **Correlations** | | | | |
|---|---|---|---|---|
| | | Fut_Dem | Fut_Gro | Tot_Fut |
| Fut_Dem | Pearson Correlation | 1 | .383* | .894** |
| | Sig. (2-tailed) | | .040 | .000 |
| | N | 29 | 29 | 29 |
| Fut_Gro | Pearson Correlation | .383* | 1 | .756** |
| | Sig. (2-tailed) | .040 | | .000 |
| | N | 29 | 29 | 29 |
| Tot_Fut | Pearson Correlation | .894** | .756** | 1 |
| | Sig. (2-tailed) | .000 | .000 | |
| | N | 29 | 29 | 29 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | |

**Table 10.** Correlation for the Id_Env and Id_Comp Scale

| Correlations | | | | | | |
|---|---|---|---|---|---|---|
| | | Id_Env | Id_Comp_Dom | Id_Comp_Imp | Id_Comp_Ren | Tot_Id_EnvComp |
| Id_Env | Pearson Correlation | 1 | .188 | .077 | .488** | .569** |
| | Sig. (2-tailed) | | .329 | .691 | .007 | .001 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Comp_Dom | Pearson Correlation | .188 | 1 | .364 | .180 | .652** |
| | Sig. (2-tailed) | .329 | | .052 | .349 | .000 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Comp_Imp | Pearson Correlation | .077 | .364 | 1 | .148 | .682** |
| | Sig. (2-tailed) | .691 | .052 | | .442 | .000 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Comp_Ren | Pearson Correlation | .488** | .180 | .148 | 1 | .696** |
| | Sig. (2-tailed) | .007 | .349 | .442 | | .000 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Tot_Id_EnvComp | Pearson Correlation | .569** | .652** | .682** | .696** | 1 |
| | Sig. (2-tailed) | .001 | .000 | .000 | .000 | |
| | N | 29 | 29 | 29 | 29 | 29 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | |

**Table 11.** Correlation for the Id_Pol Scale

| Correlations | | | | | | |
|---|---|---|---|---|---|---|
| | | Id_Pol_Std | Id_Pol_EU | Id_Pol_Sub | Id_Pol_Int | Tot_Id_Pol |
| Id_Pol_Std | Pearson Correlation | 1 | -.082 | -.310 | -.223 | .353 |
| | Sig. (2-tailed) | | .674 | .102 | .245 | .061 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Pol_EU | Pearson Correlation | -.082 | 1 | .000 | .685** | .769** |
| | Sig. (2-tailed) | .674 | | 1.000 | .000 | .000 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Pol_Sub | Pearson Correlation | -.310 | .000 | 1 | .265 | .203 |
| | Sig. (2-tailed) | .102 | 1.000 | | .165 | .291 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Pol_Int | Pearson Correlation | -.223 | .685** | .265 | 1 | .761** |
| | Sig. (2-tailed) | .245 | .000 | .165 | | .000 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Tot_Id_Pol | Pearson Correlation | .353 | .769** | .203 | .761** | 1 |
| | Sig. (2-tailed) | .061 | .000 | .291 | .000 | |
| | N | 29 | 29 | 29 | 29 | 29 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | |

**Table 12.** Correlation for the Id_Pri Scale

| Correlations | | | | |
|---|---|---|---|---|
| | | Id_Pri_Dif | Id_Pri_Bio | Tot_Id_Pri |
| Id_Pri_Dif | Pearson Correlation | 1 | .220 | .906** |
| | Sig. (2-tailed) | | .251 | .000 |
| | N | 29 | 29 | 29 |
| Id_Pri_Bio | Pearson Correlation | .220 | 1 | .613** |
| | Sig. (2-tailed) | .251 | | .000 |
| | N | 29 | 29 | 29 |
| Tot_Id_Pri | Pearson Correlation | .906** | .613** | 1 |
| | Sig. (2-tailed) | .000 | .000 | |
| | N | 29 | 29 | 29 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | |

**Table 13.** Correlation for the Id_Log Scale

| Correlations | | | | | | |
|---|---|---|---|---|---|---|
| | | Id_Log_Co | Id_Log_Cur | Id_Log_Cop | Id_Log_Log | Tot_Id_Log |
| Id_Log_Co | Pearson Correlation | 1 | .467* | .243 | .161 | .727** |
| | Sig. (2-tailed) | | .011 | .204 | .404 | .000 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Log_Cur | Pearson Correlation | .467* | 1 | .470* | .083 | .740** |
| | Sig. (2-tailed) | .011 | | .010 | .669 | .000 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Log_Cop | Pearson Correlation | .243 | .470* | 1 | .394* | .706** |
| | Sig. (2-tailed) | .204 | .010 | | .034 | .000 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Id_Log_Log | Pearson Correlation | .161 | .083 | .394* | 1 | .579** |
| | Sig. (2-tailed) | .404 | .669 | .034 | | .001 |
| | N | 29 | 29 | 29 | 29 | 29 |
| Tot_Id_Log | Pearson Correlation | .727** | .740** | .706** | .579** | 1 |
| | Sig. (2-tailed) | .000 | .000 | .000 | .001 | |
| | N | 29 | 29 | 29 | 29 | 29 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | |

**Table 14.** Correlation for the Id_Pre Scale

| Correlations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Id_Pre_Pol | Id_Pre_Com | Id_Pre_Inv | Id_Pre_Raw | Id_Pre_Rd | Id_Pre_Dom | Id_Pre_Hs | Id_Pre_Env | Id_Pre_Oth | Tot_Id_Pre |
| Id_Pre_Pol | Pearson Correlation | 1 | .369* | 0.35 | -0.048 | 0.326 | 0.127 | 0.32 | -0.033 | 0.055 | .419* |
| | Sig. (2-tailed) | | 0.049 | 0.063 | 0.806 | 0.085 | 0.512 | 0.09 | 0.867 | 0.776 | 0.024 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pre_Com | Pearson Correlation | .369* | 1 | .698** | 0.181 | .546** | .568** | .590** | 0.042 | -0.024 | .684** |
| | Sig. (2-tailed) | 0.049 | | 0 | 0.346 | 0.002 | 0.001 | 0.001 | 0.827 | 0.901 | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pre_Inv | Pearson Correlation | 0.35 | .698** | 1 | 0.067 | .449* | .648** | .640** | 0.319 | 0.099 | .746** |
| | Sig. (2-tailed) | 0.063 | 0 | | 0.732 | 0.015 | 0 | 0 | 0.092 | 0.608 | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pre_Raw | Pearson Correlation | -0.048 | 0.181 | 0.067 | 1 | 0.113 | 0.268 | 0.346 | -0.019 | 0.139 | .435* |
| | Sig. (2-tailed) | 0.806 | 0.346 | 0.732 | | 0.559 | 0.161 | 0.066 | 0.924 | 0.472 | 0.018 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pre_Rd | Pearson Correlation | 0.326 | .546** | .449* | 0.113 | 1 | .414* | .464* | 0.128 | 0.059 | .671** |
| | Sig. (2-tailed) | 0.085 | 0.002 | 0.015 | 0.559 | | 0.025 | 0.011 | 0.508 | 0.76 | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pre_Dom | Pearson Correlation | 0.127 | .568** | .648** | 0.268 | .414* | 1 | 0.338 | 0.267 | -0.105 | .621** |
| | Sig. (2-tailed) | 0.512 | 0.001 | 0 | 0.161 | 0.025 | | 0.073 | 0.162 | 0.589 | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pre_Hs | Pearson Correlation | 0.32 | .590** | .640** | 0.346 | .464* | 0.338 | 1 | 0.099 | 0.18 | .736** |
| | Sig. (2-tailed) | 0.09 | 0.001 | 0 | 0.066 | 0.011 | 0.073 | | 0.608 | 0.349 | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pre_Env | Pearson Correlation | -0.033 | 0.042 | 0.319 | -0.019 | 0.128 | 0.267 | 0.099 | 1 | .410* | .484** |
| | Sig. (2-tailed) | 0.867 | 0.827 | 0.092 | 0.924 | 0.508 | 0.162 | 0.608 | | 0.027 | 0.008 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pre_Oth | Pearson Correlation | 0.055 | -0.024 | 0.099 | 0.139 | 0.059 | -0.105 | 0.18 | .410* | 1 | .421* |
| | Sig. (2-tailed) | 0.776 | 0.901 | 0.608 | 0.472 | 0.76 | 0.589 | 0.349 | 0.027 | | 0.023 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Tot_Id_Pre | Pearson Correlation | .419* | .684** | .746** | .435* | .671** | .621** | .736** | .484** | .421* | 1 |
| | Sig. (2-tailed) | 0.024 | 0 | 0 | 0.018 | 0 | 0 | 0 | 0.008 | 0.023 | |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | | | | | |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | | | | |

**Table 15.** Correlation for the Id_Pro Scale

| Correlations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Id_Pro_Lar | Id_Pro_Sm | Id_Pro_Hh | Id_Pro_Mer | Id_Pro_Sp | Id_Pro_Lp | Tot_Id_Pro |
| Id_Pro_Lar | Pearson Correlation | 1 | .474** | 0.106 | .432* | 0.012 | .885** | .687** |
| | Sig. (2-tailed) | | 0.009 | 0.584 | 0.019 | 0.95 | 0 | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pro_Sm | Pearson Correlation | .474** | 1 | .443* | .529** | 0.179 | .457* | .700** |
| | Sig. (2-tailed) | 0.009 | | 0.016 | 0.003 | 0.353 | 0.013 | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pro_Hh | Pearson Correlation | 0.106 | .443* | 1 | .564** | -0.062 | 0.293 | .532** |
| | Sig. (2-tailed) | 0.584 | 0.016 | | 0.001 | 0.75 | 0.124 | 0.003 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pro_Mer | Pearson Correlation | .432* | .529** | .564** | 1 | 0.362 | .536** | .833** |
| | Sig. (2-tailed) | 0.019 | 0.003 | 0.001 | | 0.053 | 0.003 | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pro_Sp | Pearson Correlation | 0.012 | 0.179 | -0.062 | 0.362 | 1 | 0.154 | .501** |
| | Sig. (2-tailed) | 0.95 | 0.353 | 0.75 | 0.053 | | 0.424 | 0.006 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Id_Pro_Lp | Pearson Correlation | .885** | .457* | 0.293 | .536** | 0.154 | 1 | .806** |
| | Sig. (2-tailed) | 0 | 0.013 | 0.124 | 0.003 | 0.424 | | 0 |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Tot_Id_Pro | Pearson Correlation | .687** | .700** | .532** | .833** | .501** | .806** | 1 |
| | Sig. (2-tailed) | 0 | 0 | 0.003 | 0 | 0.006 | 0 | |
| | N | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | | |

Views regarding the Turkish pellet fuel industry reflected by different participants agree in general. Occasions with significant differences in views between different participant groups are given and analyzed in the following section.

### 3.1.2. Data

In this section information about the sample will be given. Overall sixty-four participants responded the survey. Figure 20 reflects the percentage distribution of the participants' occupation which is derived based on the organization they are belong to. All of the participants were from Turkey, the survey was not sent

to any potential participants outside of the Turkey. The largest share of participants belongs to the category of “Household Consumer”. “Researchers” category represents the 20% of the overall participants. Researchers who participated to the survey study are from research organizations and institutions including state institutions as General Directorate of Forestry Eastern Black Sea Forestry Research Institute, Eastern Mediterranean Agricultural Research Institute, Tekirdag Viticulture Research Institute, Black Sea Agricultural Research Institute-Samsun, TUBİTAK Marmara Research Center - Energy Institute and other private organizations. “Producer” category follows right after the Researchers with representing the 16% of the participants. Producers are Pellet Fuel producers all around the Turkey both large-scale producers with above 1000 metric tons of pellet fuel production per year and small-scale producers with below 1000 metric tons of pellet fuel production per year. As stated in the section 2.5.1, there are a small number of producers – approximately 30- operating officially in Turkey as pellet fuel producers. However, “actively” operating pellet fuel producers are seeming to be lesser than this figure, and for this survey study, the most active and properly operating pellet fuel producers were tried to be reached. “Other Participants” category represents 12% of the total participants. Participants in this category are people from companies operating in boiler suppliers, heating systems manufacturers, pellet machinery producers, certification offices, municipal companies, Heat Equipment Manufacturers Association and independent forest industrial engineer. “Academician” category represents the 11% of the participants and people from this category are scholars from faculty of agriculture of public research universities in Turkey including a professor whom also the president of the Soil Science Society of Turkey. “Government Officer” category is comprised of people who are working for government institutions including Turkish Standardization Institute (Certification for pellet fuels), General Directorate of Agricultural Research and Policies, Ministry of Agriculture and Forestry and Ministry of Environment and Urbanization. The remaining 10% of the participants are equally distributed between the categories of “Traders” –whom

are retailers, importers and exporters of various fuels for heating purposes including the pellet fuel- and “Corporate Consumers” whom are preferring pellet fuel for heating up their workplaces.

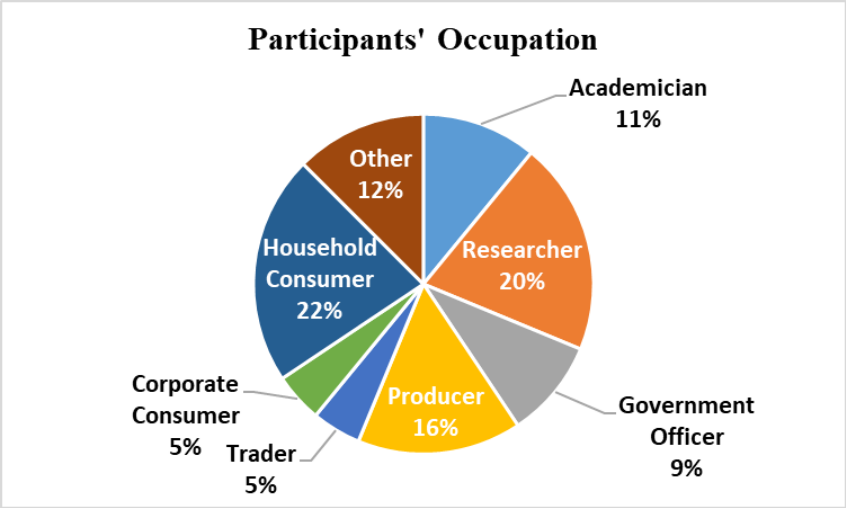



**Figure 20.** Percentage Distribution of the Participants’ Occupation

Figure 21 shows the participants’ city of origin. More than half of the participants are from Ankara where most of the universities and public institutions are located. Ankara also hosts some of the producers and heating system manufacturers in Turkey. Istanbul holds the second place in terms of participation with representing 16% of the whole participants. The majority of the remaining participants are from the Black Sea Region of Turkey where is the most forested area with holding 27% of the Turkey’s forests [50]. Another region with significant number of participants is the Mediterranean Region which is the second most forested area of Turkey [50]. These two regions have relatively low infrastructure in terms of heating systems using natural gas and they hold nearly half of the nation’s forest assets so we can state that the residents of these regions are highly familiar with pellet fuels and other biofuels for heating purposes [51].

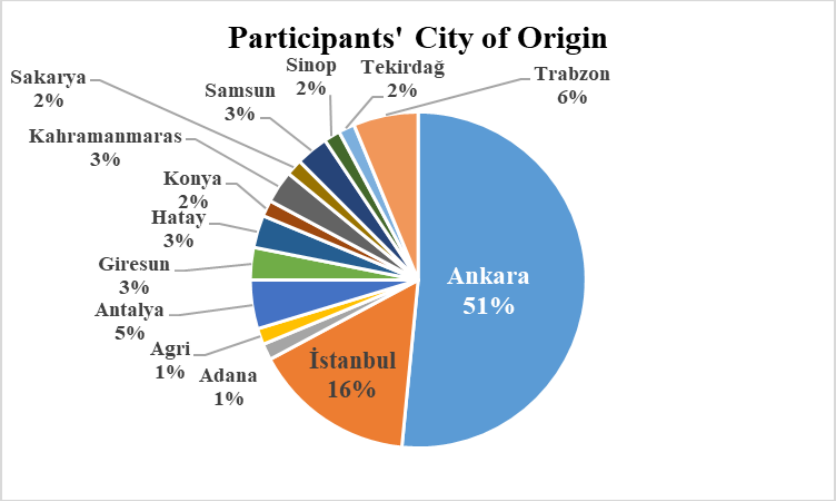



**Figure 21.** Percentage Distribution of the Participants' City of Origin

Figure 22 shows the participants' level of experience in the Biofuel area. As shown in the figure, we can observe that more than half of the participants have three to twenty-five years of experience in the biofuel area. Only 3% of the participants bear more than twenty-six years of experience in the area which is fair since biofuel is a relatively young area for Turkey. Although the very first studies about biofuels started back in 1934, however the subject is not being elaborated commercially until 1998 [52]. Table 16 shows the minimum and the maximum level of experience of the participants based on their occupational categories. As we can observe, "Academician" and "Researcher" categories hold the highest maximum level of experience in the biofuel area. Based on the results we can also state that that the area is relatively new for the remaining categories although there are still participants with significant level of experience in the biofuel area in those categories.

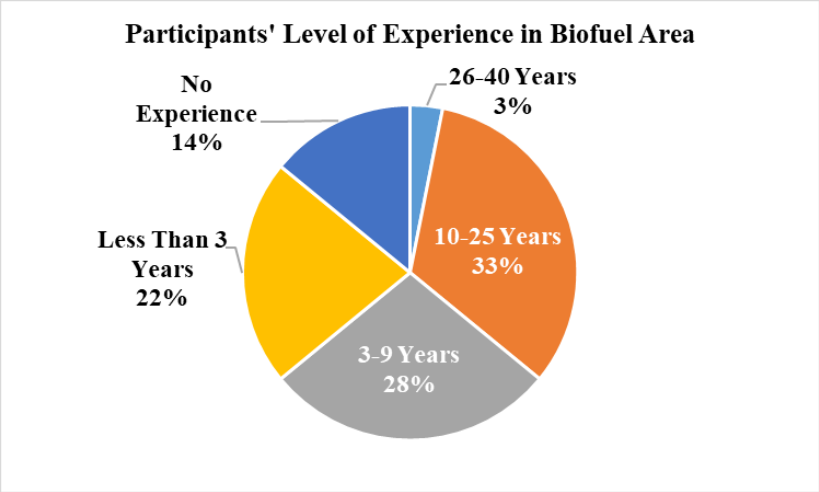



**Figure 22.** Participants' Level of Experience in The Biofuel Area

**Table 16.** Minimum and the Maximum Level of Biofuel Experience of the Participants Based on Categories

| Experience in the Biofuel Area | | |
|---|---|---|
| **Participant Occupation** | **Level of Experience** | |
| | **Minimum Level** | **Maximum Level** |
| Academician | 3-9 Years | 26-40 Years |
| Researcher | Less Than 3 Years | 26-40 Years |
| Government Officer | Less Than 3 Years | 10-25 Years |
| Producer | Less Than 3 Years | 10-25 Years |
| Trader | Less Than 3 Years | 10-25 Years |
| Corporate Consumer | Less Than 3 Years | 3-9 Years |
| Household Consumer | No Experience | 10-25 Years |
| Other | No Experience | 10-25 Years |

Figure 23 shows the participants' level of experience in the pellet fuel area. Similar to the results in the biofuel area, more than half of the participants have three to twenty-five years of experience in pellet fuel area. Table 17 reflects the minimum and the maximum level of pellet fuel experience of the participants based on their occupational categories. Similar to the biofuel, "Academician" category has the highest maximum level of experience in the pellet fuel area with a participant having 26-40 years of experience. Based on the results again we can say that that the area is relatively new for the remaining categories although there are still participants with significant level of experience in the pellet fuel area. One assumption regarding the participants with "No Experience" is that the

participants who have just started to use/know the pellet fuel may have answered in this way rather than selecting the “Less Than 3 Years” option.

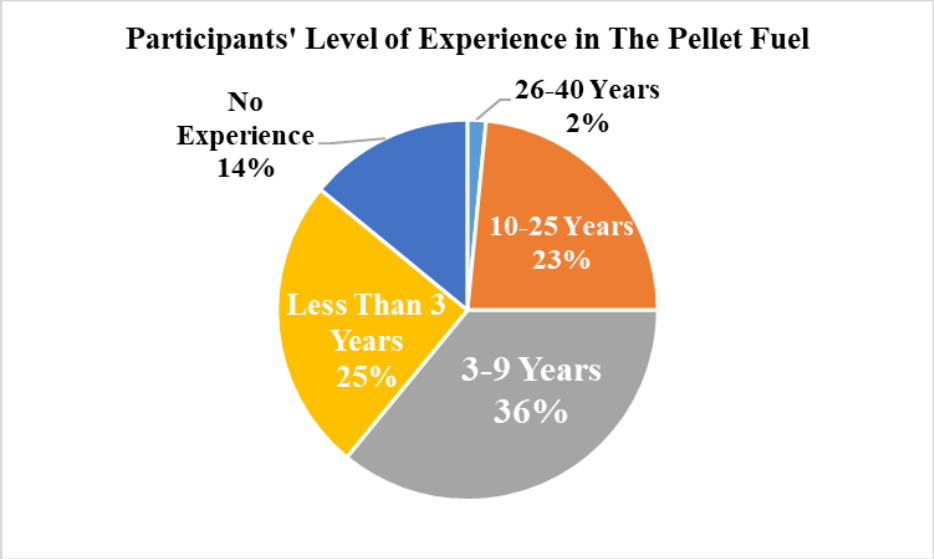



**Figure 23.** Participants’ Level of Experience in The Pellet Fuel Area

**Table 17.** Minimum and the Maximum Level of Pellet Fuel Experience of the Participants Based on Categories

| Experience in the Pellet Fuel Area | | |
|---|---|---|
| **Participant Occupation** | **Level of Experience** | |
| | **Minimum Level** | **Maximum Level** |
| Academician | 3-9 Years | 26-40 Years |
| Researcher | Less Than 3 Years | 10-25 Years |
| Government Officer | Less Than 3 Years | 10-25 Years |
| Producer | Less Than 3 Years | 10-25 Years |
| Trader | 3-9 Years | 10-25 Years |
| Corporate Consumer | Less Than 3 Years | 3-9 Years |
| Household Consumer | No Experience | 3-9 Years |
| Other | Less Than 3 Years | 10-25 Years |

# CHAPTER 4

# RESULTS AND DISCUSSION

In this section of the thesis study the main results will be presented and discussed. Firstly, participants' responds regarding the factors encouraging or hindering the development of the Turkish pellet industry will be given and discussed. Secondly, the flow will be continued with the main factors and challenges that are inhibiting the Turkish pellet fuel industry, and further with the profitability of the Turkish pellet fuel industry. Finally, the future perspectives of the participants will be elaborated.

## 4.1. Participants' Views on the Current Situation in the Turkish Pellet Fuel Industry

In this section of the survey study, participants were asked to specify their opinions regarding the different factors as if they are either encouraging or hindering the development of the Turkish Pellet Fuel Industry.

### 4.1.1. Environmental Aspect

#### 4.1.1.1. Turkish Pellet Fuel Industry is Environmentally Friendly

The vast majority (90%) of the participants opted that the Turkish pellet fuel industry is environmentally friendly. The results shown in the Figure 24 below. Although the recycling nature and the bio origin of the raw material make the pellet fuel highly environmentally friendly, the industry is still containing certain challenges with regards to environmental aspects, for example, the transportation of the pellet fuels.

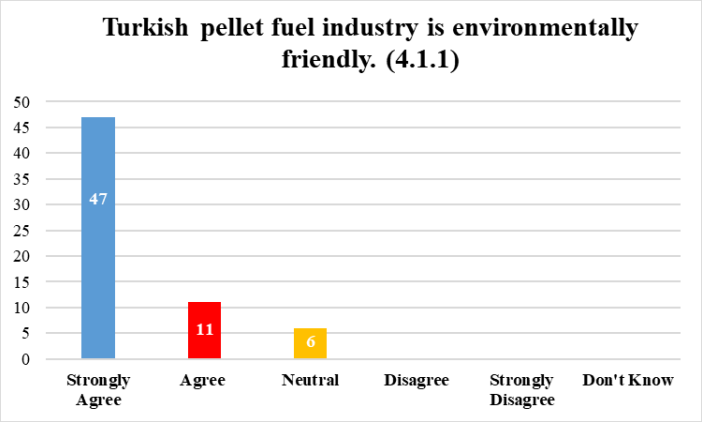



**Figure 24.** Participants Responds for the Environmental Aspect

In order to reveal the impacts of different fuel usage models with regards to sustainability, an assessment study was carried out back in 2012 comparing fossil fuels and fuels produced using wood biomass. The study showed that primarily due to the additional drying stage, the process of pellet fuel production causes higher greenhouse gas emission (65 kg of CO2/MWh) compare to the process of making solid biofuels including firewood and chips (Based on the carrying distance 7e15 kg CO2/MWh) [53].

The participants were highly concerned regarding the climate change and the depletion of the natural sources. The negative pressure on natural resources due to the current usage, especially the impact of fossil fuels on climate change, continues to increase the interest in green energy. Consequently, people will prefer environmentally friendly fuels such as pellet fuel. In order for the pellet fuel, which has a wide usage area in EU countries, to be widespread in our country, first of all, producers should make quality products. In general, businesses that illegally produce pellet fuel from MDF dust should be prevented. They are harmful in many ways, the flue gas they cause is harmful to the environment, the product causes damages to the heating systems, chimneys, clogging wear and etc. On top of these they are causing negativity to the publicity of the industry thus hindering its development. Renewable energies are needed so that natural resources are not degraded. For sustainable living and

clean energy, pellet fuel should be given due importance and become widespread. Biomass energy seems to be a solution to reduce the amount of carbon dioxide in the atmosphere. Two other main advantages of biomass are; firstly, the unlimited availability of biomass and secondly, it has no environmental damage compared to other energy sources [54].

### 4.1.2. Competition Between the Pellet Fuel and Other Fuels (Fossil and Renewable Fuels)

#### 4.1.2.1. The Low Prices of the Fossil Fuels (Domestic Coal), in Turkey Hinders the Development of the Turkish Pellet Fuel Industry.

The majority of the participants (78%) felt that the relatively low prices of the fossil fuels (especially domestic coal) compare to the pellet fuel is a challenge for the industry by hindering its development, the distribution of the responds is given in the Figure 25 below.

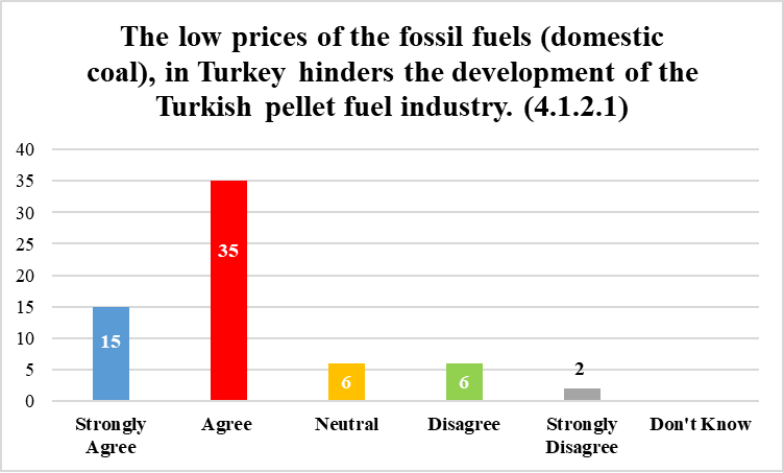



**Figure 25.** Participants Views About 4.1.2.1

There three major domestic coal centers in Turkey, Tavsanli (Kutahya), Soma (Manisa), and Can (Canakkale) owned and operated by the Turkish Coal Enterprises, an economic state enterprise runs its activities under the Ministry of

Energy and Natural Resources. Details about the domestic coal determined by the Turkish Coal Enterprises are given in the Table 18 below as of May 2021.

**Table 18.** Price and Analysis Details About the Domestic Coal in Turkey [55]

| Name | Diameter (mm) | TL Price/Ton (Before VAT) | Calorific Value (kcal/kg) | Humidity (%) | Ash Content (%) | Sulfur Content (% | Region of Origin |
|---|---|---|---|---|---|---|---|
| Tuncbilek Washed | 18 mm | 516.00 | 4344 | 12.14 | 26.6 | 1.05 | |
| Tuncbilek Washed (Bagged) | 18 mm | 551.00 | 4588 | 10.18 | 28.62 | 1.81 | |
| Tuncbilek Washed | 10-18 mm | 516.00 | 4624 | 11.42 | 26.09 | 1.52 | Tavşanlı/Kütahya |
| Tuncbilek Washed (Bagged) | 10-18 mm | 551.00 | 4791 | 10.46 | 25.48 | 1.66 | |
| Tuncbilek Washed | 0.5-18 mm | 413.00 | 4838 | 15.84 | 19.75 | 1.32 | |
| **Name** | **Diameter (mm)** | **TL Price/Ton (Before VAT)** | **Calorific Value (kcal/kg)** | | **Ash Content (%)** | | **Region of Origin** |
| S.Kisrakdere Washed | 18 mm | 516.00 | 4506 | 17.3 | 14.58 | 1.42 | |
| S.Kisrakdere Washed (Bagged) | 18 mm | 551.00 | 4788 | 15.9 | 13.06 | 1.37 | |
| S.Kisrakdere Washed | 10-18 mm | 516.00 | 5016 | 15.8 | 11.05 | 1.4 | Soma/Manisa |
| S.Kisrakdere Washed (Bagged) | 10-18 mm | 551.00 | 4944 | 16.5 | 10.85 | 1.68 | |
| S.Kisrakdere Washed | 0.5-18 mm | 413.00 | 4680 | 20.2 | 10.99 | 1.51 | |
| Briquette | | 477.00 | 4363 | 12.73 | 15.27 | 0.85 | |
| Kisrakdere Krible | 20 mm | 579.00 | 4957 | 17 | 10.64 | 1.09 | |
| Kisrakdere Krible (Bagged) | 20 mm | 614.00 | 4949 | 17.1 | 8.86 | 0.88 | |
| Kisrakdere Krible | 0-20 mm | 221.00 | 3443 | 18.6 | 31.6 | 0.84 | |
| **Name** | **Diameter (mm)** | **TL Price/Ton (Before VAT)** | **Calorific Value (kcal/kg)** | | **Ash Content (%)** | | **Region of Origin** |
| Can Krible | 30 mm | 395.00 | | | | | |
| Can Krible (Bagged) | 30 mm | 430.00 | 4052 | 21.82 | 15.56 | 6.25 | Çan/Canakkale |
| Can Krible | 0-30 mm | 264.00 | 3787 | 22.7 | 17.57 | 6.44 | |

Pellet fuel industry is not organized under any government institute and it is held by private sector thus its price fluctuates from region to region however based on the information received from the participant producers to the survey study, average pellet fuel produced using pine tree dust priced at 1000 TL/ton before value added tax as of winter 2021 season. From the Table 18, we can state that the domestic coal prices are significantly lower than the pellet fuel however the latter has several competitive advantages over the former. First of all, an analysis conducted by the General Directorate of Mineral Research and Exploration of Turkish Republic to a sample of pellet fuel is given in the Table 19 below.

**Table 19.** Analysis Values of Pellet Fuel

| ANALYSIS VALUES OF PELLET FUEL | |
|---|---|
| **Lower Calorific Value** | **4640 kcal/kg** |
| **Upper Calorific Value** | **4960 kcal/kg** |
| **Raw Material** | **Pine Tree** |
| **Humidity Content (%)** | **1.5-3.92** |
| **Ash Content (%)** | **1.68-1.75** |
| **Volatile Matter (%)** | **80** |
| **Fixed Carbon (%)** | **12** |
| **Total Sulfur (%)** | **0.04** |

After the comparison between the pellet fuel and the domestic coal, it is clearly seen that the humidity content of the pellet fuel is substantially lower than the domestic coal, which means the former has an higher level of combustion efficiency compare to the latter. Higher combustion efficiency enables consumers to obtain more efficiency from the fuel they purchase and to burn the fuel better in overall to obtain heat. Another advantage of the pellet fuel is its ash content; it is considerably lower than the domestic coals' ash content. As the participants stated, it is a crucial matter for a solid fuel in terms of handling, maintenance of the heating device and hygiene. Domestic coals have a high ash content which causes dust and a dirt when it is burned, moreover it leaves slag in the chimney. On the other hand, pellet fuel is a clean solid fuel with a very low ash content which means it is much cleaner than the coal, enabling a better experience for the users. Thirdly, a smoke comes out when a solid fuel is burned; it is cleaner for pellet fuel than coal. Pellet fuel is a fuel produced from biomass mainly from wood, and biomass is a renewable energy source compared to fossil energy sources [56]. The conversion of solar energy into stored energy in the form of biomass is essential for life. While organic substances, which are a source of energy, synthesize through photosynthesis, they release the oxygen necessary for all living things to breathe into the atmosphere. Since the carbon dioxide generated as a result of the burning of the organic substances produced has been taken from the atmosphere during the formation of these substances, the environment will be protected in terms of carbon dioxide emission during the production of energy from biomass and it will be easier to comply with the Kyoto protocol. Atimtay and Topal carried out a study [57] to obtain clean energy from biomass in Turkey; the study found out that the SO2 emission of coal is around 2400-2800 mg / Nm3, while the SO2 emission of biomass is zero, and in all combustion experiments it is determined that the NOX emissions of biomass' are below limit determined by the Air Quality Control Regulation (2002). Another study stated that the C / H ratio of biomass is lower than coal and is around 8-10, and that biomass contains lower sulfur and more potassium and sodium than coal [58]. Similarly, based on the comparison of sulfur contents

of pellet fuel and domestic coal, it is clear that the pellet fuel has a sulfur content nearly three times lower than the domestic coal, thus pellet fuel has a lower SO3 emission making it a cleaner energy source compare to the domestic coal.

#### 4.1.2.2. The High Calorific Value of the Fossil Fuels (Imported Coal) In Turkey Hinders the Development of the Turkish Pellet Fuel Industry.

Comparing to the previous question there is a more balanced distribution between the participants who agreed and who were either neutral or did not agree. The distribution of the responds is given in the Figure 26 below.

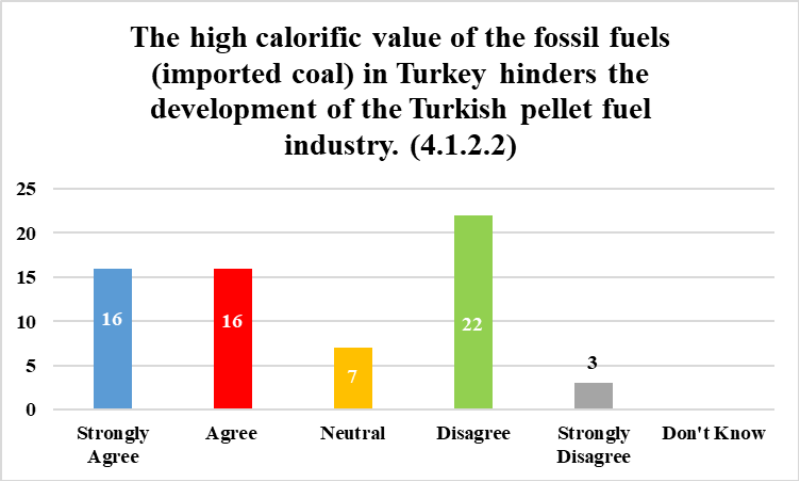



**Figure 26.** Participants Opinions About 4.1.2.2

As of 2017, Colombia was the country that Turkey imported the majority of its imported coal with 14.22 million tons while the import from Russia was 14.16 million tons. These two countries were followed by the USA with 5.44 million tons, the Republic of South Africa with 2.42 million tons, Australia with 1.3 million tons, and Canada with 621.000 tons. In 2017, coal imports from these 6 countries reached 98 percent of total imports [59]. Amount of coal import, foreign exchange paid to the import and average import costs between the years 1990 and 2017 are given in the Table 20 below. The amount of coal imported by Turkey increased drastically during this timeline. However, since August 2018,

Turkish Lira dramatically depreciated against foreign currencies, especially US Dollar as seen in the Table 21.

**Table 20.** Amount of Coal Import, Foreign Exchange Paid to The Import and Average Import Costs Between the Years 1990 And 2017 [59]

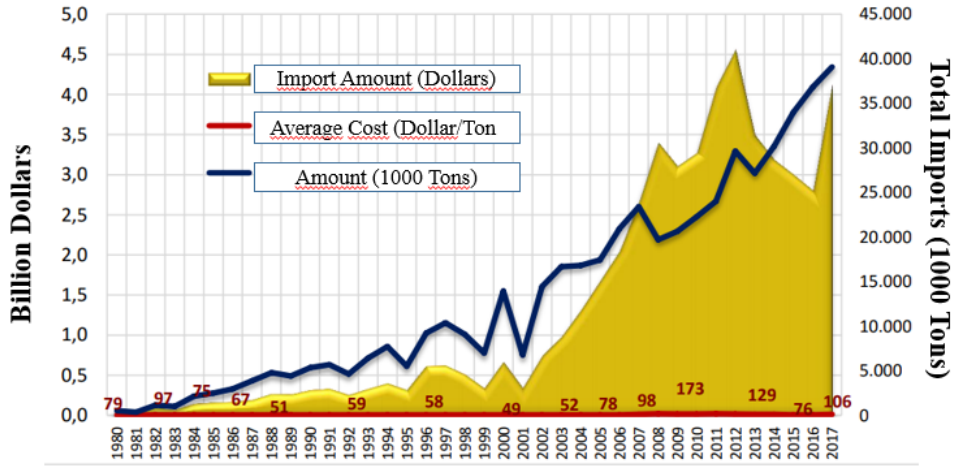



**Table 21.** USD/TRY Rate Between 01.01.2018 and 06.05.2021 [60]

| Date | 2018-01 | 2018-04 | 2018-09 | 2018-12 | 2019-01 | 2019-02 | 2019-05 | 2019-08 | 2019-10 | 2019-11 | 2020-05 | 2020-06 | 2020-11 | 2021-02 | 2021-05 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USD/TRY | 3.77 | 4.05 | 6.37 | 5.31 | 5.37 | 5.26 | 6.05 | 5.62 | 5.78 | 5.73 | 6.95 | 6.81 | 8.00 | 7.07 | 8.34 |

The technical features of this fuel is highly similar to domestic coal with a one significant difference, which is its higher calorific value. The price and technical features of the imported coal in Turkey are given in the Table 22 below.

**Table 22.** Price and Analysis Details About the Imported Coal in Turkey [61]

| Calorific Value (kcal/kg) | Diameter (mm) | Humidity (%) | Ash Content (%) | Sulfur Content (%) | Price |
|---|---|---|---|---|---|
| +7500 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 218 Usd |
| +7500 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 205 Usd |
| +7500 Kcal / Kg | 80 – 110 mm | 6-10 | 6-22 | 1-1.5 | 225 Usd |
| +7500 Kcal / Kg | +110 mm | 6-9 | 6-22 | 1-1.5 | 225 Usd |
| +7500 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 210Usd |
| +7500 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 205 Usd |
| +7500 Kcal / Kg | 80 – 110 mm | 6-10 | 6-22 | 1-1.5 | 225 Usd |
| +7500 Kcal / Kg | +110 mm | 6-9 | 6-22 | 1-1.5 | 225 Usd |
| +7500 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 210 Usd |
| +7500 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 200 Usd |
| +7500 Kcal / Kg | 80 – 110 mm | 6-10 | 6-22 | 1-1.5 | 225 Usd |
| +7500 Kcal / Kg | +110 mm | 6-9 | 6-22 | 1-1.5 | 225 Usd |
| +7500 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 200 Usd |
| +7500 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 200 Usd |
| +7500 Kcal / Kg | 80 – 110 mm | 6-10 | 6-22 | 1-1.5 | 215 Usd |
| +7500 Kcal / Kg | +110 mm | 6-9 | 6-22 | 1-1.5 | 215 Usd |
| +7000 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 180 Usd |
| 7000 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 180 Usd |
| 7000 Kcal / Kg | 80 – 110 mm | 6-10 | 6-22 | 1-1.5 | 200 Usd |
| 7000 Kcal / Kg | +110 mm | 6-9 | 6-22 | 1-1.5 | 200 Usd |
| +7000 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 160 Usd |
| +7000 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 160 Usd |
| +7000 Kcal / Kg | 80 – 110 mm | 6-10 | 6-22 | 1-1.5 | 190 Usd |
| +7000 Kcal / Kg | +110 mm | 6-9 | 6-22 | 1-1.5 | 190 Usd |
| +7000 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 155 Usd |
| +7000 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 155 Usd |
| +7000 Kcal / Kg | 80 – 110 mm | 6-10 | 6-22 | 1-1.5 | 200 Usd |
| +7000 Kcal / Kg | +110 mm | 6-9 | 6-22 | 1-1.5 | 200 Usd |
| +7000 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 140 Usd |
| +7000 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 140 Usd |
| +7000 Kcal / Kg | 80 – 110 mm | 6-10 | 6-22 | 1-1.5 | 185 Usd |
| +7000 Kcal / Kg | +110 mm | 6-9 | 6-22 | 1-1.5 | 185 Usd |
| +7000 Kcal / Kg | 10 – 20 mm | 6-10 | 6-22 | 1-1.5 | 140 Usd |
| +7000 Kcal / Kg | 22 – 70 mm | 6-20 | 6-22 | 1-1.5 | 140 Usd |

As seen on the Table 22, imported coal has a higher calorific value than the pellet fuel however, its price before taxes and the transportation costs is nearly 70% higher than the pellet fuel. The participants' opinions are towards increasing the Turkey's domestic solid fuel production through utilizing the country's biomass assets to decrease its dependency on imported fuels. Turkish Lira's continuing depreciation against foreign currency began to burden its back and make it difficult to continue importing solid fuels. Renewable energy sources such as pellet fuel have high potential to become an alternative to imported fuels. Recycling national biomass wastes into the economy is a must for countries like Turkey, further the pellet fuel is a cleaner alternative energy source against imported coal.

#### 4.1.2.3. Pellet Fuels Can Compete with Other Renewable Fuels in Turkey.

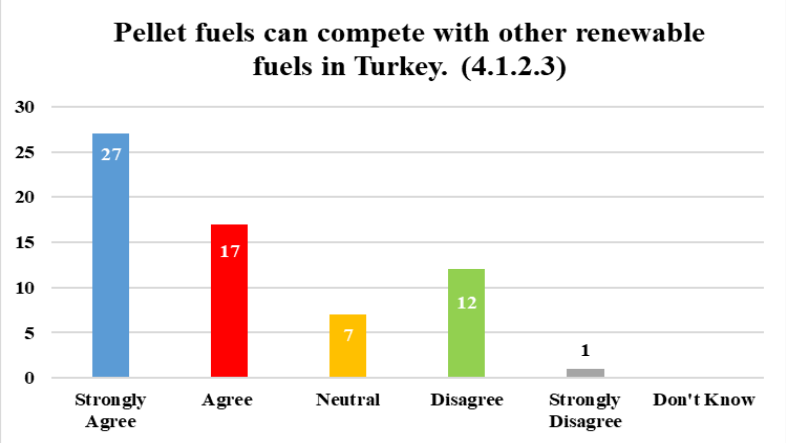



**Figure 27.** Participants Views Regarding the Competition with Renewable Fuels

The vast majority (69%) of the participants strongly felt that pellet fuel can compete against other renewable fuels in Turkey. Other primary renewable fuels for heating purposes in Turkey include nut shell (especially in the Black Sea Region), geothermal, solar and dry dung fuel. Hazelnut shell is a potentially important biomass resource in Turkey with an annual production amount of approximately 350,000 tons. Hazelnut shells have no alternative uses and are constantly accumulating solid waste due to their large storage volume. However, the calorific value of the hazelnut shell, which is 19.2 MJ / kg, corresponds to 1,9 x 106 kW energy per hour. This is a clear indication that the hazelnut shell can be used as an energy source [62, 63]. The calorific value of walnut shell, which is another important biomass waste for Turkey, has been reported in the literature as 13.8-18.4 MJ / kg. There is no other usage area other than burning the walnut shell for domestic heating similar to the nutshell [64, 65]. Nut shells are utilized as fuels for heating purposes however they are rather regional than convenient for every part of the Turkey. Same applies for the geothermal energy, Turkey has a great potential for geothermal energy however it is far from utilizing it for every part of the country, Figure 28 shows the geothermal resources distribution of the Turkey [66]. As seen in the figure, Turkey has a

significant amount of geothermal resources however these resources unfortunately do not cover the entire country, further the number of houses heated by geothermal resources is very few and it requires serious investment to benefit from it.


**Figure 28.** Geothermal Resources Distribution of the Turkey

Hazelnut shells, dry dung, wood and other renewable fuels are important renewable energy resources for Turkey, but they are far from meeting the demand in the country and reaching all parts of the country, meanwhile pellet fuels can be produced and distributed all over the country with high heating values, high combustion efficiencies. Being a clean resource, it has the power to compete with other renewable fuels.

### 4.1.3. Matters Regarding the Pellet Fuel Standards and The Policy Support

#### 4.1.3.1. Pellet Fuel Standards (TSI, permits, license etc.) are Helping the Development of the Turkish Pellet Fuel Industry.

The distribution of the responds is rather balanced for this question. One significant difference between the participants is that, the government officers,

academicians and researchers tended to vote for either “Strongly Agree” or “Agree” to this question while Producers and Traders chose “Disagree” and “Strongly Disagree”. They disagreed definitively and clearly on this matter. The participants’ opinions on 4.1.3.1 are given in the Figure 29 below.

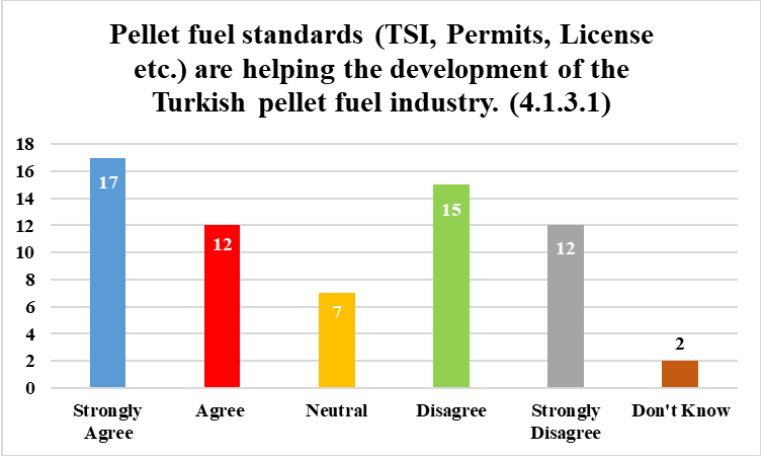



**Figure 29.** Participants Opinions Regarding Pellet Fuel Standards

In an economy, regulatory actions are addressing obligations which are mainly health, safety and environmental quality to protect customer safety. The natural target of these actions are not only international spreads and market failures but they are also addressing the trade flow instead of protecting manufacturers from import competition. Sometime the standards for a product can become a barrier for trade activities through increasing the set-up and production costs substantially. Standards can cause a reduction in the quantity of the competitors and can decrease the number of available products [67]. Maskus, Otsuki, and Wilson develop econometric models to lay out the initial forecasts of increasing production costs for companies in emerging countries in accordance with the standards forced by primary importing nations. The study’s outcomes show that the standards indeed cause an increase in the short-term production costs through necessitating extra labor and capital inputs, moreover the results of the study can be elucidated as a sign of to the degree where standards and technical regulations can hinder trade operations in a market [68]. Government officers, academicians

and researchers are supporting product standards for pellet fuel because product technical regulations and standards are necessary to make sure the consumer safety. Additionally, regulations and standards help government to track the products produced in the country. Producers and traders voted negatively to the question because in Turkey, regulations and standards for producing a pellet fuel is rather harsh. Producers must obtain licenses and permits from more than one official government agency. This creates extra burden and costs for the producers, and therefore the development of the Turkish pellet fuel industry is somewhat disrupted. If regulations and standards related to pellet fuel production are facilitated by the government and producers are financially supported in this process, pellet fuel production will increase and the sector will develop. Producers must first obtain a "Environmental Impact Assessment" certificate from the Ministry of Environment and Urbanization. This process is quite a long and difficult process. The company should then get a Capacity Report. After obtaining the capacity report, enterprises that are subject to the environmental permit and license process are required to obtain an Environmental Permit and Temporary Activity Certificate prior to the license in order to operate. The company that completes its documents must obtain a Standard Certificate from the Turkish Standards Institute. In order to obtain this certificate, it is obliged to meet the standard determined by TSE in production and to continuously analyze within the company. Getting the standard certificate is a difficult and long stage. The company is also obliged to complete the Environmental Permit and Environmental License documents simultaneously. As required by the regulations, the company has to make an agreement with an environmental engineering firm and receive service throughout its activity period [69]. On the other hand, a pellet fuel producer must receive an ENplus License in order to export its products to the Europe, otherwise the importers in Europe will not buy the producer’s pellet fuels. The process of obtaining an ENplus Certificate similarly requires a long time of auditing, analysis and other stages and it’s also quite costly, especially for a newly established firm. Obtaining a standards certificate, licensing and keeping the firm within the limits of a regulation

requires a lot of effort in Turkey. The processes currently protect the consumer, but put a huge burden on producers and encourage them to illegally produce their product. Because of this, it poses an obstacle to the development of the Turkish pellet fuel industry. For all these reasons, the current bureaucracy should be updated from being a burden for the producers for the development of the industry, and should be reorganized and implemented.

#### 4.1.3.2. The European Union (EU) Renewable Energy Targets, Encourages the Development of the Turkish Pellet Fuel Industry.

Pellet fuel is a clean energy and it is in line with the European Union Renewable Energy targets. The vast majority of the participants voted positively for this part of the survey study and the distribution of the answers is given in the Figure 30 below. As mentioned in the earlier chapters, Turkey prepared its own NREAP for the 2013-2023 period which is in line with the EU RE targets and established the strategies in line with the EU's directive. Pellet fuel is a renewable energy source and the main mentality of this fuel is to recycle the nation's biomass waste mainly wood into renewable energy. EU targets affected the Turkey's NREAP and the country is willing to act accordingly with this plan so we can state that EU RE targets are encouraging the development of the Turkish pellet fuel industry.

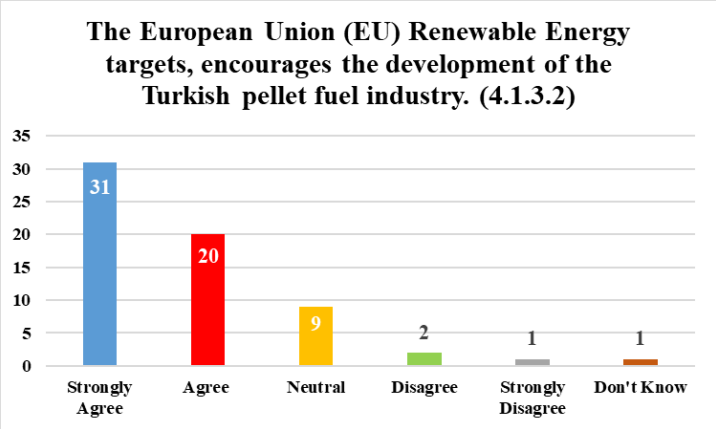



**Figure 30.** Participants Views Within the Context of EU Energy Targets

#### 4.1.3.3. In Turkey the Lack of Government Support Towards the Fuels Derived from Biomass for "Heating Purposes" Including Pellet Fuels, Hinders the Development of the Turkish Pellet Fuel Industry.

94% of the participants agreed that the lack of government support towards the fuels derived from biomass for "heating purposes" including pellet fuels, hinders the development of the Turkish pellet fuel industry as seen in the Figure 31 below.

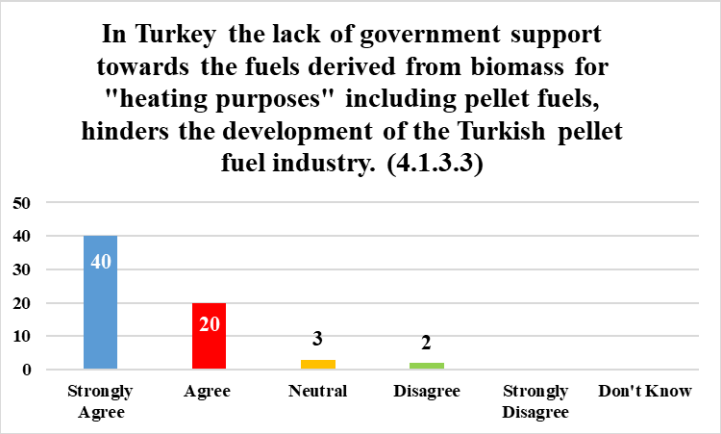



**Figure 31.** Participants Views about the Lack of Government Support for the Biomass Fuels for Heating Purposes

Nations have been utilizing state incentives from past to present with various intentions such as to increase economic growth, employment, to reduce regional imbalance and foreign dependency [70]. Sometimes an incentive is given in order to reach a more stable environment and to comply with international environmental protocols. In Turkey, government incentives, supports and subsidies play a crucial role on the sake of industries. Government influences trade and production at the maximum level in the country and its affect cannot be ignored. Citizens of Turkey tend to follow the government supported products since the supports generally come with financial advantages for the consumers, such as purchase aids made within the scope of supporting the agricultural production. Incentives for organic fertilizers for farmers is an example for this

situation. With the decision, which will be effective as of January 1, 2020, the fertilizer support provided to farmers for the year 2020 has been doubled. Accordingly, the 10 Turkish Liras support decided to be given per acre for solid-organic-organomineral fertilizer was increased to 20 Turkish Liras. Soil and water resources are at risk of contamination with the intensive application of mineral fertilizers in order to increase the amount of crop production. In order to prevent this, organomineral fertilizers obtained by combining the soil healing properties of organic materials and the benefits of minerals in a single fertilizer have emerged as a "new generation fertilizer". The Ministry of Agriculture and Forestry also provides support of 20 TL per acre to farmers who use organomineral fertilizers in order to prevent soil and water pollution caused by the use of chemical fertilizers (Communiqué on the Amendment of the Communiqué on Support Payment for Crop Production (Communiqué No: 2020/31) (Notification No: 2021/10) [71]. This is an example of an incentive given to prevent contamination of the national soils. Similarly, government can give incentives for pellet fuel to consumers. Pellet fuel is a renewable energy source and its usage will affect the environment positively. If the government provides such supports accordingly, then it will encourage the Turkish pellet fuel industries development. The participants also expressed their opinions in this direction in the survey study. Their opinions stated that pellet fuel must be promoted and its consumption must be encouraged in the domestic market. One specialist stated that the increasing the awareness and orientation in the use of pellet fuel in end-users consisting of institutions and organizations including household type, small-scale SMEs, large-scale SMEs and public institutions with government support, grants and incentives will have positive results. The industry will make great progress with the encouragement of domestic producers, supporting investments, informing consumers, and regulations for producers and consumers in terms of legislation.

### 4.1.3.4. International Pellet Fuel Market is Encouraging the Development of the Turkish Pellet Fuel Industry.

Nearly 67% of the participants were either strongly agreed or agreed that the international market of pellet fuels is encouraging the development of the Turkish pellet fuel industry. 20% of the pellet fuel specialists were neutral about the issue while 9% of them were disagreed and a small fraction of the participants which were equal to 2% were strongly disagreed. The quantity distribution of the responds are given in the Figure 32 below.

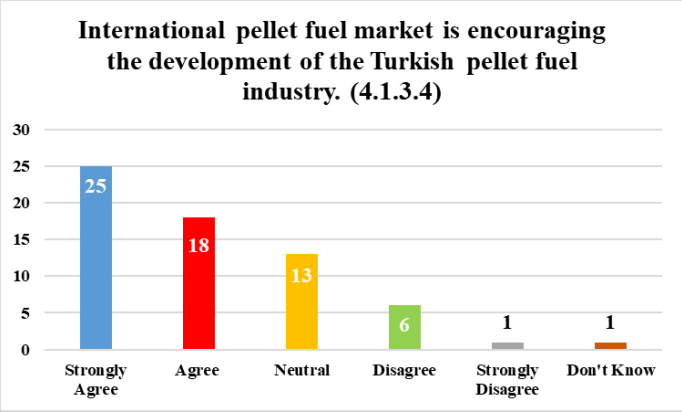



**Figure 32.** Participants Views About the Relationship Between International Market and Domestic Market

As mentioned earlier, Turkish pellet fuel producers must obtain certain licenses and standards documentation in order to become an exporter especially for the EU region. Turkey is a candidate country for EU membership and its location is very convenient for conducting trade and business with the EU. Turkey is highly dependent on the status of renewable energy in the EU. Other EU countries' actions including pellet fuel technology, standards, licensure, R&D activities, logistics and etc. highly affects and influences what is happening in the Turkish pellet fuel industry and its future. Based on the participants' opinions, in terms of international trade, exporting is considered as an option for the Turkish producers rather than importing pellet fuel to Turkey. However, the Turkish Lira

depreciated against both Euro and the Dollar and obtaining licensure for exporting pellet fuel to the EU is costly and requires a great effort. Yet, the exchange rates strongly enable Turkey as a potential pellet fuel exporter. Further, Turkey is a wealthy country in terms of forest assets and biomass waste of this nature. Combined with the exchange rates, if the nation can utilize its assets and recycle its biomass efficiently, it can strongly compete in the international market. The participants supported this idea by stating that Turkey could be a pellet fuel exporter due to high pellet prices and wide usage in Europe. One participant's opinion was about how can Europe set an example for the development of the Turkish pellet fuel industry by stating that "Currently we are talking about a raw material supply chain at the mercy of monopolists and the General Directorate of Forestry. You can establish a pellet fuel plant, but you may not be able to find raw materials. First of all, the use of pellets in our country is not supported by the state. If the government policy actively supports it, this (to stove and pellet producers) will make things better for the industry. This is the case in EU countries. Market formation will be healthy and market regulation will be evident." In Turkey the pellet fuel is currently used only by the commercial heating sector, however in the international market the pellet fuel is also widely used for the electricity production purposes in great amounts. This bears a great potential for the Turkish pellet fuel industry.

### 4.1.4. Domestic Raw Material and The Market Price

#### 4.1.4.1. The Pellet Fuel Production Costs in Turkey are Higher Than in Europe.

61% of the participants are feeling that it is costlier to produce pellet fuels in Turkey than in Europe. 23% of them were neutral about the matter while there are 14% of participants who were either disagreed or strongly disagreed and felt that it is less costly to produce pellet fuel in Turkey than in Europe. The distribution of the responds is given in the Figure 33 below.

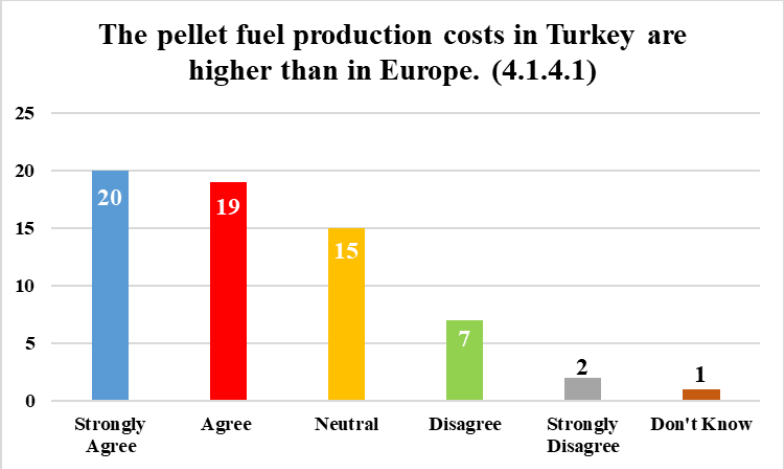



**Figure 33.** Participants Responds Regarding the Comparison of Production Costs Between Turkey and Europe

The survey study asks a comparison of the production costs between Europe and the Turkey since, pellet fuel has a big market in Europe and Turkey –an EU candidate member- has a great potential to become a prominent pellet producer, we can say that Europe is a target market for Turkish pellet fuel industry. The historic and the forecasting of the global pellet fuel demand (residential and commercial) is given in the Figure 34 below. The pellet fuel industry is expected to grow substantially especially for the European countries. The pellet fuel producers in Europe must be able to catch upon these figures. The global pellet fuel production figures are also shown in the Figure 35 below.

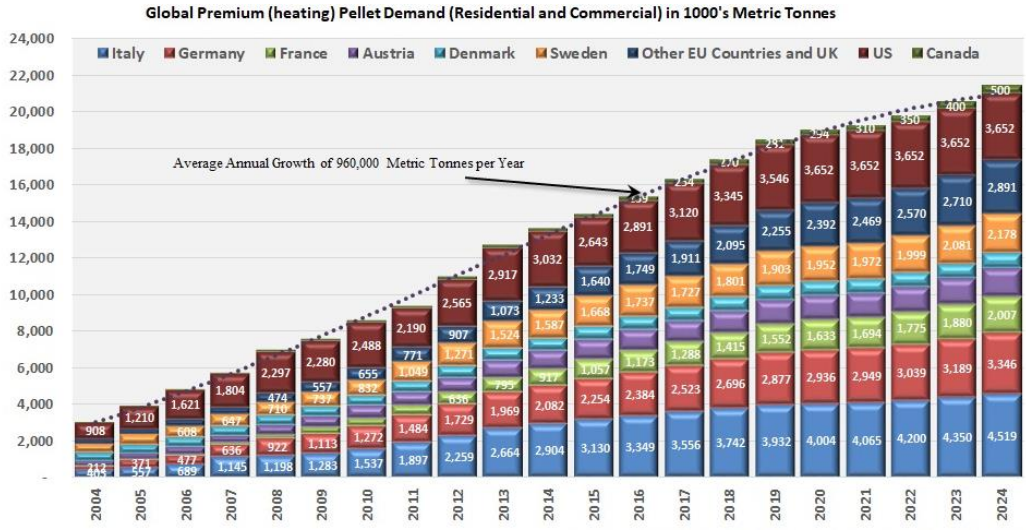



**Figure 34**. Global Pellet Fuel Demand Forecasting (Residential and Commercial) [72]

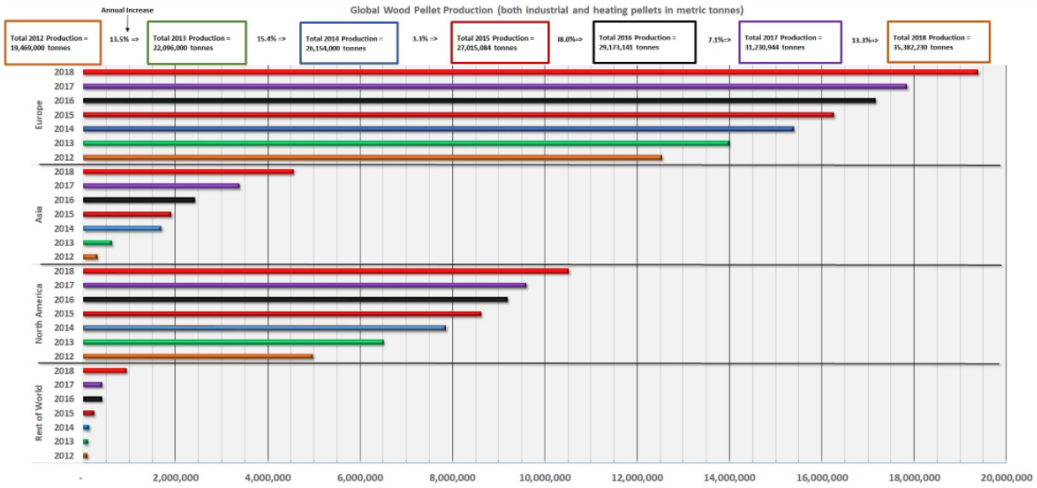



**Figure 35.** Global Wood Pellet Fuel Production Figures Between 2012-2018 [72]

Accordingly, we can derive from the Fig 17. that the Europe is leading the world in the pellet fuel production. Based on this fact one can state that the Europe's pellet production costs are lower due to the economies of scale as it settled processes such as pellet production systems, policies, logistics and raw material supply at very high production volumes. Legal requirements for pellet fuel production license is costly. Additionally, in Turkey the raw materials for pellet

fuel is under control of either the government or the private sector. These entities demand a significant amount of money for even wood residues. One participant stated that the price of pine wood dust per ton is 450 Turkish Liras (Logistics cost included) and wood pellet is traded at 1000 Turkish Liras on average. The electricity cost is near 15% and labor cost is again 15% of the final price. The profit margin is about 20-25% before taxes and under these conditions, it becomes very hard for small and/or medium sized producers to compete. Further, it is very difficult to access raw material with a standard quality at a fixed price. The quality and the price of the raw material differs a lot in each batch. For example, a producer can purchase raw material from an auction of the General Directorate of Forestry of Turkey or it can buy the raw material from a private company. The price is not fixed and this causes businesses to operate unsteady. In contrast, in Europe the producers are mainly recycling the wood and similar biomass wastes in to pellet fuel and the raw material market is much more settled and regulated. The access to raw material depends highly on the weather conditions but the quality is mainly standardized and prices are fixed as well. We can state that the European producers have a competitive advantage in terms of cost, however given the Turkey's high level of forest assets and biomass potential, with the help of government subsidies and regulations, the Turkish pellet fuel market has the potential to compete intensely with the European industry.

#### 4.1.4.2. Turkey's Potential of Biomass is not Utilized as Raw Materials in an Efficient Manner for the Turkish Pellet Fuel Industry.

The overwhelming majority of the survey participants either strongly agreed or agreed the fact that Turkey's potential of biomass is not utilized as raw materials in an efficient manner for the Turkish pellet fuel industry. The distribution of the responds is given in the Figure 36 below.

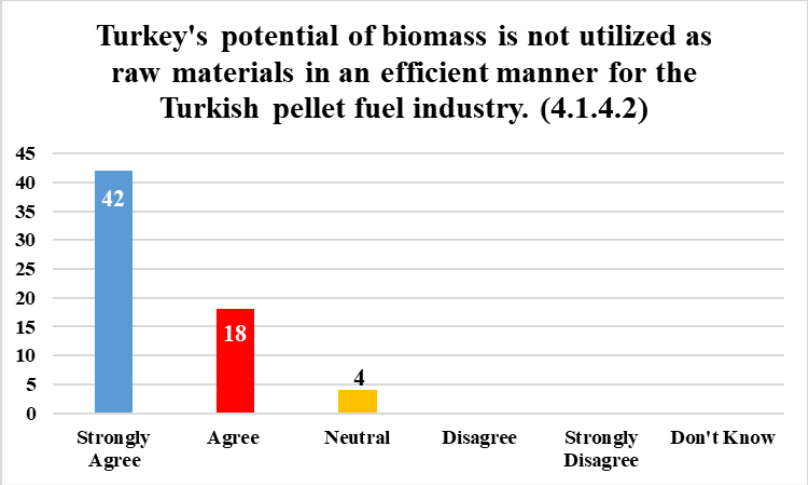



**Figure 36.** Participants Views About the Utilization of Turkey's Biomass Potential as a Raw Material

According to the Bioenergy Pellet Report 2019, the primary raw materials are defined in three categories for pellet fuel production in Europe, which are [73]:

- Main Raw Material: Residues of round wood and harvesting (e.g. wood extracted for pellet fuel production.)
- Secondary Raw Material: Wood industry's by-products (e.g. sawdust, shavings, etc.)
- Tertiary Raw Material: Used wood (waste wood, reclaimed wood)

The estimation of the distribution of raw materials utilized for pellet fuel production in Europe for the year 2018 in percentages is given in the Figure 37 below. From the data, we can state that the prominent pellet producers in Europe are mainly utilizing the wood residues, industry by-products and used woods, and recycling those into pellet fuel industry. This must be the main essence of the pellet fuel business; it must aim to recycle the assets of the earth. Moreover, this situation boosts the European industry and enables it to become the pioneers of pellet fuel production. In Turkey, recycling wood industry and forestry residues cycle is not yet settled. Almost every participant stated that it is not sustainable to base the Turkish pellet fuel industry on the raw materials sales and bids of the General Directorate of Forestry of the Turkish Republic. The

producers cannot compete if they base their entire raw material procurements on government forest sales or private sector deals. The producers must utilize biomass wastes of forests in Turkey, wood residues of the industry and used woods such as scrap pallets, furniture and etc. One participant's opinion stated that producers can become competitive by establishing their facilities at the source of biomass wastes, not only providing less costly raw materials but also reducing their logistics costs to a minimum. He continued by typing biomass wastes can be converted into pellet fuels through utilizing both biomass wastes (forest fire risks also will be reduced by pruning from forests etc.) and scrap pallets and other wood wastes, especially in places where the population density is high throughout the country, and then the industry can achieve development. According to the opinion of another participant, the industry should not operate solely on forestry raw materials, and agricultural residues (cotton stalk, sunflower stalk, hazelnut sap, pruning residues, etc.) should be utilized as raw materials. Yet, utilization of pruning residues left as "useless" as a result of agricultural pruning and forest weeding are also represent a significant source of raw materials. Municipal pruning waste is also a serious source of raw materials for the industry.

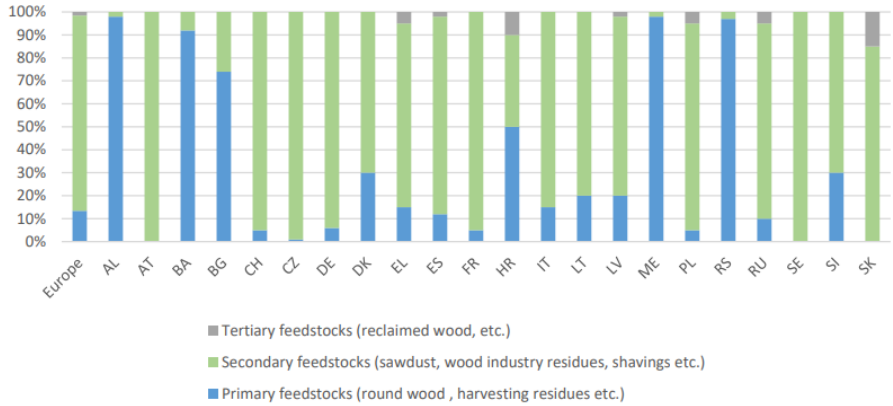



**Figure 37**. The Estimation of the Distribution of Raw Materials Utilized for Pellet Fuel Production in Europe for the Year 2018 in Percentages

As a result, although Turkey has a significant source of raw materials for the pellet fuel industry, it is currently unable to utilize this presence. Effective and efficient utilization of these resources is of vital importance for the development of the industry. If realized, Turkey has the potential to become an important competitive power in the pellet fuel market.

### 4.1.5. Matters Regarding International & Domestic Co-Operation and Logistics

#### 4.1.5.1. The Development of the Turkish Pellet Fuel Industry is Facing Setback Due to the Lack of International Cooperation.

73% of the participants think that lack of international cooperation is hindering the development of the Turkish pellet fuel industry while 20% of the participants were neutral towards this issue. The answers according to the scale are given in the Figure 38 below.

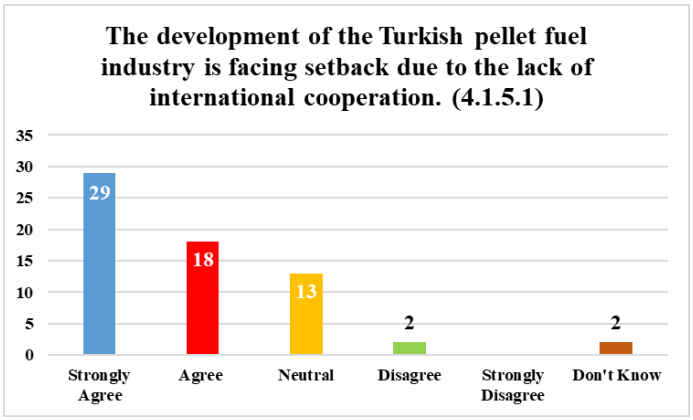



**Figure 38.** Participants Views About the International Co-Operation Effect on Domestic Development

In terms of international co-operation, the Turkish pellet fuel industry is a newly emerged industry which is at between the introduction and the growth stage of its life-cycle while the pellet industry is more mature especially in Europe. In the

year 2018, the pellet consumption amounted to 35 million tons with a 14% increase from the year 2017, excluding China where the total consumption was near 18 million tons. The world's largest pellet consumer is the Europe with a total pellet consumption of 27 million tons per year. The figure increased by 2 million tons compared to 2017 where the United Kingdom led the area with its industrial pellet fuel consumption. Europe nearly supplies 74% (16.9 million tons) of its internal consumption with producing 20 million tons of pellet fuel and it is one of two regions who are also importers of pellet fuel, the other one is being the Asia region. The Europe and the Asia are the two drivers of the development of pellet fuel market in the world, which is depicted in the Figure 39 below [74].

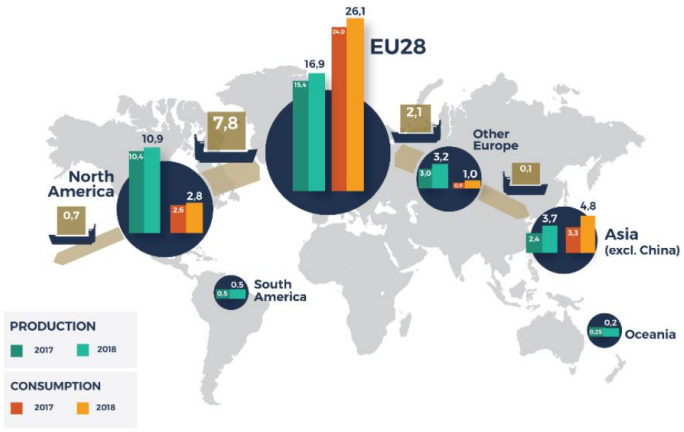



**Figure 39.** World Pellet Production and Consumption Figures (2017-2018) [74]

Turkey is a relatively new player amongst these giants. The country is not represented in the European Pellet Council, which is a network platform of Bioenergy Europe which is focused on decision-making in the industry through bringing its members together to brainstorm and discuss new technologies, policies, industry trends and market strategies. The list of organizations and countries in the pellet fuel sector which are represented in the European Pellet Council is given in the Table 23 below. The other sectors represented in the EPC include district heating, electricity/CHP, heating and solid biomass fuels. In total,

there are 19 associations and 18 countries are represented as members in the EPC, Bioenergy Europe and the list of countries is given in the Table 24 below [75].

**Table 23.** List of European Pellet Council Members (Pellet Associations) [75]

| List of Member Organizations of the European Pellet Council | |
|---|---|
| **Organization Name** | **Country** |
| Association of Industries of Wood and Furniture Portugal (AIMMP) | Portugal |
| Belgian Interprofessional Federation for Wood Fuel (FEBHEL) | Belgium |
| Croatian Biomass Association (CROBIOM) | Crotia |
| Czech Pellets Cluster | Czech Republic |
| Polish Pellet Council | Poland |
| Propellet France | France |
| proPellets Austria | Austria |
| proPellets Switzerland | Switzerland |
| Russian Pellet Council | Russia |
| UK Pellet Council (UKPC) | United Kingdom |
| Wood Pellet Association of Canada (WPAC) | Canada |

**Table 24.** List of Countries Represented in the European Pellet Council [75]

| List of the Countries Represented in the European Pellet Council |
|---|
| Portugal |
| Belgium |
| Crotia |
| Czech Republic |
| Poland |
| France |
| Austria |
| Switzerland |
| Russia |
| United Kingdom |
| Canada |
| Finland |
| Greece |
| Italy |
| Latvia |
| Lithuania |
| Spain |
| Sweeden |

Another crucial establishment for the pellet fuel industry is ENplus, which is a Brussels based certification scheme that requires certain quality standards, production requirements and other necessities to give certificates for both producers and traders around the world. ENplus's projected certified production

figure for the year of 2021 is 13 million tons. Almost every net pellet importer around the world demands an ENplus certificate from the exporter producer or the trader as proof of quality and standard. Currently there are more than 500 ENplus certified pellet producer and trader around the world. The system enables producers and traders to be in a network. Turkey is represented with only two ENplus certified private pellet fuel producers as of 2021 [76]. As a result, Turkey is currently not involved in the primary global pellet networks. The mentioned arenas provide its members with opportunity to discuss new technologies, market trends, new policies and strategies. This situation hinders Turkey from international co-operation which is a barrier in front of the development of the Turkish pellet fuel industry. In the following sections this paper will discuss the current situation of pellet fuel associations in Turkey, which is another crucial matter for industry. The producers and traders must be organized and united to be able to enter the international co-operation network which will eventually provide them with ability to compete in the global market.

#### 4.1.5.2. The Increase in The Exchange Rates in Turkey, Have Reduced the Solid Fuel Imports from Abroad.

Turkey faced with strong exchange rate fluctuations in recent years. Turkish Lira's depreciation against US Dollar from January 2018 to May 2021 is given in the Table 21 and against Euro is given in the Table 25.

**Table 25.** EUR/TRY Rate Between 01.01.2018 and 06.05.2021 [77]

| Date | 2018-01 | 2018-05 | 2018-09 | 2018-12 | 2019-01 | 2019-02 | 2019-05 | 2019-08 | 2019-10 | 2019-11 | 2020-03 | 2020-09 | 2020-11 | 2021-02 | 2021-05 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EUR/TRY | 4.60 | 5.23 | 7.44 | 6.05 | 6.14 | 5.99 | 6.78 | 6.27 | 6.40 | 6.35 | 7.00 | 8.88 | 9.47 | 8.57 | 10.15 |

As seen in the tables, the Turkish Lira depreciated greatly against both exchange rates. The impact of these exchange rate movements is felt in all sectors in the country, especially in the imported products market. The majority of the answers of the survey participants, who are aware of this situation, also came true in this direction. 64% of the participants either strongly agreed or agreed that the solid

fuel imports are affected negatively from the exchange rate fluctuations in Turkey. 19% of the participants were neutral towards the issue while 16% of them were strongly disagreed or disagreed. The distribution of their responds is given in the Figure 40 below.

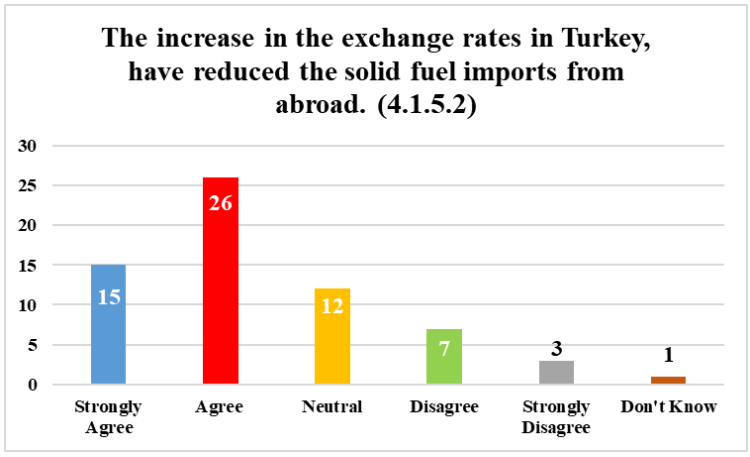



**Figure 40.** Participants Opinions Regarding the Relationship Between Exchange Rate Increase and Fuel Imports to Turkey

One important aspect of the distribution of the responds is that the traders strongly agree on this issue. They are traders of pellet fuel with other fuels including imported solid ones. Since they are directly involved in this business it can be said that they are the type that experiences the market trends and the pulse of the market most accurately in practice. The solid fuel imports are highly controlled and regulated by the government with strong requirements. Combined with high exchange rates, imports are subject to be affected. When we look at import figures between 2019 and 2020, we can see hard coal import increased by 7.4% followed a relatively horizontal cruise while if we compare the import figure for the December 2019 and December 2020 the import figure decreased by 10.3%. For the coke coal, the import figure increased by 2.2% between 2019 and 2020, again we can say that is a horizontal movement when we compare the imports between the months of December 2019 and December 2020, the imports decreased by 41.2%, which is a substantial decrease [78]. As can be seen from the figures, the coal import sector has lost its previous growth momentum and is

moving more stable and horizontal. On the other hand, the need for solid fuel is increasing day by day in Turkey, whose population is constantly increasing and is experiencing economic difficulties in terms of exchange rates. Consumers do not want to pay more and more every day to the imported fuels. The country must find a solution to this situation that will use sustainable and indigenous resources. At this point, the country should evaluate its domestic resources as a solution. Considering its renewable energy targets, the European Union harmonization process and the international carbon emission protocols, this situation can be considered as an opportunity for the development of the Turkish pellet fuel sector.

#### 4.1.5.3. The Absence of Associations, Cooperatives and etc. in the Turkish Pellet Fuel Industry Hinders the Development of the Industry.

Almost every survey participant, with a rate of 94% either strongly agreed or agreed that the deficiency in forming business associations, industry bodies or cooperative and etc. in the Turkish pellet fuel industry constitutes an obstacle to the industries development. Below, the distribution of the responds is given in the Figure 41.

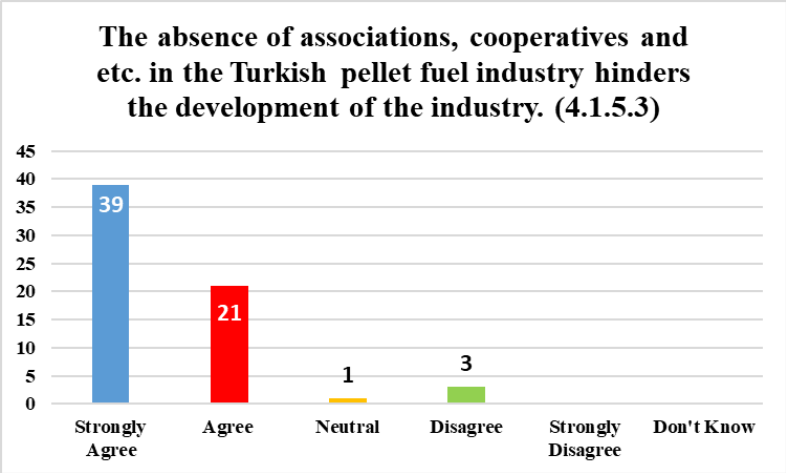



**Figure 41.** Participants Views About the Associations and its Effects on the Development of the Industry

Business associations are important organizations for sectors. They have crucial functions for the sake of the industry. A properly established and managed association is of great importance for the development of that sector. It is more common a business association's involvement in price and wage determination on national level in western world than has been the case in emerging economies. According to a study, functions of associations for market complementing are given in the Table 26 below.

**Table 26.** Business Associations' Market Complementing Functions [79]

| Market Complementing Functions of Associations |
|---|
| Macroeconomic Stabilization Reform |
| Horizontal Coordination (Quota Allocation, Capacity Reduction) |
| Vertical Coordination (Upstream– Downstream), |
| Lowering the Costs of Information |
| Setting Standards |
| Quality Upgrading |

On top of that business association actions are crucial for price stabilizations. They are also significant for forming platforms for networks in order to share and discuss new technologies, market trends, business strategies and market policies. Currently in Turkey the pellet fuel industry is far from being organized. The price of raw material, the production techniques, types of raw material and the price of the fuel varies greatly between the regions. It is not true to state there must be an association however if there was one it is possible to state that given the current circumstances it would accelerate the industries development. We can observe its examples especially in the Western Europe where there are many strong pellet associations who are also forming the European Pellet Council. An industry body's presence would regulate raw material prices, bring its members together for alliances, stabilize the price of the product and standardize the final pellet fuel which would benefit the consumers. There is an association of heating system manufacturers for pellet fuel but it's at its early stages and far from influencing the industry. As a result, the presence of a business association for

pellet fuel producers is not necessary however if it does, it will certainly be beneficial to the development of the Turkish pellet fuel industry.

#### 4.1.5.4. Pellet Fuel Logistics in Turkey is not Sufficiently Developed.

Overwhelming majority of the survey participants feel that logistics of the pellet fuels is not sufficient in Turkey. The distribution of the responses by scale is given in the Figure 42 below.

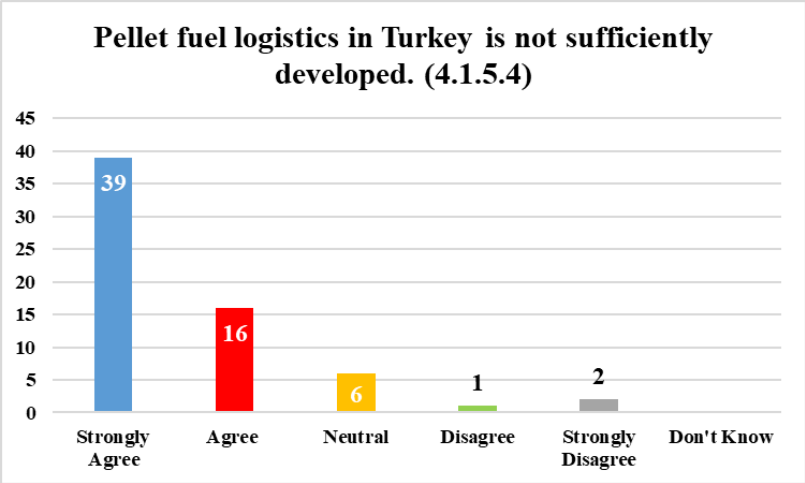



**Figure 42.** Participants Views About the Current Status of the Pellet Fuel Logistics in Turkey

Logistics is a controversial issue. It is a challenge to keep customers satisfied and reach every one of them in a cost efficient way. Turkey is the world's 37th largest country by total land area of 769,630 km2 [80]. The primary heating source in Turkey, especially for households, is heating by natural gas. Although the natural gas supply reaches 81 provincial centers, there are still too many settlements that it cannot reach. In addition, for reasons such as cost, consumption habits etc. it is not the primary heating option for every consumer profile. There are few radiators installed in regions with hot climates where the winter session is not harsh such as the Aegean, Mediterranean and Southeast Anatolia. In the Black Sea Region, nut shell is a popular heating option against natural gas. In these regions and in the rural areas of the other regions heating

boilers and stoves are preferred for heating purposes. Other than heating, solid fuels and natural gas are used for industrial purposes such as electricity generation. Pellet fuel has the potential to become a sustainable and renewable alternative to the mentioned energy sources. The current production volume is not sufficient to meet the demand for pellet fuel. Regional demand plays an important role in this matter. According to opinions of the participants, in the mentioned regions more people start to consume pellet fuel every year. As the awareness of the product increases, the consumption rate increases. The majority of the survey participants who are household and corporative consumers have stated that they are only consuming pellet fuel a few years or less from now. Moreover, they have also indicated that it is rather difficult to reach pellet fuel every time they need compare to its fossil fuel counterparts. A further problem with the supply of the pellet fuel is that its standard, consumer groups pointed out that they are facing troubles finding a standard quality of pellet fuel. To minimize cost of logistics for raw material, the producers are usually located near to the wood processing factories such as sawmills, pallet manufacturers or furniture factories. However, for delivering the pellet fuel to the consumer is the controversial part. Almost every participant mentioned the high costs of pellet logistics in Turkey. Pellet fuel is often bought in tons. According to an insight information from one of the stakeholders in the industry –who also participated to the survey study- producers usually pack 20 or 25 kg of pellet fuel in 50x70 cm bags.1 ton of pellet fuel means 40 to 50 bags and consumers tend to purchase at least 4 tons per order, which is amounted to near 17.5 m3 for a 4 tons of order, a volume that would fill a medium sized pickup trucks trailer to the fullest. For bigger orders, the carrier vehicle must be bigger, which adds further transportation cost. When a consumer orders a pellet fuel from another city, the carrying job is usually undertaken by a large sized truck rather than a medium sized pickup. This situation causes abnormal transportation costs since it is unfeasible to hire a truck with a 55 m3 trailer for one customer. If the producer is unable to unite several different orders into one shipment than it is not possible to complete the sales, resulting in disadvantage for both the consumer and the

producer. Based on the participant's opinions these are common cases for the current Turkish pellet fuel industry. Many participants stated that Turkey lacks infrastructure for pellet fuel logistics. One suggestion is to build networks such as dealerships in certain city centers. It requires intensive business development processes. One other solution is to utilize the warehouses in different regions. Warehouses are locations where a large number of different kinds of merchandise are gathered and shipped to their destinations in a mass. Yet, they are rather irregular and far from standard structures, so it is not the definite solution. Sorting out the logistics problem of the pellet fuel industry is highly crucial for its future domestic development. Logistics to abroad countries is handled to sea transport but, logistics is an important issue in order to meet the demand in the domestic market on time and on site.

## 4.2. Challenges and the Main Factors Inhibiting the Development of the Turkish Pellet Fuel Industry

In this section of the survey study the participants were required to rank the main factors and challenges that are hindering the development of the Turkish pellet fuel industry. For each factor they were given a scale from 5 to 1 where 5 corresponds to "Most Important" and 1 corresponds to "Least Important". Distributions of responses and the results are given and discussed in the following subsections.

### 4.2.1. Lack of Policy Support and Regulation

As the Figure 43 depicts nearly 90% of the participants felt that lack of policy support combined with insufficient regulatory framework are strong factors in front of the development of the Turkish pellet fuel industry.

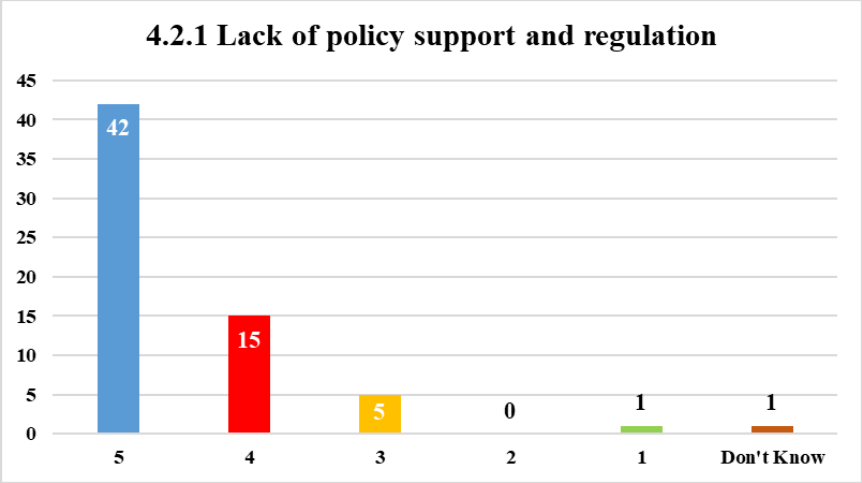



**Figure 43.** Participants Ratings About the Policy Support and Regulation Factors

Although Turkey has prepared and put into action its National Renewable Energy Plan compatible with the European Union policies, the country lacks concrete steps in the pellet fuel field. The nation planned to take further steps in terms of conversion to renewable energy sources and making new investments, however if it is not supported by concrete directives, policies and successful implementations of suitable regulations, it is incomplete and simply makes no sense. As noted in the section 4.1.3.1 the process to obtain a legal pellet production license is harder than it should be and the government is not providing any supports and/or incentive for renewable fuels for heating purposes as discussed in the section 4.1.3.3. Making and implementing regulations on these issues, supporting the issue with policies by the state, giving tax advantages, etc. such incentives are vital to the development of the industry, which is at an early stage of its life cycle.

### 4.2.2. Competition with Other Solid Fuels (Both Renewable and Fossil)

Almost 80% of the participants suggest that competition with other fuels is a significant factor against the development of the Turkish pellet fuel industry. The results are shown in the Figure 44 below.

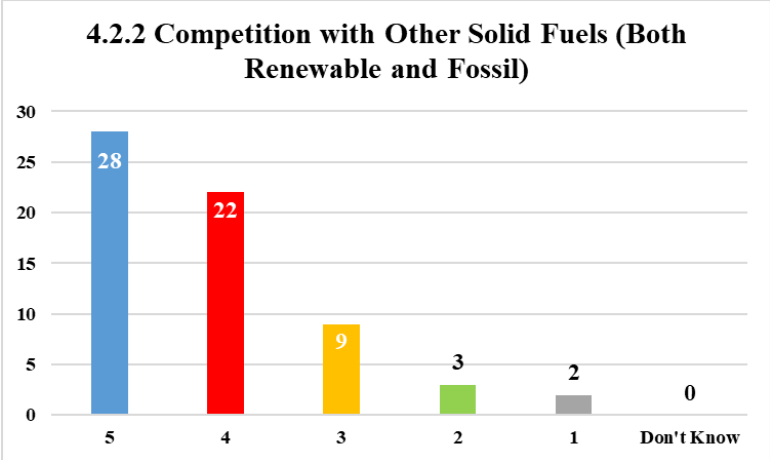



**Figure 44.** Participants Ratings About the Competition with Other Solid Biomass Fuels Factor

As discussed in the sections 4.1.2.1, 4.1.2.2, 4.1.2.3, pellet fuel has specific competitive advantages against other solid fuel alternatives both renewable and fossil. However, at the end of the day, the price is what is always counts. Pellet fuel must become more advantageous in terms of price against its competitors. Participants indicated other possible strategies. Pellet fuels can be a substitution for domestic coal through two options; the consumer can fully convert his/her system to use pellet fuel or he/she can choose co-burning. For a full conversion, the whole heating system is converted to burn pellet fuel instead of coal, a producer which requires a number of modifications. Although it seems like a troublesome process, the long term benefits cannot be ignored. It is more beneficial for environment to burn pellet fuels instead of coal. Further, pellet fuel is better in terms of health and hygiene for the consumers. It does not have a potential to poison through smoke yet it has a very little ash content so it gives less trouble to the consumer. Co-burning is the other option where the consumer burns pellet fuel and coal jointly. It might make sense for especially corporate consumers who require to burn excessive amounts of fuel due to their large areas and number of employees. These types of factories, farms, workshops, warehouses or etc. can opt to burn both coal and pellet fuel since burning only pellet fuel can significantly increase their costs. Because of this, they tend to

decrease their heating expenses through co-burning; specifically, they are combining domestic coal and the pellet fuel. Domestic coal since it costs less than other fuels and pellet fuel since it is a clean energy source.

### 4.2.3. Lack of Investment

Another major challenge against the Turkish pellet fuel industry is lack of investment to the field as supported by the participants with an 89% rate illustrated in the Figure 45 below.

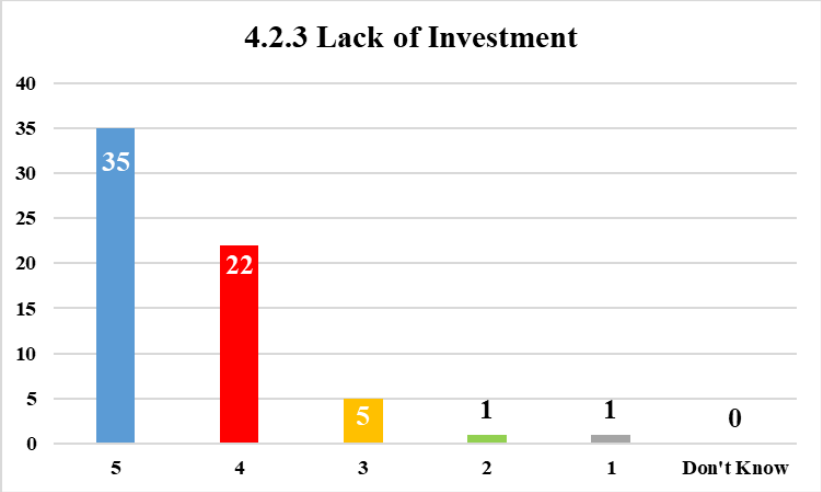



**Figure 45.** Participants Ratings About the Investment Factor

According to the participants, the industry does not lack of investment on the production side yet attention is needed on the heating systems and devices part. In the opinions given, there was a consensus that investment was needed to make more pellet-boilers, stoves and heating systems. The pellet fuel is facing challenges regarding its incompatibility with the large portion of the current heating systems installed in the houses and corporate areas. If pellet compatible broilers, stoves and heating systems become more common than the pellet fuel will become more competitive in the domestic market.

### 4.2.4. Raw Material Shortage

In terms of raw material shortage as a factor inhibiting the development of the Turkish pellet fuel industry the responses were rather equally distributed between scale options. 41% of the participants voted 5 and the remaining 59% voted for the other options, the distribution of the responses is given in the Figure 46 below.

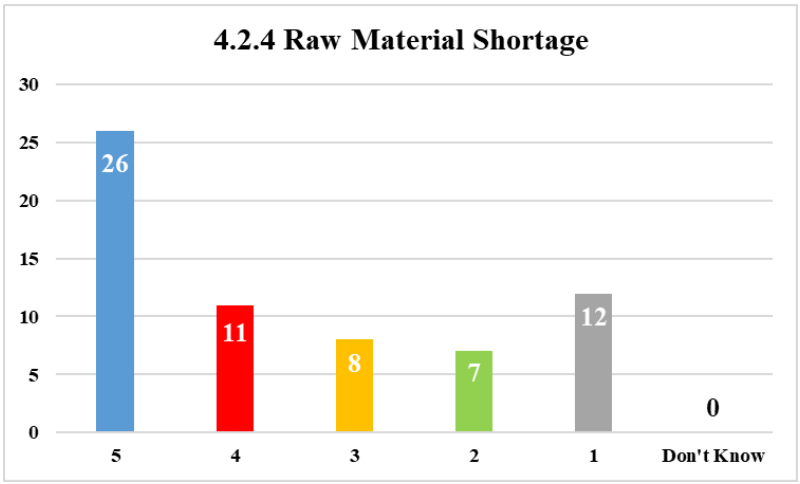



**Figure 46.** Participants Ratings About the Raw Material Factor

41% of the participants felt that lack of raw material is a major challenge against the development of the industry. However according to their opinions the main reason behind their thought is not because they believe the country's forest wealth and biomass potential are insufficient, but because these current assets are not being used properly. One participant stated that the raw material supply chain is at the mercy of monopolists (sawmills, furniture factories and other private wood industry establishments) and the General Directorate of Forestry. An investor can establish a pellet production facility, but it may not be able to purchase raw materials of sufficient quality at a standardized price rate. One other participant's opinion stated the same; the most important problem with pellet production is to provide cheap and sustainable raw materials. Meanwhile, 42% of the participants voted 3 or less, indicating that nearly half of the

participants believe that raw material is not a major factor against the development of the industry. Opinions put forward that instead relying only on wood type raw materials, the industry must also utilize other kinds of biomass to produce pellet fuel. One participant specifically indicated that the industry should not only operate based on forestry raw materials, but should use agricultural residues (cotton stalk, sunflower stalk, hazelnut sap, pruning residues, etc.), which have an annual potential of 15-20 million tons and have different varieties almost everywhere in our country. Another participant took attention to plant and forest residues and wastes as a secret energy source and its importance to be recycle back to the economy potentially as pellet fuels. To conclude, Turkey has a great potential of biomass sources and forest assets. The country does not lack the necessary raw material for the pellet fuel industry however measures must be taken to fully utilize these assets for the development of the Turkish pellet fuel industry.

### 4.2.5. Lack of R&D Activities

56% of the participants suggested that the lack of R&D activities is a major factor inhibiting the development of the Turkish pellet fuel industry while 44% of them did not prioritize it is as a major challenge. The distribution of the responses is shown in the Figure 47 below.

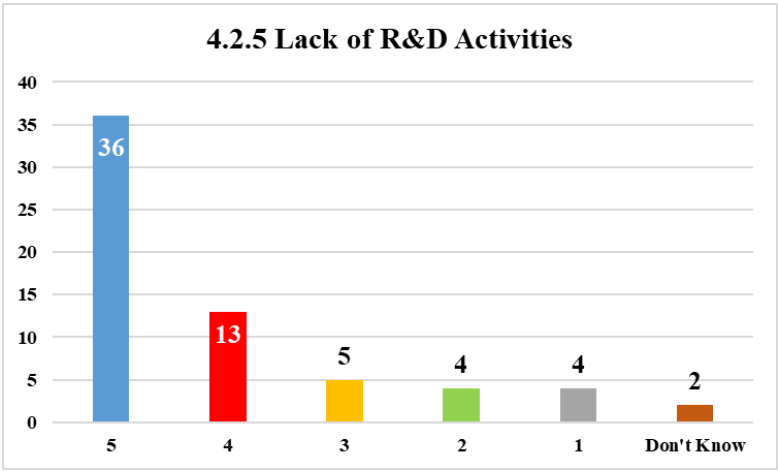



**Figure 47.** Participants Ratings About the R&D Activity Factor

Local, national and EU funds are used for R&D projects in Turkey. When we examine the local and country level grant supports, the European Union, regional development agencies, KOSGEB, TUBITAK, TESKOMB, the Ministry of Industry and Technology, the Ministry of Agriculture and Forestry, the Ministry of Trade, and etc. are among the institutions and foundations providing the supports and grants. Within the scope of these supports, renewable energy grants are listed. Supports are provided for renewable energy production facilities within the scope of Instrument for Pre-Accession Assistance Rural Development (IPARD) Program by the Agriculture and Rural Development Support Institution however it does not include either biomass energy or energy for heating purposes. Further, the program prepared by Ministry of Agriculture did not consider biomass as a renewable energy source for the 2023 projection [81]. Three different supports are provided by the Technology Development Foundation of Turkey within the scope of Green Technology Projects, namely "Climate Friendly Technologies Support", "Cleaner Production Technologies Support" and "Energy Efficiency, Renewable Energy and Other Energy Technologies Support". The main purpose of Climate-Friendly Technologies Support is to use climate-friendly, energy-efficient, reliable and proven alternatives to reduce the use and emission of high global warming potential (GWP) gases such as hydrofluorocarbons (HFCs) and hydro chlorofluorocarbons (HFCs) used in the refrigeration industry. Supporting projects for the implementation of local and innovative technologies. The main purpose of the Cleaner Production Technologies Support is the clean production technologies that are applicable in the industry and have economic value, which includes technological innovation for minimum energy, water, raw material consumption and minimum waste generation in production processes within the framework of resource efficiency (eco-efficiency / cleaner production / sustainable production) understanding and to support projects for the development, realization and commercialization of applications. The main purpose of Energy Efficiency, Renewable Energy and Other Energy Technologies Support is to increase energy efficiency in industrial applications and to ensure the use of renewable energy in

order to protect Turkey's competitive power in the face of increasing energy prices in the world, especially in energy-intensive sectors, to reduce foreign dependency and greenhouse gas emissions, In addition, environmentally friendly technology practices in energy production and use, as well as supporting projects for the development and realization of domestic and innovative technologies that generate fuel and energy from waste [82].

Apart from these, the primary institutions providing support in the field of R&D are TUBITAK, The Ministry of Industry and Technology and Small and Medium Enterprises Development Organization (KOSGEB). In TUBITAK, Technology and Innovation Support Programs Directorate (TEYDEB) is giving grants and supports mainly to the private sector. The list of support titles provided from TEYDEB is given in the Table 27 below.

**Table 27.** List of Support Programs of TUBITAK TEYDEB [83]

| **TUBITAK, Technology and Innovation Support Programs Directorate - R&D Support Programs** |
|---|
| 1501 - TUBITAK Industry R&D Projects Support Program |
| 1503 - TUBITAK Project Markets Support Program |
| 1505 - TUBITAK University-Industry Cooperation Support Program |
| 1507 - TUBITAK SME R&D Startup Support Program |
| 1509 - TUBITAK International Industry R&D Projects Support Program |
| 1511 - TUBITAK Priority Areas Research Technology Development and Innovation Projects Support Program |
| 1512 - TUBITAK Individual Entrepreneurship Progressive Support Program |
| 1513 - TUBITAK Technology Transfer Offices Support Program |

KOSGEB institution provides support within the scope of its R&D and Innovation Support Program. The purpose of the supports is to enable small and medium-sized enterprises and entrepreneurs with new ideas and inventions based on science and technology to produce new products, new processes, knowledge and / or services through research and development and innovation projects to be supported. An upper limit of 750,000 Turkish Liras per business is provided [84].

We can state that there are a large number of support programs for R&D activities in Turkey. The industry players must be more active especially building heating systems more compatible with the pellet fuel. This requires certain R&D activities. A participant stated that by carrying out the necessary R&D studies of systems using pellet fuel (not only heating, but also considering the energy sector such as turbines, etc.), by taking into the scope of social responsibility, by developing projects in NGOs and municipalities in appropriate regions will encourage the Turkish pellet fuel industries development.

### 4.2.6. Incompatibility and / or Lack of Installed Heating Systems

Approximately, 80% of the participants felt that incompatibility and / or lack of installed heating systems is a major challenge against the development of the Turkish pellet fuel industry. The survey results are given in the Figure 48 below.

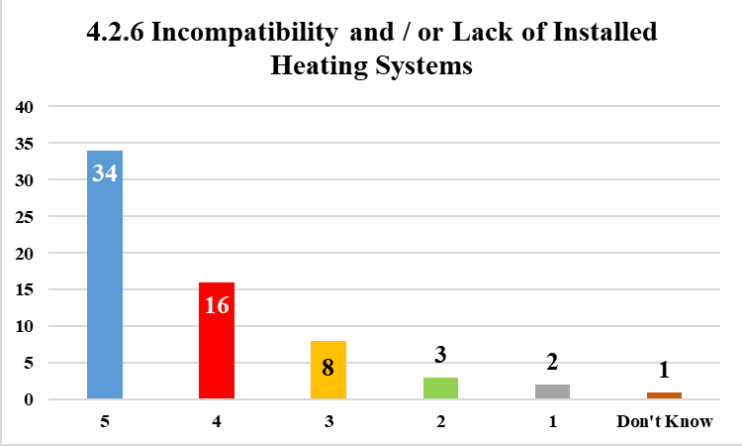



**Figure 48.** Participants Ratings About the Current Installed Heating Systems in the Turkey Factor

Currently, coal is the most widely preferred solid fuel in Turkey. As stated in the section 4.2.2, pellet fuels can be a substitution for coal through two options; the consumer can fully convert his/her heating system to use pellet fuel or he/she can choose co-burning. Conversion of current heating systems to burn pellet fuel either requires renovation or simply purchasing a new device, which is additional cost. On top of its cost, consumers need to change their current fuel consumption

habits. A portion of the current systems in Turkey are able to use pellet as a fuel. However, serious effort and time are required for heating systems compatible with pellet fuel to become widespread. For this, heating system manufacturers have a great responsibility. Currently, co-burning seems to be a right strategy for pellet fuel. It is a good way to introduce pellets to consumers and help them better understand its benefits. Over time, more and more consumers will convert their current systems to make it compatible with pellet fuel. Nevertheless, it stays as a major challenge in front of the Turkish pellet industry in the present case.

### 4.2.7. Environmental Factors

Almost half of the participants think that environmental factors are not a factor that is hindering the development of the Turkish pellet fuel industries development. The participants' votes are depicted in the Figure 49 below.

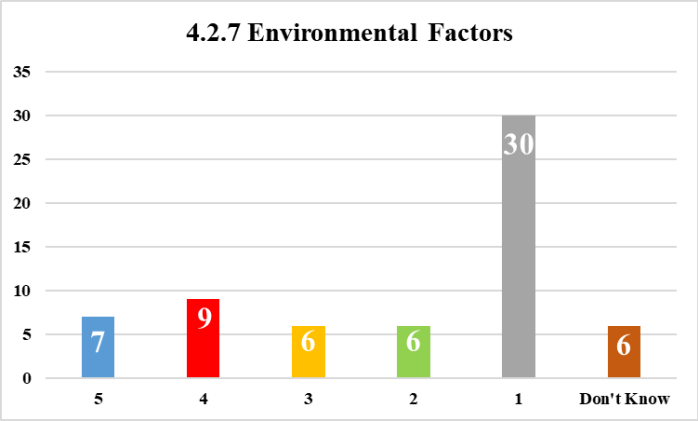



**Figure 49.** Participants Ratings About the Environmental Factor

Turkey joined the United Nations Framework Convention on Climate Change as of 2004. The country also signed the Kyoto Protocol back in 2009. Moreover, Turkey took serious actions to make its legal regulations and framework compatible with the energy acquis of the European Union and "20-20-20 Targets" of the EU. According to the Turkey's National Climate Change Action Plan, by 2023 Turkish government aims to satisfy the 30% of the electricity consumption from renewable sources [81]. Given its environment friendly

nature, besides being challenges, environmental factors and renewable energy targets are factors that support the development of the Turkish pellet fuel industry.

### 4.2.8. Other Factors

The opinions of the participants varied in terms of other factors affecting the development of the Turkish pellet fuel industry. The distribution of the results is illustrated in the Figure 50 below.

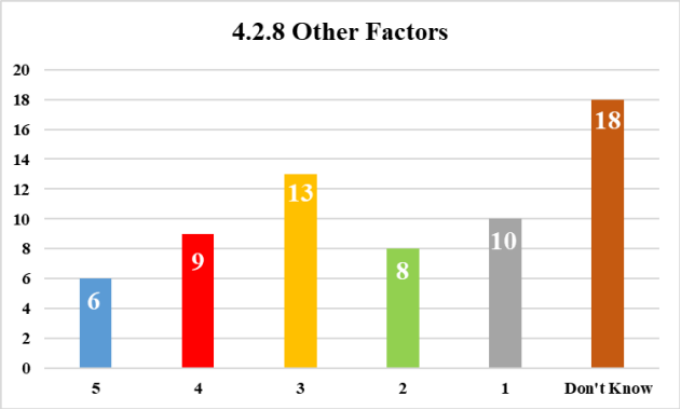



**Figure 50.** Participants Ratings About Other Factors

One important factor against the industries development is the awareness of the pellet fuel in Turkey. One participant stated that, in order to raise the awareness of the public, institutions such as the Ministry of Agriculture, Ministry of Environment and Urbanization, Provincial Environmental Directorates and Ministry of Industry and Technology should utilize methods such as Public Service Advertisements and education. These activities can be carried out to increase awareness of the public about the benefits of consuming pellet fuel and its significance for the environment and economy. Significant growth can be achieved by increasing the awareness of citizens about pellets in a short period of time. Economic downturn is another potential other factor against the development of the industry. Economic downturns reduce new investments and R&D activities, further, it decreases the level of consumption of the consumers.

Lack of consumer guidance from the producers and policy makers is another factor stated. Absence of full service packages considered an important other factor. Pellet fuels should be sold along with compatible boilers and devices. Producers should enrich their product range by adding suitable heating devices and providing maintenance and services for them.

### 4.3. Views Regarding the Profitability of the Turkish Pellet Fuel Industry

In this section of the survey study, the participants were asked to evaluate the profitability of the Turkish pellet fuel industry for certain industry stakeholders. The results are given and discussed in the following subsections.

#### 4.3.1. Large-Scale Corporate Consumers

The vast majority of the participants answered that pellet fuel is a profitable product for large-scale corporate consumers. The results are shown in the Figure 51 below.

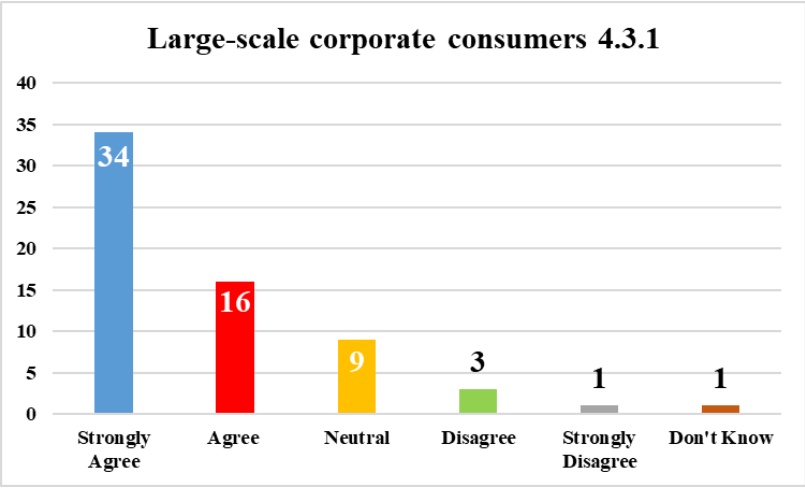



**Figure 51.** Participants Assessment About the Profitability of Large-Scale Corporate Consumers

For this survey study, large-scale corporate consumers are assumed as factories or companies with an at least 1000 m2 business area with at least 200 staff member working for every day operations. These kinds of establishments tend to prefer solid fuels instead of natural gas because of economic reasons. Due to their high level of consumption, they also hold a significant effect on environment and carbon emission. Almost all of the participants expressed their opinions in the same way that because of its higher combustion efficiency compared to other solid fuels, it enables consumers to obtain more efficiency from the product they buy. Especially, it is economically advantageous because pellet fuel gives the same heat by burning less fuel compared to domestic coal with low combustion efficiency. In addition, due to its low ash ratio, it requires less effort in terms of cleaning after burning and reduces the man/hour rate allocated for this job.

### 4.3.2. Small-Scale Corporate Consumers

Exactly 89% of the participants felt that consumption of pellet fuel is profitable for small-scale corporate consumers. The distribution of the results is depicted in the Figure 52 below.

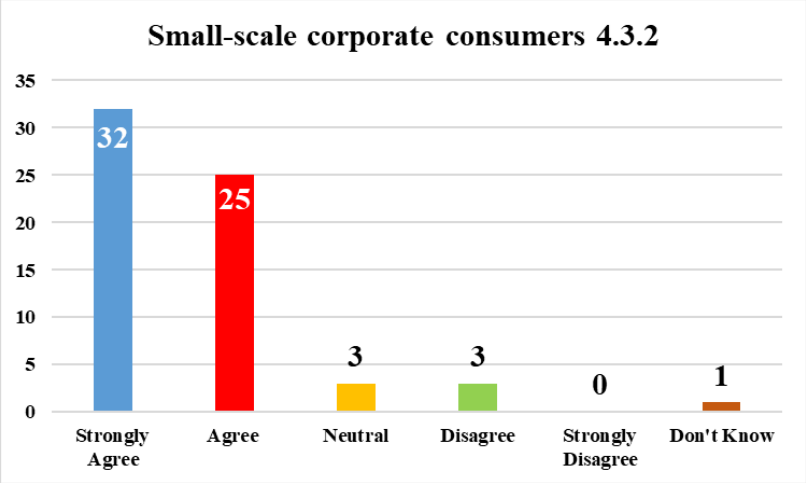



**Figure 52.** Participants Assessment About the Profitability of Small-Scale Corporate Consumers

Small-scale corporate consumers are assumed as establishments like shops, workshops in the industrial zones, offices or small buildings. Similar to the large-scale corporate consumers, business establishments regardless of size tend to burn solid fuels for heating purposes. As noted in the 4.3.1, consumers are switching to pellet fuel day by day due to its advantages. Especially participants who are classified as corporate consumers stated that economic advantages are mainly the number one concern of for-profit establishments, in addition, pellet fuel's handling requires less effort and it is more hygienic than its counterparts. There is a conversion cost for the already installed heating system but in the long-term it compensates it through its advantages.

### 4.3.3. Household Consumers

According to the results, 80% of the participants either strongly agree or agree that pellet fuel consumption is profitable for household consumers. The scale distribution is given in the Figure 53 below.

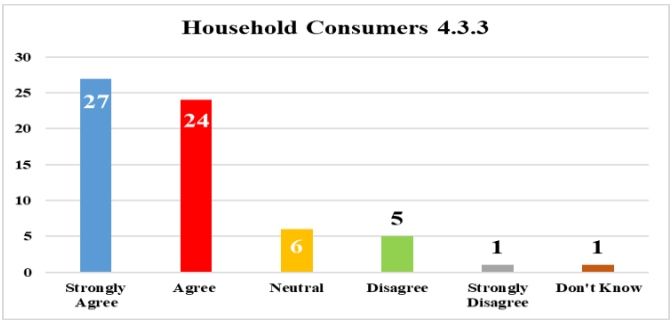



**Figure 53.** Participants Assessment About the Profitability of Household Consumers

Although some household consumers who are participants to the survey study stated that the pellet producers do not prioritize small size consumers since they are not profitable as large size consumers. Further, Turkey's level of promotion for small scale pellet fuel devices and appliances is insufficient, yet providers of service and maintenance are not enough for the potential demand. Participants

noted that local craftsmen have a certain level of knowledge regarding the installation and maintenance of the heating systems however it is far from being enough and when such problems occur, consumers become victims in the middle of the season. Participants also stated that because of the absence of government supports and subsidies, households and private consumers facing abnormal costs of converting their already installed system to be compatible with pellet fuel. However, they also indicated that although pellet consumption is very low comparing to especially European countries, the pellet fuel is a promising energy source for households with its features.

### 4.3.4. Artisan/Traders

In terms of profitability of pellet fuel for its traders, 88% of the participants felt positively and the results are shown in the Figure 54 below.

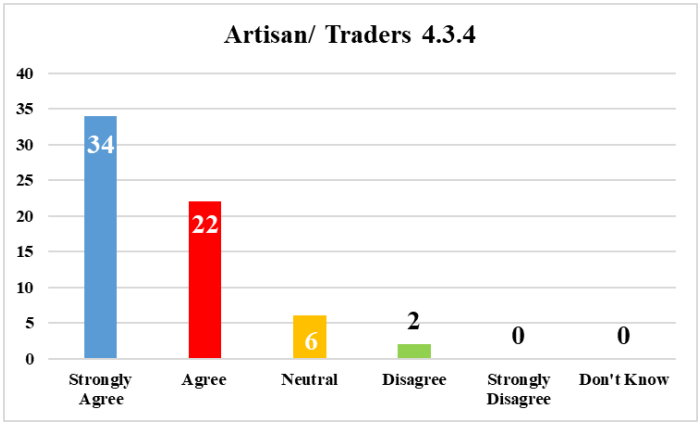



**Figure 54.** Participants Assessment About the Profitability of Artisan/Traders

Artisans ("Esnaf" in Turkish) and traders are classified as shops, importers, dealers and retailers of the pellet fuel. In Turkey, rather than selling a single product, they operate like a solid fuel dealer. In fact, they have the most valuable information about the industry together with the producers for the current status of pellet fuel in the commercial market. They try to determine the products they will sell and their stock amounts in the best way based on the current status of

the market. They create a product portfolio based on current consumption habits and both micro and macro-economic situations. Among the tradesmen, there are those who only sell to small-scale (private households) consumers, and there are also those who target all segments, including large-scale consumers. Pellet fuel traders noted that pellet fuel is low-margin profitable commodity for them yet still provides them with income. They also strongly drew attention to the point that the logistics and production costs of the pellet fuel are higher than it should be, wood and biomass potential of the Turkey must be utilized in order to optimize the fuel's cost which will enable higher profit margins for everybody in the supply chain eventually. A participant who is also a solid fuel trader stated that in certain far east regions pellet fuel is traded at a higher price than the country average because of its low level of supply but logistics costs are also higher than the regular rates because of the distance. So there are regions which require investments to produce pellet fuels to normalize the local pellet fuel market. Participants also put forward another advantage that the traders increase the convenience of this heavy, bulky, high volume and difficult to transport in high amounts product through the location of their shops. Traders tend to be located very near to residential centers and this is an advantage especially for household consumers. They can easily visit the shop to purchase small amounts of pellet fuel for their current needs. In this way, traders are also important to producers by facilitating the distribution and sale of their products, yet producers noted that they sell under the actual retail price to the traders and this lowers their unit profit margin but making them to earn from selling higher quantities reaching a version of scale economy.

### 4.3.5. Small-Scale Producers (Working with a Capacity Below 1000 tons/year)

Although most of the participants thought it to be profitable for small-scale producers, unlike other categories, almost 30% of the participants gave either a neutral or negative answer about the profitability of the sector for small-scale

producers. Participants were also explained the reasons that they gave their opinions different from other categories. The distribution of the answers given according to the scale is shown in the Figure 55 below.

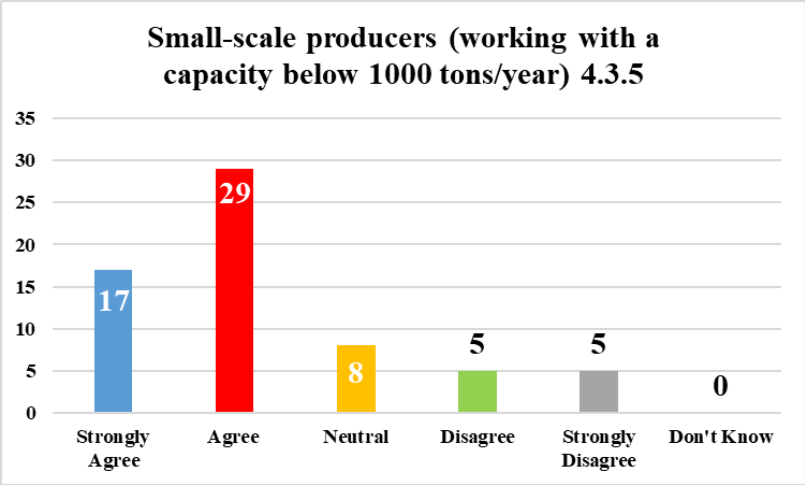



**Figure 55.** Participants Assessment About the Profitability of Small-Scale Producers

Participants who are also producers have stated that pellet fuel production requires a significant amount of initial capital to begin operation. Due to the high amount of capital required, entrepreneurs/investors tend to join forces to build a business partnership. However, producers also indicated that the pellet production is a low profit margin business and combined with a small volume of production, already divided income lefts partners unsatisfied. Same applies with single owner production facilities, the amount of production is not enough against the capital and effort put forward for the entire operation. Based on the current situation, it does not appear to be a very profitable industry for small-scale producers due to non-standard high priced raw materials, high labor and electricity inputs, and high logistics costs in the supply chain.

### 4.3.6. Large-Scale Producers (Working with a Capacity of Over 1000 tons/year)

Unlike small-scale producers, the overwhelming majority of respondents clearly concluded that the pellet fuel industry is a profitable sector for large-scale producers. They gave negative responses as little as 5%. The distribution of answers is illustrated in the Figure 56 below.

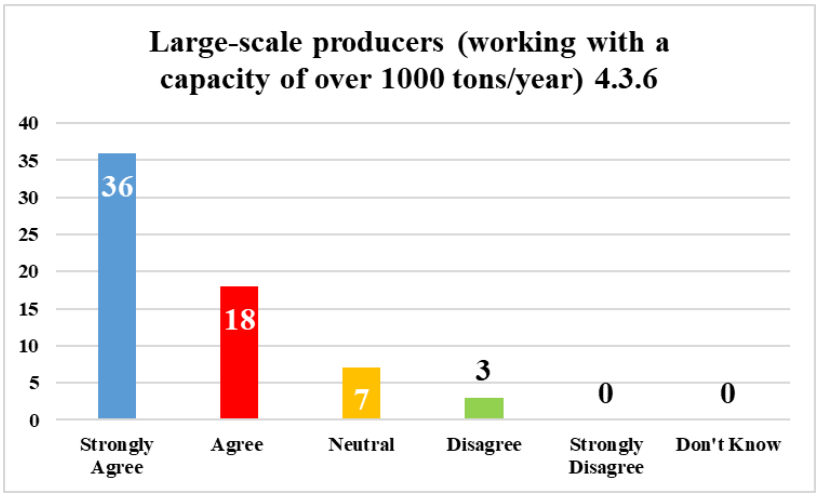



**Figure 56.** Participants Assessment About the Profitability of Large-Scale Producers

Large-scale producers generally consist of companies that can access large amounts of raw materials. Companies that can access high-quality raw materials in high quantities have well established their production process and can produce high amounts per year. These companies generally operate in sectors such as wood, agriculture, etc. as their main business and use materials such as forest waste, wood, biomass, which are by-products of these works, as raw materials in pellet fuel production. In addition, companies that have forest resources or purchase allocated forest assets from the tenders of the General Directorate of Forestry can be competitive in the field of pellet fuel and reach high production amounts. For these producers, the unit profit margin and volume of sales are higher than the small-scale producers. Large-scale producers are also able to

compete in terms of logistics since they tend to already own vehicles for logistics matters, so they do not need to hire external resources for that aim. Participants indicated that large-scale producers tend to prioritize overseas markets than the domestic market, in the domestic market, they target large-scale corporate consumers or traders with large distribution networks. Small size private household consumers can reach their products through traders, and the product is much more expensive than the wholesale price, since the logistics cost and dealer profit are on the product until it reaches the household consumers. Another important aspect is that; large-scale producer's consumer base usually already has heating systems compatible with the pellet fuel. However, the majority of household consumers lack compatible devices and large-scale pellet producers do not take any concrete actions on this subject. It is important that the big players in the industry must take initiatives for the future of the pellet fuel.

## 4.4. Participants' Future Perspectives About the Turkish Pellet Fuel Industry

In this section of the survey study the participants were asked to respond questions and state their opinions regarding the future of the Turkish pellet fuel industry. Results are given and discussed in the following subsections.

### 4.4.1. During the Next 5-10 Years in Turkey, How Can the Domestic Demand of the Pellet Fuels Can be Met?

The participants were asked about the methods and options to meet the increasing need for pellet fuel in the domestic market in Turkey over the next 5-10 years. The overwhelming majority of the participants have chosen that increasing the domestic production as the best option to meet near future demand. The pie chart illustrating the distribution of the responses is given in the Figure 57 below.

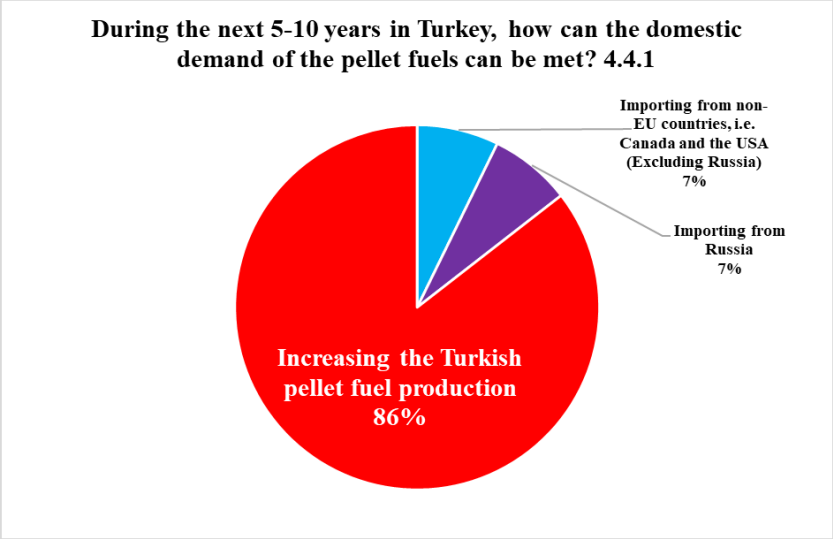



**Figure 57.** Participants Preferences Regarding Meeting the Domestic Demand in the Next 5-10 Years

Participants were asked to mark one or more options for this question, unlike other questions. As mentioned in the previous sections, Russia amongst the leading countries exporting coal to Turkey, thus people in the solid fuel industry are highly recognized with Russian solid fuels. Participants also mentioned this situation by their opinions, the domestic market is highly familiar with Russian coal and importing another solid fuel from Russia might be an option to meet the demand. One participant who is also a fuel trader stated that he is already importing Russian coal to sell in the domestic market and he can easily use his connections to also import pellet fuel to Turkey. The same situation applies also to option of importing pellet fuel from non-EU countries such as USA, Canada, Australia and etc. Industry players tend to follow their habits about this issue. Regarding the most popular option, increasing the pellet fuel production of Turkey, participants indicated that it is crucial for the country. Nearly all of the participants are optimistic about the Turkish pellet fuel production and they clearly stated that Turkey has all the infrastructure and capacity necessary for the production of large quantities of pellet fuel. Processes should only be improved with the directives and regulations of the state, the current source of raw materials should be streamlined, the purchase incentives should be provided by

the state as the product is a renewable energy source, heating systems compatible with the product should become widespread and the awareness of the product should be increased. These aforementioned stages are steps that require time and work. When these actions are taken, pellet fuel will develop considerably in the domestic market and the appropriate environment will be ready to be competitive in the foreign market for the Turkish pellet fuel industry.

### 4.4.2. Participants' Opinions About the Expectations for the Next 5-10 Years of the Turkish Pellet Fuel Industry (in%)

91% of the participants are confident that the future of the Turkish pellet fuel industry is promising, they voted for either significant growth or growth options. A small 9% of the participants are expecting stagnation for the future. The pie chart illustrating the distribution of the responses is given in the Figure 58 below.

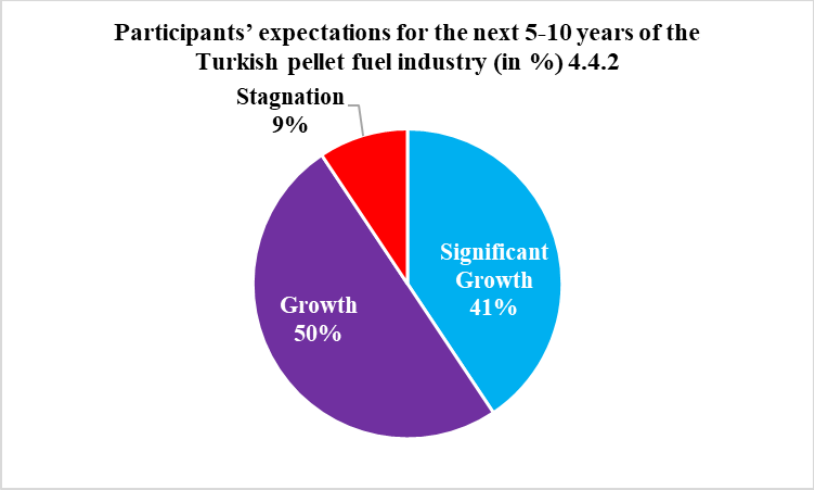



**Figure 58.** Participants Perspectives About the Industry's Status for the Next 5-10 Years

The 9% of participants answered stagnation for the future of the industry are comprised of researcher, academician, executive of a public economic organization, household consumer and a pellet production machine company executive. Academician noted that the supply of sustainable and affordable raw

material is the most crucial subject against the development of the industry, and without solving this issue the industry will face stagnation, not growth. The pellet machinery company executive indicated that the pellet fuel must be recognized by everyone and the industry agents must work to increase the awareness of pellet fuel, which will enable the industries growth. One researcher who felt that the industry will face with stagnation stated that with the current depreciation of the Turkish Lira and high amount of consumption in the Europe, the industry should concentrate its efforts towards exporting pellet fuel to Europe. If it can manage to export the Turkish pellet fuel, then the industry can achieve significant growth. Participants who felt that the industry will experience a significant growth or a growth drew attention to a point that the industry must take certain actions which are mentioned in the section 4.4.1, and then the industry can develop to become able to compete in the international arena. Thanks to the steps to be taken in the domestic market, the industry can grow and mature within 5-10 years. When the industry is steadily settled in the domestic market, the Turkish pellet fuel industry thus become competitive in the international market and Turkish pellet producers can gain a large market share in the global pellet fuel trade. For this aim, public and private sectors should act together in a harmony, and the effort must be supported through research conducted by academicians and researchers. Such coordination has the potential to bring success to the industry. To sum up, Turkish pellet fuel industry is highly promising and has the potential to become one of the largest producers and consumers in the Eurasia region. Producers are optimistic and they are planning to increase their production volume to meet the domestic demand, also investors are highly interested to be part of this industry since the industry is still at the early stages of its life cycle.

# CHAPTER 5

# CONCLUSION

Pellet fuel is a secret and significant renewable energy potential for Turkey and its future energy mix. Being compatible with the Turkey's renewable energy targets, this solid biofuel has competitive features against its rivals including its heating qualifications, its convenient nature compared to raw biomass fuels in terms of handling, storage and transportation, its cleanness with less soot, slag and ash when burnt, its environmental benefits compared to its fossil fuel counterparts in wide usage, its raw material sources being from forest and biomass wastes which are in large amounts in Turkey and its simply being a clean and sustainable energy source for a country which is importing a significant amount of energy each and every year.

Accordingly, pellet market is developing more and becoming a stable energy source in the global energy markets. Most importantly, in Europe, the pellet fuel consumption is increasing every year and the fuel is positioning as a leading biofuel. In the current situation, the majority of pellet fuels produced in Turkey are for the domestic market. Even though Turkey has a great potential for raw material, pellet fuel industry is at its early stages and it still requires further investment, both to the production side and the heating systems side, thus we can state that currently pellet fuel has a small share in the Turkish renewable energy mix. Yet, Turkey is required to utilize its every potential renewable energy source to reach supplying 30% of its energy needs from renewable sources by the year 2023.

As a result, from the participants' responses, absence of government supports, underdeveloped logistics, nonstandard and irregularity in raw material supply,

incompatibility of currently installed heating systems and competition with other fuels are the major challenges against the development of the Turkish pellet fuel industry. Nevertheless, due to the participants' possible seek for self-interest and them being self-selected participants and other limitations from the survey methods, we can say that the results are not definitive but indicative. The survey results further indicate that the pellet fuels are more directed to both large and small-scale corporate consumers due to their high amount of consumption and having relatively more compatible already installed heating systems. However, it is still promising for household consumption depending on the future spread of service for installment and maintenance. Turkish government should facilitate the licensing and permit processes of pellet fuel producers to make it more convenient. It should provide incentives for pellet fuel consumers. Renewable energy sources such as pellet fuels and fossil fuels should not be taxed in the same way, the legislation and the policies should be reviewed.

This studies results and discussions are permitted to be utilized by decision makers in both the Turkish and global pellet fuel industries. The results are compelling and credible for industry players, researchers, academics, policy makers and government officials. The method for this studies research can be applied to both micro and macro pellet fuel markets. In the section 3.1 the limitations of both the survey method in general and for this particular study were mentioned. These limitations can be eliminated in the further research projects through concentrating on singular issues of the pellet fuel industry. In addition, matters regarding different disciplines under business research such as marketing can be derived as potential future research topics. Future studies on this industry must elaborate the methods to increase the awareness of the pellet fuel, possible solutions for problems regarding logistics, advices for future policies specially to enhance its consumption by primarily private household consumers, and utilizing national wood and biomass assets combined with exchange rate advantage to become competitive in the international pellet market.

## REFERENCES


1. GDP ranking (GDP) | Data Catalog, August 20, 2010. https://datacatalog.worldbank.org/dataset/gdp-ranking, Accessed April 10, 2021.

2. Enerji Görünümü, 2020, https://www.tskb.com.tr/i/assets/document/pdf/enerji-sektor-gorunumu-2020.pdf, Accessed April 10, 2021.

3. Turkey Energy Outlook, 2020, https://www.mmo.org.tr/sites/default/files/gonderi_dosya_ekleri/TURKEY%20ENERGY%20OUTLOOK_%202020_%2813.7.2020_A%29.pdf, Accessed April 21, 2021.

4. Türkiye-AB İlişkilerinin Tarihçesi. Accessed April 23, 2021. https://www.ab.gov.tr/turkiye-ab-iliskilerinin-tarihcesi_111.html.

5. The European Parliament and of The Council. 2009. the promotion of the use of energy from renewable source. Directive 2009/28/EC. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:en:PDF

6. Global Forest Resources Assesment Report, 2020, http://www.fao.org/forest-resources-assessment/2020/en/, Accessed April 21, 2021.

7. http://www.peletandic.com/pellet.htm. Accessed March 21, 2021. http://www.peletandic.com/pellet.htm.

8. "Ankamass Pelet." Ankamass Pelet – Güven veren yakıt, March 8, 2021. http://www.ankamasspelet.com/.

9. Saraçoğlu, N. 2017.Küresel İklim Değişimi, Biyoenerji, Enerji Ormancılığı ve Yenilenebilir Enerji Kaynakları, Efil Yayınevi, 2. Baskı, ISBN : 978-605-2294-08-6, 696s., Ankara.

10. Karawandy J. (2007) Pellet Production From Sawmill Residue : a saskatchewen Perspective. Forest Development Fund Project Final Report 2006/07, For/ntek Canada Corporation.

11. http://www.cu.edu.tr/insanlar/mceker/avrupabirligihukuku/anayasasininilkeleri.doc. Accessed April 21, 2021. http://www.cu.edu.tr/insanlar/mceker/avrupabirligihukuku/anayasasininilkeleri.doc .

12. Wood Pellet Association of Canada, 2013. Ontario FuelPellet Opportunities. Presentation for ONTARİO Ministry of Energy, February 5, 2013, Toronto, ON.

13. Bioenergy, 2010. AEBIOM Ibeeco European Bioenergy Conference. Brussels, Bioenergy Int. No: 46, 5-2010, 17, The Bioenergy INT. Stockholm.

14. Voegele, E. 2013. Annual EU Report Projects Increased Pellet, Biogas Production. Biomass Magazine, August 23, 2013.

15. "About Us." Bioenergy International. Accessed April 25, 2021. https://bioenergyinternational.com/about-us.

16. Report Pellet, Bioenergy Europe, 2019, https://epc.bioenergyeurope.org/wp-content/uploads/2020/02/SR19_Pellet_final-web-1.pdf, Accessed April 21, 2021.

17. Mizuta, A. 2010. Views on Pellets From A Global Company, Bioenergy International, No: 44, 3-2010, p. 11.

18. Bioenergy, 2011, https://www.ieabioenergy.com/wp-content/uploads/2013/10/IEA-Bioenergy-2011-Annual-Report.pdf, Accessed April 20, 2021.

19. Edwardes-Evans, H. 2014. Germany's RWE "Very Positive" About UK Lynemouth Coal-to-Biomass Conversion. Canadian Biomass Magazine 17 January 2014.

20. Erskine, B. 2014. N.S. Wood Pellets Bound to Europe. Canadian Biomass Magazine, 3.3.2014

21. Schaps, K. 2013. EU Biomass Needs to Triple by 2020, 66% Imported. Reuters, 11.01.2013.

22. Çelik, B. 2011. Türkiye'de Pelet Üretimi ve Uygulanabilirliği. Bartın Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Bartın.

23. Schütte, A., 2006. Holzpellets – Komfortabel, effizient, zukunftssicher. Bundesministreium für Ernaehrung, Landwirtschaft und Verbraucherschutz, herausgeber: Fachagentur Nachwachsende Rıhstoffe e.V. (FNR), Gülzow.

24. Alakangas, E., 2002. Wood Pellets in Finland. Technology, Economy and Market. Energy, Environment, Sustainable Development. OPET Report 5, Jyvaskyla, VTT Processes, 2002.

25. Lam, Pak Sui Wilson & Tooyserkani, Zahra & Naimi, Ladan & Sokhansanj, Shahab. (2013). Pretreatment and Pelletization of Woody Biomass. 10.1007/978-3-642-32735-3_5.

26. Alakangas, E., 2000. VTT Research Notes 2045. VTT Technical Research Centre of Finland, Espoo

27. "Vernetzte Energiewelt." Smart Renewables | SP - Solar Promotion. Accessed April 26, 2021. https://www.solarpromotion.com/smart-renewables/.

28. "Erste Verordnung Zur Durchführung Des Bundes-Immissionsschutzgesetzes *)." 1. BImSchV - nichtamtliches Inhaltsverzeichnis. Accessed April 28, 2021. https://www.gesetze-im-internet.de/bimschv_1_2010/.

29. Hansen, H., 2006. Holzpellets. Komfortabel, Effizient, Zukunftsicher. Bundesministerium für Ernaehrung, Landwirtschaft und Verbraucherschutz, 33 S., Gülzow.

30. Samuelson, W. F., Marks, S. G., & Zagorsky, J. L. (2021). Managerial economics. Wiley

31. TÜGĐAD, 2004. Türkiye'nin Enerji Sorunları ve Çözüm Önerileri, Ajans-Türk Basın ve Basım A.Ş., Batıkent, Ankara, Accessed April 14, 2021.

32. Orman Genel Müdürlüğü'nde Biyoenerji Konusunda Yapılan Çalışmalar, 2009, www.ogm.gov.tr, Accessed April 14, 2021.

33. Karayilmazlar, S., Saraçoğlu, N., Çabuk, Y., Kurt, R. (2011). Biyokütlenin Türkiye'de Enerji Üretiminde Değerlendirilmesi. Bartın Orman Fakültesi Dergisi, 19(13).

34. Saraçoğlu, N., 2001. Türkiye'nin Uluslararası Enerji Politikalarında Enerji Ormancılıgının Önemi, 1. Ulusal Ormancılık Kongresi, 19-20 Mart 2001, 183-194, Ankara.

35. Konukçu, M., 1998. Statistical Profile of Turkish Forestry, T.R Prime Ministry, State Planning Organization, June 1998, 44 p., Ankara.

36. Saraçoğlu, N., 2010. Küresel Đklim Değişimi, Biyoenerji ve Enerji Ormancılığı. Efil Yayınevi, 300 S., Ankara.

37. Doğan, M., 2000. Enerji Kaynakları, Çevre Sorunları ve Çevre Dostu Alternatif Enerji Kaynakları, Standard Dergisi, 39/468 s.28-36.

38. Peng J. H., Bi H. T., Sokhansanj S., Lim J. C. & Melin S. (2010) An Economical and Market Analysis of Canadian Wood Pellets, International Journal of Green Energy, 7:2, 128-142, DOI: 10.1080/15435071003673518

39. Trømborg, Erik, Tapio Ranta, Jörg Schweinle, Birger Solberg, Geir Skjevrak, and Douglas G. Tiffany. “Economic Sustainability for Wood Pellets Production – A Comparative Study between Finland, Germany, Norway, Sweden and the US.” Biomass and Bioenergy 57 (2013): 68–77. https://doi.org/10.1016/j.biombioe.2013.01.030.

40. Kristöfel, Christa, Christoph Strasser, Erwin Schmid, and Ulrich B. Morawetz. “The Wood Pellet Market in Austria: A Structural Market Model Analysis.” Energy Policy 88 (2016): 402–12. https://doi.org/10.1016/j.enpol.2015.10.039.

41. Proskurina, S., E. Alakangas, J. Heinimö, M. Mikkilä and E. Vakkilainen. “A survey analysis of the wood pellet industry in Finland: Future perspectives.” Energy 118 (2017): 692-704.

42. Küsek, Gürsel, Cahit Güngör, Hüseyin Öztürk, and Şinasi Akdemir. “Tarımsal Artıklardan Biyopelet Üretimi.” U. Ü. ZİRAAT FAKÜLTESİ DERGİSİ 29, no. 2 (2015): 137–45.

43. Sungur, Bilal, Bahattin Topaloğlu, and Mustafa Özbey. “Pelet Yakıtlı Yakma Sistemlerinin Isıl Performans Ve Emisyon Açısından İncelenmesi .” Engineer and Machinery 59, no. 693 (2018): 64–84.

44. Nardi PM. Doing survey research. A guide to quantitative methods. third ed. USA: Paradigm Publishers; 2014.

45. Hair, J. J., Black, W.C., Babin, B. J., & Anderson, R. E. (2014). Multivariate data analysis. New Jersey: Pearson.

46. GHAURI, P. & GRONHAUG, K. 2005. Research Methods in Business Studies, Harlow, FT/Prentice Hall.

47. FIELD, A. P. 2005. Discovering Statistics Using SPSS, Sage Publications Inc.

48. Leslie R. Odom & James R. Morrow, Jr. (2006) What's this r? A Correlational Approach to Explaining Validity, Reliability and

Objectivity Coefficients, Measurement in Physical Education and Exercise Science, 10:2, 137-145, DOI: 10.1207/s15327841mpee1002_5

49. Tritschler, K. (2000). Barrow & McGee's practical measurement and assessment (5th ed.). Philadelphia: Lippincott Williams & Wilkins.

50. http://tucaum.ankara.edu.tr/wpcontent/uploads/sites/280/2015/08/semp4_9.pdf . Accessed March 27, 2021. http://tucaum.ankara.edu.tr/wp-content/uploads/sites/280/2015/08/semp4_9.pdf .

51. EPDK Dogalgaz Piyasasi Sektor Raporu, 2018, https://www.epdk.gov.tr/Detay/Icerik/3-0-94/dogal-gazyillik-sektor-raporu, Accessed April 16, 2021.

52. Sabancı, Alaettin, Mehmet Atal, and Abdülkadir Yaşar. "Türkiye'de Biyodizel Kullanım Ve Olanakları." Tarım Makinaları Bilimi Dergisi 2, no. 1 (2006): 33–39.

53. den Herder M, Kolstrom M, Lindner M, Suominen T, Tuomasjukka D, € Pekkanen M. Sustainability impact assessment on the production and use of different wood and fossil fuels employed for energy production in North Karelia, Finland. Energies 2012;5:4870e91.

54. Gemtos, T.A., Tsiricoglou, T. 1999. Harvesting of cotton residue for energy production. Biomass and Bioenergy 16 (1), 51-59.

55. Kömür Fiyatları. Accessed April 26, 2021. https://www.tki.gov.tr/tr-TR/komur-fiyatlari.

56. Scholz, V., Berg, W., Kaulfuss, P. 1998. Energy Balance of Solid Biofuels. J. agric. Engng Res. 71 pp. 263-272.

57. Atimtay, A. T., Topal, H., "Co-Combustion of Olive Cake with Lignite Coal in a Circulating Fluidized Bed", Fuel, Vol. 83 (7- 8), pp. 859-867, 2004.

58. Dutta, A. 2007. Bio-energy, MDG's and global sustainability. A Training Workshop on Technology and Management, asian Institute of Technology, 26-28 September, Pathumthani, Thailand.

59. Türkiye Kömür İşletmeleri Kömür (Linyit) Sektör Raporu, 2018, https://www.enerjiportali.com/wp-content/uploads/2020/01/TK%C4%B0-2018-K%C3%96M%C3%9CR-L%C4%B0NY%C4%B0T-SEKT%C3%96R-RAPORU.pdf, Accessed April 21, 2021.

60. "Elektronik Veri Dağıtım Sistemi." EVDS. Accessed April 24, 2021. https://evds2.tcmb.gov.tr/index.php?%2Fevds%2FserieMarket%2F#collapse_2.

61. Kömür Analizleri. Accessed April 22, 2021. https://www.yilmazkomur.com.tr/page/komur-analizleri.

62. Kaygusuz K., 2009. Bioenergy as a clean and sustainable fuel. Energy Sources Part a Recovery Utilization and Environmental Effects, 31(12), 1069-1080.

63. Kocabas-Atakli Z.O., Okyay-Oner F., Yurum Y., 2015. Combustion characteristics of Turkish hazelnut shell biomass, lignite coal, and their respective blends via thermogravimetric analysis. Journal of Thermal Analysis and Calorimetry, 119(3), 1723-1729.

64. Shah M.A., Khan M.N.S., Kumar V., 2018. Biomass residue characterization for their potential application as biofuels. Journal of Thermal Analysis and Calorimetry, 134(3), 2137-2145.

65. Açıkalın K., 2011. Thermogravimetric analysis of walnut shell as pyrolysis feedstock. Journal of Thermal Analysis and Calorimetry, 105(1), 145-150.

66. "Enerji HARİTALARI." MTA Genel Müdürlüğü. Accessed April 26, 2021. https://www.mta.gov.tr/v3.0/hizmetler/jeotermal-harita.

67. Lionel Fontagné, Gianluca Orefice, Roberta Piermartini, Nadia Rocha, Product standards and margins of trade: Firm-level evidence, Journal of International Economics, Volume 97, Issue 1, 2015, Pages 29-44, ISSN 0022-1996, https://doi.org/10.1016/j.jinteco.2015.04.008.

68. Maskus, Keith & Otsuki, Tsunehiro & Wilson, John. (2005). The Cost of Compliance with Product Standards for Firms in Developing Countries: An Econometric Study.

69. "ÇEVRE İZİN VE LİSANS." T.C. Çevre ve Şehircilik Bakanlığı. Accessed April 26, 2021. https://csb.gov.tr/sss/cevre-izin-ve-lisans.

70. TAKIM, A., & ERSUNGUR, S. M. (2018). Türkiye'de Teşvik Sisteminin Yapisi, Sorunlari Ve Etkinliği Üzerine Bir Politika Önerisi: Tek Bir Uygulamaci Kuruluş Sorunlari Çözer Mi? [Abstract]. Atatürk Üniversitesi İktisadi Ve İdari Bilimler Dergisi, 3(32).

71. T.C. Resmî Gazete. Accessed April 15, 2021. https://www.resmigazete.gov.tr/eskiler/2021/03/20210306-9.htm.

72. "2020 Global Pellet Markets Outlook." Canadian Biomass Magazine, January 22, 2020. https://www.canadianbiomassmagazine.ca/2020-global-pellet-markets-outlook/.

73. Pellet Report 2019, 2019, https://epc.bioenergyeurope.org/wp-content/uploads/2020/02/SR19_Pellet_final-web-1.pdf, Accessed April 25, 2021.

74. "World Pellet Map." European Pellet Council. Accessed May 2, 2021. https://epc.bioenergyeurope.org/about-pellets/pellets-statistics/world-pellet-map/.

75. "EPC Members." European Pellet Council. Accessed May 2, 2021. https://epc.bioenergyeurope.org/about-us/epc-members/.

76. "Producer." ENplus. Accessed May 3, 2021. https://www.enplus-pellets.eu/en-in/certifications-en-in/producer-en-in.html.

77. “Elektronik Veri Dağıtım Sistemi.” EVDS. Accessed May 4, 2021. https://evds2.tcmb.gov.tr/index.php?%2Fevds%2FserieMarket%2F#collapse_2.

78. https://tuikweb.tuik.gov.tr/PreHaberBultenleri.do?id=37443. Accessed May 3, 2021. https://tuikweb.tuik.gov.tr/PreHaberBultenleri.do?id=37443.

79. Richard F. Doner & Ben Ross Schneider (2000) Business Associations and Economic Development: Why Some Associations Contribute More Than Others, Business and Politics, 2:3, 261-288, DOI: 10.1080/713991579

80. “Largest Countries in the World (by Area).” Worldometer. Accessed May 11, 2021. https://www.worldometers.info/geography/largest-countries-in-the-world/.

81. Pre-Accession Assistance Rural Development (IPARD) Programme, https://ec.europa.eu/info/food-farming-fisheries/farming/international-cooperation/enlargement/pre-accession-assistance/pdf, 2014-2023, Accessed May 10, 2021.

82. Ülkemizde Proje Desteği Sağlayan Kurum ve Kuruluşlar, 2019, https://bakkakutuphane.org/upload/dokumandosya/proje_destek_rehberi.pdf, Accessed May 21, 2021.

83. Özel Sektör AR-GE ve Yenilik Destekleri, 2013, https://www.tubitak.gov.tr/sites/default/files/teydeb_kitapcik_190413.pdf ,Accessed May 21, 2021.

84. “AR-GE Ve İnovasyon Destek Programı - KOSGEB T.C. Küçük Ve Orta Ölçekli İşletmeleri Geliştirme Ve Destekleme İdaresi Başkanlığı.” Accessed May 15, 2021. https://www.kosgeb.gov.tr/site/tr/genel/destekdetay/1229/arge-ve-inovasyon-destek-programi.

# APPENDICES

## A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
uearc@metu.edu.tr
www.uearc.metu.edu.tr

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

Sayı: 28620816 /

22 MART 2021

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

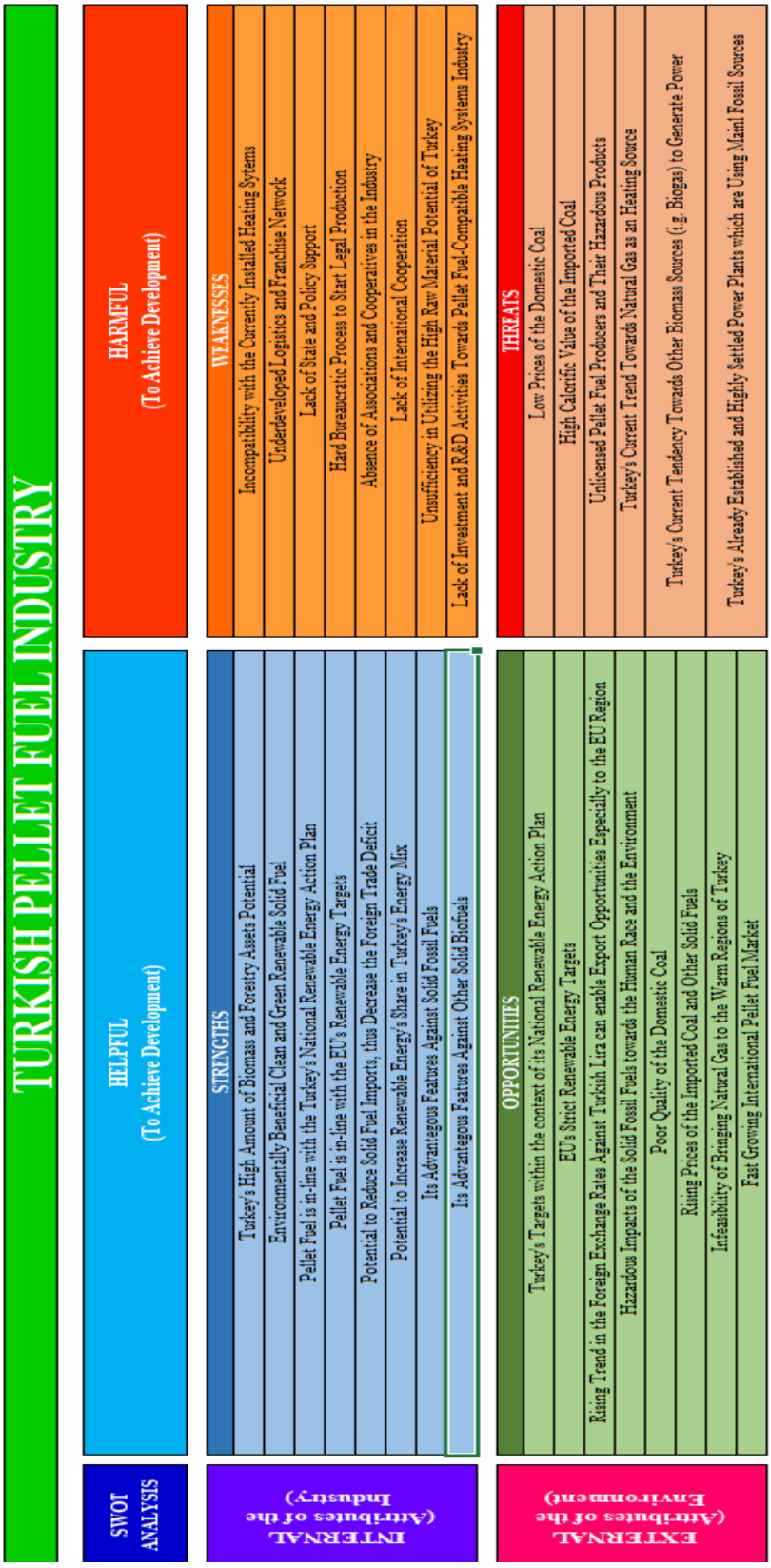
**Sayın Prof.Dr. Özlem ÖZDEMİR**

Danışmanlığını yürüttüğünüz Neşet Kutay KARACA'nın "Explaining Currents Status and Future Development of the wood Pellet İndustry in Turkey: A Survey Study" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **072-ODTU-2021** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Dr.Öğretim Üyesi Ali Emre TURGUT
İAEK Başkan Vekili

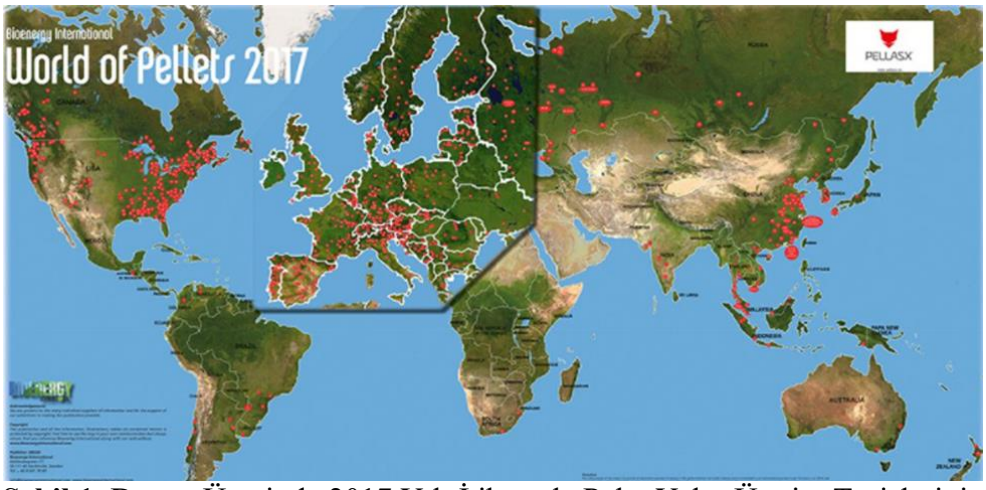
## B. SWOT ANALYSIS OF THE TURKISH PELLET FUEL INDUSTRY



## C. TURKISH SUMMARY / TÜRKÇE ÖZET

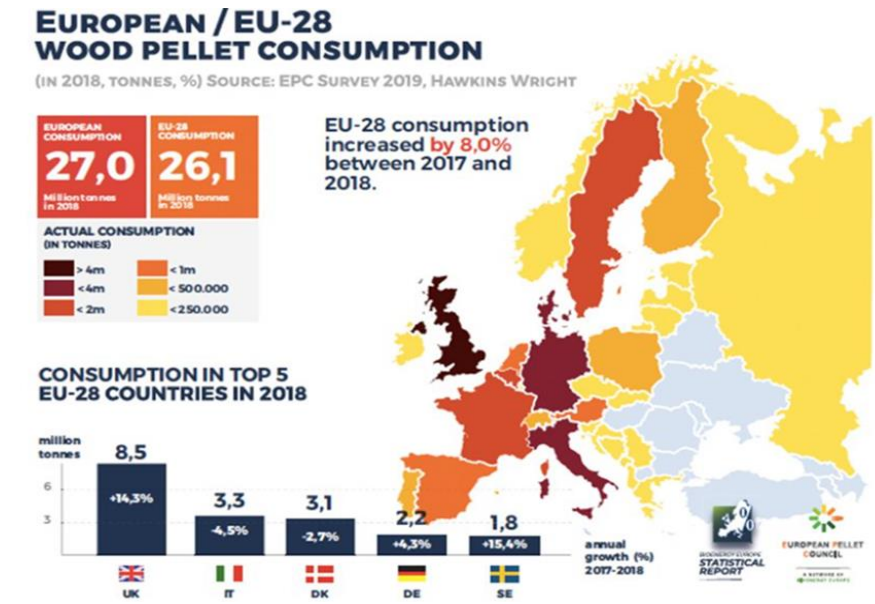
Bu tez çalışması, Türkiye pelet yakıtı endüstrisinin mevcut durumunu detaylandırmayı ve özellikle Avrupa'da gelişmiş bir endüstri olan ve Türkiye'de erken yaşam döngüsü aşamasında olan ve stratejik bir öneme sahip olan endüstrinin gelecekteki gelişiminin önündeki temel fırsatları, engelleri ve zorlukları araştırmayı amaçlamıştır.

2019 yılı itibarıyla Türkiye 22 milyon 933 bin hektar orman varlığına sahiptir ve dünya genelinde 31. Sıradadır [6]. Bu durum, Türkiye'yi potansiyel bir büyük hacimli pelet yakıt üreticisi olarak konumlandırmaktadır. USDA Dış Tarım Servisi'nin Küresel Tarım Bilgi Ağı tarafından yayınlanan rapora göre, Avrupa Birliği (AB) 2018'de yaklaşık 29 milyon ton odun pelet yakıtı tüketmiştir; bu tüketim hacmi AB'yi dünyanın en büyük pelet pazarı haline getirmektedir. Rapor, pelet yakıt talebinin 2020'de 30,8 milyon tona çıkacağını öngörmüştür. Türkiye, belirli stratejik adımların atılması halinde küresel pelet yakıtı pazarlarında daha önemli bir üretici ve tüketici olma potansiyeline sahiptir. Şekil 1'de Dünya'da 2017 yılı itibarıyla pelet yakıtı üretim tesislerinin dağılımı gösterilmiştir.

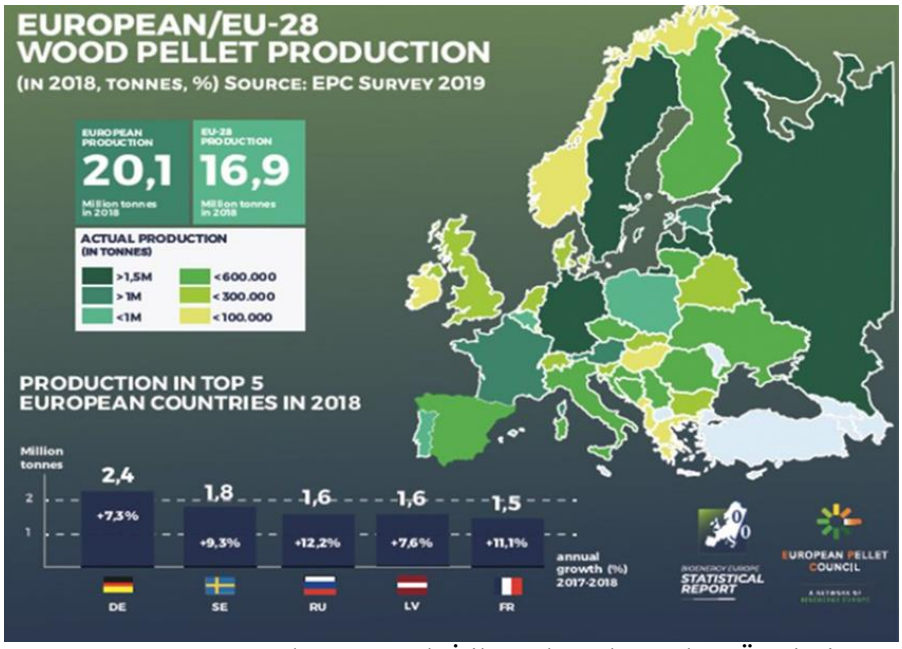



**Şekil 1.** Dünya Üzerinde 2017 Yılı İtibarıyla Pelet Yakıt Üretim Tesislerinin Dağılımı [15]

2018 yılı itibarıyla Avrupa'da pelet yakıtı tüketimi Şekil 2'de, pelet yakıtı üretimi ise Şekil 3'te gösterilmiştir.




**Şekil 2.** Avrupa'da 2018 Yılı İtibarıyla Pelet Yakıtı Tüketimi




**Şekil 3.** Avrupa'da 2018 Yılı İtibarıyla Pelet Yakıtı Üretimi

Ulusal yenilenebilir enerji eylem planı, yenilenebilir enerji hedefleri ve yüksek biyokütle potansiyeli doğrultusunda pelet yakıtı endüstrisi ülke için yüksek

potansiyele sahiptir. Biyoyakıt ve pelet yakıtı alanlarında uzman olarak kabul edilen 64 kişi ile anket çalışması yapılmıştır. Anketin amacı, sektörün şu anda karşı karşıya olduğu zorlukları ve engelleri belirlemek ve uzmanların sektörün geleceğine ilişkin beklenti ve görüşlerini anlamaktır. Politika desteği, hammadde, Avrupa Birliği uyum süreci, lojistik, çevresel faktörler, diğer katı yakıtlar ile rekabet vb. konulardaki zorluklara odaklanılmakta, bu konularda uzmanların beklentileri ve sektörün gelecek perspektifi çizilmekte ve olası senaryolar belirlenmektedir. Bu kalıplar, endüstri, genel sorunlar ve engeller ile bunların bağımlı oldukları kaynaklar için bir çerçeve sağlayarak endüstrinin geleceği için iyileştirme gerektiren alanları anlamamıza yardımcı olacaktır.

Pelet yakıtı, 6 ila 10 mm çapında ve 10 ila 50 mm uzunluğunda, küçük silindirik formda, biyokütleden ve odun talaşı, ağaç kabuğu, ağaç kabuğu, tarım ürünleri, tarım ürünlerinin sapları ve fındık, badem ve ceviz kabukları gibi malzemelerin pelet presinde preslenmesi ile üretilen organik bir katı yakıttır [7]. Ülkemizde başlıca odun talaşından üretilmekte olup, Akdeniz ve Marmara bölgelerinde prinadan da üretilmektedir. Düşük nem oranı ve yüksek yanma verimine sahip olan pelet yakıtı 4200-5000 kcal/kg ısı enerjisi üretmektedir. Isınma amaçlı fosil yakıtlara ve diğer biyokütleden üretilmiş yakıtlara karşı birçok avantajı bulunmaktadır [9]:

Pelet yakıtlar tamamen atık maddelerden üretildiği için ekonomiktir. Fosil yakıtlardan daha ucuzdurlar.

- Yenilenebilir bir enerji kaynağı sunarlar. Kendi yerli malzemelerimizden temin edilmektedir.
- Pelet yakıt kullanan ısıtma sistemleri ozon dostudur ve Kyoto Protokolü'nde belirlenen CO2 emisyonları için kabul edilebilir eşik değerlerinin oldukça altındadır. Pelet yakma sistemleri katı yakıt sistemleri arasında en temiz yanmayı sağlar.

- Pelet yakıtların taşınması oldukça kolaydır. Her ikisi de borulama yoluyla bir depoya yerleştirilmek üzere, merkezi ısıtma sistemleri için paketler halinde satın alınabilir veya tankerlerde sipariş edilebilirler.
- Ticari pelet yakıt üretimi için ağaç kesilmesine gerek yoktur. Pelet yakıtlar, orman atıklarının kullanımına izin verir. Sonuç olarak yanıcı orman atıklarının toplanması ile ormanlar da yangınlara karşı korunmaktadır.
- Yeni teknoloji pelet yakma sistemleri, düşük işletme maliyetleri ve daha iyi konfor anlamına gelen otomatik yakıt beslemesi ile donatılmıştır.
- Pelet yakıtlar, ithalat yoluyla tedarik edilmediğinde, dış ekonomilerdeki ve döviz kurlarındaki dalgalanmalardan etkilenmez ve üretim maliyetlerinde ani artışlara maruz kalmaz.
- Pelet yakıtları aşırı derecede yüksek sıcaklıklarda yanar, bu nedenle yalnızca küçük miktarlarda katı veya gazlı atıkla sonuçlanır. 18 kg'lık bir pelet yakıt torbası sadece 85 gram kül üretmektedir.
- Pelet yakıtları, oduna göre nispeten daha küçük depolama alanı gerektirir.
- Pelet yakıtları %10'dan daha az nem içerir, bu da özellikle oduna kıyasla yanma verimini iki katından fazla artırır.
- Konvansiyonel katı yakıt sistemleri bacalarda önemli miktarda kreozot üretirken, pelet yakıt sistemlerinde neredeyse hiç kreozot görülmez ve bu özellik bacasız (hermetik kazanlarda olduğu gibi) dumanın dışarı atılmasına imkân verir.
- Pelet yakıtı, yanma enerjisinin %95'inin kullanılmasına izin vererek enerji kaybını ortadan kaldırır.
- Pelet yakıtların %0,5 oranında çok az kül içeriği vardır, bu da temiz ve pratik kullanım sağlar. Bu içerik diğer yakıtlar için %10 ile %15 arasında değişmekte ve bu da enerji kayıplarını artırmaktadır.
- Pelet yakıtlar, yandıklarında zehirli gaz çıkarmadıkları için zehirlenme riski taşımazlar.
- 1 kg pelet yakıtı 5 kw enerjiye karşılık gelirken, 2 kg pelet yakıtı 1 litre akaryakıta eşdeğer enerjiyi üçte bir fiyatla üretmektedir.

- Pelet yakıtları, doğal gaza göre 4 kat daha az CO2 ve fuel oil'e göre 5 kat daha az CO2 salan çevre dostu ve temiz bir enerji kaynağıdır.
- Sanayide pelet yakıtların kullanılması hava kirliliğini önemli ölçüde azaltacak ve baca filtre sistemleri ile ilişkili yüksek maliyetleri ortadan kaldıracaktır. Bu özellikler üreticilere ekonomik avantajlar sunacaktır.
- Pelet yakıt üretimi yoluyla biyokütle yoğunlaştırıldığında, depolama ve nakliye daha az maliyetli ve daha uygun maliyetli hale gelir.

Pelet yakıtı endüstrisi Türkiye'de henüz emekleme aşamasındadır. Türkiye'de resmi olarak pelet yakıt üreticisi olarak faaliyet gösteren az sayıda - yaklaşık 30- üretici bulunmaktadır. Bu firmalar pelet yakıtı üretmek için genellikle odunu - genellikle çam ağacını ve aynı zamanda diğer ağaç türlerini- kullanır, ancak özellikle Ege ve Akdeniz Bölgelerinde hammadde olarak pirina kullanan üreticiler vardır. Şekil 4, Türkiye'deki üreticilerin yoğunluklarının bölgelere göre dağılımını göstermektedir.


**Şekil 4.** Türkiye'de Pelet Yakıtı Üreticilerinin Şehirlere Göre Dağılım Haritası

Üreticiler, hammadde kaynaklarına ve ulaşım yollarına yakınlıklarına göre konumlarını belirlemektedirler. Örneğin Ankara'da palet üreticileri, mobilyacılar, ağaç işleme fabrikaları gibi çok sayıda işletme bulunmaktadır. Benzer şekilde, Karadeniz Bölgesi de orman varlığı açısından zengindir ve bu nedenle pelet yakıt üretimi için önemli bir kaynak sağlamaktadır. Ege ve Akdeniz bölgelerinde

çok sayıda zeytin ağacı ve zeytinyağı fabrikası vardır, bu nedenle pelet yakıtı için hammadde kaynağı olan çok miktarda zeytin prinası sağlamaktadır. Resmi pelet yakıt üreticilerine ek olarak, Türkiye'nin hemen her bölgesinde önemli miktarda kaçak pelet yakıt üreticisi bulunmaktadır. Bu yasadışı üreticiler, pelet yakıtı üretmek için genellikle MDF ve sunta talaşlarını odun tozuyla karıştırmaktadır. MDF ve suntalar, ahşap ve diğer biyokütle kaynaklarına göre maliyet avantajlarına sahiptir, ancak yandıklarında tehlikeli hale gelen yapıştırıcı ve çeşitli kimyasallar içerirler. Bu durum Türk pelet yakıt sektörünün itibarını zedelemektedir. Türk pelet yakıtı endüstrisinin türü en iyi şekilde, çok sayıda firmanın benzer ancak birbirinin aynısı olmayan ürünler ürettiği, çok sayıda tüketici tarafından tüketildiği ve bir üreticinin eylemlerinin rakipleri üzerinde doğrudan bir etkiye sahip olmadığı tekelci bir rekabet olarak tanımlanabilir. [30]. Türkiye'nin hemen her bölgesinde resmi ve gayri resmi pelet yakıt üreticileri bulunmaktadır. Benzer şekilde, tüketicilerin miktarı da kaydadeğer bir miktardadır. Farklı üreticiler tarafından üretilen ürünler hemen hemen aynıdır; konum, boyut ve hammadde karışımı bakımından farklılık gösterir, ancak hammadde genellikle ahşaptan veya diğer tarımsal biyokütleden elde edilmektedir.

Bu tez çalışması, Türkiye pelet yakıt endüstrisinin son durumunu ortaya koymayı ve gelişiminin önündeki zorlukları ve geleceğine ilişkin perspektifleri daha da detaylandırmayı amaçlamış ve böylece politika ve endüstriyel uygulamalarla ilgili güncel konularda öneriler ortaya koymayı hedeflemiştir. Pelet yakıtı sektörü, batı ülkelerinde oldukça gelişmiş bir sektördür ve ekonomik başarı ve enerji karışımında daha yüksek oranda yenilenebilir enerji kaynaklarına ulaşma açısından Türkiye için büyük bir potansiyel taşımaktadır. Özellikle batı ülkelerinde önemli bir konu olduğu için akademi bu konuya ağırlık vermiştir.

Kanada'da gerçekleştirilen bir çalışmada, Kanada'da karbonize edilmiş pelet yakıtlarının maliyetini öngörerek ve bunu geleneksel pelet yakıtlarının maliyetiyle karşılaştırarak pelet yakıt pazarının bugünkü durumunu ve geleceği

incelenmiştir. Çalışmanın sonucu, Avrupa'nın yenilenebilir enerjiye yönelik teşvikleri ve artan fosil yakıt maliyetleri nedeniyle pelet yakıt endüstrisinin yükselişte olduğunu göstermiştir [38].

Norveç, ABD, İsveç, Almanya ve Finlandiya ülkeleri arasında ekonomik olarak sürdürülebilir pelet yakıt üretimi üzerine karşılaştırmalı bir çalışma yapılmıştır. Çalışma, kuru odun artıklarını kullanan küçük ölçekli pelet yakıt üretim tesisi ile hem kuru hem de yaş odunsu artıkları kullanan büyük ölçekli pelet yakıt üretim tesislerini üretim girdileri açısından karşılaştırmıştır. Çalışma, pelet yakıt üretiminin geleceğinin ıslak hammaddelere, örneğin yuvarlak odun ve nemli talaş, bağlı olacağına ulaşmıştır [39].

Avusturya'da yapılan bir başka çalışma, Avrupa pelet yakıt pazarının karakterini vurgulamış, Avusturya'da pelet yakıtları için bir pazar modelini, öngörülen arz ve talep fiyat esnekliklerini ortaya çıkarmış ve kısa vadede pelet yakıtları için talebin esnek olmadığı, pelet yakıtları için arzın ise esnek olduğu sonucuna ulaşmıştır. Ayrıca, talebi canlandıracak politikaların pelet yakıt fiyatlarında ve hammadde maliyetlerinde artışa neden olacağı sonucuna varmıştır [40].

Odun pelet yakıt endüstrisinin mevcut genel görünümü, gelecekteki gelişimi için karşı karşıya olduğu başlıca fırsatlar ve zorluklar hakkında ayrıntılı bir çalışma, 2017 yılında Finlandiya için gerçekleştirilmiştir. Çalışma, yaklaşık 60 pelet yakıt uzmanından ayrıntılı bir anket çalışması aracılığıyla veriler toplamıştır ve bunları detaylandırmıştır. Sonuç olarak, politika desteğinin olmaması ve uygun düzenlemelerin eksikliği Finlandiya pelet yakıt endüstrisinin gelişmesinin önündeki başlıca faktörlerdir. Bununla birlikte, hammadde maliyetleri ve diğer katı yakıtlarla rekabet gibi zorluklara ağırlık verilirse sektörün gelişme gösterebileceği vurgulanmıştır. Etkili politika destekleri ve düzenlemeler için pratik bir çerçeve oluşturulmasının, doğrudan rakip endüstrilere karşı rekabet avantajı elde etmek için esas olduğu sonucuna varılmıştır [41].

Türkiye örneği için, pelet yakıt endüstrisinin mevcut görünümüne ve gelecekteki gelişiminin parametrelerine ilişkin bir araştırma çalışması yapılmamıştır. Odun ve tarımsal biyokütlenin pelet yakıtlara dönüştürülmesine ilişkin teknik özellikleri, üretim teknikleri ve yöntemleri kapsamında pelet yakıtla ilgili çalışmalar yapılmıştır [42, 43].

Yukarıda bahsedildiği gibi özellikle batı ülkelerinde benzer çalışmalar yapılmıştır. Ayrıca, pelet yakıtı endüstrisi ile ilgili olarak batı ülkelerindeki birlikler, dernekler ve araştırma kurumları tarafından periyodik olarak ayrıntılı endüstri raporları ve sektör trendleri yayınlanmaktadır. Türkiye'de bu konuda bir çalışma ve araştırma eksikliği bulunmaktadır. Bu çalışma, bu alandaki Avrupalı muadilleri doğrultusunda Türkiye için bu boşluğu doldurmayı amaçlamıştır.

Bu tez çalışmasında nitel bir araştırma yöntemi olan anket kullanılmıştır. Tez çalışması, pelet yakıtı uzmanlarının bakış açılarına ilişkin bir anketin sonuçlarıyla birleştirilen literatür incelemeleri aracılığıyla Türk pelet yakıtı endüstrisinin mevcut durumu üzerine inşa edilmiştir. Anketin amacı, Türk pelet yakıt endüstrisinin mevcut durumu ve gelecekteki gelişimi hakkında veri toplamaktır. Anket, Google Dokümanlar aracılığıyla internet kullanılarak yapılmış ve Türk pelet yakıt endüstrisi ile yüksek oranda ilişkili olan farklı meslek gruplarını temsil eden uzmanlara gönderilmiştir.

Sektörün gelişimini teşvik eden veya engelleyen faktörlerin araştırılması, sektörden en fazla kârı kimlerin (üreticiler, tüketiciler veya tüccarlar) elde ettiği ve Türkiye'de sektörün geleceği için uzmanların perspektiflerinin neler olduğu araştırılarak sektörün ana itici güçleri ortaya çıkarılmıştır. Anketin katılımcılara gönderimi 26 Mart 2021 tarihinde başlamış olup, anket 17 Nisan 2021 tarihine kadar aktif kalmıştır. Anketi alan ve görüntüleyen toplam uzman sayısı, Türk pelet üreticileri, tüketiciler, tüccarlar, akademisyenler, araştırmacılar ve STK üyeleri olmak üzere toplamda 64 kişidir. Anket, Türk uzmanlar için özel olarak hazırlanmış olup dört farklı bölümden ve üçü açık uçlu olmak üzere otuz yedi

sorudan oluşmaktadır. Katılımcılardan yaşadıkları ve çalıştıkları şehir ile birlikte hangi kurum/kuruluştan olduklarını belirtmeleri istenmiştir, ancak bu bilgilerin dışında anonim kalmayı tercih etmişler, ancak yine de çoğunluk, çalışmanın sonucuyla ilgili daha fazla bilgi almak adına iletişimde kalmaya istekli oldukları dolayısıyla iletişim bilgilerini bırakmışlardır. Bu durum uzmanların, tez çalışmasının sonuçlarına ve Türk pelet yakıtı endüstrisinin geleceğine olan ilgilerini göstermektedir. Dolayısıyla anket çalışmasının sonuçları altmış dört Türk pelet yakıtı uzmanının görüşlerinden oluşmaktadır.

Katılımcıların tamamı Türkiye'den olup, anket Türkiye dışından herhangi bir potansiyel katılımcıya gönderilmemiştir. Katılımcılar arasında en büyük pay "Hane Tüketicisi" kategorisine aittir. "Araştırmacılar" kategorisi, toplam katılımcıların %20'sini temsil etmektedir. Anket çalışmasına katılan araştırmacılar, Orman Genel Müdürlüğü Doğu Karadeniz Ormancılık Araştırma Enstitüsü, Doğu Akdeniz Tarımsal Araştırma Enstitüsü, Tekirdağ Bağcılık Araştırma Enstitüsü, Karadeniz Tarımsal Araştırma Enstitüsü-Samsun, TÜBİTAK Marmara Araştırma Enstitüsü gibi devlet kurumları da dâhil olmak üzere araştırma kurum ve kuruluşlarındandır. "Üretici" kategorisi, katılımcıların %16'sını temsil ederek Araştırmacılar'ın hemen ardından gelmektedir. Üreticiler, Türkiye'nin dört bir yanındaki Pelet Yakıt üreticileridir, hem yılda 1000 metrik tonun üzerinde pelet yakıtı üretimi ile büyük ölçekli üreticiler, hem de yılda 1000 metrik tonun altında pelet yakıtı üretimi ile küçük ölçekli üreticiler ankete katılım sağlamışlardır. Yukarıda da belirtildiği gibi, Türkiye'de resmi olarak pelet yakıt üreticisi olarak faaliyet gösteren az sayıda - yaklaşık 30- üretici bulunmaktadır. Ancak "aktif" çalışan pelet yakıt üreticileri bu rakamdan daha az gibi görünmekte olup, bu anket çalışması için en aktif ve düzgün çalışan pelet yakıt üreticilerine ulaşılmaya çalışılmıştır. "Diğer Katılımcılar" kategorisi toplam katılımcıların %12'sini temsil etmektedir. Bu kategorideki katılımcılar, kazan tedarikçileri, ısıtma sistemleri üreticileri, pelet makinesi üreticileri, sertifikasyon ofisleri, belediye şirketleri, Isı Ekipmanları İmalatçıları Derneği ve bağımsız orman endüstri mühendisliği alanında faaliyet gösteren firmalarda

çalışan kişilerdir. “Akademisyen” kategorisi, katılımcıların %11'ini temsil etmektedir ve bu kategorideki kişiler, Türkiye'deki devlet araştırma üniversitelerinin Ziraat Fakültelerinden akademisyenler olup, aralarında Türkiye Toprak Bilimleri Derneği'nin de başkanı olan bir profesör bulunmaktadır. “Devlet Memuru” kategorisi, Türk Standartları Enstitüsü (pelet yakıtları sertifikasyonu), Tarımsal Araştırma ve Politikalar Genel Müdürlüğü, Tarım ve Orman Bakanlığı ve Çevre ve Şehircilik Bakanlığı gibi devlet kurumlarında çalışan kişilerden oluşmaktadır. Katılımcıların geriye kalan %10'luk kısmı ise pelet yakıtı da dahil olmak üzere çeşitli yakıtların ısınma amaçlı perakendeci, ithalatçı ve ihracatçısı olan “Tüccarlar” ile işyerlerini ısıtmak için pelet yakıtı tercih eden “Kurumsal Tüketiciler” kategorileri arasında eşit olarak dağılmıştır.
Anket çalışmasının sonuçlarının analizi çevresel boyutla başlamaktadır. Katılımcıların büyük çoğunluğu (%90) Türk pelet yakıt endüstrisinin çevre dostu olduğunu seçmiştir. Hammaddenin geri dönüşüm niteliği ve biyolojik kökeni pelet yakıtını son derece çevre dostu yapsa da, endüstri, örneğin pelet yakıtlarının taşınması gibi çevresel yönlerle ilgili olarak hala belirli çevresel zorluklarla karşı karşıyadır.

Katılımcıların çoğunluğu (%78), fosil yakıtların (özellikle yerli kömür) pelet yakıtına kıyasla nispeten düşük fiyatlarının, endüstrinin gelişmesini engelleyerek sektör için bir zorluk oluşturduğunu düşünmektedir. Pelet yakıt endüstrisi herhangi bir devlet kurumuna bağlı değildir ve özel sektöre aittir, bu nedenle fiyatı bölgeden bölgeye değişmektedir ancak anket çalışmasına katılan üreticilerden alınan bilgilere göre, çam ağacı tozu kullanılarak üretilen ortalama pelet yakıtı fiyatı 2021 kış sezonu itibariyle katma değer vergisi öncesi 1000 TL/ton’dur. Pelet yakıtı yerli kömür karşısında düşük kül miktarı, yüksek yanma verimi ve çevre dostu olması avantajlarına sahiptir.

Türkiye'deki fosil yakıtların (ithal kömür) yüksek kaloriferlik değerinin Türkiye pelet yakıt endüstrisinin gelişimini engelleyip engellemediğine karar verenler ile tarafsız kalan veya katılmayan katılımcılar arasında bir önceki soruya göre daha

dengeli bir dağılım oluşmuştur, katılımcıların çoğunluğu bu duruma katılmamıştır. İthal kömürlerin yüksek kaloriferlik değerlerine karşı dövize bağlı fiyatları artmaktadır ve Türkiye'nin dış ticaret açığını arttırmaktadır. Pelet yakıtının yerli kömüre karşı olan avantajları ithal kömüre karşı da bulunmaktadır.

Pelet yakıt standartlarının (TÜİK, İzinler, Lisans vb.) Türk pelet yakıt sektörünün gelişimine yardımcı olduğu sorusuna verilen yanıtların dağılımı oldukça dengelidir. Katılımcılar arasındaki önemli bir fark, devlet memurları, akademisyenler ve araştırmacıların bu soruya "Kesinlikle Katılıyorum" veya "Katılıyorum" şeklinde oy verme eğiliminde olmaları, Üreticiler ve Tüccarların ise "Katılıyorum" ve "Kesinlikle Katılmıyorum" seçeneklerini seçmeleri olmuştur. Bu konuda kesin ve açık bir şekilde ihtilafa düşmüşlerdir. İlk grup ürünü ve tüketicileri korumak adına standartları ve lisansları savunurken, ikinci grup lisans ve standart süreçlerinin maliyetli ve ağır süreçlerini gerekçe göstererek karşısında durmaktadırlar.

Avrupa Birliği yenilenebilir enerji hedefleri de başka bir faktör olarak katılımcılara sorulmuş ve büyük çoğunluk bu faktörün sektörün gelişmesine katkı sağlayan bir faktör olduklarını seçmişlerdir.

Katılımcıların %94'ü pelet yakıtları da dâhil olmak üzere "ısıtma amaçlı" biyokütleden elde edilen yakıtlara yönelik devlet desteğinin olmamasının Türk pelet yakıt endüstrisinin gelişimini engellediği konusunda hemfikirdir. Milletler geçmişten günümüze ekonomik büyümeyi, istihdamı artırmak, bölgesel dengesizliği ve dışa bağımlılığı azaltmak gibi çeşitli amaçlarla devlet teşviklerinden yararlanmaktadırlar [70]. Türkiye'de devlet teşvikleri, destekleri ve sübvansiyonları sanayiler adına çok önemli bir rol oynamaktadır. Devlet, ülkede ticareti ve üretimi maksimum düzeyde etkiler ve etkisi göz ardı edilemez. Türk vatandaşları devlet destekli ürünleri, örneğin tarımsal üretimin desteklenmesi kapsamında yapılan satın alma yardımları gibi tüketiciler için

finansal avantajlar sağladığı için takip etme eğilimindedir. Pelet yakıtı yenilenebilir bir enerji kaynağıdır ve kullanımı çevreyi olumlu yönde etkileyecektir. Devlet bu tür destekleri buna göre sağlarsa, Türk pelet yakıt endüstrisinin gelişimini teşvik edecektir. Anket çalışmasında katılımcılar da bu doğrultuda görüşlerini dile getirmişlerdir. Katılımcılar, pelet yakıtının iç piyasada tanıtılması ve tüketiminin teşvik edilmesi gerektiğini belirtmişlerdir.

Diğer önemli faktörler arasında uluslararası pelet yakıtı piyasası, diğer biyokütle yakıtlara karşı olan rekabet ve uluslararası işbirliği de bulunmaktadır. Gelişmiş uluslararası pelet piyasası sektörün gelişmesi için iyi bir faktör olarak görülürken, pelet yakıtı diğer biyokütle yakıtlara karşı rekabet edebilir olarak nitelendirilmiştir. Uluslararası işbirliğindeki eksiklik ise sektörün önünde engel olarak belirlenmiştir.

Ankete katılanların ezici çoğunluğu, Türkiye'nin biyokütle potansiyelinin Türk pelet yakıt endüstrisi için verimli bir şekilde hammadde olarak kullanılmadığı gerçeğine ya şiddetle katılıyor ya da hemfikir.

Biyoenerji Pelet Raporu 2019'a göre, Avrupa'da pelet yakıtı üretimi için birincil hammaddeler üç kategoride tanımlanmıştır, bunlar [73]:

- Ana Hammadde: Yuvarlak odun ve hasat artıkları (örneğin pelet yakıt üretimi için çıkarılan odun.)
- İkincil Hammadde: Ahşap endüstrisinin yan ürünleri (örn. talaş, talaş vb.)
- Üçüncül Hammadde: Kullanılmış ahşap (atık ahşap, geri kazanılmış ahşap)

Türkiye'de ağaç endüstrisi geri dönüşüm ve orman artıkları döngüsü henüz oturmamıştır. Hemen hemen her katılımcı, Türkiye pelet yakıtı sektörünün Türkiye Cumhuriyeti Orman Genel Müdürlüğü'nün hammadde satış ve tekliflerine dayandırılmasının sürdürülebilir olmadığını ifade etmiştir. Ayrıca, üreticiler tüm hammadde alımlarını devlet orman satışlarına veya özel sektör anlaşmalarına dayandırırlarsa rekabet edemezler şeklinde görüş belirtmişlerdir. Üreticiler, Türkiye'deki ormanların biyokütle atıklarını, sanayinin odun

artıklarını ve hurda palet, mobilya vb. kullanılmış odunları değerlendirmelidir. Bir katılımcı, üreticilerin tesislerini sadece biyokütle atıklarının kaynağında kurarak rekabet edebileceklerini belirtmiştir. Böylece daha az maliyetli hammadde sağlarken aynı zamanda lojistik maliyetlerini de minimuma indireceklerine vurgu yapmıştır. Biyokütle atıkları, özellikle nüfus yoğunluğunun yüksek olduğu yerlerde hem biyokütle atıkları (ormanlardan budama ile orman yangını riskleri de azaltılacaktır) hem de hurda paletleri ve diğer odun atıklarını kullanarak pelet yakıtlara dönüştürülebilir. Biyokütlenin değerlendirilmesiyle pelet yakıtı endüstrisi kalkınmayı başarabilir. Sonuç olarak, Türkiye pelet yakıt endüstrisi için önemli bir hammadde kaynağına sahip olmasına rağmen, şu anda bu varlığı kullanamamaktadır. Bu kaynakların etkin ve verimli kullanımı sektörün gelişimi için hayati önem taşımaktadır. Gerçekleştirildiği takdirde, Türkiye pelet yakıt pazarında önemli bir rekabet gücü olma potansiyeline sahiptir.

Türkiye son yıllarda güçlü döviz kuru dalgalanmaları ile karşı karşıya kalmıştır. Türk Lirası'nın Ocak 2018'den Mayıs 2021'e kadar ABD Doları karşısındaki değer kaybı Tablo 1'de, Avro karşısındaki değer kaybı ise Tablo 2'de verilmiştir.

**Tablo 1.** 01.01.2018 - 06.05.2021 Arası TL/USD Kuru [60]

**Tablo 2.** 01.01.2018 - 06.05.2021 Arası TL/EUR Kuru [77]


Tablolarda görüldüğü gibi Türk Lirası her iki döviz kuru karşısında da büyük oranda değer kaybetmiştir. Bu döviz kuru hareketlerinin etkisi ithal ürünler piyasası başta olmak üzere ülkedeki tüm sektörlerde hissedilmektedir. Bu durumun farkında olan anket katılımcılarının cevaplarının büyük çoğunluğu da bu yönde gerçekleşmiştir. Katılımcıların %64'ü katı yakıt ithalatının Türkiye'deki döviz kuru dalgalanmalarından olumsuz etkilendiğine ya kesinlikle katılmakta ya da katılmaktadır. Katılımcıların %19'u konuya karşı nötr iken, %16'sı kesinlikle katılmıyorum veya katılmıyorum cevabını işaretlemişlerdir. Ülke bu duruma sürdürülebilir ve yerli kaynakları kullanacak bir çözüm bulmalıdır. Bu noktada ülke, çözüm olarak yerli kaynaklarını değerlendirmelidir. Yenilenebilir enerji hedefleri, Avrupa Birliği uyum süreci ve uluslararası karbon salınımı protokolleri dikkate alındığında, bu durum Türk pelet yakıt sektörünün gelişimi için bir fırsat olarak değerlendirilebilir.

Türkiye pelet yakıt sektöründe iş birlikleri, sanayi kuruluşları veya kooperatifler vb. oluşturma eksikliğinin sanayinin gelişmesine engel teşkil ettiği konusunda hemen hemen her anket katılımcısı %94 oranında ya kesinlikle katılmakta ya da katılmaktadır. Bir endüstri birliğinin varlığı, hammadde fiyatlarını düzenler, üyelerini ittifaklar için bir araya getirir, ürünün fiyatını dengeler ve tüketicilere fayda sağlayacak nihai pelet yakıtını standartlaştırır. Halihazırda Türkiye'de pelet yakıtı için ısıtma sistemi üreticilerinin bir birliği vardır ama henüz başlangıç aşamasındadır ve sektörü etkilemekten çok uzaktadır. Sonuç olarak, pelet yakıtı üreticileri arasında iş birliğinin, kooperatifin vb. varlığı gerekli

değildir, ancak olması halinde Türk pelet yakıtı endüstrisinin gelişimine kesinlikle faydalı olacaktır.

Ankete katılanların büyük bir çoğunluğu pelet yakıt lojistiğinin Türkiye'de yeterli olmadığını düşünmektedir. Bir öneri, belirli şehir merkezlerinde bayilikler gibi ağlar oluşturmaktır ve bu durum yoğun iş geliştirme süreçleri gerektirmektedir. Diğer bir çözüm ise farklı bölgelerdeki ambarları kullanmaktır. Ambarlar, çok sayıda farklı türde malın toplandığı ve toplu olarak varış noktalarına sevk edildiği yerlerdir. Ancak oldukça düzensiz ve standart yapılardan uzak oldukları için kesin çözüm değildir. Pelet yakıt endüstrisinin lojistik sorununu çözmek, gelecekteki yurtiçi gelişimi için son derece önemlidir. Yurtdışına yapılan lojistikler deniz taşımacılığına kadar ele alınmaktadır ancak iç pazardaki talebi zamanında ve yerinde karşılamak için lojistik önemli bir konudur.

Katılımcıların yaklaşık %90'ı, yetersiz düzenleyici çerçeve ile birlikte politika desteği eksikliğinin Türk pelet yakıt endüstrisinin gelişiminin önündeki güçlü faktörler olduğunu düşünmüştür.

Katılımcıların yaklaşık %80'i, diğer yakıtlarla rekabetin Türk pelet yakıt endüstrisinin gelişimine karşı önemli bir faktör olduğunu belirtmektedir.

Türkiye pelet yakıtı sektörünün önündeki bir diğer önemli zorluk ise %89 ile katılımcılar tarafından belirtilen sahada yatırım eksikliğidir. Pelet yakıtı endüstrisinin pelet yakıtı ile uyumlu ısıtma sistemleri sanayine yatırım eksikliği içerisinde olduğunu belirtmişlerdir.

Türk pelet yakıt endüstrisinin gelişimini engelleyen bir faktör olarak hammadde kısıtlığı açısından, cevaplar ölçek seçenekleri arasında oldukça eşit bir şekilde dağılmıştır. Katılımcıların %41'i 5'e (En önemli) oy vermiş ve kalan %59'u diğer seçeneklere oy vermiştir.

Katılımcıların %56'sı Ar-Ge faaliyetlerinin eksikliğinin Türk pelet yakıt endüstrisinin gelişimini engelleyen önemli bir faktör olduğunu belirtirken, %44'ü bunun büyük bir zorluk olduğunu öne sürmemiştir.

Katılımcıların yaklaşık %80'i kurulu ısıtma sistemlerinin pelet yakıtı ile uyumsuzluğunun ve/veya eksikliğinin Türk pelet yakıt endüstrisinin gelişimine karşı büyük bir zorluk olduğunu belirtmişlerdir.

Katılımcıların büyük çoğunluğu pelet yakıtının büyük ölçekli kurumsal tüketiciler için karlı bir ürün olduğu yanıtını vermiştir.

Katılımcıların tam olarak %89'u pelet yakıt tüketiminin küçük ölçekli kurumsal tüketiciler için karlı olduğu şeklinde oy kullanmıştır.

Sonuçlara göre, katılımcıların %80'i pelet yakıt tüketiminin hane halkı tüketicileri için karlı olduğuna ya kesinlikle katılmış ya da katılmaktadır.
Pelet yakıtının tüccarlar için karlılığı açısından, katılımcıların %88'i olumlu hissetmektedir.

Katılımcıların çoğu, diğer kategorilerden farklı olarak küçük ölçekli üreticiler için karlı olduğunu düşünmesine rağmen, katılımcıların yaklaşık %30'u sektörün küçük ölçekli üreticiler için karlılığı konusunda nötr veya olumsuz yanıt vermiştir. Aynı zamanda üretici kategorisinde olan katılımcılar, pelet yakıt üretiminin faaliyete geçmesi için önemli miktarda başlangıç sermayesi gerektirdiğini belirtmişlerdir. Gereken yüksek miktarda sermaye nedeniyle, girişimciler/yatırımcılar iş ortaklığı kurma eğilimindedir. Ancak üreticiler, pelet üretiminin düşük kar marjlı bir iş olduğunu ve küçük bir üretim hacmiyle birleştiğinde, zaten bölünmüş gelirin ortakları tatmin etmediğini belirtmişlerdir. Aynı durum tek sahipli üretim tesisleri için de geçerlidir, tüm işletme için ortaya konan sermaye ve emek karşısında küçük ölçekli üretim miktarı yeterli kalmamaktadır. Mevcut duruma göre, standart dışı yüksek fiyatlı hammaddeler,

yüksek işçilik ve elektrik girdileri ve tedarik zincirindeki yüksek lojistik maliyetleri gibi sebepler dolayısıyla pelet yakıtı endüstrisi küçük ölçekli üreticiler için çok karlı bir sektör olarak görünmemektedir.

Küçük ölçekli üreticilerin aksine, katılımcıların ezici çoğunluğu pelet yakıt endüstrisinin büyük ölçekli üreticiler için karlı bir sektör olduğu sonucuna varmıştır. Büyük ölçekli üreticiler genellikle büyük miktarlarda hammaddeye erişebilen firmalardan oluşmaktadır. Kaliteli hammaddeye yüksek miktarlarda ulaşabilen firmalar, üretim süreçlerini iyi kurmuş ve yılda yüksek miktarlarda üretim yapabilmektedir. Bu firmalar genel olarak ağaç, tarım vb. sektörlerde ana iş kolu olarak faaliyet göstermekte ve bu işlerin yan ürünü olan orman atıkları, odun, biyokütle gibi malzemeleri pelet yakıt üretiminde hammadde olarak kullanmaktadırlar. Ayrıca orman kaynaklarına sahip olan veya Orman Genel Müdürlüğü ihalelerinden tahsisli orman varlığı satın alan firmalar pelet yakıtı alanında rekabet edebilir ve yüksek üretim miktarlarına ulaşabilirler. Bu üreticiler için birim kar marjı ve satış hacmi küçük ölçekli üreticilere göre çok daha yüksektir. Büyük ölçekli üreticiler, lojistik konularda zaten kendi filolarına sahip oldukları için lojistik açısından da rekabet edebilirler, bu nedenle bu amaç için dış kaynak kiralamalarına vs. gerek duymamaktadırlar. Katılımcılar, büyük ölçekli üreticilerin ayrıca iç pazara göre yurtdışı pazarlara öncelik verme eğiliminde olduklarını, iç pazarda ise büyük ölçekli kurumsal tüketicileri veya geniş dağıtım ağlarına sahip tüccarları hedeflediklerini belirtmişlerdir.

Katılımcılara, önümüzdeki 5-10 yıl içinde Türkiye iç pazarında artan pelet yakıt ihtiyacını karşılamanın yöntem ve seçenekleri sorulmuştur. Katılımcıların ezici çoğunluğu, yakın gelecekteki talebi karşılamak için en iyi seçenek olarak yerli üretimi artırmayı seçmiştir.

Katılımcıların %91'i Türk pelet yakıt endüstrisinin geleceğinin umut verici olduğunu, ya önemli büyüme ya da büyüme seçeneklerine oy vererek göstermişlerdir. Katılımcıların %9 gibi küçük bir oranı endüstrinin geleceği için

durgunluk beklemektedir. Sektörün geleceği için durgunluk yanıtı veren katılımcılar araştırmacı, akademisyen, bir kamu iktisadi kuruluşunun yöneticisi, ev tüketicisi ve bir pelet üretim makinesi şirketi yöneticisinden oluşmaktadır. Akademisyen, sürdürülebilir ve uygun fiyatlı hammadde tedariğinin sektörün gelişimi karşısında en önemli konu olduğunu, bu sorunu çözmeden sektörün büyüme değil durgunlukla karşı karşıya kalacağını vurgulamıştır. Pelet makinesi şirketi yöneticisi, pelet yakıtının herkes tarafından tanınması gerektiğini ve sektör temsilcilerinin pelet yakıtı bilincini artırmak için çalışmaları gerektiğini ve ancak bunun sektörün büyümesini sağlayacağını belirtmiştir. Sektörün durgunluk yaşayacağını düşünen bir araştırmacı, Türk Lirası'ndaki mevcut değer kaybı ve Avrupa'daki yüksek tüketim miktarı ile sektörün Avrupa'ya pelet yakıt ihracatına ağırlık vermesi gerektiğini ifade etmiştir. Türk pelet yakıtını ihraç etmeyi başarabilirse, sektörün ancak o durumda önemli bir büyüme sağlayabileceğine dikkat çekmiştir.

Sonuç olarak, katılımcıların yanıtlarına göre, hâlihazırda devlet desteklerinin olmaması, yetersiz lojistik, hammadde tedarikinin düzensiz ve standart dışı olması, mevcut kurulu ısıtma sistemlerinin uyumsuzluğu ve diğer katı yakıtlarla rekabet, Türk pelet yakıt endüstrisinin gelişiminin önündeki en büyük zorluklardır. Bununla birlikte, katılımcıların olası kişisel çıkar arayışları ve kendi seçimleri ile katılımcı olmaları ve anket yöntemlerinin diğer kısıtlayıcı yönleri nedeniyle, sonuçların kesin değil, gösterge niteliğinde olduğu belirtilebilir. Anket sonuçları ayrıca, pelet yakıtlarının yüksek tüketim miktarları ve nispeten daha uyumlu hâlihazırda kurulu ısıtma sistemlerine sahip olmaları nedeniyle hem büyük hem de küçük ölçekli kurumsal tüketicilere yönelik olduğunu göstermektedir. Ancak, kurulum ve bakım hizmetlerinin gelecekteki yaygınlığına bağlı olarak hane halkı tüketimi için pelet yakıtı umut verici gözükmektedir. Devlet, pelet yakıt üreticilerinin izin ve lisans süreçlerini kolaylaştırmalı ve daha makul hale getirmelidir. Pelet yakıt tüketicilerini teşvik etmeli ve pelet yakıtını desteklemelidir. Pelet yakıtları, fosil yakıtlar ile aynı şekilde vergilendirilmemeli, mevzuat ve politikalar gözden geçirilmelidir.

Bu çalışmanın sonuçlarının ve bulgularının hem Türkiye'de hem de küresel pelet yakıtı endüstrilerinde karar vericiler tarafından kullanılmasına izin verilmektedir. Bu araştırmaların yöntemi, hem mikro hem de makro pelet yakıt pazarlarına uygulanabilir. Bölüm 3.1'de hem genel olarak anket yöntemi hem de bu çalışma için kısıtlayıcı etmenlerden bahsedilmiştir. Bu sınırlamalar, pelet yakıt endüstrisindeki tekil konularına odaklanarak ilerideki araştırma projelerinde ortadan kaldırılabilir. Örneğin, pazarlama gibi işletme araştırması kapsamındaki farklı disiplinlerle ilgili konular, gelecekteki potansiyel araştırma projeleri olarak çıkarılabilir. Bu sektörle ilgili gelecekteki çalışmalar, pelet yakıtının farkındalığını artırma yöntemlerini, lojistikle ilgili sorunlara olası çözümleri, özellikle ev tüketicileri tarafından tüketimini artırmak için gelecekteki politikalara yönelik tavsiyeleri, artan döviz kuru ile beraber ihracatı arttırmaya yönelik araştırmalar ile birlikte ulusal odun ve biyokütle varlıklarını kullanmayı detaylandırmalıdır.

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**YAZARIN** / AUTHOR

**Soyadı** / Surname : KARACA
**Adı** / Name : Neşet Kutay
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