POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL

2021 ✦ Volume 24 ✦ Issue 1 ✦ 67–84

DOI: 10.33223/epj/134003

Elnur Mekhdiev[1], Igbal Guliev[2], Kristina Benashvili[3]

Australia's green energy development strategy

Abstract: Today green energy agenda is in the lead position in the media space and scientific community. The countries have put forward ambitious strategies for green energy development: cut CO_2 emissions, introduce new financial instruments. Australia is no exception. The country is trying to start a massive green energy transformation, but its effect on the economy of Australia is dubious, especially taking the losses of profit from coal exports into account. The article aims at answering the main question: is massive green transformation necessary for Australia and the ones, which follow it, namely, how can green energy transformation be conducted in the country, what sources of renewable energy are preferable in the country and how does the green energy transition influence the Australian economy? The key findings include: the proof of the non-necessity of massive green energy transformation in Australia, the proof that solar and wind power are the most effective renewable energy resources in the country and the proof that Australia should slow down the green energy transformation if it wants to preserve its economic prosperity.

Keywords: Australia, energy, green energy, transformation, coal, analysis, strategy

✉ Corresponding Author: Elnur Mekhdiev; e-mail: e.mehdiev@gmail.com

[1] Center for Analysis, Risk Management and Internal Control in Digital Space, Financial University under the Government of the Russian Federation, Russia; ORCID iD: 0000-0001-6248-6673; e-mail: e.mehdiev@gmail.com

[2] International Institute of Energy Policy and Diplomacy, MGIMO University, Russia; ORCID iD: 0000-0002-8667-8132; e-mail: guliyevia@mail.ru

[3] International Institute of Energy Policy and Diplomacy, MGIMO University, Russia; ORCID iD: 0000-0002-7911-0581; e-mail: k.benashvili@inno.mgimo.ru

Introduction

The introduction of green energy in the energy balance is the new trend of the development of energy industries in the majority of the countries. The United Nations (UN) Agenda 2030 includes the goal of a greener future for the next generations (UNGA 2015), so the countries seek ways to develop new technologies in order to enhance the share of unconventional energy resources in energy generation.

While the research on the European green energy politics is extensive and covers a significant number of topics, just as the research on the Asian and the US situation, the research on the situation in the countries that have declared a green transition, but are not among the leaders of the movement for greener energy are scarce. Australia has significant financial resources, which many countries, introducing green energy lack (Donastorg et al. 2017), it has the potential for the implementation of green energy technologies, both natural and technological (Onu and Mbohwa 2019; Renewable energy technologies 2009), but the discussion on the necessity and effectiveness of such technologies in Australia is rather active.

The major issue with the Australian green energy development is the inferior state of the coal industry and hydrocarbons industry, which generate a significant share of the country exports, in the case of active green energy development. In addition to that, new research (Salygin et al. 2019; Zhao et al. 2020), shows that Australia hosts shale oil and gas resources, which can be extracted without high investments, so the country can repeat the American shale revolution.

The contradiction between those, who push for the green energy development in the country and those who argue that the development of green energy will destroy the national economy, followed by the non-transparent discussion in the scientific sphere leads to the necessity to figure out what the real situation in Australian energy industry is and how it should develop to get the most of energy transition.

The aim of the article is to assess the possibilities of the green energy development in Australia and to answer the questions (goals of the article): a) is massive green energy transfer suitable for Australia; b) if it is, how shoould it be conducted, if not, what should the energy policy of the country be; c) what are the optimal alternative energy sources in Australia; d) how will the green energy influence the economy. The scope of the research is the formulation of the best practices for the Australian energy sector development.

1. Literature review

The literature both scientific and journalist on the green energy transformation in the world and in Australia is extensive. But majorly, this literature lacks a critical approach – it states that

green energy is beneficial for any country (Singh et al. 2019; Maradin et al. 2017). The basis for this article lies in the critique of this position, expressed in (Sun et al. 2019). The authors of this paper point out that the institutions, society and government of the country should be ready for the costs they will bear as a result of the green energy transformation. The other article proves this position, based on the labor market (Boromisa et al. 2015) – in case it's underdeveloped, the country won't be able to manage green energy facilities and infrastructure normally. The Australian case and the question on whether the country should start green energy transformation is raised in (Maxim and Zander 2020). It's notable that the authors prove that the financial measures do have a significant potential in green energy promotion, but don't estimate whether this promotion is needed. Such position is countered by, (Leal et al. 2018) where the authors prove that there is no clear connection between green energy and the reduction of CO_2 emissions, while (Sarkodie and Strezov 2018) prove that renewable energy has a significant effect on carbon dioxide emissions and (Pearse 2017) proves that the current system of carbon pricing in Australia, including carbon credits, has failed. These contradictions are massively found in the literature on this theme. Moreover, some articles point out that the coal industry has modernized and is not as "dirty", as it was considered to be. For example, (Zhiznin and Cherechukin 2020; Azad et al. 2014), conduct in-depth research on the econometric modelling of economic growth in connection with green energy development, figuring out that the research previously conducted can't agree on the methodology and the results of green energy for Australia. The Australian case for green energy is discussed in (Byrnes and Brown 2015). The authors do not doubt the need for green energy transition, they seek the best instruments for it, including state interventions in energy sphere. This approach is undermined by (Jones 2009), where the authors point out the fact, that Australia is a federal country and the state politics in any sphere depends on the states' decisions, so the approach of state intervention in the country is very difficult to develop and organize. While both previously mentioned authors agree on the need for green energy transformation, (Trainer 2012) doubts this can be achieved by the contemporary measures, because the massive and urgent green energy transformation isn't needed in the country.

The provided research on the theme of green energy allows to make a conclusion that green energy impacts on the Australian economy and energy sphere are not clear. These effects are to be clarified through the analysis of the green energy effects on all the spheres of life in Australia, hence the PESTEL methodology (analysis of the political, economic, social, ecological and legal factors) suits this goal most of all. In order to reach the article goals, the formulation of several sub-objectives is needed.

2. Methodology

The methods used in the article can be divided into 4 major parts according to the sub--objectives reached. In order to specify the first one, the authors state that green energy transfer is considered massive in case the country aims to become carbon-neutral by the means of green energy introduction. This is the case of the European Union (EU) energy policy, which is one of the most ambitious among the contemporary ones (Kulovesi and Oberthür 2020). The first sub-objective is to prove or reject that the massive green energy transfer is suitable for Australia.

In order to prove it, the authors conducted a PESTEL analysis of the factors, characterizing the institutional green energy development in Australia. The average relevance, impact and weight were calculated according to the following method:

$$\begin{cases} Average\ impact = \sum_{n=5}^{1<impact<5} Impact \\ Average\ relevance = \sum_{n=5}^{1<relevance<5} Relevance \\ Average\ weighted = average\ impact \cdot average\ relevance \end{cases} \quad (1)$$

The PESTEL analysis includes the estimation of the factors' influence, on the green energy transformation and vice versa. The factors for the PESTEL analysis were taken from the literature, mentioned hereabove. The authors asked 2 independent experts (taking into account the three authors' expert columns) – The first is editor in chief of the *International Journal of Energy Economics and Policy* (IJEEP), a member of the editorial boards in numerous international journals, the author of over 160 papers and a member of an Expert Board under the State Duma Energy Committee, Deputy Chairperson of the PAO Rosseti Science and Engineering Board, a member of Sustainable Development Council under PAO Gazprom Science and Engineering Board Chairman to estimate the factors influence according to the factor importance and impact, and then, using the formula hereain calculated the average for every factor.

The results of the PESTEL analysis allow to answer the question whether the green energy transfer is positive or negative for Australia. In the event it's positive, massive green energy transfer should start as the national policy of Australia, otherwise, the energy transfer should be of a various nature depending on the optimal energy sources.

Every factor was estimated according to the two main criteria – relevance and impact. The first one refers to the importance of the criteria for the overall situation in the country and/or industry (in the case of this paper, relevance indicates whether this factor is very important (5)

or not nearly important (1) for the development of green energy in Australia). Impact depicts what kind of changes are expected due to the existence of the factor – from very negative (–5) to very positive (5). The values of the criteria are based on the expert opinions, which are then analyzed according to the formulas given in the methodology. The weighted value in the column average relevance/impact//weighted depicts the final numerical value of the significance of the factor for green energy development (the higher by module the more significant) and its positive or negative influence.

In order to find it out, the authors refer to the forecasting methods of the ordinary least squares (OLS) forecasting. The authors used the Gretl statistical package, while the methodology of OLS forecasting is taken from (Stewart 2016). The model is adequate in case R^2 and p-criteria for every variable are higher than 0.95. The analysis of the previous budgets shows that the future budget expenses tend to be lower in forecast, than the real ones, so there is no need for the sophisticated methods of forecasting, the relevant major track or the growth rates are enough. The explanation of the method used is given hereinafter.

The third sub-objective of the article has its basis in the results of the second sub-objective results. At this stage the authors have either proved or refuted that the green energy transfer should be massive. In case the massive energy transfer is suitable for the country, the natural potential of Australia allows all the sources of renewable energy to be developed with the same pace and effectiveness, so the sub-objective is to find out the future generation potential of the country. In case it is not, the search for the most effective green energy sources is the major sub-objective.

In order to answer the question on the best energy mix in the country, the authors conduct the statistical retrospective analysis of the energy mix in Australia and calculate the average chain delta index (CDI) for every energy source in the years 1990–2019 (as the data for these years is available). The average CDI is calculated according to the formula:

$$ACDI = \sum (ES_t - ES_{t-1}) / ES_{t/T} \tag{2}$$

Source: own study based on (von der Lippe 2001).

Where ACDI is the average CDI, ES is the volume of energy generated by a specific energy source in the period, t and t-1 is the current and previous periods, and T is the total number of periods (29).

The other sources of energy, for instance, geothermal, and other exotic energy sources, are statistically unimportant and can be neglected in the analysis.

Based on the results of the previous sections, the authors put forward the last hypothesis, aiming to answer the last question of the article – does the renewable energy prove to be economically efficient in the case of the rational development of the country?

The sub-objective is to be reached based on the testing of E3ME model for the renewables, provided by IRENA (Renewable energy benefits: measuring the economics 2016). The authors

figured out the major negative results of the green energy transition, conducted in Australia, based on this and several other sources and systemized them in order to put forward a possible strategy, that can eliminate them.

3. Results

The authors have conducted the PESTEL analysis of the green energy transfer in Australia. Table 1 depicts the results of the analysis.

TABLE 1. PESTEL analysis of the massive green energy transition in Australia (importance/impact)

Tabela 1. Analiza PESTEL dotycząca masowej transformacji zielonej energii w Australii (znaczenie/wpływ)

Political	1	2	3	4	5	Average relevance/ impact// weighted
1	2	3	4	5	6	7
National support for the green energy transition	2/2	2/3	2/1	3/4	3/1	2.4/2.2//5.28
Reluctance of the current states' establishments to conduct green reforms	3/–2	4/–2	3/–1	1/–1	4/–4	3/–2//–6
Influence of the international organizations	1/1	1/2	1/1	1/1	1/1	1/1.2//1.2
The impact of the Asian green transition, especially of the Chinese one	2/2	2/1	3/–1	2/1	2/–2	2.2/1//2.2
Economic						
The high costs of green transition	4/–4	5/–3	4/–3	5/–4	5/–5	4.6/–3.8//–17.48
The higher average electricity costs in green energy economies	3/–2	2/–2	3/–3	2/–1	2/–2	2.4/–2//–4.8
Higher costs for energy facilities	2/–1	1/–1	2/–3	3/–2	3/–1	2.2/–1.6//–3.52
Lower income of the coal miners' corporations	2/–1	2/–1	2/1	3/–1	3/–2	2.4/–0.8//–1.92
Lower income of shale oil extracting companies	1/–1	1/1	1/–1	2/1	2/–1	1.4/–0.2//–0.28
Lower budget incomes from energy producers	3/–2	2/–1	4/–2	3/–2	2/–1	2.8/–1.6//–4.48
Lower exports of coal	4/–4	3/–4	4/–5	5/–5	5/–4	4.2/–4.4//–18.48
Social						
Higher taxes	3/2	4/2	3/1	2/1	1/1	2.6/1.4//3.64
Higher costs of electricity for households	1/2	2/1	1/1	2/1	2/1	1.6/1.2//1.92

1	2	3	4	5	6	7
Higher public costs of energy production	2/–2	2/–2	2/–1	2/–1	2/–2	2/–1.6//–3.2
Social unrest due to the loss of jobs in Southern Australia territories	1/–1	1/–1	1/–1	1/–2	1/–2	1/–1.4//–1.4
Higher cost of fuel	1/–1	1/–1	1/–1	1/–2	1/–1	1/–1.2//–1.2
Influence of the public organizations on the political parties	2/2	3/2	2/2	1/2	2/2	2/2//4
Energy producers' lobbies	3/–2	2/–2	3/–2	2/–2	3/–2	2.6/–2//–5.2
Better public opinion of the government due to the image of socially responsible one	3/3	4/3	4/4	3/2	3/1	3.4/2.6//8.84
Ecological						
Better ecological situation in cities	2/1	2/3	2/3	2/2	3/3	2.2/2.4//5.28
Lower ecological risks of energy production due to the lower fracking activities	3/2	3/1	3/2	3/2	2/1	2.8/1.6//4.48
Better conditions for the nature preservation	2/1	2/2	2/2	2/1	2/3	2/1.8//3.6
Lower greenhouse effect in Australia	1/2	1/1	1/2	2/1	3/2	1.6/1.6//2.56
Legal						
A more transparent legal framework for energy producers	2/2	2/1	2/1	1/1	1/1	1.6/1.2//1.92
A non–transparent pricing for households, causing the higher burden of cases for the judicious system	1/–1	1/–1	1/–1	1/–1	1/–1	1/–1//–1
Overall experts' estimation	2.12/–0.08	2.2/–0.04	2.28/–0.08	2.2/–0.24	2.44/–0.52	2.30/–0.14//–0.95

Source: own study.

The results in Table 1 allow to make the following conclusions on the first sub-objective: firstly, the overall importance of the green energy transition in Australia is relatively high, but its importance for the country seems to be overestimated. The average relevance of 2.3 (varying by experts from 2.12 to 2.44) points out that the energy sector of the country will be influenced significantly, but the other sectors will only have several changes due to green energy. Secondly, the overall negative impact of –0.14 points at the little negative consequences of the energy transfer, which, in turn, denies the big benefits or high losses from green energy transfer for Australia. The average weighted estimation of –0.95 gives reasons for the second thought on the necessity of the massive green energy transfer for Australia. With respect to the above-mentioned, a massive green energy transfer should be regarded as not appropriate for Australia, hence the necessity of the search for another way is obvious.

In this regard, we conclude that the massive energy transfer in the country is inappropriate. In order to provide evidence of this , the authors have decided to forecast the budget expenses on the energy sphere. The supposition is the following – in the case of the massive energy transfer, the volume of green energy production should grow at the same pace as the budget expenses on the energy. The major limit in the model is that the energy production volume shouldn't exceed the volume of budget spending, because in this case the sector tends to overuse the social resour-

ces as it needs financial support from the state or massive investments, which are generated by other sectors and the private sector, increasing the economic burden for the economy in general and on the society. In case the overall growth of green energy production exceeds the budget expenditures both in the long and short run, the national policy should proclaim an adaptive approach to the green energy and use the most effective green energy sources in the country. The forecast model for energy budget spending looks as follows:

The renewable energy production was forecasted by the linear extrapolation. The results of forecasting are depicted on Figure 1.

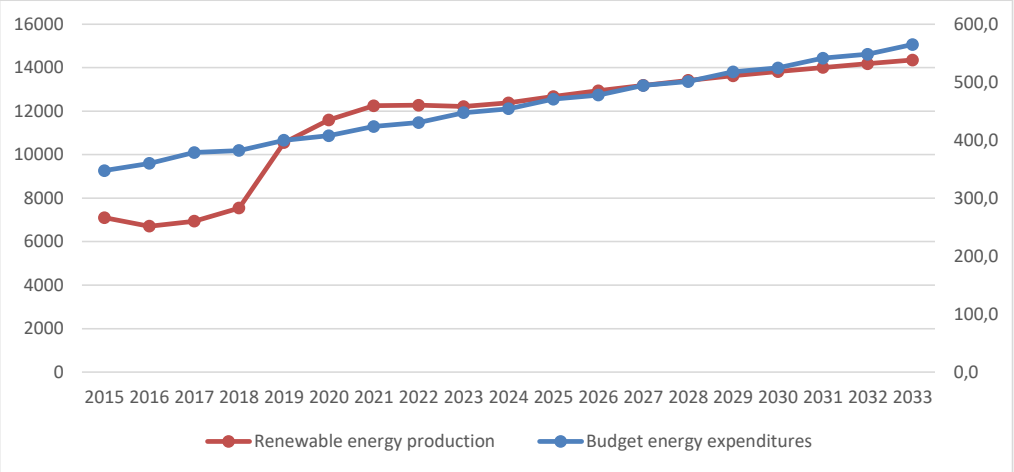

Fig. 1. Data and forecast on the renewable energy production and energy budget expenditures
Source: own study based on (Evershed 2015; BUDGET 2017; BUDGET 2018; Energy Budget Information 2020; Australian Energy Update 2020)

Rys. 1. Dane i prognozy dotyczące produkcji energii odnawialnej i wydatków budżetowych na energię

Figure 1 clearly demonstrates the tendency that renewable energy develops faster than the growth of the budget spending on energy, so in the current state of being, the economy of Australia will start to lose significant resources on renewable energy in the nearest future. The legal framework and the public opinion on the massive energy transfer in the country requires change. In order to do that, Australia has to decide which of the renewable sources is the most effective for the country, hence, which ones are to be stimulated by the public sector.

Table 2 reflects the value of the CDI for every energy source for the period 1990–2019.

The fact that the results of Table 2 are supported by the energy mix of renewable energy sources in Australia is notable, as the current 34.5% and 28% of renewable energy is generated by wind and solar energy sources respectively. 30.7% is generated hydroenergy, but the ecological conditions of the major river in the country don't allow for it be exploited as a major energy source (Australian renewable export COVID-19 recovery package 2019). Table 2 is clearly divided into two parts, where wind and solar energy are developed quickly and represent more than half

Table 2. CDI for the renewable energy sources

Tabela 2. Autorski wskaźnik CDI dla odnawialnych źródeł energii

Source	CDI	Source	CDI
Wind	0.444	Bioenergy	0.089
Solar	0.343	Hydroenergy	0.008

Source: own study.

of the green energy generated in Australia, while bioenergy and hydroenergy develop slowly and require significant investments on the part of the public sector. Due to the fact that solar and wind energy are inexpensive and adaptive, they suit the conditions of the country best, hence, based on the data from Table 2, the authors conclude that the two best renewable energy sources for Australia are solar and wind energy.

At the same time, despite being inexpensive energy sources for the country, both of them require technological solutions and have significant constructive costs, which are considered low in Australia due to the high development of the country and its stable economy. One of the pillars of the Australia economy is coal and its exports. In case the country stops exporting this resource, the economy will lose its stability and development pace, especially in the conditions of the developing market of the clean energy. In this regard, the estimation of the effect of the renewable energy on the economy of the country is needed.

The basic source for the negative effects of renewable energy transition assessment is the E3ME, created for IRENA. The major negative factors and threats for the Australian economy are the following:

1. The lower exports (varying from –0,1 to –0,8% of exports) in the case of the implementation of the green energy scenario. This estimation is close to truth, as China and other Asian countries have started green energy strategies (Froestad and Benney 2019), so the key export resource of Australia coal is depreciated. In this market situation, the former exports of coal can be directed for domestic use, but in the case of the green energy transformation, they won't find their customer.
2. Lower investments in the Australian economy because of the lower average ROI, as today the energy sector provides the highest returns in the Australian economy.
3. High costs of the new infrastructure, especially due to the necessity to modernize the power grid (Byrnes et al. 2013).
4. The overall growing prices for electricity and higher financial burden for the citizens of the country (de Atholia et al. 2020).

The major negative and positive impacts of green energy development in Australia have been developed hereabove. When comparing them, the positive impacts overweight the negative, in this regard, it can be said that the benefits of green energy transition overweight the challenges. The authors consider this statement true in many ways, but in order to finalize the analysis of the green energy transition, which, as it seems now, has neared its limits, the development of the possible strategy for the further green energy development in the country is needed.

One of the major issues of the development of green energy in Australia is the economy (as demonstrated in Table 1 and proven afterwards). There is no obvious possibility to develop green energy and to preserve the coal industry at the same time. Due to the fact that coal is not just an export resource, but a major fuel for energy production in Australia, the future development of green energy will give it a fierce blow. In order to avoid or lessen the shock for the coal industry, the authors give several region-specific recommendations (for every state of the country). The recommendations are based on the PESTEL analysis results, taking the results of green energy forecasting in the country into account.

New South Wales (NSW) as one of the major energy consumers (Electricity supply, demand and prices in New South Wales 2018), should pursue the policy of green energy transition, but the major aim of the region should be the step-by-step change with the development of projects of the reuse of energy facilities, which were earlier working on coal. These facilities should be bought by the state or private investors, seeking short-run profits before the energy operator closes because of bankruptcy. This will allow the latter to pay for the coal reserves and potentially to provide jobs for the former employees in the new businesses (economic pillar of PESTEL analysis).

The other important measure for the NSW is to subsidize the coal producers through carbon credits, so that the coal industry of Australia can survive in the upcoming 10 years and adapt to the new conditions on the global and national market (economic pillar of PESTEL analysis).

NSW has significant resources of lignite and black coal (hard coal), so the strategy for the development of the state should include the export possibilities of these resources. As we have already mentioned, Asia is undergoing a green transformation, but there are several markets, which are still not developed and coal is the major source of power for them. These are the African markets and those economies, which produce significant amounts of steel and metal, but don't have enough coal. In order to preserve the state economy, it should reorient its trade flows to these regions, especially taking into regard the fact that coal supply on the global market exceeds the demand (Sribna et al. 2019; Hudson 2019) (political pillar of PESTEL analysis).

Queensland is the biggest coal exporter in Australia. The major measures, which should be undertaken by the state are the same, except for one – the state should try to slow the green transformation down on its territory through carbon credits. The only way to preserve the social situation in Queensland is the slow decrease of coal industry importance in its budget, so the producers of coal can reorient and have enough time to understand the new market conjuncture. This will allow market shock to be avoided and to distribute the losses of GDP over time (social and economic pillars of PESTEL analysis).

The other option for Queensland is to gradually take coal producers under state control in order to take the economic burden away from its citizens. This option is not the best one, as the problem remains the same, but the public expenses will rise (political and economic pillar of PESTEL analysis).

The other important task for Queensland is to attract new investments, as its major difference from NSW is that the other industries in the state are underdeveloped. In the contemporary con-

ditions, tourism could have been a new driver for the states' economy, but the pandemic doesn't allow it.

Victoria is another state with significant coal reserves, but they involve brown coal. In this regard and taking the high level of economic development of the state into account, the recommendations for it are the same as for the NSW. Victoria along with NSW can become Australia's green energy pioneers, make the burden of the countries' citizens and coal companies smaller through the investments in the other states' economies, especially in the most vulnerable regions (economic and ecological pillar of PESTEL analysis).

South Australia and Western Australia don't have significant coal basins, except for the brown coal, which is far less economically and technically effective, so they won't have such significant problems as the previous states. The major recommendation, that comes from the big territories of the states is to develop energy infrastructure in order to distribute the costs of its construction and modernization over time (economic pillar of PESTEL analysis).

The Capital territory is another net consumer of energy, the plan of actions for it is the same as for the NSW, but because of its territory and relatively small population it can't provide significant effects for the energy industry of the country (economic and ecological pillar of PESTEL analysis).

The recommendations for Northern territory are the same as for the South Australia, except for the one additional aspect – the significant reserves of shale oil allow the state to export it, so the profits from oil exports, which won't fall due to the global green energy transfer, are to be aimed at the development of the state and support of the national economy through the diverse investment portfolio. It should be constructed in such a way that the other states receive proportional investments, just as the industries, except for the energy industry, should receive proportionate investments as well. These revenues are not to be used for energy industry development as in this case their effectiveness will fall due to the non-synergic effect with the rest of the economy. The state will generate the Dutch effect (Koitsiwe and Adachi 2015) through the investment in energy infrastructure, so the latter will be dependent on hydrocarbons' exports, while the other industries won't be able to form any reserves before the inevitable economic shock form green energy transformation (economic, ecological and political pillars of PESTEL analysis).

When speaking of Tasmania, its effect on the overall situation with green energy is rather low, but the major recommendation for the island state is to rely on the current major source of energy and heat – coal, but gradually double it with the renewable energy sources (economic pillar of PESTEL analysis).

4. Discussion

The Australian budget is used in order to develop energy infrastructure, rather than support producers of coal, which is a significant problem for the country. The development of measures aimed at the support of the current energy industry leaders, given hereabove in the strategy for many states is supported by (Bridge et al. 2018; Yang et al. 2019; de Atholia et al. 2020). In this regard, it's notable that the support measures for coal industry is the major goal for Australia in the current period of time.

At the same time, the development of green energy in the country is necessary and the authors have proven the two best renewable energy sources for Australia are solar and wind energy (this statement is proven by for instance (Hinkley et al. 2017). At the same time, (CSIRO 2007) proves that biofuels play a significant role in the Australian energy balance, but doesn't take the green framework of Australian energy system into account (Federal Register of Legislation 2000). At the same time, one of the pillars of the Australian economy is coal and its exports (Sribna et al. 2019; Hudson 2019), so green energy development should be connected with energy efficiency and a drop in CO_2 emissions. For example, (Australia's 2030 Emission Reduction Target Strong, credible, responsible) describes the existence of such targets, but focuses on the green energy development not the energy efficiency just as (Australia's rising greenhouse gas emissions). In this regard, the formulation of the strategy for a sustainable coal industry development is necessary in future research on the issue.

The authors have come to a conclusion, that green energy is not that efficient, as it seems to be in Australia, but the analysis provided hereabove only demonstrates challenges, but misses such significant positive effects as the new jobs in the country (Thomas et al. 2010; Renewable energy jobs: future growth in Australia 2016; IRENA 2020; CSIRO 2007), the economic drivers' creation through green energy investments (Polzin et al. 2014), tourism development, which could have been a new driver for the states' economy (Ruhanen and McLennan 2009; Hajkowicz et al. 2013).

Conclusion

The analysis of the Australian energy sphere allows to conclude that the contemporary stage of the energy market in the country is a transfer stage. The next one will inevitably be massive green energy production.

Massive green energy transition is not suitable for Australia, as the country's economy will have several negative consequences, the first and the most important of which is the decrease in the production of coal, which is the major export resource. The other consequences, such as the

rise of electricity tariffs and public expenses are important too, but don't bear such devastating consequences. At the same time, the decrease of the coal production in the country is inevitable, green energy transformation will only affect the speed of the process, so the major measure of the government should be aimed at lengthening the green energy transformation process.

The country should act according to the estimation of the most effective sources of renewable energy, which are wind and solar energy in Australia. The development of other sources is possible, but will bring additional expenses, leading to the higher economic shock during the green energy transformation. In addition to that, the potential of hydroenergy in Australia is limited, biofuels don't comply with the carbon neutral goal and tidal, geothermal and other exotic renewable energy sources are not technically ready for massive implementation.

The country needs to develop green energy in accordance with the rational decisions and estimations, not on the basis of strategic visions, dictated by the politics or short-run interests of lobbies. The future of Australian economy due to the green energy transition looks rather difficult, as the exports will fall, the just as the investments in the economy of the country, and combined with the high costs of the construction of the new energy infrastructure and the higher social and public costs, it will lead to the stagnation and credit overheating of the national economy.

In this regard, the only thing that the country can do is to rely on the weighted policy of states, which in turn should generate reserves and credit those states, where the coal industry is the main source of revenues. The ways to do it are: carbon credits, slowdown of the green energy transformation, economic support to the coal producing companies, leaving the business and the activation of social work with the unemployed, especially in the sphere of human capital creation, leading to their work on green energy facilities.

We appreciate the help of Dr. prof. Ilhan Ozturk and Dr. prof. Valery Salygin in expert counseling.

Reference

Australian Energy Update 2020. [Online] www.energy.gov.au/publications/australian-energy-update-2020 [Accessed: 2020-09-03].

Australian renewable export COVID-19 recovery package 2019. WWF-Australia, Sydney. [Online] www.sustainablefinance.hsbc.com/carbon-transition/australian-renewable-export-covid-19-recovery-package [Accessed: 2020-11-13].

Australia's 2030 Emission Reduction Target Strong, credible, responsible. [Online] www.pmc.gov.au/sites/default/files/publications/Summary%20Report%20Australias%202030%20Emission%20Reduction%20Targetpdf [Accessed: 2021-02-03].

Australia's rising greenhouse gas emissions. [Online] www.climatecouncil.org.au/wp-content/uploads/2018/06/CC_MVSA0143-Briefing-Paper-Australias-Rising-Emissions_V8-FA_Low-Res_Single-Pages3.pdf [Accessed: 2021-02-03].

Azad et al. 2014 – Azad, A.K., Rasul, M.G., Khan, M.M.K., Omri, A., Bhuiya, M.M.K. and Hazrat, M.A. 2014. Modelling of Renewable Energy Economy in Australia. *Energy Procedia* 61, pp. 1902––1906.

Boromisa et al. 2015 – Boromisa, A.-M., Tišma, S. and Ležaić, A.R. 2015. Green jobs for sustainable development. Green Jobs for Sustainable Development. *Taylor and Francis Inc.* 41, pp. 1–193.

Bridge et al. 2018 – Bridge, G., Özkaynak, B. and Turhan, E. 2018. Energy infrastructure and the fate of the nation: Introduction to special issue. *Energy Research & Social Science* 41, pp. 1–11.

BUDGET 2017–18 2017. [Online] https://archive.budgetgov.au/2017-18/ [Accessed: 2020-09-03].

BUDGET 2017–18 2018. [Online] https://archive.budgetgov.au/2018-19/ [Accessed: 2020-09-03].

Byrnes et al. 2013 – Byrnes, L., Brown, C., Foster, J. and Wagner, L. 2013. Australian renewable energy policy: Barriers and challenges. *Renewable Energy* 60(1), pp. 711–721.

Byrnes, L. and Brown, C. 2015. Australia's renewable energy policy: the case for intervention. MPRA. University Library of Munich, Germany, paper 64977.

Circelli, M. and Stanwick, J. 2014. Economic vulnerability in Australia, 2002–12: an employment perspective. NCVER, Adelaide. [Online] www.ncver.edu.au/__data/assets/file/0024/8862/economic-vulnerability-2707.pdf [Accessed: 2020-11-13]

CSIRO 2007. Biofuels in Australia – issues and prospects. [Online] https://www.agrifutures.com.au/wp-content/uploads/publications/07-071.pdf [Accessed: 2021-02-03].

de Atholia et al. 2020 – de Atholia, T., Flannigan, G. and Lai, S. 2020. Renewable Energy Investment in Australia. Reserve bank of Australia. [Online] www.rba.gov.au/publications/bulletin/2020/mar/pdf/renewable-energy-investment-in-australia.pdf [Accessed: 2020-09-03].

Donastorg et al. 2017 – Donastorg, A., Renukappa, S. and Suresh, S. 2017. Financing Renewable Energy Projects in Developing Countries: A Critical Review. *IOP Conf. Series: Earth and Environmental Science* 83, 012012. [Online] https://iopscience.iop.org/article/10.1088/1755-1315/83/1/012012/pdf [Accessed: 2020-12-03].

Electricity supply, demand and prices in New South Wales 2018. Select Committee on Electricity Supply, Demand and Prices in New South Wales. Report, Sydney. [Online] www.parliament.nsw.gov.au/lcdocs/inquiries/2457/Electricity%20Supply,%20Demand%20and%20Prices%20in%20New%20South%20Wales%20-%20Final%20report.pdf [Accessed: 2020-11-13].

Energy Budget Information 2020. [Online] www.energy.gov.au/government-priorities/energy-budget-information [Accessed: 2020-09-03].

Evershed, N. 2015. Budget 2015: full breakdown of revenue and expenditure. [Online] www.theguardian.com/australia-news/ng-interactive/2015/may/12/budget-2015-full-breakdown-of-revenue-and-expenditure [Accessed: 2020-09-03].

Federal Register of Legislation 2000. Renewable Energy (Electricity) Act 2000. No. 174. [Online] www.legislation.gov.au/Details/C2019C00061 [Accessed: 2020-11-13].

Froestad, J. and Benney, T.M. 2019. China: A global renewable energy fulcrum? *Environmental and Planning Law Journal* 36(6), pp. 605–618.

Hajkowicz et al. 2013 – Hajkowicz, S., Cook, H. and Boughen, N. 2013. The Future of Tourism in Queensland. Megatrends creating opportunities and challenges over the coming twenty years. CSIRO, Australia. [Online] https://publications.csiro.au/rpr/download?pid=csiro:EP134277&dsid=DS1 [Accessed: 2020-11-13].

Hinkley et al. 2017 – Hinkley, J.T., McNaughton, R.K., Hayward, J.A. and Lovegrove, K. 2017. A solar fuels roadmap for Australia – Study outcomes. AIP Conference Proceedings. *22nd International Conference on Concentrating Solar Power and Chemical Energy Systems* 1850, DOI: 10.1063/1.4984467.

Hudson, M. 2019. Enacted inertia: Australian fossil fuel incumbents' strategies to undermine challengers. The Palgrave Handbook of Managing Fossil Fuels and Energy Transitions. *Springer International Publishing. Cham.,* pp. 195–222.

Hydropower study report 2017. A technical report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development

Fund: Water Resource Assessments. Entura, CSIRO, Australia. [Online] www.csiro.au/~/media/Major-initiatives/NorthernAustralia/NAWRA-technical-reports/NAWRA-Technical-Report---Hydropower_LORES.pdf?la=en&hash=A08015FA8FDEEA6DC1D1C0D9935C4B514B13BBD2 [Accessed: 2020-11-13].

IRENA 2020. The post-covid recovery. An agenda for resilience, development and equality 2020. International Renewable Energy Agency, Abu Dhabi. [Online] https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_Post-COVID_Recovery_2020.pdf [Accessed: 2020-11-13].

Jones, S. 2009. The Future of Renewable Energy in Australia: A Test for Cooperative Federalism? *The Australian Journal of Public Administration* 68(1), pp. 1–20.

Koitsiwe, K. and Adachi, T. 2015. Australia Mining Boom and Dutch Disease: Analysis Using VAR Method. *Procedia Economics and Finance* 30, pp. 401–408.

Kulovesi, K. and Oberthür, S. 2020. Assessing the EU's 2030 Climate and Energy Policy Framework: Incremental change toward radical transformation? *Review of European, Comparative and International Environmental Law* 29(2), pp. 151–166.

Leal et al. 2018 – Leal, P.H, Marques, A.C. and Fuinhas, J.A. 2018. How economic growth in Australia reacts to CO_2 emissions, fossil fuels and renewable energy consumption. *International Journal of Energy Sector Management* 12(4), pp. 696–713.

Maradin et al. 2017 – Maradin, D., Cerović, L. and Mjeda, T. 2017. Economic Effects of Renewable Energy Technologies. *Naše gospodarstvo/Our Economy* 63(2), pp. 49–59, DOI: 10.1515/ngoe-2017-0012.

Maxim, M.R. and Zander, K. 2020. Green Tax Reform and Employment Double Dividend in Australia Should Australia Follow Europe's Footsteps? *A CGE Analysis. Margin* 14(4), pp. 454–472.

Onu, P. and Mbohwa, C. 2019. Renewable Energy Technologies In Brief. *International Journal of Scientific & Technology Research* 8(10), pp. 1283–1289.

Pearse, R. 2017. Pricing Carbon in Australia: Contestation, the State and Market Failure. pp. 1–156, DOI: 10.4324/9781315363455.

Polzin et al. 2014 – Polzin, F., Migendt, M., Täube, F.A. and von Flotow, P. 2014. Public Policy Influence on Renewable Energy Investments – A Longitudinal Study Across OECD Countries. *Energy Policy* 80, pp. 98–111, DOI: 10.2139/ssrn.2423310.

Renewable energy benefits: measuring the economics 2016. International Renewable Energy Agency. Abu Dhabi United Arab Emirates. [Online] www.irena.org//media/Files/IRENA/Agency/Publication/2016/IRENA_Measuring-the-Economics_2016.pdf [Accessed: 2020-09-03].

Renewable energy jobs: future growth in Australia 2016. Climate Council of Australia Limited. [Online] www.climatecouncil.org.au/uploads/7b40d7bbefbdd94979ce4de2fad52414.pdf [Accessed: 2020-09--03].

Renewable energy technologies. Module 7. 2009. Sustainable energy regulation and policymaking for Africa. [Online] www.unido.org/sites/default/files/2009-02/Module7_0.pdf [Accessed: 2020-12-03].

Ruhanen, L. and McLennan, C. 2009. Strategic Issues in the Australian Tourism Industry: An Analysis of National Tourism Strategies and Plans. *18th Annual CAUTHE Conference: See Change – Tourism & Hospitality in a Dynamic World*. Queensland, Australia.

Salygin et al. 2019 – Salygin, V., Guliev, I., Chernysheva, N., Sokolova, E., Toropova, N. and Egorova, L. 2019. Global Shale Revolution: Successes, Challenges, and Prospects. *Sustainability* 11, DOI: 10.3390/su11061627.

Sarkodie, S.A. and Strezov, V. 2018. Assessment of contribution of Australia's energy production to CO_2 emissions and environmental degradation using statistical dynamic approach. *Science of the Total Environment* 639, pp. 888–899.

Singh et al. 2019 – Singh, N., Nyuur, R. and Richmond, B. 2019. Renewable Energy Development as a Driver of Economic Growth: Evidence from Multivariate Panel Data Analysis. *Sustainability* 11(8), 2418, DOI: 10.3390/su11082418.

Sribna et al. 2019 – Sribna, Y., Trokhymets, O., Nosatov, I. and Kriukova, I. 2019. The globalization of the world coal market – Contradictions and trends. *E3S Web of Conferences. 13th International Scientific and Practical Conference on Ukrainian School of Mining Engineering* 123, DOI: 10.1051/e3sconf/201912301044.
Stewart, B. 2016. Week 5: Simple Linear Regression. [Online] https://scholar.princeton.edu/sites/default/files/bstewart/files/lecture5handout.pdf [Accessed: 2020-09-03].
Sun et al. 2019 – Sun, H., Edziah, B.K., Sun, C. and Kporsu, A.K. 2019. Institutional quality, green innovation and energy efficiency. *Energy Policy* 135, DOI: 10.10.16/j.enpol.2019111002.
Thomas et al. 2010 – Thomas, I., Sandri, O. and Hegarty, K. 2010. Green jobs in Australia: A status report. *Sustainability* 2(12), pp. 3792–3811.
Trainer, T. 2012. Can Australia run on renewable energy? The negative case. *Energy Policy* 50, pp. 306––314.
Transforming Our World: The 2030 Agenda for Sustainable Development. [Electronic resource]: adopted by resolution Gener. Of the UN Assembly 25 sep. 2015A/70/L.1. [Online] www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=R [Accessed: 2021-01-21].
UNGA 2015. Resolution adopted by the General Assembly on 25 September 2015. Transforming our world: the 2030 Agenda for Sustainable Development. [Online] https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E [Accessed: 2021-03-17].
von der Lippe, P. 2001. Chain Indices A Study in Price Index Theory. Federal Statistical Office. *Spectrum of Federal Statistics* 16, p. 291.
Yang et al. 2019 – Yang, M., Sandu, S., Li, W. and Khalid, M.T. 2019. Renewable energy in Australia: a wider policy discourse. *Chinese Journal of Population Resources and Environment* 17(3), pp. 1–13.
Zhao et al. 2020 – Zhao, W., Ma, Y. and Zhu, H. 2020. Shale gas potential of goldwyer formation in canning basin, Australia. *8th International Field Exploration and Development Conference*, IFEDC 2018, Xi'an, China, pp. 560–572.
Zhiznin, S.Z. and Cherechukin, A.V. 2020. Factors of development and introduction of clean coal-mining technologies in the world economy. *Mining Informational and Analytical Bulletin* 6, pp. 27–37.

Elnur Mekhdiev, Igbal Guliev, Kristina Benashvili

Strategia rozwoju zielonej energii w Australii

Streszczenie

Dziś programy dotyczące zielonej energii zajmują wiodącą pozycję w przestrzeni medialnej wśród społeczności naukowej. Kraje przedstawiają ambitne strategie rozwoju zielonej energii: ograniczenie emisji CO_2, wprowadzenie nowych instrumentów finansowych. Australia nie jest w tym obszarze wyjątkiem. Kraj próbuje rozpocząć masową transformację w kierunku zielonej energii, ale jej wpływ na gospodarkę Australii jest wątpliwy, zwłaszcza jeśli weźmie się pod uwagę utratę zysków z eksportu węgla.

Artykuł ma na celu dać odpowiedź na podstawowe pytania: czy w Australii konieczna jest masowa zielona transformacja, oraz w jaki sposób można przeprowadzić transformację w kierunku zielonej energii

w kraju, jakie źródła energii odnawialnej są preferowane i w jaki sposób przejście na zieloną energię wpłynie na australijską gospodarkę?

Kluczowe ustalenia są następujące: wykazano brak konieczności masowej transformacji w kierunku zielonej energii w Australii; wykazano, że energia słoneczna i wiatrowa są najskuteczniejszymi odnawialnymi źródłami energii w kraju oraz udowodniono, że Australia powinna spowolnić transformację w kierunku zielonej energii, jeśli chce zachować dobrobyt gospodarczy.

Słowa kluczowe: Australia, energia, zielona energia, transformacja, węgiel, analiza, strategia