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Energy generation, transition and sustainable growth in Turkey

ABSTRACT: The structural economic problems of Turkey have led to the significant challenges for the development of the country, especially in the postcoronavirus economy. One of such challenges is the achievement of the sustainable development imperatives in combination with the preservation of the competitive advantages of the Turkish economy. The loss of the major drivers of the economy of the country, including tourism and logistics, in complex with the economic deterioration of the monetary system of the country are the major components of the current crisis. This controversy is analyzed in the paper along with the search for the best options of the energy sphere development in Turkey. This search covers economic aspects of the current situation in the country. The authors put forward and prove a hypothesis that Turkey energy system can be more influential on its economic development. This proof is based on the energy mix analysis and on the thorough review of the potential of the country for the green energy development and its economic effectiveness for the country. The key findings of the article include the proof that the sustainable development and the green energy development in Turkey are quite different processes, which are on intention divided by political measures, the proof that Turkey has serious issues in development of the energy sector due to its low influence on the economic development in its current state, the developed recommendations for the better structuring of the energy sector development.

KEYWORDS: Turkey, energy sector, green energy, sustainable development, structure, transition

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Introduction

The energy system of any country basically consists of 3 major sectors – upstream, midstream and downstream. The domination or inferiority of any of those sectors leads to the imbalances in the energy system in general (Basit et al. 2016). In this paper we review the energy system of Turkey, which is an extremely important energy transition hub, while the energy production in the country is rather inferior to the possibilities of its energy generation. The aim of the article is to prove that Turkey has a significant potential for the generation of green energy while the hypothesis states that Turkey energy system can be more influential on its economic development.

In the article sustainability is assessed as a complex of economic, social and ecology factors, which lead to the overall more stable development of the economic sphere and to the growth of life quality. Due to the political characteristics of the country, political sphere is omitted from the analysis, still the authors state that in this perspective the analysis can be based on the general principles of ESG-analysis (ecology, social and government) (Bătaea et al. 2020). The main findings of the article include the proof of the hypothesis, the proof of the unsustainable character of the Turkish energy sphere and energy policy in general, the proof of the misunderstanding of the sustainability issue in the country, leading to the economic crisis and the positive role of hydroenergy and power consumption on the GDP. The other important results, defining practical and theoretical significance of the article include developed recommendations, the GDP forecast and the proof of the relatively low efficiency of green energy development for the economic development of Turkey.

1. Literature review

The article encompasses two major themes – sustainable development and energy system of Turkey with focus on the latter. Hence, all the literature on the theme can be divided into two groups.

The issues of the sustainable development are widely covered in numerous articles, still the implications of the sustainable development for economic and social spheres are given in (Mensah and Casadevall 2020). The complex literature review, given in the article, are limited by the non-practical character of the article. The other article (Kroll et al. 2019) reviews the practical aspects of the SDGs in the sense of their influence on the human development. This article is based on the two mentioned articles, including theoretical aspects from the first and relying on the practical understanding of SDGs.

The Turkish position on the global energy market is revealed in (Erşen and Çelikpala 2019), where the authors state, that the current situation on the global energy market can threaten the

relations between Turkey and Russia and Turkey and EU, while the latter is introducing new politics and Russia seeks for geopolitical allies. In (Shaffer 2006) the authors refer to the energy mix of the country and its future in nuclear energy policy. The state of the Turkish electric grid is described in (Saygin et al. 2021). The authors state that the country has rather developed electric grid, but its effectiveness can be improved up to 50%. The generation of energy from renewables is analyzed in (Ceren and Ozkaya 2019), where the authors prove the need for green transformation in the country, but don't analyze thoroughly the economic effects of this transformation.

2. Methodology

First of all, it's necessary to figure out the major characters and issues of the Turkish energy system. In order to do that, we have conducted regression analysis of the country energy sphere.

The second step is the analysis of the potential for the green energy development, as it follows from the goals stated in the introduction. It's based on the dynamics of the green energy generation in the country.

In order to determine the influence of a specific energy source on the economy of the country the linear OLS method is used.

$$f(GDP) = \alpha x_1 + \beta x_2 + \dots + \omega x_n \quad (1)$$

where:

$x_1 - x_n$ – volume of energy generation from specific sources and the volume of energy consumption in the country.

The third step is the provision of the correlation analysis between the development of the green energy and the economic development of Turkey. In case the hypothesis is true, the correlation will be significant, the higher, the more suitable the chosen source of energy is for the country, in the opposite case, the authors put forward a supposition, that the best and the most effective measure for the country is to stay the major energy hub in the region and use its privileges as such for the better conditions on energy market as a consumer.

The three named steps result in the possibility to construct a system of measures, aimed at the improvement of the energy sector in the country and on the solution of the issues, figured out in the first step.

2. Results

Turkey is one of the most dynamically developing economies in the region, the country has a rapidly growing demand for energy, which is for the major part satisfied from imports of energy resources. This happens despite the fact that the country has some reserves of natural gas and oil (the reserves of the first have been significantly increased lately (Yilmaz-Bozkus 2018)). The overall demand for energy is satisfied by the domestic production by 24%, which is rather a small part. First of all, let's figure how the energy mix influences the country energy market and policy. Figure 1 depicts the major sources of energy in Turkey.

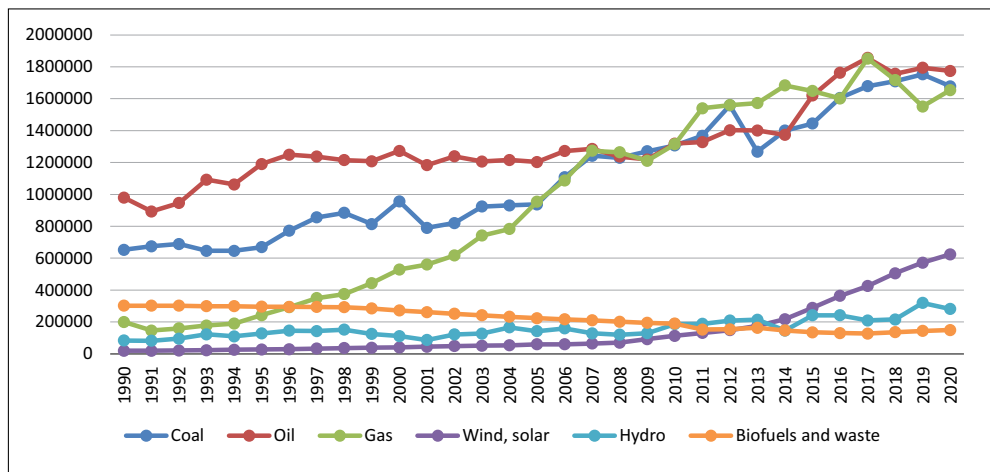


Fig. 1. Major energy sources in Turkey [TJ] (made by authors, based on: IEA 2020)

Rys. 1. Główne źródła energii w Turcji [TJ]

The data on figure 1 allows to make several important conclusions. First of all, the overall growing supply of energy reflects the growing demand, but the major growth is gained by the use of traditional resources, namely, oil, gas and coal. The rapid growth of wind and solar energy in the past 5 years reflects the general trend, but can't be compared with the growth of the traditional resources' use.

The second important fact is that the country significantly relies on coal, which is cheap, but at the same time unecological source of energy. As a result, the country energy sector can't be named ecological at all. The economy of Turkey is developing rapidly, mostly due to the competitive advantages of cheaper labor force and lower ecology standards. In addition to that the logistic services and tourism are highly contributive to the Turkish economy (Akan et al. 2008; Yildirim 2019). This leads to the high demand for the cheap energy sources, like coal and to the cheaper energy sources, such as oil and gas. The relative cheapness of the latter is explained by the general economic logic:

$$HP = EWP + TC + RC \quad (2)$$

where:

- HP* – importer price of hydrocarbons,
- EWP* – ex-works price of oil and gas,
- TC* – transit costs,
- RC* – costs of risk-acceptance.

In case of Turkey the transit costs are lower because the country receives hydrocarbons directly from the exporter (Russia, Iran or Azerbaijan) and has little or no transit expenses, moreover, these countries pay Turkey for transit. When speaking of costs of risk, Turkey has one of the most diversified portfolios of suppliers of energy resources, including USA, the Persian Gulf countries and African exporters (Esen 2016). In this regard, the costs of risk-acceptance for the country are low.

The third very important part of the country energy sector is the use of oil and gas. As we have already mentioned earlier, Turkey has some hydrocarbon resources, but majorly imports energy. This import is based on the geographically determined intersection of major trade routes between Europe, Asia and the Persian Gulf countries. The country has significant benefits from the major pipelines from Iraq (TANAP), Russia (Southern Stream), Azerbaijan (Baku-Dzejhan) (Öge 2019) and from the distribution and transit of hydrocarbons to Europe as the big energy consumer and importer. In this regard the European green energy politics are a threat not only to the energy exporting countries, but for Turkey too, as the country will lose significant revenues from energy transit in case it falls significantly.

The fourth conclusion is that the country doesn't put significant efforts in development of hydroenergy generation, biofuels and waste energy, obviously focusing on the cheaper or more ecofriendly sources. Let's refer to the potential for green energy generation in the country.

First and foremost, it's necessary to say, that Turkey announced the transition to the greener energy (Kalehsar 2019; Haci et al. 2018), leading to the necessity to fulfil the goals in this sphere. In this regard, the green energy ventures and initiatives receive significant support (legal framework is based on (Turkey 2013)). The state of the electricity grid in the country is the first question to ask, when speaking about green energy transition. Today 21% of energy in the country comes from green energy sources and is majorly produced and consumed by the private sector and households (Erat et al. 2021). The state of the Turkish energy grid is quite satisfactory, it can freely distribute and store the current capacities of the green energy produced (Saygin et al. 2021). At the same time, the hereabove mentioned article points out the fact, that the energy grid in the country requires investments and in case these investments are made can distribute and store 30% of overall energy consumption in the country in green energy. As a result, the state of energy grid isn't a barrier for the country green energy sector.

The second question is whether the natural conditions allow to install green energy capacities. Figures 2 and 3 demonstrate the photovoltaic potential of the country and the wind speeds in Turkey.

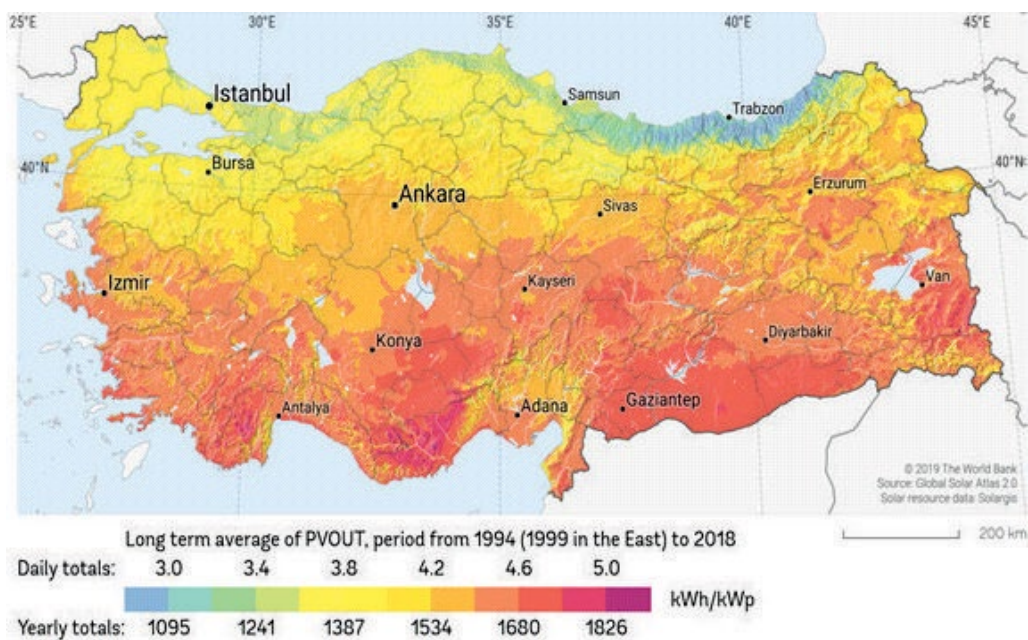


Fig. 2. Photovoltaic potential of Turkey (GSA 2019)

Rys. 2. Potencjał fotowoltaiczny Turcji

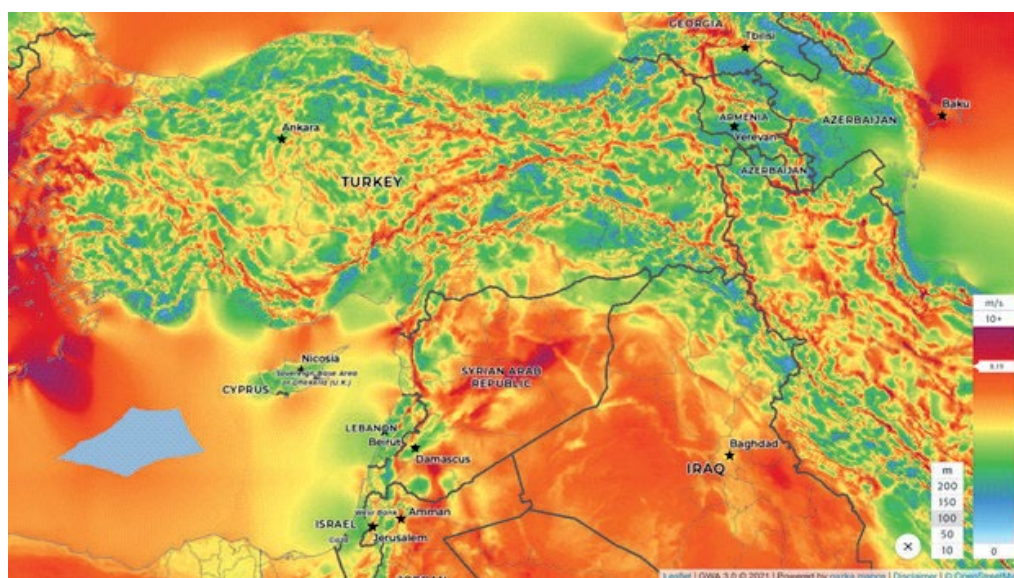


Fig. 3. The wind speeds in the country (Global wind atlas 2021)

Rys. 3. Prędkości wiatru w kraju

As we can conclude from Figure 2, the major regions, suitable for the solar energy generation are the regions along the Southern coast of the country, which at the same time are the major touristic regions of the country. These two factors are synergetic as the touristic industry has become very sensitive to the clean and sustainable use of natural resources by the local facilities, especially taking into account the will to preserve the natural beauties (regarded as the resources for sightseeing revenues) (Wondirad 2019). As a result, the use of solar panels in the Southern regions of the country is highly profitable, especially when counting the potential for the energy costs amortization via the revenues from touristic flows.

The potential for the wind energy generation in the country lies majorly in the mountainous regions of the country and nearby the Strait of Botsford, which in turn compliments the lack of photovoltaic potential on the European part of the country.

The results of the analysis of the green energy natural potential demonstrate, that the country has significant resources for the development of green energy, while the rapid growth of the last years demonstrates the effective use of this potential.

From the other hand, Turkey has limited financial resources for green energy development (Aslan 2005) and significant geoeconomics ambitions of becoming a regional transport hub and energy hub. In order to achieve this goal the country spends significant amounts of money (Ozdamar et al. 2020).

The economic development of Turkey highly depends on the energy supply and demand in the country. In order to provide insights in the correlation between the energy sector and economic development, it's necessary to review the energy consumption. Let's refer to Figure 4, demonstrating energy consumption in Turkey and the emissions of CO₂ in the country.

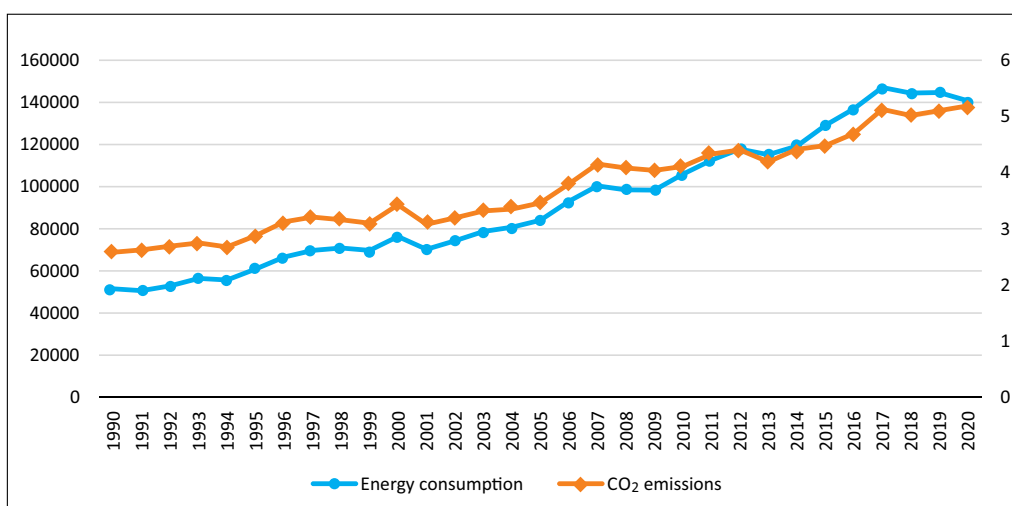


Fig. 4. Carbon dioxide emissions intensity of energy demand in Turkey [ktOE, metric tons] (created by authors, based on: Enerdata 2020)

Rys. 4. Intensywność emisji dwutlenku węgla zapotrzebowania na energię w Turcji [ktOE, tony metryczne]

In the long run Figure 4 demonstrates the rapid growth of energy consumption in the country along with the even faster growth of CO₂ emissions. This is a result of the Turkey industrialization. Simultaneously, it's necessary to mention, that the last 5 years have made a sharp turn in this tendency, leading to the higher growth of energy demand, than CO₂ emissions. The results of the 5-year analysis of the dynamics of the two factors are presented in Table 1.

TABLE 1. Carbon dioxide emissions and energy demand growth (created by author)

TABELA 1. Emisja dwutlenku węgla i wzrost zapotrzebowania na energię (opracowane przez autora)

Period	Energy consumption growth	CO ₂ emission growth
1990–1994	3.52%	4.22%
1995–1999	4.68%	11.39%
2000–2004	2.08%	15.48%
2005–2009	4.86%	9.87%
2010–2014	4.11%	2.36%
2015–2019	1.82%	-3.52%
1990–2020	3.40%	6.42%

Table 1 clearly demonstrates the following tendencies. First of all, the economy of the country demands less energy, but as we will see in from figure 5, doesn't become less energy-intense, moreover, the demand of energy, divided by the volume of GDP demonstrates rapid growth from 2013. The second important point is that the CO₂ emissions in Turkey are declining rapidly – with the average decline of 3.52% a year, the country has all the chances to meet the 30% CO₂ decline by 2030, fulfilling the UN Sustainable Development Goals in the sphere of ecology (Karasoy 2019). Still, the major consumer of energy in any country is industry, the household sector has the second place, while the services sector and agriculture are usually far behind (Ginevicius et al. 2021). It's true for Turkey too – the major consumers are enterprises and companies of the real sector (Sica and Senturk 2019).

This explains the fact, why Turkish economy demands less energy – the economy of the country is in deep crisis. The dynamics of GDP clearly represent it (Fig. 5).

This economic crisis lies in the several important factors for the economy of the country, which are: high inflation rates, low interest rates, high indebtedness of the country, companies and its population, the fall of demand for Turkish goods and the loss of significant drivers for economic growth in the last years – tourism (because of COVID-19) and strong currency, which has hit record lows in 2021 (Shuabiu et al 2021). The consequence of such politics on the economy of the country is rather bad, still, the industrial development of the economy of the county has reached significant successes.

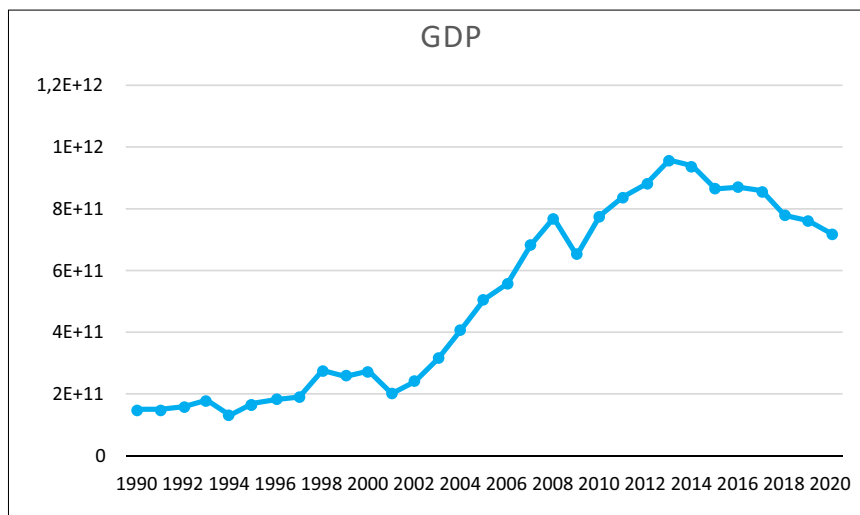


Fig. 5. Turkish GDP, current prices in US dollars (created by authors, based on: The World Bank 2021)

Rys. 5. PKB Turcji, ceny bieżące w dolarach amerykańskich

The two major vectors of the research – energy sector and economy are tightly bound, which leads to the conclusion, that the well-developed energy sphere is one of those drivers, capable of improving the situation in the Turkish economy. Let's test this hypothesis.

Table 2 depicts the results of OLS modelling of the Turkish GDP. The major results are: the low influence of the missed in the model energy sources on the GDP of Turkey, the high positive influence of the energy consumption on the GDP and the negative influence of oil and coal on the GDP due to their imports, the positive influence of the hydroenergy (the attention to which in Turkey is low), and the negative influence of the wind and solar energy generation.

These results can be explained by economic consequences of the Turkish energy and economic policy. First and foremost, the development of wind and solar energy requires significant investments. As a result of the high indebtedness of the country the further development of this sphere will lead to the negative effects of overborrowing on the GDP (especially taking into account the current negative effects of high debt in Turkey). Imports of coal and oil do have a constant negative effect on GDP as they generate stable outflows of capital. In this regard, the positive influence of energy consumption is one of the pillars, which ground the current economic policy of R. Erdogan – the stimulation of economic activity via low interest rates (Cohen 2021). Still, it's necessary to mention, that in the long run the positive effects of public and corporate spending can lead to significant problems of monetary character, while the current situation with lira demonstrates, that these problems have already come. The important fact for Turkish energy sector is the positive influence of hydroenergy on the GDP. As we have concluded hereabove, Turkey misses out the development of this energy sector, so special attention should be given to it in the context of better economic performance.

TABLE 2. Regression statistics (created by authors, based on Gretl)

TABELA 2. Statystyki regresji

	Coefficient	std.error	t-ratio	P-value	
Oil	-894,694	55585.6	-16.10	<0.0001	***
Windsolar	-737,186	91733.5	-8.036	<0.0001	***
Hydro	658,353	346,680	1.899	0.0687	*
Energyconsumption	2.7072e+07	2.16596e+06	10.02	<0.0001	***
Coal	-296047	155,863	-1.899	0.0687	*
Mean dependent var	5.06e+11	S.D. dependent var	3.02e+11		
Sum squared resid	5.89e+22	S.E. of regression	4.76e+10		
R-squared	0.994478	Adjusted R-squared	0.978397		
F(5, 26)	936.5508	P-value (F)	1.78e-28		
Log-likelihood	-803.4349	Akaike criterion	1616.870		
Schwarz criterion	1624.040	Hannan-Quinn	1619.207		
rho	0.326490	Durbin-Watson	1.275855		

Based on the presented model, we have forecasted the GDP of the country (Fig. 6), which is inclined to fall if the current situation remains.

The negative trend of the GDP of Turkey tends to remain for a long time, if the trends in energy sphere won't change. Energy sector, as we have already said, is one of the drivers of the

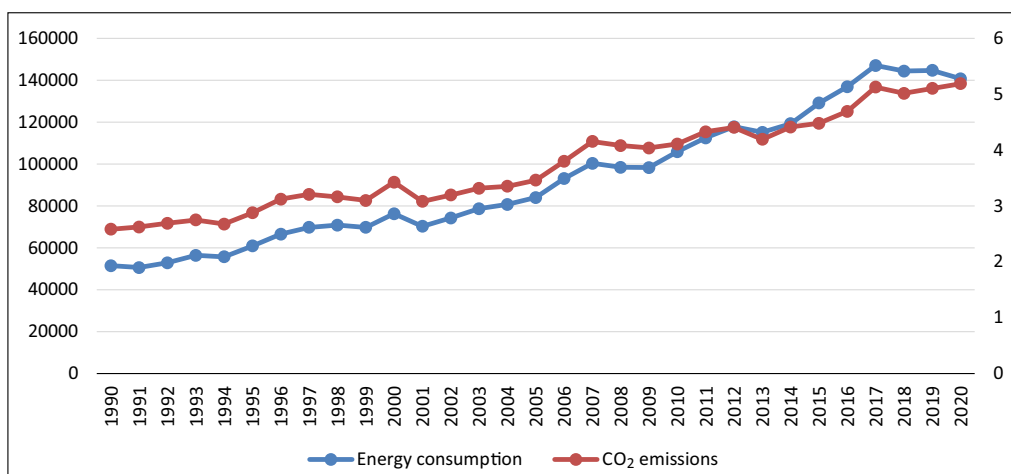


Fig. 6. GDP of Turkey, current prices forecast in US dollars (created by author)

Rys. 6. PKB Turcji, prognozy cen bieżących w dolarach amerykańskich (opracowane przez autora)

Turkish foreign policy and of the economy of the country. The regional hub, which Turkey wants to become in energy sector requires it to have sustainable economy. Still, in order to achieve it, the country has to overcome serious economic problems, which require investments in rather unecological ventures, including imports of coal and oil. The last tendency controverses the strive for sustainable development. As a result, the country has no visible options for becoming a center for sustainable economy and energy.

Let's figure out is there any correlation between GDP growth and green energy development in the country – to do that, let's refer to Table 3 with correlation data.

TABLE 3. Correlation analysis of GDP and wind and solar energy development (created by author)

TABELA 3. Analiza korelacji PKB z rozwojem energetyki wiatrowej i słonecznej (opracowane przez autora)

	1990–1994	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019	1990–2020
Correlation	-0.345	0.907	0.669	0.380	0.879	-0.906	0.644

As we can conclude from Table 2, the correlation between the GDP growth and the green energy development exists only in some periods, but this is a mere coincidence, as the green energy development in Turkey is stimulated with no regard to the real potential of the economy of the country. This leads to the disproportions of the green energy development, that demonstrate the stive of the country to become a regional leader with no regard to the sustainable development and the consequences of the taken political decisions. This is one of the high risks of green energy development, which today usually demonstrates either economic potential of the country or its political inclination to the green values, when this green development is realized without economic rationale and social responsibility under it.

4. Discussion

Despite the fact, that sustainable development in Turkey is supported by the current government, the country doesn't satisfy the major requirements for it – its economy is rapidly degrading (Yurukoglu 2020). Hereabove, we mentioned, that those energy factors, which contribute to the fall of the GDP, are imports of hydrocarbons, imports of coal and the high costs of green energy development in the country.

In order to improve the situation and form an approach, that will contribute to the overall positive influence of energy sector on the GDP we suggest taking several steps, which combine both sustainable development imperatives and the economic rationale.

First of all, it's necessary to build up oil and gas storage capacities in the country. It will both increase economic activity with rather low costs and boost the energy transit through Turkey. This will happen because of the two major factors – the first one is that storage capacities for LNG, for instance, are highly demanded now and the increase of their quantity will lead to the growth of LNG transit through Turkey, the second reason is that the long-term energy policy of Turkey is the creation of the logistics hub, while the availability of the storage capacities for hydrocarbons will allow the country to realize market arbitrage strategies, receiving additional revenues from hydrocarbons market volatility. This measure, just as the other, is available with the government support – the willingness of the current administration to pursue the same goals is the major driver of financial character for this measure.

The second step to take is the use of synergetic drivers for energy sphere. These drivers include tourism, transport and services sector development. These sectors have the potential to attract financial resources to the country, as they are determined by the geographical (constant), not economic (conjuncture) advantages of the country, but because of the COVID-19 crisis these drivers have been lost. In order to restore they need time and the end of the pandemic. When restored, we suggest using them as the drivers for the green energy development and as the foremost drivers of sustainable growth of Turkish economy. In order to fulfil that recommendation, the special tax can be imposed for tourists, which will be accounted as a firm sum of money, depending on the length of the stay (the longer, the higher). For those tourists, who choose hotels with a special “green certificate” – an accreditation paper, given to the facilities, running of green energy and fulfilling the basic recommendations for waste sorting and utilization, ecological standards of building and using the facilities, including energy-saving features, this tax is to be reduced significantly. In case of transport stricter regulations for entering cities and special taxes for transport of lowest ecological standards are to be introduced. Services sector is to be encouraged to the green transformation by a special energy tariff system – for enterprises of the services sector the price of electric energy is to be established with a special coefficient, rising year after year, for instance, if established in 2022 as 1%, it should step by step increase to 8% in 2030, forcing services sector ventures to use either their own energy sources (i.e. solar panels, wind generators etc.) or use energy-saving technologies and measures.

The third important step is to stimulate small hydroplants. This sector, as we have already mentioned has significant positive influence on the GDP of the country. Small hydroplants have proved to be effective in many countries, Sweden and Norway, for instance (Johannes 2017) in general their construction and will decrease the need for building up electricity storage capacities and developing the electricity grid in some regions, which, in turn, will allow the country to pass the difficult economic period with lower expenses.

In addition to that, we recommend to slow down the process of green transition in energy sphere, when speaking of government-financed projects. In the current conditions the ratio of the development of green energy is very high and in the circumstances of the relatively bad economic forecast adding this financial burden to the public expenses is a bad decision, taking into account not only economic, but social side of the issue.

We would like to add, that the best option is the one, the country doesn't have today – it's nuclear energy. It's cheap, doesn't require incredibly high investments as the development of the green energy, and has little or no direct impact on nature, which turn is to one of the most sustainable energy sources for Turkey.

Conclusion

Turkey has a significant potential in energy sphere, especially in the sphere of energy transportation and trade. The country possesses all the needed resources to combine sustainable development and energy sector development, still the current economic situation imposes significant limits to the sustainability of the Turkish energy development.

In order to be competitive Turkish economy has to have access to cheap energy, the dilemma is that this energy isn't green. Coal remains a significant source of energy in the country, along with oil and gas. The rapid development of the green energy in Turkey is the consequence of the state support policy and the synergetic sectors' drivers, namely, tourism, transport and services sector. COVID-19 and the Turkish economic crisis have significantly weakened these drivers, so today Turkey is highly limited in financial resources for the energy sector development.

Green energy in Turkey isn't a part of sustainable development strategy, it's a political vision, which potentially will allow the country to become the regional leader in energy transition, independent from energy exporters, in this regard, green energy development should be guided by the economic rationale.

In order to overcome the major economic issues, it's suggested to introduce special taxes in tourism, transport and services sector in order to stimulate the enterprises to use and generate more green energy. Along with that, it's recommended to cut down government expenditures on green energy.

The hydroenergy, which has a positive effect on the GDP, is underestimated in Turkey. The development of this sphere will allow the country to significantly ease the issue of the modernization of electric grid and infrastructure and save money during this crisis.

Turkey has to diversify its assets in energy sphere – today the country is concentrated on hydrocarbons transit and wind and solar energy development. Still, the possibilities of energy resources trade are omitted – the country in case it builds hydrocarbons storage facilities can become a significant arbitrage player on the global market.

Last, but not the least is the conclusion on the ecological part of the Turkish energy sphere – the country despite growing green energy facilities has rising dynamics of CO₂ emissions, which points on the need for structural energy sector transformation, the future research on this theme can be dedicated to the nuclear energy potential of the country, as in the current conditions nuclear energy looks like one of the best choices for Turkey.

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Ibragim PASHAEV

Produkcja energii, transformacja i zrównoważony rozwój Turcji

Streszczenie

Strukturalne problemy gospodarcze Turcji doprowadziły do poważnych wyzwań dla rozwoju kraju, zwłaszcza w gospodarce po pandemii koronawirusa. Jednym z takich wyzwań jest osiągnięcie założeń zrównoważonego rozwoju w połączeniu z zachowaniem przewag konkurencyjnych tureckiej gospodarki. Utrata głównych sił napędowych gospodarki kraju, w tym turystyki i logistyki, w połączeniu z po-

gorszeniem się sytuacji gospodarczej systemu monetarnego kraju to główne elementy obecnego kryzysu. Kontrowersje te są analizowane w artykule wraz z poszukiwaniem najlepszych opcji rozwoju energetyki w Turcji. Poszukiwanie to obejmuje ekonomiczne aspekty aktualnej sytuacji w kraju. Autorzy stawiają i udowadniają hipotezę, że system energetyczny Turcji może mieć większy wpływ na jej rozwój gospodarczy. Dowód ten opiera się na analizie miksu energetycznego oraz na wnikliwym przeglądzie potencjału kraju dla rozwoju zielonej energii i jej efektywności ekonomicznej. Kluczowe wnioski z artykułu są takie, że zrównoważony rozwój i rozwój zielonej energii w Turcji to zupełnie różne procesy, które celowo dzieli się środkami politycznymi, powodując, że Turcja ma poważne problemy z rozwojem energetyki, ponieważ w obecnym stanie ma ona niewielki wpływ na rozwój gospodarczy. Zostały wypracowane rekomendacje, których realizacja pozwoli na lepsze ustrukturyzowanie rozwoju energetyki.

SŁOWA KLUCZOWE: Turcja, sektor energetyczny, zielona energia, zrównoważony rozwój, struktura, transformacja