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Bioenergy Focused Smart Specialisation Potential in İzmir Within the Scope of Tackling Climate Change

İklim Değişikliği ile Mücadele Kapsamında İzmir'de Biyoenerji Odaklı Akıllı Uzmanlaşma Potansiyeli

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ÖZ

İklim değişikliği, dünyanın ve insanlığın sürdürülebilir geleceğine yönelik en başta gelen risklerden birisi olarak gösterilmekte ve olumsuz etkileri her geçen gün artan bir yoğunlukta karşımıza çıkmaktadır. Enerji üretimi ve kullanımı, iklim değişikliğinin temel etkenlerinden birisi olan küresel sera gazı salımlarının en büyük sebebidir. Bu sebeple enerji, iklim değişikliğiyle mücadelede en çok odaklanılması gereken alanlardan birisidir. Enerjinin iklim değişikliği üzerindeki bu olumsuz etkisi, temiz enerjiye dönüşüme yönelik çalışmaların ve yatırımların tüm dünyada artmasına sebep olmaktadır. Rekabetçi ve katma değeri yüksek sektörlerde gelişerek kalkınmasını hızlandırmak isteyen ülkeler ve şehirler, bu durumu aynı zamanda önemli bir ekonomik fırsat olarak görmektedir. Biyoenerji başlıca temiz enerji kaynaklarından birisi olarak, dünyanın temiz enerji dönüşümünde önemli sektörlerden birisidir. Avrupa'daki bölge ve şehirler biyoenerji alanındaki potansiyellerini kullanmak üzere akıllı uzmanlaşma çalışmaları yürütmekte ve bölgesel kalkınmalarını ivmelendirmeye çalışmaktadır. Bu çalışmada, İzmir'de biyoenerji odaklı akıllı uzmanlaşma potansiyeli, Avrupa Birliği Akıllı Uzmanlaşma Platformu'nun (S3 Platform) İyi Akıllı Uzmanlaşma Uygulaması Kriterleri'ne göre değerlendirilmiştir. Değerlendirme, literatür araştırması ile elde edilen veriler ışığında fark analizi yöntemi kullanılarak niteliksel olarak yapılmıştır. Bölgesel kalkınma ve temiz enerji alanlarında disiplinlerarası olarak gerçekleştirilen çalışmanın sonucunda, İzmir'de biyoenerji odaklı bir akıllı uzmanlaşma uygulamasına yönelik öneriler sunulmuştur.

Anahtar Kelimeler: Biyoenerji, Temiz Enerji, Yenilenebilir Enerji, Akıllı Uzmanlaşma, Bölgesel Kalkınma, Kümelenme, İklim Değişikliği

ABSTRACT

Climate change is seen as one of the foremost risks to the sustainable future of the world and humanity, and its negative effects are increasing from day to day. Energy production and usage are the biggest cause of global greenhouse gas emissions, which is one of the main factors of climate change. Therefore, energy is one of the primary areas that should be focused on in tackling climate change. This negative effect of energy on climate change results in an increase in efforts and investments toward clean energy conversion all over the world. Countries and cities that want to accelerate their development by growing in competitive and high-value-added sectors see this situation as an important economic opportunity at the same time. As one of the main clean energy sources, bioenergy is one of the important sectors in the world's clean energy transformation. Regions and cities in Europe carry out smart specialisation studies to use their bioenergy potential and try to accelerate their regional development. In this study, the bioenergy focused smart specialization potential in İzmir was evaluated according to the Good Smart Specialization Practice Criteria of the European Union Smart Specialization Platform (S3 Platform). The evaluation was made qualitatively using the gap analysis method considering data gathered from the literature search. As a result of this interdisciplinary study in the fields of regional development and clean energy, suggestions for a bioenergy focused smart specialisation implementation in İzmir were presented.

Keywords: Bioenergy, Clean Energy, Renewable Energy, Smart Specialisation, Regional Development, Clustering, Climate Change

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INTRODUCTION:

The concept of smart specialisation has been developed to enable optimal outcomes through a judicious and strategic allocation of public capital and is grounded on the understanding that regions cannot excel in all areas in regard to science, technology, and innovation. It is indicated that the concept is necessitating a deliberate process of prioritization that targets specific domains of expertise in accordance with the unique needs and available resources of each region, with a view toward fostering circularity (Stanojev & Gustafsson, 2021).

The European Union (EU) has implemented smart specialisation as a framework for innovation and industry policy to enhance innovation and economic growth in various EU regions. The key component of smart specialisation is the Entrepreneurial Discovery Process (EDP), which is a collaborative, bottom-up process that involves the coworking of businesses, research institutions, public organizations, and civil society. It is specified that the goal of the EDP is to identify a region's most promising areas of specialisation, as well as to address any potential barriers to innovation (Roman & Nyberg, 2017). To overcome the difficulties of ensuring smart specialisation more easily, this process is carried out with policy documents called “Smart Specialisation Strategy (S3)”. S3s are also described in detail in Regulation (EU) No: 1303-2013 of the European Parliament and of the Council of 17 December 2013, as national or regional innovation strategies that set priorities for creating competitive advantage.

Given the imperative of transitioning towards clean energy sources to address the global challenge of climate change, as well as the potential socio-economic benefits associated with such a transformation, energy has become a highly prioritized topic among regions in the context of their S3. Therefore, energy is among the first thematic platforms created under the S3 Platform established by the European Commission. Smart Specialisation Platform on Energy (S3PEnergy), has prepared a working paper titled “Good Practices for Smart Specialisation in Energy” to identify good examples of smart specialisation and the implementation of clean energy priorities. The working paper contains a definition of good practice in the smart specialisation and energy framework and a methodology for criteria used to identify good practices.

Biomass, one of the clean energy sources, is a non-fossil organic matter mass of biological origin, which can be renewed in less than a 100-year period. All organic substances of vegetable and animal origin, the main components of which are carbohydrate compounds, are defined as biomass energy sources, and the energy obtained from these sources is defined as biomass energy (Koçar et al., 2013). Biomass energy is also briefly used as bioenergy in the international literature. Modern bioenergy stands as the primary renewable energy source globally, comprising 55% of the overall renewable energy and exceeding 6% of the total worldwide energy supply (IEA, 2021).

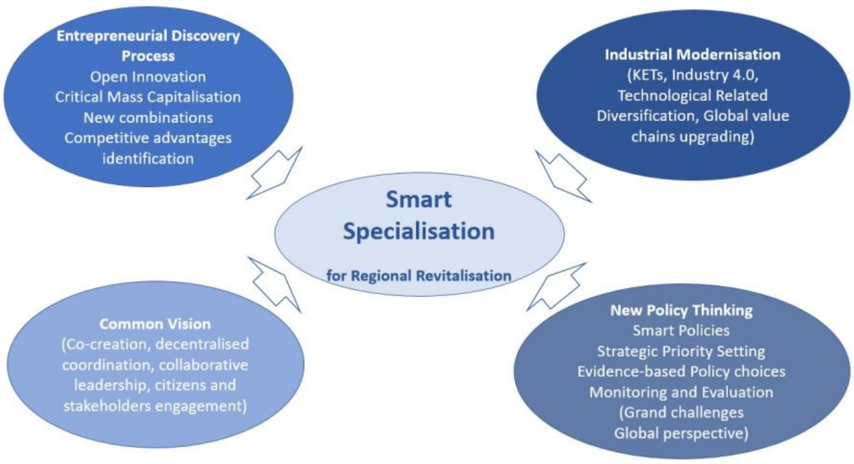
In this study, the potential to conduce to the economic development of İzmir, which is one of the largest cities in Türkiye and has large-scale bioenergy resources, with a smart specialisation focused on bioenergy was evaluated. In the qualitative evaluation done according to the Good Smart Specialisation Practice Criteria developed by S3PEnergy, gap analysis was conducted utilizing the information garnered from the examination of relevant literature. Based on the findings of the study, suggestions have been formulated for the implementation of a bioenergy focused smart specialization strategy in the city of İzmir.

1. Bioenergy Focused Smart Specialisation

1.1. Smart Specialisation and Clean Energy

Smart specialisation is suggested as an entrepreneurial process of discovery that can reveal what a country or region does best in terms of science and technology. By this, it is meant a learning process to discover the research and innovation domains in which a region can hope to excel (Foray et al., 2009). As depicted in Figure 1, the key principles of smart specialization are the Entrepreneurial Discovery Process, Common Vision, Industrial Modernization and New Policy Thinking (Ortega-Argiles, 2019). Owing to the concept of Smart Specialisation becoming a regional development policy in Europe, European Commission provides advice to regional and national authorities on how to develop and implement their S3s; via a mechanism called "Smart Specialisation Platform".

Figure 1: Key Elements of Smart Specialisation



Source: Ortega-Argiles, 2019.

Because of this; over 180 S3s have been developed, at regional and national levels; over EUR 67 billion funds have been created to support these strategies, under the European Structural and Investment Funds and national/regional funding. In total, 19 EU Member States and 7 non-EU countries as well as 180 EU and 42 non-EU Regions have registered in S3Platform (S3 Platform, n.d.a).

As an international organization that addresses wider geography beyond the EU, the Organisation For Economic Co-Operation and Development (OECD) defines smart specialisation as an industrial and innovation framework for regional economies that aims to illustrate how public policies, framework conditions, but especially R&D and innovation investment policies can influence economic, scientific and technological specialisation of a region and consequently its productivity, competitiveness and economic growth path. OECD acknowledges the significance of clusters as a building block of an S3 (OECD, 2013). The implementation of S3s can effectively utilize public resources and mobilize and stimulate private sector investment. S3s help regions to focus on investments at a few key priority sectors, rather than scattered and underfunded investments (Kumral & Güçlü, 2015). Through the utilization of an evidence-based monitoring and evaluation process, S3s can effectively assess the achievement of policy objectives. As a result, viable development strategies are determined (Kutgi & Maden, 2018).

In Türkiye, S3s have started to be adopted as a guide for implementing institutions. Türkiye has started work within the scope of smart specialisation initiated by the EU and has made progress in strengthening the institutionalization of support systems for S3 (Akgüngör et al., 2021). Among the 26 Development Agencies in Türkiye, there are 10 Development Agencies that prepare a Regional

Innovation Strategy Plan within the scope of smart specialisation (Şahin & Ertürk, 2021). S3s, which emerged as a novel approach in the field of regional development literature, emphasize the competencies of the regions with a perspective that will enable each region to discover its own growth paths. S3s, based on identifying diversification opportunities and prioritizing these opportunities according to their feasibility, socio-economic impacts, and differentiation with rival and neighboring regions; have gained greater importance in efforts to tackle issues that have emerged because of the Covid-19 pandemic which has affected the whole world and deeply affected the regional economies since March 2020 (Kuştepeli et al., 2021).

According to the Global Risks Report - 17th Edition issued by the World Economic Forum (WEF) in 2022, the risk that is most likely to occur and will affect the world the most is climate action failure and its negative consequences (World Economic Forum, 2022). The United Nations (UN) stated that the activities for energy production and use in the world, cause 60% of the global greenhouse gas emissions that cause climate change and has determined one of its 17 Sustainable Development Goals for clean energy transformation with the title of “Accessible and Clean Energy” (UN, 2022). Another detailed study showing the state of energy in the sectoral distribution of global greenhouse gas emissions was made on the 2016 data of the World Resources Institute Climate Watch Platform. According to this study, 73.2% of greenhouse gas emissions in 2016 are due to energy use for electricity generation, heating, and transportation (Ritchie, 2020). In Türkiye's overall greenhouse gas emissions in 2020, energy-related emissions have the biggest share with 70.2% as CO2 equivalent (TURKSTAT, 2022a).

Energy is the most important element of modern human life. As the economic development level of countries increases, the need for energy also rises. The environmental issues reasoned by the energy used during production and consumption on a global scale have reached an unsustainable level. Countries and international organizations have started to develop new strategies on issues based on the green economy to reduce these problems (Atış & Kaya, 2016). After the oil crisis in 1973-74, the International Energy Agency (IEA), which was established to ensure the security of oil supply in the world; shifted its mission, which started with oil, to areas such as energy access and energy efficiency, especially clean energy. The IEA states that the climate change problem is now an energy problem and shows the investments to be made for the transformation to clean energy as a priority investment. According to a joint analysis by the IEA with the International Monetary Fund (IMF), the amount of global investment in the clean energy transition is projected to rise to 5 trillion USD annually in 2030, contributing 0.4% per year to annual global GDP growth. It is indicated that while these investments create millions of jobs in the engineering, manufacturing, and construction sectors, they will also contribute significantly to the countries' recovery from the economic crisis caused by the Covid-19 pandemic (IEA, 2021). As claimed by the International Renewable Energy Agency (IRENA), which is another international organization working in the clean energy area; events such as the Covid-19 pandemic and the Ukraine Crisis in recent years have emphasized the cost of a centralized energy system that is intensely dependent on fossil fuels to the global economy and the global clean energy transition process has become even more urgent (IRENA, 2022b). IRENA predicts that, if this transition process is supported by stronger policies, its economic contributions will be significant in two main indicators, GDP, and employment. According to IRENA, in this scenario there will be an increase in global GDP by 1.95% until 2030 and by 2.38% until 2050; while the number of direct and indirect clean energy sector employees was 12.28 million in 2017, will reach 29.5 million people in 2030 and 41.9 million people in 2050 (IRENA, 2020).

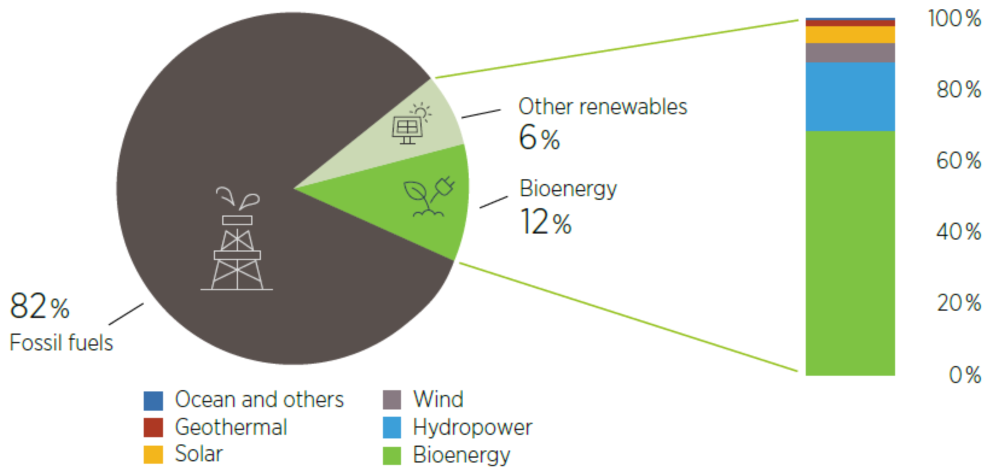
These future projections announced by international organizations reveal the magnitude of the economic opportunities created by the transformation to clean energy. Accordingly, countries and regions aim to utilize these opportunities in their own development processes. While countries and regions are trying to do this, they see the areas where they can achieve the highest added value, especially as being able to produce technology in this field and therefore R&D and innovation activities. Therefore, one of the areas of greatest interest in studies in the smart specialisation is the clean energy sector.

1.2. Bioenergy Sector

Biomass has been used since humans began burning wood for cooking and heating. Wood is still the largest source of bioenergy today. Other sources include food products, grassy and woody plants, agricultural or forestry residues, oil-rich algae, and organic components of municipal and industrial waste. Gases from landfills can also be used as a source of bioenergy because they contain methane, the main component of natural gas. Biomass and other organic wastes; it is widely used in both developed and developing countries due to its electricity and heat energy production, liquid or gaseous fuel production for transportation, and various chemical substances as by-products (Koçar et al., 2013).

Bioenergy utilization is commonly categorized into two primary classifications: "traditional" and "modern". Traditional utilization pertains to the combustion of biomass in such forms as wood, animal waste, and traditional charcoal. On the other hand, modern bioenergy technologies comprise liquid biofuels derived from bagasse and other plants, bio-refineries, biogas produced via anaerobic digestion of residues, wood pellet heating systems, and other advanced technologies (IRENA, 2022c).

Figure 2: Share of Bioenergy and Other Renewables n Global Total Final Energy Consumption



Source: IRENA, 2002c.

On a global scale, bioenergy retains its position as the foremost renewable energy source, with a contribution of approximately 12% to the final energy consumption (see Figure 2). 21% of bioenergy is used for industrial heating, 12% for building heating, 7% for transportation fuel, 6% for electricity generation and 54% for traditional cooking and heating purposes. Currently, cooking and heating in buildings and industry account for over 80% of bioenergy usage. In 2020, bioenergy contributed about 20% of total heat consumption worldwide, with modern forms of bioenergy making up 8% and traditional biomass use making up 12% (IEA, 2021; IRENA, 2022b). Besides the use of bioenergy has the potential to greatly reduce greenhouse gas emissions all over the world; countries' use of domestic clean energy resources, reducing the use of conventional and generally foreign-dependent resources such as coal and oil, creating new green jobs and reviving rural economies, etc. provides many benefits. When the situation is evaluated in terms of carbon footprint; it is understood that the 10 countries that emit the most greenhouse gas emissions in the world are China, USA, India, Indonesia, Russia, Brazil, Japan, Iran, Canada, Saudi Arabia, and they constitute 60% of the world's greenhouse gas emissions (Climate Watch, 2022). Research carried out in China, a country with high greenhouse gas emissions, found that biomass gasification power generation has an emission reduction rate of 97.69% compared to coal-fired power generation, followed by biomass biogas power generation (79.69%), biomass direct combustion power generation (72.87%), and biomass mixed-combustion power generation (14.56%) (Chen et al., 2020). Biomass can greatly increase energy production in heavily populated countries that are experiencing increased demand, including Brazil, India, and China. It can be burned directly for power generation or heating, or it can be transformed into a substitute for oil or gas. Liquid biofuels are commonly used as a renewable substitute for gasoline, mainly for transportation (IRENA, 2022a). Bioenergy, which is seen as an important clean energy alternative within the scope of tackling climate change, has the potential to contribute remarkably to the economic development of countries or regions. In a study conducted in the USA, bio-based activities in the economy of the year 2014 were estimated to have directly generated more than 48 billion USD in revenue and 285,000 jobs. That estimates showed that developing biomass resources could expand direct bioeconomy revenue by a factor of 5 to contribute nearly 259 billion USD and 1.1 million jobs to the US economy by 2030 (Rogers et al., 2016). Looking at the global employment figures of the bioenergy sector, the employment of 2.4 million people in 2012 reached 3.52 million in 2020 with an increase of 46%. In the same period, while employment in all clean energy sectors on a world scale increased by 65% from 7.3 million to 12 million, the bioenergy sector was the clean energy sector that provided the highest employment increase after solar energy (192%) and wind energy (66%). When the necessary investments are made, projections are made that the bioenergy sector can reach 13.7 million jobs by 2050 (IRENA & International Labour Organization [ILO], 2021).

Bioenergy is produced using various sources. Certain sources like black liquor, which is a residue from paper production, are derived from industrial processes that would have taken place anyway. However, bioenergy is usually obtained from purpose-grown crops or trees, which require a lot of lands and are not as efficient as other energy sources. Producing bioenergy in an unsustainable manner can lead to social issues such as affecting food prices and competing for land usage. Additionally, it can have negative environmental effects such as harming biodiversity and increasing emissions. IEA indicates that the achievement of its Net Zero Scenario necessitates an increase in bioenergy production, albeit with a cautious approach to prevent significant adverse outcomes for society or the environment. In keeping with these sustainability considerations, the expansion of cropland for bioenergy production or conversion of existing forested land into bioenergy crop production is not envisaged in the Net Zero Scenario. The bioenergy supply in 2030, under this scenario, will be 60% derived from waste and residues that do not require land use (IEA, 2022).

Projections for the bioenergy sector on a global scale and the basis of some countries with high bioenergy resource potential; in addition to the contribution of the development of this sector to the tackling against climate change, it also reveals the socio-economic benefits it will provide all over the world. Türkiye has an important potential in terms of clean energy resources and bioenergy has an important place among these resources. Türkiye could benefit from the socio-economic benefits that bioenergy can provide with strategic steps to be taken. The amounts of biomass resources and their energy equivalents (TOE/year) can be reached on the level of provinces from the Turkish Biomass Energy Potential Atlas (BEPA) Geographical Information System, prepared by the Ministry of Energy and Natural Resources (MoENR). Türkiye's Theoretical Energy Equivalent of Animal Waste is 4.385.371 TOE/year, The Theoretical Energy Equivalent of Vegetable Waste is 25.384.268 TOE/year, The Theoretical Energy Equivalent of Municipal Waste is 3.373.011 TOE/year, The Energy Equivalent of Forest Residues is 859.899 TOE/year, and The Total Energy Equivalent of Wastes in Türkiye has been determined as 34.002.549 TOE/year (BEPA, 2022). Excluding aquaculture and food production in Türkiye, although it is calculated that the gross theoretical biomass energy potential due to photosynthesis is 135-150 million TOE/year and the net potential can reach 90 million TOE/year after the deduction of losses; since it is not possible to use all agricultural areas of the country through the year for biofuel production only, the theoretical potential calculated according to the current technology and land use possibilities is between 14-32 million TOE/year (İlleez, 2022). By evaluating biomass resources including urban solid wastes, energy crops, animal manure and urban wastewater treatment sludge and by calculating biogas and biomass energy potential for each resource separately; when methods and technical and economic parameters suitable for the Türkiye conditions for energy conversion from waste are used, the total primary energy value of the biogas that can be obtained from the examined sources is determined as 188.21 TWh/year, and the total primary energy value related to the potential of the evaluated biomass sources is determined as 278.40 TWh/year (Özcan et al., 2014).

In rural Türkiye, biomass is predominantly utilized as a primary source of energy, catering to various energy requirements such as electricity generation, household heating, vehicular fueling, and process heating for industrial establishments. The potential for electrical production from usable bioenergy sources was estimated as 73 MW with associated employment opportunities exceeding 280,000 jobs in 2010. These figures indicate a significant potential for biomass energy to contribute to climate change mitigation and promote energy sustainability in Türkiye (Toklu, 2017). According to 2015 figures, 12% of Türkiye's total greenhouse gas emissions originate from agriculture, and 11% of this is from fertilizer management processes. Biogas production is suggested as one of the main strategies that can be applied in terms of improving fertilizer management processes (Ağaçayak & Öztürk, 2017). The determination of biogas potentials in Türkiye for two different scenarios with varying manure recovery rates resulted in the production of 8.41 billion m3 and 4.18 billion m3 of biogas in 2015, respectively. It is observed that scenario 1 could meet 5.25% of Türkiye's total electricity demand while scenario 2 could meet 2.3%. Furthermore, greenhouse gas emissions from manure management can be reduced by 1.13% through biogas production (Ersoy & Uğurlu, 2020).

Another dimension of the bioenergy sector, which has a significant potential globally in terms of the use of clean energy resources, needs to be addressed from a socio-economic perspective, is the development of technology and equipment used in this sector. Türkiye is in the position of a net importer in renewable energy machinery-equipment foreign trade. The foreign trade deficit in the sector is at the level of 2.8 billion dollars, which is 1% percent of the total foreign trade deficit. Despite an average of 1.2% growth in exports, a 5% growth in imports indicates that Türkiye's foreign trade deficit in renewable energy equipment may increase in the coming period (Türkiye Economic Policy Research Foundation [TEPAV], 2016). While concrete reactors, horizontal and vertical mixers, liquid and gas pumps, sludge pumps, chemical substance dosing systems, biogas storage balloons, biogas safety and alarm systems, biogas safe combustion chimney, automation (pH, temperature, liquid and biogas level, etc. controls), sludge separators, gas engines, electric generators, electric transformers, power line connection equipment and civil works are necessary for the production of electricity from biogas obtained by fermentation from animal and vegetable wastes; it is possible to make half of the investment cost of biogas plants with domestic equipment. However, gas engines, some control units and technology (know-how) come from abroad (Karaosmanoğlu et al., 2014).

The bioenergy sector shows a development trend globally and it is forecasted that all countries will continue to make investments in this field. Considering the current biomass potential in Türkiye, it is understood that a significant amount of investment is needed in this area. While these investments, which are likely to be realized on a global and national scale, contribute to tackling climate change by making use of a clean energy source; it will create an important socio-economic development potential for the development of countries and regions, especially including the production of new value-added technologies and products. It is important to assess these developments in smart specialisation studies to be carried out by cities and regions that have comparative advantages in bioenergy in Türkiye.

1.3. Clean Energy and Bioenergy Focused Smart Specialisation

Due to the need for clean energy transformation in the world and the socio-economic opportunities it creates, energy is one of the most preferred topics by the regions for prioritization in S3s. For this reason, Energy is among the first thematic platforms established under the S3Platform by the European Commission, together with Agricultural Food and Industrial Modernization. The thematic platforms offer a framework to leverage synergies across sectors (S3 Platform, n.d.b). The goal of the Energy Thematic Platform named S3PEnergy is to set up a collaborative framework that will accelerate the development and deployment of innovative low-carbon technologies in the EU in the framework of Smart Specialisation. Under S3Penergy, the main working topics are determined as bioenergy, solar energy, geothermal energy, marine renewable energy, smart grids, and sustainable buildings (S3PEnergy, 2022).

An inductive methodology has been developed by S3PEnergy to facilitate the identification of good examples of smart specialization and energy priorities implementation for clean energy. The purpose of this methodology is to provide guidance to EU regions and Member States during the implementation phase of their smart specialization strategies (S3s). This methodology was detailed in a working paper titled “Good Practices for Smart Specialisation in Energy” and policy support was provided to members. The Working Paper explains the method developed for the identification of good practices, including a definition of good practice within the framework of smart specialisation and energy, and the criteria used to identify good practices and contains 11 good practices sample cases identified by applying this method. In this study, the definition of good practice is an effective behavior, initiative, or action that addresses a given problem or achieves a particular goal. Such practices serve as sources of inspiration for others facing similar problems or pursuing similar objectives. In the context of the smart specialization approach and strategies, the application of this conceptual framework aims to identify good practices that highlight local capacities and resources, suitable research and development and innovation areas, and appropriate financing tools to support these areas (Nauwelaers et al., 2018).

The method established for determining good practices in smart specialisation includes criteria in three categories as Necessary Eligibility Criteria, Necessary Relevance Criteria and Optional Quality Criteria as listed in Table 1.

In energy focused smart specialisation, 2 of 11 good practice case studies determined by the methodology of good practices, are bioenergy focused smart specialisation studies. The "BioBIP - BioEnergy and Business Incubator of Portalegre" project implemented in Portugal's Alentejo Region and the "Arctic Smartness - Decentralized Renewable Energy Solutions " project implemented in Finland's Lapland Region were determined as good practice examples in bioenergy focused smart specialisation. The BioBIP structure is dedicated to the incubation of technology-based companies and projects with a focus on the field of bioenergy (Nauwelaers et al., 2018). In a study that seeks to demonstrate the importance of connecting technological base incubators to higher education, as well as their alignment with regional development strategies; it was found that most of the incubated companies in BioBIP are aligned with the areas of the respective regional strategy of smart specialisation (Antunes et al., 2021).

Table 1: The Criteria for Evaluating Best Practices within the context of S3Penergy

Necessary Eligibility Criteria:	**Optional Quality Criteria:**
• Part of S3 • Use of ESIF • Implemented	• Clear Relevance to National and/or Regional Energy Strategy • Interactions Between Responsible Agencies and/or Authorities From Different Domains (R&D&I and Energy) • Synergetic Use of Several Funds • Ambitious • Inter-Regional Cooperation Dimension • Leading to Private Investments • Sustainability Beyond Funding Period • Transferability of The Practice • Including a Monitoring System
Necessary Relevance Criteria:	
• Framed Along The S3 Concept • Innovative Character • Minimum 3 out of 4 "Pillars" of The Quadruple Helix Involved • Outcome-oriented	

Source: Nauwelaers et al., 2018.

The development of decentralized bioenergy solutions in rural Lapland is currently being pursued by the Arctic smart rural community cluster, which has been established as an implementation activity for the Arctic Specialisation (S3) strategy (Nauwelaers et al., 2018). The Finnish National Bioeconomy strategy and Lapland's S3 framework define the bioeconomy policy landscape. The Finnish strategy employs a value chain approach to the bioeconomy, recognizing Finland's dominant position in global forest product markets and its abundant natural resources such as forestland and fresh water. These assets enable Finland to become a reference point for the bioeconomy and support the transition to a fossil fuel-free economy. Moreover, the strategy recognizes the traditional Finnish relationship between people and nature as an additional and valuable strength for bioeconomy development (Morales, 2020). The internationally significant status and acknowledgment for innovativeness and efficient cluster activities have been achieved by Lapland which is another good practice. The connectivity of different regional development actors, including universities, research institutes, and development companies, has been facilitated by a concrete concept based on smart specialisation (S3). The collaboration across organizational boundaries and national borders has been fostered by smart specialisation, which has generated novel approaches (Arctic Smartness, 2018).

2. Evaluation of Bioenergy Focused Smart Specialisation Potential in İzmir

2.1. Bioenergy Sector in İzmir

Bioenergy, which is seen as a fundamental component of the clean energy transformation necessary in the tackling climate change, is one of the main sources of renewable energy and is used in many areas from the energy used in electricity production to heat production for industry and buildings, and transportation. Bioenergy, which has a wide usage area, also has a wide sectoral value chain. This value chain creates opportunities for different sectors to provide products and services for the bioenergy sector. Another important dimension of the bioenergy sector is the use of waste as basic input and, consequently its relationship with the size of the main branches of activity such as agriculture and industry in the cities and the density of the population. When the Gross Domestic Product (GDP) figures are considered, İzmir received a share of 6.8% of the total GDP of Türkiye with 306,712,772 TL in 2020 and ranks third after İstanbul and Ankara. According to these figures, while İzmir is seen to be the third largest city in Türkiye in terms of economy, when the GDP of the main activity of "Agriculture, forestry and fishery" is considered, it is also located as the second largest city in Türkiye after Konya (TURKSTAT, 2021). İzmir, which is also among the largest cities of Türkiye in the main activities of "Industry" and "Services", is the third largest city in Türkiye in terms of population with 4,425,789 inhabitants (TURKSTAT, 2022b). The energy potential that may arise only due to the production of field crops in

İzmir; considering the amount of waste generated during the use of the products in the food sector; and even without considering the grass and other weed that are not used as animal feed, aquatic plants, energy agriculture and forestry products, reaches the remarkable value of 88,150,000 GJ/year as the total thermal capacity (Koçar et al., 2013).

One of the current sources that analyze the situation of İzmir in the bioenergy sector is the report "Biogas and Organic Fertilizer Production Potential in İzmir" dated 2021. With this report, it is aimed to analyze the status of biogas production and use potential, which is important in terms of regional development, in İzmir and to determine its technical and economic applicability on a provincial basis. In the section titled "Economic Analysis" of the report; considering the existing cattle numbers of İzmir, the amount of investment required when biogas systems of different scales are installed and the theoretical capacity is used, the electricity production that can be acquired as a result of these investments (kWh/year), heat production (kcal/year), coal substitution (tons/year), fertilizer substitution (ton/year) monetary equivalents have been determined. In the "Environmental Impacts" section of the report, the environmental benefits that can be acquired as a result of these investments are calculated based the emission removal values from wastes, the emission values reduced by electricity and heat energy production, the emission values arising from the establishment of the systems, and the emission values arising from the operation of the systems (tonCO2/year). Considering the economic and environmental benefits of only the village-type systems, which are medium-sized systems, among the detailed data in the report, İzmir has an economic value of 338,574.772 USD/year and a carbon emission reduction potential of 1,275,059 tons of CO2/year with an investment of 550,594,435 USD (Kocar et al., 2021).

In İzmir, 66 wastewater treatment plants with daily treatment capacities of 949,848 m3 are operated, including 23 advanced biological, 37 biological and 6 natural wastewater treatment plants, which treat at EU standards. In 2019, a total of 278,531,502 m3 of wastewater was treated in operating wastewater treatment plants. Çiğli Wastewater Treatment Plant was built within the Grand Canal Project to save İzmir Bay from wastewater pollution. The wastewater collected through the main bonding channel built along the İzmir Bay and the collectors connected to it is pumped from the Customs, Bayraklı, Karşıyaka, Çiğli Pumping Stations and transferred to the Çiğli Wastewater Treatment Plant. To collect the sludge accumulated in the wastewater treatment plants without harming nature and to prevent odor, the construction of the Sludge Digestion - Drying Unit started in January 2012 and in 2013, Türkiye's largest Sludge Digestion and Drying Unit was put into operation. The facility has the capacity to reduce 800 tons of sludge per day to 200 tons by reducing its mass by 4 times. Digested-dried sludge, which reaches 92% solids content, can be used both in agriculture and urban green areas and in the industry as additional fuel. In 2019, a total of 5,259 tons of dried sewage sludge and 5,533,176 m3 of biogas were obtained in the Sludge Digestion - Drying Unit. The dried sludge obtained in 2019 was used as additional fuel in cement factories (İzmir Water and Sewerage Administration [İZSU], 2022).

The amount of municipal waste collected throughout İzmir in 2019 is 1,971,904 tons and 93.26% of it in the Harmandalı Solid Waste Landfill, 3.49% of it in the Bergama Solid Waste Landfill and 3.25% of it in the Tire Irregular Dump, are disposed (Ministry of Environment, Urbanization and Climate Change of Türkiye, 2020). For the management of these high-volume wastes, solid waste management and disposal facilities have been continuing to be constructed by the İzmir Metropolitan Municipality (İMM). The Harmandalı Biogas and Electricity Production Facility was put into operation in 2019 with a power of 16 MW, and the installed power of the facility reached 32 MW in 2021. At "Güney-1 Ödemiş Integrated Solid Waste Management Facility" which was established in 2021 with a waste processing capacity of 1200 tons/day; raw materials are provided to the recycling sector; along with methane gas with high energy value produced from organic wastes, as well as compost which is a soil-improving material, and solid organic fertilizer that can be used in agriculture is obtained. The electrical energy produced at the facility, which has reached a power of 7.80 MWh, has the capacity to meet the electricity needs of 116,000 households per month. Bergama Integrated Facility, where the wastes generated on the northern axis of İzmir are recycled, started its operations in 2020 and meets the monthly average electricity needs of 90 thousand households with its capacity reaching 4.23 MWh of energy. In addition to these facilities, the Güney-2 Project in the Menderes district, which is planned to have a maximum capacity of 4,000 tons/day, is targeted to be the 3rd facility in İzmir that provides energy based on biomass (İMM, 2022).

The provinces where waste vegetable oils are recycled the most in Türkiye were determined as İzmir and Eskişehir. From the calculations made depending on the amount of vegetable waste oil, it was determined that 435 tons of waste vegetable oil were recycled annually in İzmir; and the amount of biodiesel formed was calculated as 437 tons (Nacar & Durmuş, 2019). Aviation is steadily growing worldwide as well as in the European Union (EU). Overall, EU transports increased their Green House Gas (GHG) Worldwide, as well as in the European Union (EU), the aviation industry is experiencing steady growth. Despite the constant reduction of greenhouse gas emissions achieved by other energy sectors since 1990, the overall EU transports have increased their emissions. Given the limited options that can be implemented, such as the optimization of flight routes and the enhancement of jet engine energy efficiency, among a few others, air transport is considered the most critical area to decarbonize. Therefore, the primary opportunity for the aviation sector is specified to reduce its carbon footprint lies in switching to renewable or low-carbon fuels (Chiaramonti, 2019). In the upcoming years, a significant increase in biofuel production for the aviation industry is expected as a part of the world's clean energy transformation. İzmir has two refineries to produce petroleum products, and these facilities also produce jet fuel. Being one of the largest industrial facilities in Türkiye, these refineries also constitute an important infrastructure for biofuel production. Tüpraş, one of these refineries, has started to work on converting approximately 8,300 barrels of waste raw materials per day into sustainable aviation fuel (SAF), renewable diesel and other products. With its investments, Tüpraş foresees processing 400 thousand tons of biofuel raw materials in 2030 and plans to become Türkiye's largest supplier in this field by increasing its sustainable aviation fuel production capacity by 3 times in the period after 2035 (Tüpraş, 2022).

According to the NACE codes of the companies gathered from the İzmir Chamber of Commerce and the Aegean Region Chamber of Industry in İzmir, the number of companies related to bioenergy in İzmir has been determined as 8,310 in total from 41 different NACE codes. Companies that are directly interested in bioenergy, companies that can give support in the creation of systems, companies that can be cooperated, companies that can produce system parts, companies that are related to bioenergy in different aspects such as raw material supply and technology support, were selected to this group (Koçar et al., 2012).

Considering the information provided in this section, it can be stated that İzmir is a sectoral ecosystem suitable for smart specialisation in the bioenergy sector. However, the existence of a suitable sectoral ecosystem alone is not enough; a detailed strategy, inter-institutional cooperation and a determined implementation process are required to reach the regional development opportunities provided by smart specialisation.

2.2. Bioenergy Focused Smart Specialisation Potential in İzmir

In this section, the bioenergy focused smart specialisation potential of İzmir been analyzed qualitatively based on the S3PEnergy Good Smart Specialisation Practice Criteria. The current situation of the activities in bioenergy in İzmir is evaluated according to these criteria by using the Gap Analysis Method. Gap Analysis describes the gap between the current state and the desired state to be reached in the future. The aim here is to create the necessary works/strategies to close the gaps. To perform the gap analysis, a three-step process is followed:

- Put forward the future situation, determine the place you want to reach,
- Analyze your current situation,
- Identify the gap between the two situations (present and future) and create the necessary strategies to reduce the gaps.

Gap Analysis is designed to explain the gap between the current situation and the smart specialisation good practice criteria, in this study. Thus, the qualitative determination of the extent of the gap between the current situation and the expected is done and it is schematized in Figure 3.

2.2.1.Evaluation in Terms of Eligibility

Part of S3: The S3PEnergy Good Smart Specialisation Practices Determination Methodology pays special attention to the S3s of regions/cities within the necessary eligibility criteria. Although there are some sectors that are prioritized by institutions in İzmir for the purposes of regional development, clustering and etc., there is not an S3 for İzmir yet. In the Izmir Regional Innovation Strategy renewable energy sector, is prioritized in terms of innovation, as being, the 6th sector with the highest innovation performance, the 4th sector with the highest share of R&D expenditures in the average turnover, the 5th sector with the highest number of independent R&D units, the 2nd sector with the highest number of university-industry cooperation and the 7th sector with the highest number of employees with Ph.D. (İzmir Development Agency [İZKA], 2012). Although it can be said that the bioenergy sector, as a sub-title of the renewable energy sector, is included in the regional innovation strategies of İzmir, it is understood that there is weak compliance with this criterion due to the lack of a focused S3 on bioenergy. It is obvious that there is an important requirement to prepare an S3 and a roadmap that will enable İzmir to use its high potential in the field of bioenergy in its economic development.

Use of ESIF (Adapted for Türkiye): As Türkiye cannot benefit from ESIF support as an EU Candidate Country; while "Use of ESIF" criterion is used for Türkiye, it is evaluated that the fact that the project has benefited from the high budget support programs such as the Research Infrastructure Support Program, Competitive Sectors Program, Development Agencies Guided Project Supports provided in similar fields; can be used as a criterion. In the field of bioenergy, these funds have been used effectively in İzmir. Ege University Biomass Energy Systems and Technologies Application and Research Center (BESTMER), which is an important research and innovation infrastructure, was established with the Research Infrastructure Support Program and İzmir Development Agency Guided Project Support. Based on this, it has been evaluated that excellent compliance with this criterion has been achieved.

Implemented: Some projects and studies are carried out by different institutions in the field of bioenergy In İzmir, but these implementations are not carried out within the scope of a certain S3 and under coordination. Given the current situation, it is evaluated that there is weak compliance with this criterion. As mentioned in the first criterion, there is an important requirement to prepare an S3 and a roadmap and execute that roadmap in İzmir.

2.2.2.Evaluation in Terms of Relevance

Framed Along The S3 Concept: The criterion that the smart specialisation is to be based on the exploitation and development of the critical mass of knowledge and economic activities of the R&D institutions and firms in the region, can be evaluated within the light of the information in the "Biomass Energy Sector in Izmir" section above. In this regard, it is understood that there is a good level of knowledge in the private sector in İzmir and there are also important research institutions working in bioenergy. In addition, the city has a significant bioenergy potential. As a result, it has been evaluated that there is good compliance which can be moved to a higher level with this criterion.

Innovative Character: One of the relevance criteria for a good smart specialisation is to have an innovative character. Going beyond the one-to-one application of well-recognized technologies or techniques in the region; product, process, organizational, system innovation, or also social innovation is expected. When bioenergy implementations of institutions in İzmir are examined, the 250-kW biogas facility established in Foça Open Prison in 2019 with the İzmir Development Agency's support can be shown as a successful case. The establishment of an animal production infrastructure and an associated biogas plant by an open prison, which is a public institution, to include prisoners in the workforce and provide social benefit to them, involves process and organizational innovation. The production of ex-proof blowers for the first time in Türkiye with the İzmir Development Agency's support is an example of incremental innovation in terms of product innovation (İZKA, 2022). However, the realization of all these implementations within the framework of a certain S3 and with regional coordination will ensure good compliance even with this criterion. From this aspect, it is evaluated that valid compliance with this criterion has been achieved.

Minimum 3 Out of 4 Pillars of The Quadruple-Helix Model Involved: The quadruple helix model, which aims to model regional innovation systems, is the advanced version of the triple helix model; focuses not only on the university, public and industry actors, but also considers the growing role played by civil society (Leydesdorff, 2012). To implement a good smart specialisation, it is expected to have at least three of these four stakeholder types. Considering the information in the "Biomass Energy Sector in İzmir" section, university, public and industry stakeholders in the field of bioenergy in İzmir carry out intensive activities as the 3 elements of the model. In addition, Biodiesel Industry Association, and Energy Industrialists and Businessmen Association (ENSİA) are based in İzmir and are NGOs operating in the sector. It has been evaluated that good compliance with this criterion can be moved to a higher level by ensuring more effective coordination of these stakeholders within the scope of S3 and more intensive cooperation in bioenergy projects.

Outcome-Oriented: For a good smart specialisation implementation; it is expected that the impacts are determined and monitored with quantitative performance criteria if possible or qualitative performance criteria, from various angles linked to S3 and energy strategy objectives. The report titled "Biogas and Organic Fertilizer Production Potential in İzmir" on biogas and organic fertilizer provides the scope to meet this criterion. In addition to this report, which is prepared based on the number of cattle in İzmir, it is possible to determine a wider range of performance indicators for the effects of bioenergy focused smart specialisation through research in other fields of bioenergy like biofuels, waste management. This research will also provide input to a bioenergy focused S3 that can be developed for İzmir. In this manner, it is evaluated that valid compliance with this criterion has been achieved.

2.2.3.Evaluation in Terms of Quality

Clear Relevance to National/Regional Energy Strategy: Good smart specialisation is preferred to be designed compatible with national and/or regional energy strategies and contribute to the achievement of the targets set in the strategies. Among the objectives and policies of Türkiye's 11th

Development Plan; increasing electricity production from renewable energy sources; realization of new investment models with mechanisms that will include the use of domestic equipment, R&D, technology transfer, public procurement n the field of renewable energy; giving priority to the production of energy equipment that is needed and that can provide competitive advantage are listed (Presidency of Türkiye, Presidency of Strategy and Budget, 2019). Within the "Domestic Production of Energy Technologies Working Group Report", which was created during the preparations for the 11th Development Plan, it is stated that the production and use of heat from biomass should be widespread (Presidency of Türkiye, Presidency of Strategy and Budget, 2018). In the 2019-2023 Strategic Plan of the MoENR of Türkiye; within the aim of ensuring sustainable energy supply security, there is the target of “increasing the ratio of the electrical installed power based on domestic and renewable energy sources to the total installed power from 59% to 65%”. And one of the performance indicators of this target is to increase the electrical installed power based on biomass (including biogas) energy to 2,884 MW cumulatively by 2023. Within the aim of technology development and indigenization in the field of energy, there is a target of “R&D projects of strategic importance in the field of energy will be increased.” One of the performance indicators of this target is “Developing, implementing and disseminating the prototype of compact type biogas plants for housing in rural areas” (MoENR, 2019). In the 2014-2023 İzmir Regional Plan, it was stated that there is a significant potential in İzmir in terms of renewable energy sources and technologies; the strategic goal of expanding the use of renewable energy in all sectors and increasing renewable energy production was included (İZKA, 2013). Within the light of all this information, it has been evaluated that the bioenergy focused smart specialisation studies to be carried out in İzmir are in good level consistency with the clean energy targets determined in the national and/or regional strategies; and they would contribute considerably to the achievement of the targets in these strategies.

<u>Interactions Between Responsible Agencies/Authorities From Different Areas:</u> Within the bioenergy activities, R&D-innovation, clean energy, agriculture-livestock, waste management, etc. many policy areas intersect. Accordingly, it is important to ensure interaction between institutions in these fields in smart specialisation studies. Within the BESTMER's activities in İzmir, many cooperation and projects have been carried out with institutions and authorities from different fields (BESTMER, 2022a). The "BEST For Biomass Ideathon"; which was realized as an activity in the field of bioenergy of the BEST for Energy Project, which was implemented in İzmir to develop a competitive cluster in the clean energy and clean technologies sector and supported within the "Competitive Sectors Program"; was organized as an open innovation event. It is an activity that provides fruitful results in terms of both increasing the interest of young people in bioenergy and ensuring the interaction of different institutions (BEST For Energy, 2022). It is possible for all these collaborations to be directed towards common goals, to increase their sustainability by structuring, and to be moved to a higher level with an S3. In this context, it is evaluated that valid compliance with this criterion has been achieved.

<u>Synergetic Use of Several Funds:</u> In smart specialisation studies, it is preferential that different funding sources like national, regional, or local funding programs, EU support programs, etc. are used wisely and in a way that creates synergy with each other. In the establishment of BESTMER, which is an important R&D infrastructure in the bioenergy sector, Research Infrastructure Support Program at the national level and İzmir Development Agency Guided Project Support at the regional level were provided. In addition, there are a total of 62 national and international projects carried out by BESTMER, 6 of which are ongoing (BESTMER, 2022b). As a Competitive Sectors Program project, the BEST For Energy Project mentioned above, also includes activities to increase the competitiveness of the bioenergy sector in İzmir. Considering the projects of other institutions in İzmir in the bioenergy sector except for high budget support programs, it has been evaluated that valid compliance with this criterion could be moved to a higher level.

Ambitious: Smart specialisation studies are preferred to be implemented in a multi-sectoral/multi-activity (technology development, education, awareness, capacity building, infrastructure, trade, etc.) structure as a program that is not limited to a one-time project; and be consist of integrated activities with an ambition for transformation and high impact potential. Establishment of BESTMER in İzmir as an R&D infrastructure; R&D and technology development projects carried out by BESTMER; İzmir Metropolitan Municipality's Vocation Factory's vocational training and capacity building activities in cooperation with institutions; the activities carried out in the field of bioenergy within the BEST For Energy Project; considering these activities, it is evaluated that valid compliance with this criterion has been achieved. However, it has been evaluated that this valid compliance would be moved to a higher level with an S3 and its application that will also ensure the cooperation of other institutions in İzmir, especially in the areas of awareness and trade.

Inter-Regional Cooperation Dimension: To increase the effectiveness of smart specialisation efforts, it is preferred to create links and collaborations with actors in other regions or countries. When the activities of the bioenergy actors in İzmir are examined, it is seen that BESTMER is a member of the EERA Bioenergy Joint Research Program and through this membership, it can conduct joint research projects with bioenergy stakeholders in Europe. It is also seen that BESTMER has an ongoing EU project. It has been evaluated that regional and international cooperation of institutions operating in the bioenergy sector in İzmir is a need for development and compliance with this criterion is weak in İzmir.

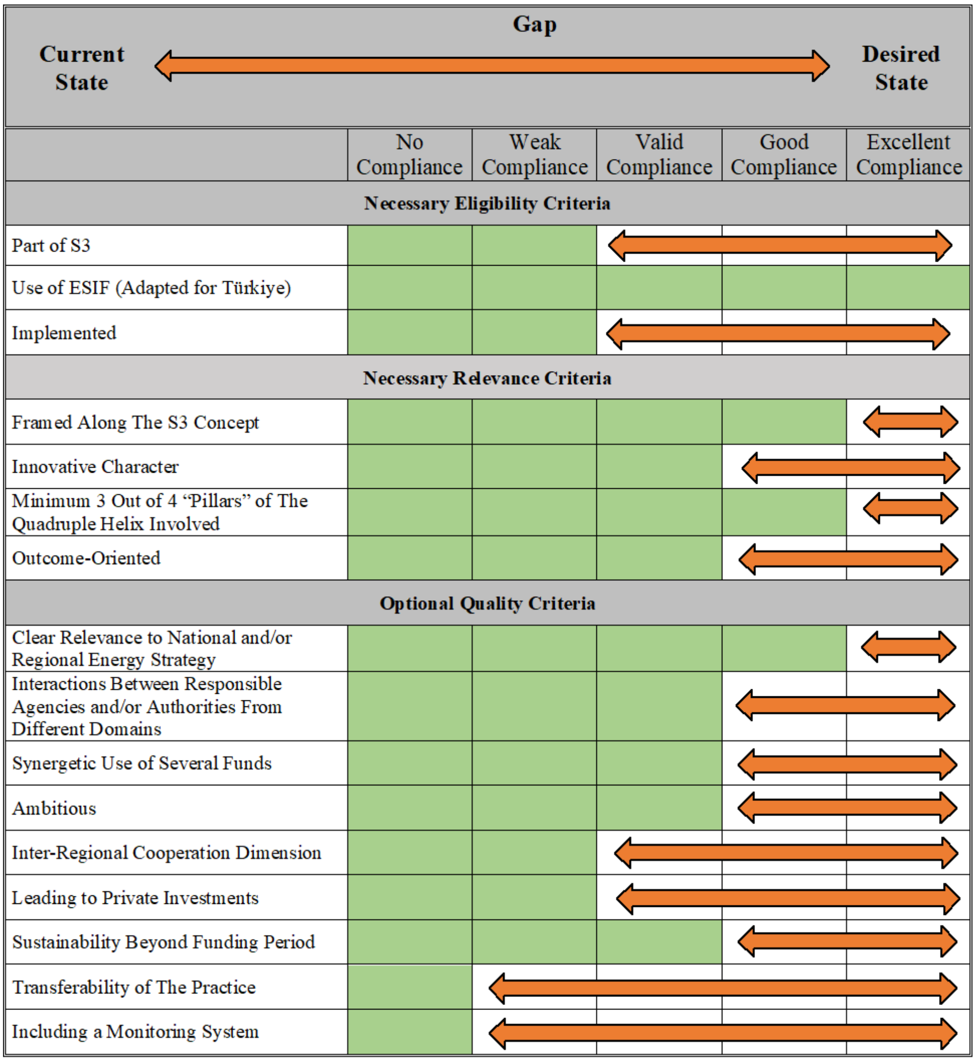
Leading to Private Investments: In a good smart specialisation practice, it is preferential that businesses are included in the process and a leverage effect is created on private sector investments. The case that a company supported by İzmir Development Agency produces ex-proof blowers for the first time in Türkiye can be shown as an exemplary project in terms of this criterion. The sustainable aviation fuel (SAF) investments to be made by the refineries in İzmir create an opportunity for the development of a sectoral value chain with the development of the right strategy. However, since there is not an S3 to direct private sector investments in the bioenergy sector in İzmir, it has been evaluated that there is weak compliance with this criterion.

Sustainability Beyond Funding Period: It is preferential that smart specialisation studies are not excessively dependent on public finance and include a continuation strategy beyond the public finance period when necessary. When the studies in the bioenergy sector in İzmir are examined, it is observed that a significant part of the studies is financed by public resources. BESTMER, which started as a guided project, was transformed into an "Application and Research Center" within Ege University in 2019, and its sustainability was ensured. It has been evaluated that, current valid compliance would be improved with the activities being carried out within the scope of a certain S3 and designed to include cooperation projects ready to be financed in the bioenergy in İzmir.

Transferability of The Practice: It is preferential that smart specialisation studies are carried out in a way that draws lessons from the implementation period and that appropriate conditions are provided for the transfer of these lessons to other regions/countries. It has been evaluated that compliance with this criterion has not been achieved due to the lack of activity in this manner in the studies for the development of the bioenergy sector in İzmir.

Including a Monitoring System: It is preferred to systematically monitor the outputs and results obtained in smart specialisation studies to draw lessons for the future and to disseminate the practice. It has been evaluated that compliance with this criterion has not been achieved.

Figure 3: Gap Analysis for İzmir's Bioenergy Focused Smart Specialisation Potential



CONCLUSION AND SUGGESTIONS:

Smart specialisation is that a region focuses its resources on a limited number of areas where it has a competitive advantage, within the scope of a certain strategy and in a way that differentiates it from other regions; and increases the efficiency and competitiveness of the regional economy through specialisation based on R&D and innovation in these prioritized areas. In smart specialisation studies, the selection of priority areas is a policy process and prioritization in any area is generally seen as risky by policymakers. To avoid the possibility that the smart specialisation process will fail due to the policymakers' tendency to not take risks; it is recommended that these studies be started in areas where a certain degree of development is already taking place in the regions.

In this study, the development status of İzmir in the bioenergy sector and its smart specialisation potential were tried to be determined by examining the studies of the institutions that constitute the elements of the quadruple spiral innovation model in the bioenergy sector in İzmir. The status of R&D and innovation studies carried out by institutions in the field of bioenergy in İzmir was examined using the Difference Analysis method according to the Good Smart Specialisation Practice Criteria developed by S3PEnergy. In the Gap Analysis study, the extent of the gap between the current status of the studies in the bioenergy sector in İzmir and the expected situation in terms of the criteria of the mentioned methodology has been determined.

In the qualitative analysis, it has been evaluated that there are areas where İzmir complies with the Good Smart Specialisation Practice Criteria at an excellent level or at a good level. (1) Considering the present situation of İzmir in the bioenergy sector, it is observed that knowledge (know-how) and economic activity in companies and research institutions have reached a certain level and a suitable framework for smart specialisation has been formed. (2) In the field of bioenergy, especially in the establishment of BESTMER, large-scale financial supports at the national and regional level were used. (3) In İzmir, universities, public, industry and NGOs in the field of bioenergy continue their activities as elements of the quadruple helix innovation model. (4) Bioenergy studies carried out in İzmir are in line with national and regional energy strategy documents. (5) In the bioenergy sector, national, regional, or local financing programs, EU support programs, etc. different funding sources were used to create synergy with each other.

The areas in which the bioenergy sector studies in İzmir comply with the Good Smart Specialisation Practice Criteria at a valid level can be listed as follows. (1) In the bioenergy sector activities in İzmir, by going beyond the one-to-one use of existing technologies at a certain level; product, process, organization, system innovation or social innovation has been applied. However, it is obvious that the existing institutional structures in İzmir should carry out more active studies on R&D and innovation. (2) It would be appropriate to determine and monitor the current situation and performance indicators for smart specialisation through research in different sub-fields of bioenergy in İzmir. (3) In the bioenergy sector, where many policy areas like clean energy, agriculture-livestock, waste management, R&D-innovation, etc. intersect, interaction and cooperation between institutions have reached a valid level; however, it is another important issue that needs to be improved. (4) Activities for the development of the bioenergy sector in İzmir, technology development, training, capacity building, etc. at a valid level. continues as multi-sectoral/multi-activity. However, the commercial dimension of these activities must also be carried out effectively. (5) In the bioenergy sector, in which a certain infrastructure was provided by creating valid public financial resources in the past; new cooperation projects, including the private sector, should be developed, and ready to be financed.

It is determined that the most important step that will increase the success in the bioenergy sector, which has reached a certain level of development status and accordingly the smart specialisation potential in İzmir, is the preparation of an S3 and a road map in this area. As a result of a bioenergy focused S3 to be developed and its implementation, İzmir's current potential in this field would highly contribute to its economic development. This mentioned S3 should include practices that lead private sector investments in bioenergy sector activities in İzmir, and the awareness of the value chain of this sector should be created in more companies, and the investments of companies in this sector should be increased. In the implementation of bioenergy focused S3, cooperation projects should be developed with actors in other regions and countries. Another point to be considered during the implementation phase is that this strategy includes a monitoring system and can be transferred in a way that contributes to tackling climate change by other countries/regions in the long run.

Considering the role of energy in climate change and the recent energy crisis all over the world, the importance of clean energy for the country and regional strategies has increased. İzmir has important potential in the clean energy and bioenergy sector. As a result of the gap analysis applied in this study, it is evaluated that by making the necessary improvements is possible to reach a good smart specialisation in the field of bioenergy in İzmir and to use bioenergy as an opportunity for the sustainable economic development of İzmir. In this way, it would be possible for İzmir to switch from its current situation, which has an important bioenergy potential but cannot adequately reflect it to its economic and social development, to become a smartly specialized region in the field of bioenergy by using its high potential.

Compliance with Ethical Standard

Conflict of Interests: *There is no conflict of interest between the authors or any third party individuals or institutions.*

Ethics Committee Approval: *Ethics committee approval is not required for this study.*

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