POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL

2023 ✦ Volume 26 ✦ Issue 2 ✦ 105–120

DOI: 10.33223/epj/163451

Vilayat Ismayilov[1], Sahib Mammadov[2], Narmina Abbasova[3], Vusala Babayeva[4], Sabina Sadigova[5]

The current state and prospects for further development in the energy sector in Australia: reforms, foreign economic relations, investment climate

Abstract: In recent years, the Australian government has changed course with regard to the gradual replacement of the country's energy supply by traditional energy resources to alternative renewable energy sources to preserve the environment. The research relevance is predefined by the need to introduce the latest technology and to find investors for the further development of the state energy sector. In this regard, the research to reveal the current state of the energy sector in Australia, the study of existing projects, their productivity, and their impact on the environment. The main methods of research are the method of analysis of existing publications describing the current state

✉ Corresponding Author: Vilayat Ismayilov; e-mail: vilayatismayilov5@gmail.com

[1] Azerbaijan Academy of Labor and Social Relations, Azerbaijan; ORCID iD: 0000-0003-0892-0365; e-mail: vilayatismayilov5@gmail.com

[2] Azerbaijan State University of Economics, Azerbaijan; ORCID iD: 0000-0002-3334-4147; e-mail: mammadov.sa@ash-sw.com.ua

[3] Azerbaijan State Oil and Industry University, Azerbaijan; ORCID iD: 0000-0001-6283-5765; e-mail: abbasova_n@mdsczu.org.ua

[4] Agricultural Economics Research Center, Azerbaijan; ORCID iD: 0000-0002-1183-9296; e-mail: babayeva.v@sc-oneu.in.ua

[5] Azerbaijan State Oil and Industry University, Azerbaijan; ORCID iD: 0000-0002-0752-5630; e-mail: sa_sadigova@tkut.in.net

of the energy sector as well as the method of comparing the country's energy performance before and after the implementation of relevant reforms to better illustrate the effectiveness of existing projects. As a result, it was determined that the Australian government pursues a policy of carbon neutrality in the energy industry to reduce the harm caused to nature by harmful emissions into the atmosphere. The state has a focus on reducing the cost of electricity. It is also determined that Australia has a positive attitude toward foreign investment and is open to proposals for new technologies that improve the efficiency and security of the energy supply. The research mentions Australia's main trading partners, their joint projects, and enterprises. The main directions of alternative energy currently used, their advantages, and their disadvantages are identified. The research result may be of practical value for investors in the field of renewable energy sources in order to better understand the energy market in Australia and possible prospects, as well as for all interested parties.

Keywords: renewable energy sources, environmental protection, energy supply, GDP growth, market structure

Introduction

Australia is a highly developed country, ranking thirteenth in the world by nominal GDP (1.6 trillion dollars) and eighteenth by purchasing power parity. Australia's economy is highly integrated into the global economic system, particularly in the Asia-Pacific region. The country's main trading partners are China, Japan, the United States, South Korea, Britain, and India. The country is pursuing an active policy to ensure access to foreign markets for domestic producers. At present, Australia has concluded fifteen free trade agreements giving access to markets of twenty-four countries. Due to the Government's strong measures to support the solvency of the population and national companies, Australia was able to exit the period of retrenchment associated with restrictive measures imposed due to the global pandemic COVID-19 at the end of 2020. However, by the end of 2020, the national GDP of the country decreased by 3.8%, the economic situation in Australia in early 2021 was characterized by active growth of business activity, increasing investment and increasing trade (Commercial and economic… 2020).

The country is a world leader in infrastructure financing and energy market regulation. In the energy sector, Australia has an advanced market structure. The Australian government is currently reforming infrastructure and investing in new projects. Public sector monopolies have been unbundled into corporatized structures, grid, and retail components, some of which are now privately owned. Despite the work that has been done, the reform energy sector is incomplete. Significant areas remain state-owned, and the legal and regulatory framework needs to be refined in order to address emerging issues. Power generation, grid, and retail companies remaining under state ownership should be transferred to private ownership as soon as possible (Shalbolova et al. 2021). Similarly, regulators and the government should adjust retail energy prices where this has not yet happened.

The development of the energy sector is particularly important because it will create new ways to supply energy to regions of such a large country. Remote areas of Australia are particularly important to indigenous Australians. Many communities lack adequate access to roads, reliable energy supplies, telecommunications, clean water and wastewater treatment services. This can be caused by extreme weather conditions, low population densities, and long distances that increase costs. Finding ways to integrate new technologies into infrastructure, especially energy, and telecommunications, will create a more reliable and affordable infrastructure that supports new opportunities for remote communities (Say et al. 2023; Wolek et al. 2021).

Australia welcomes foreign investment. It has built the country's economy and will continue to improve the well-being of Australians, supporting economic growth and innovation in the future. Foreign investment complements domestic savings; without foreign investment, production, employment, and income would be lower (About foreign investment 2022). Thus, Australia provides a favorable investment climate for foreign enterprises in the field of energy supply. As the state is gradually abandoning traditional energy and introducing alternative energy, the most promising projects are renewable energy sources. A strategy has been developed (Wood 2019a) for the complete transition of the energy sector of Australia to renewable energy sources.

These publications were only a general plan of action to change Australia's energy situation a few years ago. It is necessary to assess the effectiveness of the current reforms as well as to look in more detail at global market trends concerning energy in Australia. The research aims to disclose these topics. Relevant information on the current state of the energy industry in Australia, the impact of the reforms on the power generation companies and other energy structures as well as foreign economic relations and conditions for investment, is provided.

The described study appears to have a scientific nature as it follows a structured approach to investigate a specific research question related to the current state of the energy sector in Australia and the impact of relevant reforms on the environment. The research is relevant as it aims to provide valuable insights into the feasibility of renewable energy sources in the country and their potential impact on the energy market and the environment. The methods used in the research, including the analysis of existing publications and the comparison of energy performance before and after the implementation of relevant reforms, are commonly used scientific research methods for the purposes of gathering and analyzing data. The research also provides a clear description of the study's scope, objectives, and findings. Furthermore, the research may have practical implications for investors in the field of renewable energy sources, as it provides relevant information on the energy market in Australia and its potential prospects. The study's results may also be useful for policymakers and individuals interested in the topic.

1. Materials and methods

The methodological approach of this article is based on the analysis and comparison of the state of energy in Australia before and after the implementation of reforms, the dynamics of alternative energy, and carbon neutrality – the reduction of carbon dioxide emissions. For this purpose, several documents of the Australian Department of Industry, Science and Energy Resources and the energy programs of the relevant institutions have been studied. New publications researching the dynamics of the country's changing energy mix have been reviewed. It is necessary to analyse what types of renewable energy sources are used in Australia in order to study their efficiency and impact on the environment. A conclusion on the prospects for further development in this sector should be made on this basis.

In the first stage, an analysis of existing problems in the energy sphere of Australia was conducted and the relevant reforms for their solution performed in recent years are presented. Strategies and the main goals of innovations are investigated. The Australian government's action plan for the transition from conventional energy to renewable energy sources in order to reduce harmful emissions to the environment to zero was considered. It was also necessary to note Australia's continued focus on exporting energy resources and attracting foreign direct investment in the country's energy sector.

The second stage includes a description of the results of the performed reforms. A comparison of the share of alternative energy uses a few years ago and now is calculated. Positive and negative aspects of foreign investments in the field of energy were considered. As it was found that some foreign partners of Australia have a negative impact on the environment, it was proposed to create certain restrictions on carbon dioxide emissions from enterprises and to regulate the activities of foreign investors. Using the example of the mining industry, the current level of implementation of renewable energy sources by Australian mining companies in this industry was assessed and the prospects for the introduction of alternative energy technologies in the future were considered. The factors stimulating or hindering the introduction of renewable energy sources in the mining industry were identified. As a result of this, it is possible to make a similar assessment of other types of industry in Australia in which it is necessary to reduce emissions of harmful substances into the atmosphere.

The third stage is the consideration of this issue from an economic point of view. Studies are presented in which the impact of current energy sector reforms on the country's economy is studied, and the prospects for development are mathematically evaluated. The results of these studies are important for the national electricity market, investors, and financial institutions in terms of using clean energy as an alternative investment tool to exploit its diversification potential.

The fourth step describes in detail the efficiency of renewable energy sources currently in use. The change in productivity when switching from conventional energy to alternative sources is estimated numerically as well as the percentage of the reduction of emissions of harmful substances.

Indigenous participation in renewable energy projects in Australia is an important factor, and it was necessary to mention this in the research. The conditions under which indigenous peoples can benefit from large-scale alternative energy projects have been explored.

2. Results

Australia has been an energy superpower for most of the last century due to an abundance of coal, oil, gas and uranium. However, the fossil fuel advantage is in jeopardy as resources are depleted and the world's carbon dioxide emissions are set to fall to near zero in the coming decades. The Australian government suggests that Australia could also become an energy superpower in the next century because of its extensive opportunities with regard to solar and wind energy, which are likely to be supplemented by new uses of fossil energy with carbon storage (Wood 2019a). Realizing this opportunity will require investment.

The future of Australia's economy depends on increasing GDP growth over the long term and, therefore, on government funding and investment in sectors that have the greatest potential for global comparative advantage to take Australia to the next stage of development (Higginson et al. 2020). Australia's economy shows steady economic growth trends over the past thirty years and is quite diversified. This has been supported by a strong institutional and regulatory environment, prudent macroeconomic policies, a flexible exchange rate regime, and openness to international trade and foreign investment.

Restructuring the electricity sector is a complex process with technical, economic, commercial, legal and political aspects, and takes place in a broad social context. Greenhouse gas emissions from the energy sector need to be addressed to prevent climate change and to build a stable long-term foundation for investments in energy supply (Australian infrastructure plan 2016). The Australian government is interested in introducing renewable energy sources to replace diesel generation in remote areas of the country where this is both possible and efficient. This will increase the reliability and self-sufficiency of energy supply in remote areas, thus reducing the cost of fuel and transportation (Havyatt 2020; Baizakova et al. 2016).

A switch to renewable energy is now necessary to reduce emissions and conserve the environment. Replacing one with the other has proven to be a real challenge for the Australian government, it must be performed at the lowest possible cost while ensuring the reliability of the energy supply. Power plant closures, high electricity and gas prices, declining unit reliability, and slow and partial decarbonization have all led to the hiring of experts to address Australia's difficult energy situation. For this reason, in 2019, a decision was made to reduce carbon dioxide emissions to zero over the next thirty years. The Grattan Institute has published a policy paper "Australia's energy transition: a blueprint for success", which identified three provisions that provide a strong basis for Australia to support a long-term reform program (Wood 2019a). As approved, Australia's energy future should consist of renewables, batteries, electric cars, hydro-

gen,and possibly new uses of fossil fuels with carbon storage. The cost of electricity and fuel must also become lower.

First, energy policy has been integrated with emission reduction policies, which should cover transport, industry and energy exports. Emission reduction goals should be accompanied by mechanisms to achieve them and increase them if necessary. Secondly, the Australian Energy Market Agreement adopted in 2013 was revised (Australian energy market… 2013). This agreement established the legislative and regulatory framework for Australian energy markets. The Australian Council of Governments negotiated a new Australian Energy Agreement to ensure the decarbonization of stationary, transportation, industrial, and export energy sources. The agreement reflects a national commitment that jurisdictional proposals for unilateral intervention are subject to a formal impact assessment by a leading independent agency before a decision is made. Thirdly, institutional agencies were consolidated so that they could implement government-determined policies to make them more reliable.

The likely scenario for changing Australia's energy sector by 2050 includes the following goals: replacing gasoline-powered cars and diesel-powered trucks, buses, and trains with battery-powered, hydrogen fuel-cell, and grid-powered electric vehicles; switching ships to hydrogen fuel and planes to biofuels; decommissioning gasoline stations and replacing them with hydrogen recharging and refueling stations; replacing gas heaters with electric heat pumps and hydrogen-fueled heaters fed through our current gas pipelines; the use of fossil fuels for steel, chemicals, and plastics is to be phased out in favor of low-carbon energy and hydrogen; the shift of electricity production from large, centralized coal, oil, and gas power plants to wind and solar power plants in many locations – these will range in size from rooftop solar panels to large-scale solar and wind farms, their variable output is complemented by large amounts of stored energy (Rausch and Suchanek 2021). Implicit here is the generation of hydroelectric power and hydrogen fuel, as well as batteries and possibly bioenergy.

Natural gas energy will play a critical role in providing a steady supply while low-carbon storage facilities are built but are then gradually decommissioned. The electric grid needs to be expanded in part and reduced in others to connect these new sources of energy as coal and gas plants close. Success in commercializing carbon dioxide capture and storage can help accelerate emission reductions in the medium term and the export of low-carbon products through the production of hydrogen from coal and gas. Australia plans to export energy to countries with larger populations and/or fewer energy resources in the form of hydrogen or ammonia on ships and possibly electricity via submarine cables. Removing obstacles to this scenario has become a national priority. It should be noted that the Australian leadership does not idealize this process but rather considers the unpredictability of events and remains open to new proposals to improve the country's energy sector (Wood 2019b). For example, there is no premature choice between battery-powered and hydrogen-electric vehicles (Australia's energy strategies… 2022). Energy sources such as small-scale nuclear or geothermal energy have so far been deemed unsuitable for use for reasons such as cost, capacity and public acceptance but may become viable with further development (Energy programs 2020). New energy policies and investments aim to reduce emissions at the lowest cost while maintaining a reliable supply of electricity (Trade and Invest-

ment… 2021). For the current period, Australia's energy sector is highly competitive in terms of supply, technology, and investment (National energy performance strategy 2022).

Renewable energy sources have been playing an increasingly important role in Australia's energy balance in recent years. According to the Australian government, in 2020, renewable energy sources, including solar, wind, and hydroelectric power, accounted for around 21% of the country's total electricity generation. Australia is facing a significant challenge in reducing carbon emissions in the energy sector as it has one of the highest per capita greenhouse gas emissions in the world. To address this challenge, the Australian government has set a target of reducing greenhouse gas emissions by 26–28% below 2005 levels by 2030, under the Paris Agreement (Beasy et al. 2023). To achieve this target, the Australian government has implemented several measures, including the Renewable Energy Target (RET), which aims to ensure that 33,000 gigawatt-hours (GWh) of Australia's electricity comes from renewable sources by 2020. The RET has helped to increase the deployment of renewable energy sources in the country, and has encouraged the development of large-scale solar and wind farms.

The government has also implemented the Emissions Reduction Fund (ERF), which provides financial incentives to businesses and landholders to reduce their greenhouse gas emissions. In addition, the government is supporting the research and development of new renewable energy technologies including hydrogen and carbon capture and storage (CCS) technologies (Trinh et al. 2022). There are also several state-level initiatives to promote renewable energy deployment, such as the Victorian Renewable Energy Target (VRET) and the South Australian Renewable Energy Target (SARET). These initiatives aim to increase the use of renewable energy sources and reduce emissions in these states (Lang et al. 2022).

Australia's energy development course, approved in 2019, has already shown favorable changes by 2022. A study by Udemba and Alola (2022) presented a comparison of the energy situation before and after the reform, published the first results, as well as the impact of foreign direct investment. As the largest country in Oceania and the sixth largest in the world, Australia's energy profile remains an important source for the global energy market. Following the International Energy Agency (IEA), Australia's high position in the energy sector is because the state is a leading exporter of uranium, especially coal and liquefied natural gas. Exporting about 85% of its resources, Australia's energy market remains a major market for Asian countries. As of 2019, the country's energy consumption was mostly from fossil fuels (oil, coal, and natural gas), some statistics are provided in the above publication (Udemba and Alola 2022). Oil, coal (the largest source of energy in Australia), and natural gas energy use accounted for about 39, 29 and 26% of the primary energy mix, respectively, following the Australian Department of Industry, Science and Energy Resources. It is also noted that Australia continues to grow domestic demand for energy, which will lead to an increase in its consumption. Meanwhile, compared with fossil fuels, the share of alternative energy use in Australia's primary energy mix is low (6% in 2019). For example, renewable energy production in Australia as a share of total primary energy production was 1.7% in 2019, while energy sources from hydro, solar, and wind energy (renewable sources) accounted for 21% of the country's electricity supply. The government continues to expand carbon neutrality policies and the development of clean energy technologies.

For comparison, the export of electricity produced on the basis of renewable and green energy can be considered a new era in Azerbaijan's energy strategy. Currently, Azerbaijan contributes to the energy security of Europe with the help of renewable energy sources. Thus, the countries of the world have shown serious interest in inexhaustible and environmentally friendly energy. Recently, against the background of conflicts and economic cataclysms taking place in the world, the relevance of green energy has become even more relevant. It is assumed that in the future, this type of energy will dominate the global energy market. As for the renewable energy potential of Azerbaijan, the volume of wind and solar energy on land is more than 27 gigawatts, and in the Azerbaijani sector of the Caspian Sea, it is 157 gigawatts (Azerbaijan is among the world… 2022).

As of April 2021, the Department of Industry, Science and Energy Resources reported that the number of small renewable energy installations across Australia exceeded 4.1 million. On the one hand, this data shows that Australia is on the right track in its energy transition policy. On the other hand, the data is a demonstration of the country's commitment to reduce carbon dioxide emissions by 26–28% below 2005 levels over the next decade (by 2030). Although the country's carbon-neutral program is producing impressive results, as evidenced by its declining carbon intensity, Australia still has the highest rate among IEA countries. By studying the role of renewable energy applications in achieving the country's carbon neutrality, assessing carbon dioxide emissions from traditional energy sources, and establishing the importance of foreign direct investment in Australia in the country's pursuit of environmental sustainability, the following conclusions were drawn. It is important to note that the role of foreign direct investment is considered concerning the growing investment appeal of European and North American partners over the past two decades.

Australia has been diversifying its energy mix by investing in various alternative energy sources. The main types of alternative energy currently used in Australia include solar, wind, hydro, and bioenergy. Each of these energy sources has its own set of advantages and disadvantages.

As a result, renewable energy has been proven to improve Australia's climate and sustainability situation because it is an effective tool for controlling carbon emissions. Research has determined that in the future, if Australia's alternative energy sources increase by 1%, carbon dioxide emissions will be reduced by 23.45%. The increase in foreign direct investment, however, has a two-fold effect on the environment. Given the Australian government's level of openness to foreign investors to support a sustainable economy, the environment may be deteriorating. For example, mining partnerships with China lead to additional carbon dioxide emissions, as the study points out. There may be a certain trade-off with the country's environmental performance because of the careless attitude of foreign investors towards the environment and the priority given to economic performance.

The Australian government has been taking steps towards reducing greenhouse gas emissions and achieving carbon neutrality in the energy sector. However, the specific position of the Australian government may have evolved since then, so it's essential to verify the information with more recent sources. Historically, Australia has been heavily reliant on fossil fuels, particularly

Table 1. Advantages and disadvantages of the main directions of alternative energy currently used in Australia

Tabela 1. Zalety i wady głównych kierunków alternatywnych źródeł energii stosowanych obecnie w Australii

Energy Source	Advantages	Disadvantages
Solar Energy	✦ Abundant resource ✦ Low operating costs ✦ Environmentally friendly	✦ Intermittent energy source ✦ High initial costs ✦ Land use
Wind Energy	✦ Renewable and clean ✦ Cost-effective ✦ Scalable	✦ Intermittent energy source ✦ Noise and visual impacts ✦ Land use and wildlife impacts
Hydro Energy	✦ Reliable ✦ Energy storage ✦ Low emissions	✦ Environmental impacts ✦ Limited potential ✦ High initial costs
Bioenergy	✦ Utilization of waste ✦ Energy security ✦ Potential for carbon neutrality	✦ Competition with food production ✦ Environmental impacts ✦ Relatively low energy efficiency

coal, for its energy generation. However, the government has recognized the need to transition to renewable energy sources in order to meet global climate change goals and commitments under the Paris Agreement (Chu et al. 2022).

In the past, the Australian government has implemented policies and measures to promote renewable energy and energy efficiency and to reduce emissions. These include the Renewable Energy Target (RET), the Emissions Reduction Fund (ERF), and the Clean Energy Finance Corporation (CEFC), among others. The government's approach to achieving carbon neutrality in the energy sector has focused on supporting the development and deployment of low-emission technologies, improving energy efficiency, and encouraging the uptake of renewable energy sources. This is in line with the country's commitment to reducing its greenhouse gas emissions by 26–28% below 2005 levels by 2030, as part of the Paris Agreement (Lu et al. 2022).

3. Discussion

Mining companies in Australia are increasingly interested in generating electricity from renewable sources in order to reduce rising energy costs and reduce greenhouse gas emissions from their operations. However, the extent to which these companies are using renewable energy is currently unknown. The work of Strazzabosco et al. (2022) quantifies and characterizes the current level of implementation of renewable energy sources by Australian mining companies and the evolution of the implementation of renewable energy technologies in this industry over

time. In addition, this contributes to a better understanding of the factors driving or hindering the adoption of renewable energy in the mining industry. In 2021, only 7% of existing mines had or planned to have a renewable energy system. Of the total number of renewable energy systems identified in this analysis, fifteen were in operation, two were under construction, and ten were announced and planned for possible future deployment. An analysis of historical changes in renewable energy technology showed that 70% of existing operating systems were not installed until 2019. Mine characteristics strongly influence the decision to deploy renewable energy systems. In total, 70% of the renewable energy systems analyzed in this study were or are planned to be installed in off-grid mines powered by diesel and/or gas. Solar photovoltaic power is the preferred renewable energy technology for mining and is installed or proposed for 92% of the twenty-seven projects included in this study. By providing a detailed picture of past and current trends in renewable energy deployment, this study identifies weaknesses and intervention points in the evolving renewable energy market in the mining industry. In doing so, the research offers guidance to policy and decision-makers on developing informed solutions to increase the use of renewable energy in the mining industry.

Current energy policies aimed at spreading renewable energy sources can make a major contribution to achieving Australia's 2030 climate goal (i.e., carbon zero). To improve performance, technology innovation programs need to be introduced through an R&D program to stimulate and expand the renewable energy sector (Suleimenov et al. 2020). Furthermore, more government control is needed over investments. Strict regulation of foreign investors is needed to balance both the economic and environmental development of the country. In addition, environmental taxation can be used to curb the excesses of industry and manufacturing firms in the economy. Setting a ceiling on carbon emissions, above which a tax would be imposed, is a shortcut to environmental taxation.

The research by Pluss (2019) is a selective examination of global market trends and Australian energy policy. Carbon dioxide emissions come mainly from the burning of fossil fuels for energy production. That said, the focus of this research is on energy from an economic and business perspective. Thus, this research does not raise the issue of climate change. The research by Karim and Naeem (2022) investigates the relationship between clean energy and the Australian electricity market from May 2005 to December 2020, using a vector autoregressive method of time-varying parameters. The authors' findings are important for the national electricity market, investors and financial institutions in terms of the use of clean energy as an alternative investment tool to exploit its diversification potential.

An investigation by Martin and Rice (2021) found that Australia needs integrated financial incentives for renewable energy and storage. A cause-and-effect diagram of the Australian energy storage policy has been developed. The country has experienced several serious power outages in recent years, endangering lives and public infrastructure. Subsequently, a variety of energy storage systems have had the prospect of being a potential solution to problems with electric grid performance and resilience. The authors suggest that the growth and development of future domestic assets and energy storage infrastructure will require a combination of the currently missing targeted energy storage systems and supply development policies. The paper also proposes

a mechanism for dealing with changing climate conditions, fluctuating electricity demand and associated demand response, and reduced reliance on coal-fired power generation. It is important to note that recognizing the value of energy storage systems throughout the energy supply chain will be a critical component of future system growth. In addition, while certain regulatory changes will be required to create a new energy capacity market, most electricity market rules and procedures will need to be retained to allow the introduction of scheduled and semi-scheduled energy storage systems (Havrysh et al. 2020). The study also identified the need for effective governance that supports continued investment in renewable energy and energy storage, intergovernmental cooperation, and technical upgrades to the grid. Ideally, implementation of these policy and regulatory options should result in a reliable and resilient energy system, reduced emissions, and the deployment of cost-effective systems of energy storage (Niyazbekova et al. 2021). Australia will need comprehensive financial incentives for renewable energy and storage.

The possibilities of bioenergy applications with carbon sequestration and storage in the energy sector in Australia are considered in a study by Pour et al. (2018). In meeting international commitments to reduce greenhouse gas emissions, including the transition to the decarbonization of its emission-intensive energy sector, the Australian government is faced with the dual challenge of increasing the cost of electricity and reducing energy security. One potential contribution to reducing its emissions while ensuring a reliable energy supply is the introduction of bioenergy with carbon capture and storage. This is a carbon removal technology that provides the permanent net removal of carbon dioxide from the atmosphere along with the prospect of negative emissions (Shalbolova and Kenzhegaliyeva 2018).

The research was conducted to assess the potential contribution of this technology to achieve long-term decarbonization of the energy sector in Australia. This research considers the availability of sustainable bioenergy resources as well as the economic viability and environmental impact of the technology. To avoid the environmental uncertainties and social problems associated with growing special energy crops, this study focuses on organic waste from municipal, agricultural, and forestry operations. Based on the number of biomass resources available, bioenergy options with carbon capture and storage in Australia could potentially remove a total of 25 million tons of carbon dioxide per year from the atmosphere as negative emissions by 2050. In addition, these systems could provide Australia with up to 13.7 TWh of renewable energy by the mid-century, about 3.6% of expected gross electricity production in 2050. The widespread adoption of bioenergy with carbon capture and storage as a reliable electricity supplier would potentially increase the flexibility and diversity of Australia's energy profile and remove carbon dioxide from the atmosphere. However, the diffusion of this negative-carbon technology will require strong political support.

There is also anaerobic digestion technology, which is a new approach to organic waste processing and reduces greenhouse gas emissions. In addition, the methane gas generated in the process can be used to generate electricity. A corresponding study was conducted by Ngo et al. (2021). To ensure that Australia remains on the path to a carbon-neutral future, consideration should be given to using anaerobic digestion technology to treat abundant organic waste streams. In 2017, thirty million tons of organic waste were produced. Using anaerobic digestion to treat

one ton of waste could reduce greenhouse gas emissions by 0.143 tons of greenhouse gas. In contrast, other more commonly used waste disposals methods, such as landfilling, composting, and incineration, can lead to greenhouse gas emissions. In addition, using methane to generate electricity also results in the lowest greenhouse gas emissions per MWh. This is about three times lower than crude oil, four times lower than hard coal, and five times lower than lignite. However, the introduction of anaerobic digestion technology in Australia faces several immediate limitations. First, anaerobic digestion technology is considered uneconomical due to high initial capital costs, operating costs, and extremely long payback periods. Secondly, there is no state support in terms of a national goal for anaerobic digestion and biogas production. This article presents an in-depth analysis of the current state of the biogas sector in Australia. In addition, the review discusses opportunities to make anaerobic digestion technology more financially viable and accelerate the growth of the biogas sector in Australia.

Penesis et al. (2018) presented a study of the possibility of marine resource management in Australia. Considered the progress of a three-year project funded by the Australian National Renewable Energy Agency under the leadership of the Australian Maritime College (University of Tasmania). The project aims to assess the technical and economic feasibility of tidal energy in Australia. The project consists of three interrelated components: a national Australian tidal resource assessment, case studies at two prospective energy production sites, and an assessment of the technological and economic feasibility of integrating tidal energy into the Australian electricity infrastructure. As part of technological innovation and the transition to carbon neutrality, there is a need to ensure that marginalized communities are not further disadvantaged, which is not insignificant. O'Neill et al. (2021) prioritized the introduction of alternative energy in indigenous regions of Australia. It explored the conditions under which indigenous peoples with community property rights and interests in their land could benefit from large-scale renewable energy projects. Indigenous participation in large-scale renewable energy projects is necessary for equitable economic integration. This contributes to the selection of an appropriate framework for approaching the development of these projects.

Conclusions

Australia is on a course to reduce its emissions and conserve nature. The reforms adopted in 2019 to shift the focus of energy towards renewable resources are now yielding positive results. However, there are certain difficulties the government faces: large losses when abandoning traditional energy sources and expanding energy infrastructure, the negative impact of foreign partners' industries on the environment, and the low productivity of some alternative resources in Australia. The research examines the factors that encourage or discourage the introduction of renewable energy sources in power generation. This is why there is a need to attract more investment and the latest technology to further unlock Australia's energy potential.

The most effective unconventional energy technologies are considered. For example, the energy storage system is considered a potential solution to the productivity and sustainability of electric grids. The question of solving the problems associated with climate change, fluctuations in demand for electricity, and reducing dependence on coal-fired power generation is raised. The impact of bioenergy application is studied; this technology contributes to achieving a long-term reduction of carbon dioxide emissions. The introduction of bioenergy with carbon capture and storage will potentially increase the flexibility and diversity of Australia's energy sector and significantly reduce atmospheric carbon dioxide. Anaerobic digestion technology to treat abundant organic waste streams could reduce greenhouse gas emissions but is considered uneconomical because of high upfront capital costs, operating costs, and long payback periods. It is necessary to continue further development of alternative energy in Australia and to attract more investors to this industry. The country will continue to export its energy resources abroad as the energy market of Australia remains one of the main markets for Asian countries. At the same time, Australia itself intends to completely abandon conventional energy.

The research is of practical value for possible investors in the energy sector of Australia as it examines the issue from different angles, points out the existing shortcomings of the current state of the energy sector and suggests methods of the possible introduction and improvement of new technologies. Suggestions for new safe and efficient technologies for power generation will be widely welcomed.

While the research is comprehensive and provides valuable insights into the current state of the energy sector in Australia, there are still some research gaps that could be addressed in future studies. Firstly, while the research acknowledges the challenges and difficulties that the government faces in shifting towards renewable energy sources, it does not go into detail about the specific strategies and policies that could be implemented to overcome these challenges. For example, the research could explore the potential of financial incentives for investors, such as tax breaks or subsidies, in order to encourage the adoption of renewable energy technologies.

Secondly, while the research mentions the potential of energy storage systems as a solution to the productivity and sustainability of electric grids, it does not delve into the technical details of these systems or the challenges associated with their implementation. A more detailed analysis of the costs and benefits of various energy storage technologies could help to identify the most effective solutions for the Australian energy sector. Finally, the research briefly mentions the potential of bioenergy and anaerobic digestion technologies to reduce carbon dioxide emissions but does not explore the technical feasibility of these technologies in greater detail. Future studies could focus on the practical aspects of implementing these technologies, including their energy efficiency, economic viability, and potential environmental impacts.

In summary, while the research provides valuable insights into the current state of the energy sector in Australia and the potential for the further development of renewable energy sources, there are still some research gaps that could be addressed in future studies to provide a more comprehensive understanding of the challenges and opportunities facing the Australian energy market.

References

About foreign investment 2022. [Online] https://www.dfat.gov.au/trade/investment/about-foreign-investment [Accessed: 2022-12-10].

Australia's energy strategies and frameworks 2022. [Online] https://www.energy.gov.au/government-priorities/australias-energy-strategies-and-frameworks [Accessed: 2022-12-10].

Australian energy market agreement 2013. [Online] https://www.energy.gov.au/government-priorities/energy-ministers/energy-ministers-publications/australian-energy-market-agreement-amended-december-2013 [Accessed: 2022-06-10].

Australian infrastructure plan: Priorities and reforms for our nation's future 2016. [Online] https://apo.org.au/sites/default/files/resource-files/2016-02/apo-nid62457.pdf [Accessed: 2022-12-10].

Azerbaijan is among the world leaders of green energy 2022. *Azerbaijan State News Agency AZERTAJ*. [Online] https://azertag.az/ru/xeber/Azerbaidzhan___sredi_mirovyh_liderov_zelenoi_energetiki-2054489 [Accessed: 2022-12-10].

Baizakova et al. 2016 – Baizakova, K., Bolatkhan, M. and Baikushikova, G. 2016. Energy measurement of the safety as a factor of sustainable development in the Republic of Kazakhstan. *International Journal of Environmental and Science Education* 11(18), pp. 11569–11583.

Beasy et al. 2023 – Beasy, K., Lodewyckx, S. and Mattila, P. 2023. Industry perceptions and community perspectives on advancing a hydrogen economy in Australia. *International Journal of Hydrogen Energy* 48(23), pp. 8386–8397, DOI: 10.1016/j.ijhydene.2022.11.230.

Chu et al. 2022 – Chu, S., Sethuvenkatraman, S., Goldsworthy, M. and Yuan, G. 2022. Techno-economic assessment of solar assisted precinct level heating systems with seasonal heat storage for Australian cities. *Renewable Energy* 201, pp. 841–853, DOI: 10.1016/j.renene.2022.11.011.

Commercial and economic cooperation between Ukraine and Australia 2020. [Online] https://australia.mfa.gov.ua/spivrobitnictvo/315-torgovelyno-jekonomichne-spivrobitnictvo-mizh-ukrajinoju-ta-avstralijeju [Accessed: 2022-06-10].

Energy programs 2020. [Online] https://www.energy.gov.au/government-priorities/energy-programs [Accessed: 2022-06-10].

Havrysh et al. 2020 – Havrysh, V., Kalinichenko, A., Mentel, G., Mentel, U. and Vasbieva, D.G. 2020. Husk energy supply systems for sunflower oil mills. *Energies* 13(2), DOI: 10.3390/en13020361.

Havyatt, D. 2020. *A history of electricity reform in Australia*. [Online] https://www.researchgate.net/profile/David-Havyatt/publication/344803470_A_History_of_Electricity_Reform_in_Australia/links/5f90fe78458515b7cf937a8a/A-History-of-Electricity-Reform-in-Australia.pdf [Accessed: 2022-06-10].

Higginson et al. 2020 – Higginson, S., Milovanovic, K., Gillespie, J., Matthews, A., Williams, C., Wall, L., Moy, N., Hinwood, M., Melia, A. and Paolucci, F. 2020. COVID-19: The need for an Australian economic pandemic response plan. *Health Policy and Technology* 9(4), pp. 488–502, DOI: 10.1016/j.hlpt.2020.08.017.

Karim, S. and Naeem, M.A. 2022. Clean energy, Australian electricity markets, and information transmission. *Energy Research Letters* 3(3), DOI: 10.46557/001c.29973.

Lang et al. 2022 – Lang, A., Lane, R., Zhao, K. and Raven, R. 2022. Energy efficiency in the private rental sector in Victoria, Australia: When and why do small-scale private landlords retrofit? *Energy Research and Social Science* 88, DOI: 10.1016/j.erss.2022.102533.

Lu et al. 2022 – Lu, L.-C., Chiu, S.-Y., Chiu, Y.-h. and Chang, T.-H. 2022. Sustainability efficiency of climate change and global disasters based on greenhouse gas emissions from the parallel production sectors – A modified dynamic parallel three-stage network DEA model. *Journal of Environmental Management* 317, DOI: 10.1016/j.jenvman.2022.115401.

Martin, N. and Rice, J. 2021. Power outages, climate events and renewable energy: Reviewing energy storage policy and regulatory options for Australia. *Renewable and Sustainable Energy Reviews* 137(C), DOI: 10.1016/j.rser.2020.110617.

National energy performance strategy 2022. [Online] https://www.energy.gov.au/government-priorities/australias-energy-strategies-and-frameworks/national-energy-performance-strategy [Accessed: 2022-06-10].

Ngo et al. 2021 – Ngo, T., Ball, A. and Shahsavari, E. 2021. The current status, potential benefits and future prospects of the Australian biogas sector. *Journal of Sustainable Bioenergy Systems* 11(1), pp. 14–32, DOI: 10.4236/jsbs.2021.111002.

Niyazbekova et al. 2021 – Niyazbekova, S., Moldashbayeva, L., Kerimkhulle, S., Jazykbayeva, B., Belousssova, E. and Suleimenova, B. 2021. Analysis of the development of renewable energy and state policy in improving energy efficiency. *E3S Web of Conferences* 258, DOI: 10.1051/e3sconf/202125811011.

O'Neill et al. 2021 – O'Neill, L., Thorburn, K., Riley, B., Maynard, G, Shirlow, E. and Hunt, J. 2021. Renewable energy development on the Indigenous Estate: Free, prior and informed consent and best practice in agreement-making in Australia. *Energy Research Social Science* 81, DOI: 10.1016/j.erss.2021.102252.

Penesis et al. 2018 – Penesis, I., Hemer, M., Cossu, R., Hayward, J., Nader, J.-R., Rosebrock, U., Grinham, A., Sayeef, S., Osman, P., Marsh, P. and Couzi, C. 2018. Tidal energy in Australia – Assessing resource and feasibility to Australia's future energy mix. Paper presented at the *The 4th Asian Wave and Tidal Energy Conference* (*AWTEC 2018*), 09–13 September, Taipei, Taiwan.

Pluss, M. 2019. The world energy market and Australian energy: Economic and business perspectives. *Geography Bulletin* 51(3), pp. 64–70.

Pour et al. 2018 – Pour, N., Webley, P.A. and Cook, P.J. 2018. Opportunities for application of BECCS in the Australian power sector. *Applied Energy* 224, pp. 615–635, DOI: 10.1016/j.apenergy.2018.04.117.

Rausch, P. and Suchanek, M. 2021. Socioeconomic factors influencing the prosumer's investment decision on solar power. *Energies* 14(21), DOI: 10.3390/en14217154.

Say et al. 2023 – Say, K., Csereklyei, Z., Brown, F.G. and Wang, C. 2023. The economics of public transport electrification: A case study from Victoria, Australia. *Energy Economics* 120, DOI: 10.1016/j.eneco.2023.106599.

Shalbolova et al. 2021 – Shalbolova, U., Chikibayeva, Z. and Kenzhegaliyeva, Z. 2021. Efficiency of investment projects to modernize facilities housing and communal services (case of Kazakhstan). *IOP Conference Series: Earth and Environmental Science* 650(1), DOI: 10.1088/1755-1315/650/1/012075.

Shalbolova, U. and Kenzhegaliyeva, Z. 2018. Main directions of smart city development in the republic of Kazakhstan. *MATEC Web of Conferences* 251, DOI: 10.1051/matecconf/201825105042.

Strazzabosco et al. 2022 – Strazzabosco, A., Gruenhagen, J.H. and Cox, S. 2022. A review of renewable energy practices in the Australian mining industry. *Renewable Energy* 187, pp. 135–143, DOI: 10.1016/j.renene.2022.01.021.

Suleimenov et al. 2020 – Suleimenov, I., Egemberdieva, Z., Bakirov, A., Baipakbayeva, S., Kopishev, E. and Mun, G. 2020. Efficiency Problem of renewable energetics systems in the context of a 'smart house' concept. *E3S Web of Conferences* 164, DOI: 10.1051/e3sconf/202016413002.

Trade and Investment at a glance 2021, 2021. [Online] https://www.dfat.gov.au/publications/trade-and-investment/trade-and-investment-glance-2021 [Accessed: 2022-06-10].

Trinh et al. 2022 – Trinh, N.T., Nguyen, T.P.T. and Nghiem, S.H. 2022. Economic policy uncertainty and other determinants of corporate cash holdings of Australian energy companies. *International Journal of Energy Sector Management* 16(6), pp. 1192–1213, DOI: 10.1108/IJESM-10-2020-0005.

Udemba, E.N. and Alola, A.A. 2022. Asymmetric inference of carbon neutrality and energy transition policy in Australia: The (de)merit of foreign direct investment. *Journal of Cleaner Production* 343, DOI: 10.1016/j.jclepro.2022.131023.

Wolek et al. 2021 – Wolek, M., Suchanek, M. and Czuba, T. 2021. Factors influencing walking trips. Evidence from Gdynia, Poland. *PLoS ONE*, 16(8 August), DOI: 10.1371/journal.pone.0254949.
Wood, T. 2019a. *Australia's energy transition: a blueprint for success*. Melbourne: Grattan Institute.
Wood, T. 2019b. *Three ways to start fixing Australia's energy policy mess*. Melbourne: Grattan Institute.

Vilayat Ismayilov, Sahib Mammadov, Narmina Abbasova, Vusala Babayeva, Sabina Sadigova

Stan obecny i perspektywy dalszego rozwoju sektora energetycznego w Australii: reformy, zagraniczne stosunki gospodarcze, klimat inwestycyjny

Streszczenie

W ostatnich latach rząd Australii zmienił kurs w zakresie stopniowej wymiany zaopatrzenia kraju w energię z tradycyjnych źródeł energii na alternatywne odnawialne źródła energii w celu ochrony środowiska. Znaczenie badań predestynowane jest koniecznością wprowadzania najnowszych technologii oraz pozyskiwania inwestorów dla dalszego rozwoju państwowej energetyki. W związku z tym badania mają na celu ujawnienie aktualnego stanu sektora energetycznego w Australii, badanie istniejących projektów, ich produktywności i ich wpływu na środowisko. Głównymi metodami badawczymi są metoda analizy istniejących publikacji opisujących aktualny stan sektora energetycznego oraz metoda porównywania wyników energetycznych kraju przed i po wdrożeniu odpowiednich reform, aby lepiej zobrazować efektywność istniejących projektów. W rezultacie ustalono, że rząd Australii prowadzi politykę neutralności węglowej w energetyce, aby zmniejszyć szkody wyrządzane naturze przez szkodliwe emisje do atmosfery. Państwo koncentruje się na obniżeniu kosztów energii elektrycznej. Ustalono również, że Australia jest pozytywnie nastawiona do inwestycji zagranicznych i otwarta na propozycje nowych technologii poprawiających efektywność i bezpieczeństwo dostaw energii. W badaniu wymieniono głównych partnerów handlowych Australii, ich wspólne projekty i przedsiębiorstwa. Zidentyfikowano główne kierunki obecnie stosowanych alternatywnych źródeł energii, ich zalety i wady. Wynik badań może mieć wartość praktyczną dla inwestorów w obszarze odnawialnych źródeł energii w celu lepszego zrozumienia rynku energii w Australii i możliwych perspektyw, a także dla wszystkich zainteresowanych.

Słowa kluczowe: odnawialne źródła energii, ochrona środowiska, zaopatrzenie w energię, wzrost PKB, struktura rynku