TANULMÁNYOK / STUDIES

Thandokazi Maxam[1] – Márton Péti[2]

Approaches to energy transition: A comparative analysis of South Africa and Hungary after changes in their political systems

Countries across the world are transitioning from fossil fuel dominated energy to low carbon energy systems. They are adopting initiatives to encourage development of clean energy sources. However, the approaches, strategies and the pace of this transition differs from country to country. This study comparatively examines approaches to energy transition in South Africa and Hungary. The two countries have undergone a significant transformation in their political systems over the past 30 years, this was followed by a series of initiatives aiming to encourage adoption of environmentally friendly energy sources. While Hungary has prioritized nuclear energy as a way to achieve energy security and lower emissions from coal-based energy, South Africa has concentrated on increasing energy access and tackling energy poverty through the integration of renewable energy sources.
Keywords: Energy transition, energy policy, clean energy
JEL codes: Q01, Q40, Q42, Q48

https://doi.org/10.32976/stratfuz.2024.37

Introduction

The world is currently undergoing a substantial move away from fossil fuels and towards cleaner energy sources such as wind, solar, hydropower, geothermal, and so on; this is known as energy transition. The primary motivations for this transformation are the need to tackle climate change and environmental damage caused by fossil fuel consumption (Markard, 2018), boosting energy security and independence (Mata Pérez et al., 2019), and high energy costs. Countries around the world have established targets for their energy transition, and they are putting policies in place to help them accomplish those goals and ease the transition. A notable example is the European Union (EU), which has set a target of 32% renewable energy contribution to total energy generation by 2030. States in the United States of America, setting their own targets, Hawaii for example, aims to reach 70% energy independence by 2030, 40% of this will come from renewable energy sources (Gielen et al., 2019). While other countries have made progress in the adoption of renewable energy, some countries are facing challenges such as high upfront costs, resistance from entrenched fossil fuel interests, and the need for infrastructure upgrades to accommodate new energy sources (Babayomi et al., 2022).
This study compares the energy transition approaches of two countries, a developed country located in Europe, Hungary and a developing country, located in the African continent, South Africa. The two countries differ in terms of their geographic, economic, and social contexts. Despite these contrasts, the countries share some characteristics, such as the political transition to democracy over the last 30 years, which may have influenced their energy policies, a rise in renewable energy adoption in recent decades, and energy security concerns and diversification of energy sources. In the late 1980s and early 1990s, Hungary transitioned from a communist state to a democratic system (Bart et al., 2018; Mohammed et al., 2021). Similarly, in the mid-1990s,

[1] MSc, assistant lecturer at University of Fort Hare, South Africa thandokazi.maxam@stud.uni-corvinus.hu
[2] PhD, Associate Professor, University of Pannonia, Research Institute for National Strategy marton.peti@nski.gov.hu

South Africa transitioned from apartheid to democracy (Ayamolowo et al., 2022). This development demanded policy shifts in both countries. Examining the impact of these changes on the energy sector may offer important insights into the relationship between political shifts and energy policy. Furthermore, both countries want to strengthen their energy security because they are dealing with the same challenge, while the causes differ. The goal of this study is to investigate the key drivers and motivations for energy transition processes in South Africa and Hungary. The study is guided by two questions: (i) What are the primary drivers and incentives for energy transformation processes in South Africa and Hungary? (ii) How do South Africa's and Hungary's energy transition strategies differ in terms of policy frameworks, renewable energy adoption, and socioeconomic outcomes?

Methodology

This study used a qualitative document analysis approach to better understand the motivations behind the energy transitions in South Africa and Hungary after major political system changes.
Data Collection and Document Selection Criteria:
The choice of documents used in the study was based on their relevance to energy policies, transition or efforts following political system changes. All the documents considered were published after political changes in both countries i.e., after 1989 in Hungary and 1994 in South Africa. The main sources used to gather information include government reports, policy documents, academic papers, and media reports obtained from governmental websites, and scholarly databases and websites of international organisations such as International Renewable Energy Agency (IRENA) and International Energy Agency (IEA).
Data analysis:
The study employed a comparative analysis based on the energy policies, energy mix, energy market and energy consumption of the two countries. The qualitative information obtained is supplemented by energy related numerical data from both countries and this data is presented using charts.

Energy transition in developed and developing countries

Developed and developing countries have different approaches to energy transition. Several developed countries have deployed clean-energy resources and reduced their primary energy consumption, while fast-growing emerging countries have witnessed a rise in their energy consumption. For instance, European nations have lowered their consumption by an average of 5% during the last two decades, while primary energy consumption increased by more than double in China, India, East and Central Africa, as well as the Middle East (Berdysheva & Ikonnikova, 2021). While reducing emissions is crucial for addressing climate change, developing nations also contend with issues such as indoor pollution and poor health resulting from the use of wood and waste for cooking. As they strive to improve living standards, many of these countries see increased use of fossil fuels as a vital component of their development strategies (Yergin, 2022). Energy poverty is one of the most challenging issues for developing nations, particularly in rural areas due to poor access to affordable, modern and clean energy (Cantarero, 2020). Some of them lack sufficient generating capacity to meet base load demand, forcing utility companies perform scheduled power outages in order to provide some electricity to a large number of consumers (Babayomi et al., 2022; Cantarero, 2020; Yergin, 2022). This is known as load shedding and it is common among countries like South Africa (Uhunamure & Shale, 2021), India and Nigeria (Cantarero, 2020).

Energy transition and energy policies around the world

Over the years, there has been a series of events that resulted in significant impacts on the global energy market and energy policies across the world. One of the most significant events is the Shale

Revolution which led to a major rise in energy production in the United States, resulting in reduced prices and changes in global energy trading patterns. While the shale revolution has had a negative impact in many countries particularly African countries that export oil to the U.S like, Nigeria, Algeria, Chad, Cameroon, Gabon and other oil producing countries, it has also sparked interest on shale development in many countries, including European countries like Hungary, United Kingdom, Poland and the Czech Republic (de Zeeuw, 2014), and other countries like China and South Africa. In 2014, Hungary's interests can be seen on its numerous shale gas exploration wells, according to reports, there are around 1500 billion cubic meters of shale gas in low-permeable plays, which would cover Hungary's current demand for gas for 120 years (Janda & Kondratenko, 2018). On the other hand, the success of the shale revolution in the United States has fuelled South Africa's interest in exploring shale gas reserves in the Karoo Basin. However, environmental concerns, notably over water usage and contamination, have hindered the development of shale gas in South Africa. Fracking requires a lot of water, and the Karoo region is very dry. Environmentalists and local populations in the Karoo region have expressed worry about the possible environmental impacts. As a result, the South African government has been hesitant about permitting fracking to continue (Andreasson, 2018). Furthermore, there are other events like the Fukushima accident in Japan and the 2009 financial crisis which led to a decline in global energy consumption, followed by Covid 19 triggered energy crisis as well as the Russo-Ukrainian war. Russia-Ukraine war led to a rise in natural gas prices affecting countries depending on Russia for gas supply (Lebrouhi et al., 2022).
International communities and organizations such as the United Nations established climate change mitigation and adaptation agreements such as the Kyoto protocol and the Paris Agreement (Dogan et al., 2022). These agreements have also played a significant role in shaping energy policies and encouraging transition to clean energy sources. Following these mentioned events, several countries have tried to find ways to reduce their energy dependency, strengthen energy security and encourage the transition to clean energy sources. For instance, the European Union has introduced several directives setting binding targets for each EU Member State's share of energy from renewable sources. For instance, Directive (EU) 2018/2001 (RED II) sets a 32% target share of renewable energy in the EU's final energy consumption by 2030 (Zygierewicz & Sanz, 2021). However, priorities, approaches and viewpoints to achieving low emissions, energy security and transition differs among the countries. Notably, when it comes to nuclear energy which remains a source of debate among EU member states. Following the nuclear disaster in Fukushima, EU witnessed a gradual shutdown of nuclear power facilities (Bohdanowicz et al., 2023; Simionescu, 2023), in countries like Germany, Spain, Belgium, Austria, Denmark, and Italy due to concerns about the security and potential hazards of nuclear energy (Markard, 2018). Hungary is one of the EU countries that encourage nuclear due to its minimal greenhouse gas emissions, they see it as a vital energy source that is aligned with the environmental goals of the EU (Bohdanowicz et al., 2023; Simionescu, 2023). Similarly, despite the concerns about nuclear development as a result of the Fukushima accident, South Africa still considers nuclear energy as an important component of its energy transition efforts (Van Wyk, 2021). This paper will later touch on the nuclear situation of Hungary and South Africa, exploring their individual stances and implications for their perspectives on energy policies.

Results and Discussion

This chapter discusses South Africa's and Hungary's energy transition processes in relation to motivations, goals, and policies adopted. The first section provides an overview of the energy sector including energy policies in both countries. Second section, describes renewable energy landscape in each country, analysing and comparing their energy sector in relation to energy capacity, production, the structure of the energy market, the role of nuclear and further touches on their just transition agenda.

An overview of South Africa's energy sector

South Africa is one of the biggest CO2 emitters in the world and accounts for around 40% of Africa's total CO2 emissions due to high reliance on fossil fuels (Uhunamure and Shale, 2021). The country is also among the world's biggest energy consumers, with an energy intensity of approximately 8 MJ per unit of GDP produced in 2020 (IRENA, 2023b). According to the recent statistics, primary energy consumption of 119 Mtoe in 2021, a slight rise from 118.4 Mtoe in 2020 (KSH, 2023). This paper uses the total energy supply by source to show the diversification of energy sources in both Hungary and South Africa. Figure 1 shows South Africa's energy supply structure and the contribution of each energy source to the total energy mix. Although the South Africa has several energy sources other than coal contributing to its energy supply, their contribution is very small compared to coal. According to the latest available statistics, coal accounts for 72% of the total energy supplied in the country as shown in Figure 1.

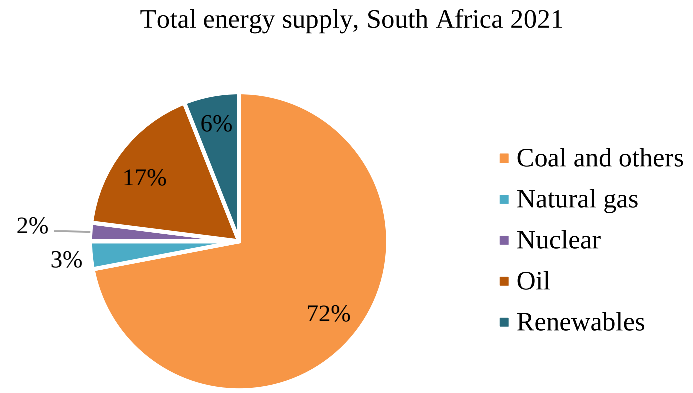

Figure 1 Total energy supply in 2021, South Africa
Source: Modified by author, data from IRENA, (IRENA, 2024b)

Fossil fuels have played a major role on the significant improvement of the country's electrification rate over the years. In 1993, South Africa's electrification rate was about 36% (Sarkodie & Adams, 2020). Throughout the apartheid era, the majority of black South Africans had challenges in getting access to electricity and other essential services due to racial segregation. After the end of apartheid in 1994, attempts were undertaken to remedy historical injustices and provide energy access for economically disadvantaged areas. In 2012, electrification rate was up to 88% (Ayamolowo et al., 2022), despite this improvement, the country still has a notable number of households without access to electricity. In 2018, over 12% of households lacked access to power. The country also has power system restrictions, which have resulted in planned power outages in specific areas to relieve the high demand pressure on the limited electrical supply (Uhunamure & Shale, 2021).

Policies relating to renewable energy adoption

South Africa has implemented several policies to address the energy crisis, including increasing the share of clean energy sources in the energy mix and meeting the country's goal of reducing CO2 emissions by 42% by 2025 (Akinbami et al., 2021). In 1998, the country adopted the White Paper on Energy Policy which was instrumental in shaping South Africa's energy policies. Its objectives were to enhance access to affordable energy particularly by previously disadvantaged communities, lower inequality, stimulate economic development, manage environmental and health impacts associated with energy, and ensure secure energy supply through diversification (Department of Minerals and Energy, 1998; Pathak & Shah, 2019). This was followed by the Renewable Energy White Paper of 2003. Its aim was to accelerate renewable energy and it

established a target of generating 10,000 GWh of renewable energy by 2013. This document also emphasised the necessity of supporting renewable energy in rural areas with limited access to power, as well as encouraging the development of small-scale renewable energy projects (Department of Minerals and Energy, 2003).
The most recent energy policy initiatives are the Integrated Resource Plan (IRP) 2010-2030 and the Renewable Energy Independent Power Procurement Programme. The IRP seeks to increase the energy supply by 42.6 GW by 2030, with 17.8 GW (42%) coming from renewable sources. The plan IRP includes plans to develop new power generation capacity from coal, nuclear, and gas and renewable sources (Pathak and Shah, 2019). The Renewable Energy Independent Power Procurement Programme (REIPPP) was launched in 2011 in response to the IRP, with the goal of encouraging private sector investment in renewable energy and diversifying the country's energy mix, lowering greenhouse gas emissions, and improving energy security. South Africa's REIPPP program has had a significant contribution in increasing renewable energy share (Akinbami et al., 2021). The country installed over 6,000 MW of renewable energy capacity by 2019, this includes solar PV, wind, biomass, and concentrated solar power, according to the International Trade Administration (ITA, 2022). The production also significantly increased from just under 2000 GW in 2012 to over 10 000 GW in 2017 (IRENA, 2019).

Overview of Hungary's energy sector

Hungary's democratic transition enabled it to join the European Union in 2004. As a result, the EU's energy policies and goals influence the country's energy landscape (Bart et al., 2018; Mohammed et al., 2021). Hungary adopted the rules of the EU's electrical market aimed at creating a common and free electricity market. This includes separating the management of electricity suppliers and grid operators, establishing independent regulators, encouraging cross-border collaboration, and expanding retail markets (Antal, 2019). In the past decade, the country's energy demand increased intensifying reliance on imported energy. In 2010, total energy consumption was 708 petajoules (Pj), which was up to 785 Pj by 2021. The industrial sector has contributed the most to this increase, with its consumption nearly doubling from slightly more than 100 Pj in 2010 to more than 190 Pj in 2021(KSH, 2023). Regardless of the country's efforts to diversify its energy supply, Russia remains the country's main source of oil and gas imports. In 2020, energy dependency on imports reached 87%, with Russia accounting for roughly 64% of crude oil and 95% of gas imports (IEA, 2022). The dependency on imports as well as the one-sidedness of those imports as almost all of the imports are from Russia, leaves Hungary in a vulnerable position, threatening the country's energy security (Ministry of National Development, 2017). Since 2000, coal-related CO2 emissions in Hungary have significantly decreased by 58%. Hungary's greenhouse emissions per capita are now lower than the EU average, and the country contributes less than 2% of total EU greenhouse gas emissions (Simoes, 2021). This can be ascribed to an increase in nuclear and renewable energy, as well as the replacement of coal-fired power plants with gas-fired ones (IEA, 2022). As part of the agreement with the EU, Hungary is obligated to reduce emissions by 10% by 2030 (Mohamed, 2019). In 2017 the country produced more than 3000 GW of renewable energy and had installed over 2,000 MW of renewable energy capacity by 2019 (IRENA, 2019). The solar energy contribution to the total electricity production from renewables was nearly 45% in 2020 (Bozsik et al., 2023). However, Hungary made a decision to ban construction of new wind projects despite the potential in wind energy generation (Bozsik et al., 2023). Despite Hungary's progress in reducing CO2 emissions and incorporating clean energy sources, energy continues to be the leading contributor to greenhouse gas emissions, accounting for 71% in 2020 (Simoes, 2021). Figure 2 shows Hungary's total energy supply (%) by source, as presented in figure 2, the country's diversification is more balanced compared to South Africa where one source of energy, coal, dominates the total supply. Hungary's total energy supply is dominated by natural gas (34%) oil (29%), and to some extent nuclear which accounts for around 17% of the total energy supply. According to the data presented in figure 2, coal has a notably less contribution to the total energy supply, which is a complete opposite of the South African case in relation to coal.

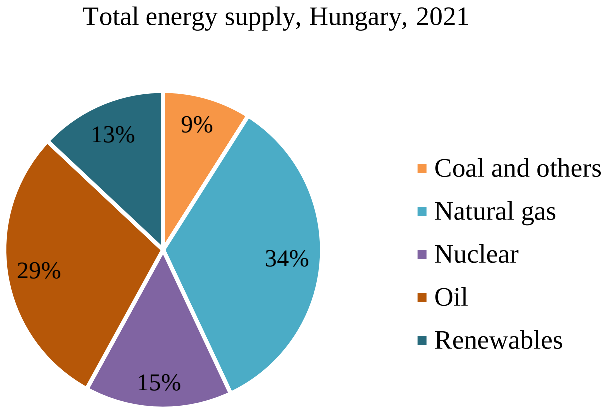

Figure 2 Total energy supply in 2021, Hungary
Source: Source: Modified by authors, data from IRENA (IRENA, 2024a)

Although Hungary has achieved significant progress in providing energy access to its population (with electrification rate at 100% in 2021) compared to South Africa (IRENA, 2023a), energy expenditures, particularly for heating and electricity, can be higher than the average household income. About a third of low-income families have insufficient heating, and nearly 40% of them experience overheating during the summer (Győri et al., 2021).

Policies relating to renewable energy adoption

According to Szabo et. Al., (2021) energy transition in Hungary is primarily driven by the need for energy security and pressure from Western institutions to implement change. Transitioning to cleaner energy sources allows Hungary to minimise its dependency on imports and meet its energy demands through domestic production. To address the issues of energy dependency, security, inefficiency and greenhouse gas emissions, Hungary has adopted several policies including the law that establishes legally binding targets for emissions reductions, energy efficiency, and renewable energy for the year 2030, as well as long-term goal of achieving net-zero emissions by 2050. The Climate Protection Law adopted by Hungary in June 2020. As per the law, Hungary commits to reduce greenhouse gas (GHG) emissions by 40% by 2030. Furthermore, the law requires that renewable energy sources account for at least 21% of gross Final Energy Consumption by 2030 (IEA, 2022). Hungary implemented its National Energy Strategy (NES) in 2011. The policy outlines goals to improve energy efficiency, increase the use of renewable energy sources, diversify the energy mix, reduce greenhouse gas emissions, and retain nuclear energy for stable and reliable power supply (Ministry of National Development, 2017). One technique to achieve energy efficiency, according to the energy plan, which is intensified by outdated heating systems without proper heat isolation in a number of buildings. Hence, energy efficiency is a crucial part of the country's climate policy (Bart et al., 2018). The country also adopted a specific strategy focusing on efficiency on buildings, aligned with National Energy Strategy 2030, the National Building Energy Performance Strategy (NABEPS) which prioritizes energy efficiency and saving by targeting reduced energy consumption in buildings (Ministry of National Development, 2015).

Renewable energy landscape in both countries

Energy Market in Hungary and South Africa

The South African energy market has been controlled by state-owned entities such as Eskom and the formerly state-owned Sasol. Although Eskom remains the country's largest energy provider owning a large share of the country's coal power fleet (Hanto et al., 2022), the country has seen a rise in private sector's participation in the energy sector due to recent energy policies calling for more diversified energy supply (Akinbami et al. 2021). Similarly, before the change of the regime, Hungary's energy industry, was state dominated. The state-owned utility company, Magyar Nemzeti Vagyonkezelő, (MNV) still plays a major role in energy generation and distribution in the country. However, during the 1990s, the Hungarian energy market has seen a considerable liberalization and privatization, and private and international companies are now more prevalent in many sectors of the industry resulting in a diverse energy market (Szabo et al., 2021).

The role of nuclear energy in both countries

Hungary and South Africa intend to continue using nuclear energy in their transition towards cleaner energy sources. For consistent and dependable energy, Hungary's National Energy Strategy promotes long-term use of nuclear (Szabo et al., 2021; Ministry of National Development, Hungary, 2017). According to Aalto et al. (2017) the share of nuclear power in Hungary's electricity generation is the fifth largest in Europe after France, Slovakia, Belgium, and Ukraine. According to Aalto et al. (2017) the share of nuclear power in Hungary's electricity generation is the fifth largest in Europe after France, Slovakia, Belgium, and Ukraine. Since its inception in the early 1980s, the Paks Nuclear Power Plant (NPP), also known as Paks I, has been a major contributor to Hungary's energy mix, with approximately 35% contribution to the country's electrical supply (Aalto et al., 2017; ITA, 2022). The oldest reactors' lifespan, which was initially intended to last for 30 years (ITA, 2022), was extended by 20 years and the Hungarian government intends to delay their final deactivation until the 2040s or 2050s (Aalto, et al 2017; ITA, 2022). In cooperation with a Russian company, Hungary is currently expanding Paks II with two more units (ITA, 2022). The government is adamant that nuclear energy strengthens energy security, despite its nuclear projects' reliance on foreign technology and fuel sources (Szabo et.al. 2021). According to Aalto et al. (2017) the expansion of nuclear energy is especially crucial in view of the frequent interruptions of Hungary's natural gas supply since the middle of the 2000s, which have been caused by conflicts between Russia and Ukraine. However, the country already depends on Russian energy imports, further reliance on Russia for nuclear money and technology may result in geopolitical or economic vulnerability.

South Africa on the other hand, according to Nkosi and Dikgang (2021), is currently the only African country with a commercial nuclear power. South Africa's two nuclear reactors produce nearly 6% of the nation's electricity (Nkosi & Dikgang, 2021; Van Wyk, 2021). The government has shown some interests on nuclear energy and expects to expand its nuclear capacity in the long-term. During his time in office, South African former president, Jacob Zuma pushed for expansion of the country's nuclear energy. In 2011, the South African government under his presidency approved the integrated resource plan (IRP) which highlighted plans to increase the total share of nuclear energy up to 13.5% by 2030. Thereafter, the country began its preparations for nuclear energy development. The country's intentions to expand its nuclear energy attracted international attention leading to the country signing agreements with countries like Russia, the United States, France, China, Japan and South Korea in 2014. However, the plans to expand nuclear were suspended after reports of corruption involving the former president and his government which led to his resignation in 2018. The country was unable to proceed with the nuclear plans due to budgetary limitations and political concerns. Furthermore, South Africa lacks proper infrastructure and technical know-how for nuclear development (Van Wyk, 2021). In 2019, South Africa revisited discussions about the expansion of its nuclear energy. The Integrated resource plan (IRP) of 2019 includes plans to increase nuclear energy by 2030 in attempt to reduce reliance on coal and adopt cleaner energy sources (Pathak and Shah, 2019).

Just energy Transition

Transitioning away from fossil fuels may have serious environmental and economic implications. For instance, mine closures may have long-term environmental consequences and incur costs associated with the restoration of former mining sites (Strambo et al., 2019). In Hungary, the number of coal mines has dropped from nine operating mines in 2015 to only four in 2021 (Rosch & Epifanio, 2022). Areas such as Baranya and Heves county that are hosts to the country's mining industry, will be directly affected by closure of mines. Currently, coal mining directly provides employment to about 2 000 people and indirectly to about 4 700 people, most of them will lose their jobs as mines close (IEA, 2022). However, the country has plans in place to tackle such issues, and the EU has special initiatives such as Just Transition Fund to support communities affected by climate transition in its member states (Rosch & Epifanio, 2022).

According to Strambo, et al. (2019) mining companies in South Africa are obligated to set aside funds for environmental restoration after closure. However, there are more issues connected to mine closure that need attention, for instance the closure of the coal fired powered station operated by Eskom has left about 2300 workers jobless as noted by Cock (2019). South African trade unions have advocated for a "just transition" for coal workers and communities, emphasising the importance of providing viable alternative employment opportunities in affected areas in response to possible job losses in the coal sector (Cock, 2019; Strambo et al., 2019). Furthermore, the projects under the REIPPP programme reflects on some elements of just transition on their socio-economic aspects. The REIPPP contains measures allowing local communities to possess a minimum stake in renewable energy. As one of the requirements for the approval of REIPPP bids, local communities must have a minimum 2.5% of the project's shareholding (Müller & Claar, 2021). There is evidence that about 25% of the projects exceed the minimum percentage going to as far as 40% of community ownership. Another requirement ensures that some of the resources used in projects are locally sourced (Müller et. al., 2021). This encourages community involvement and ownership in the transition process. The projects also support education initiatives and offer hands on training for local communities (Müller et al., 2020; Müller & Claar, 2021).

Conclusion

the comparison of the energy transitions in South Africa and Hungary, reveals a complex landscape that is influenced by a variety of factors, including energy security, energy poverty, nuclear energy interests, intentions to lower greenhouse gas emission, fulfil international climate agreements, energy efficiency, and the impact of change in political systems. Renewable energy and nuclear energy has been part of their strategies to diversify their energy mix and promote sustainability in their respective energy sectors (Antal, 2019; Nkosi & Dikgang, 2021; Szabo et al., 2021; Van Wyk, 2021). Hungary's high reliance on imports, and South Africa's unreliable energy supply and the need for improving energy access necessitate development for a more diversified energy structure in both countries. Hence energy policies in both countries push for energy diversification. While both countries rely significantly on fossil fuels, South Africa's energy supply is largely coal-based, whereas Hungary's energy mix is much more diverse, with major contributions from natural gas, oil, and nuclear energy. Hungary's diversity supports a more resilient energy structure, whereas South Africa's reliance on coal exposes it to the environmental and economic issues connected with this energy source. Transitioning to cleaner and more diverse energy sources will undoubtedly help both countries, especially South Africa, where coal dominates other possible energy prospects.

In the past three decades South Africa and Hungary have undergone significant democratic transitions which to some extent, has an impact on their current energy systems. This influence can be seen on the emphasis on addressing energy access and inequality in the energy policies of the post-apartheid South Africa. This is to ensure that previously disadvantaged communities gain better access to energy. In Hungary, the influence of democratic transition can be seen on the

influence of the European Union's energy goals in Hungary's energy policies after the integration with EU. Hungary's EU membership means that the country is expected to meet the EU's energy and climate targets and has access to EU funds to support its energy transition. In addition, political change has opened the way for the current involvement of private sector in the energy transition process of the two countries. While both countries share common goals such as achieving energy security and reducing greenhouse gas emissions, their specific approaches vary based on their unique contexts and challenges.
Furthermore, this analysis shows how varied energy security problems influence policy decisions and diversification tactics across geopolitical circumstances. Hungary's approach is expanding its energy mix with nuclear energy, renewables, and EU interconnections to lessen reliance on Russian gas. South Africa, on the other hand, is attempting to shift its energy mix away from coal and towards renewables and other sources in order to address supply reliability and environmental concerns. The findings may help policymakers develop appropriate energy diversification policies based on specific national settings. Hungary's reliance on regional energy markets teaches South Africa and other nations the value of cross-border energy collaboration and market integration. South Africa's push for renewable energy, on the other hand, emphasises the necessity of utilising domestic resources and the need for significant infrastructure investment.

References

Aalto, P., Nyyssönen, H., Kojo, M., & Pal, P. (2017). Russian nuclear energy diplomacy in Finland and Hungary. *Eurasian Geography and Economics, 58(*4), 386–417. https://doi.org/10.1080/15387216.2017.1396905

Akinbami, O. M., Oke, S. R., & Bodunrin, M. O. (2021). The state of renewable energy development in South Africa: An overview. *Alexandria Engineering Journal*, *60*(6), 5077–5093. https://doi.org/10.1016/j.aej.2021.03.065

Andreasson, S. (2018). The bubble that got away? Prospects for shale gas development in South Africa. *The Extractive Industries and Society*, *5*(4), 453–460. https://doi.org/10.1016/j.exis.2018.07.004

Antal, M. (2019). How the regime hampered a transition to renewable electricity in Hungary. *Environmental Innovation and Societal Transitions*, *33*, 162–182. https://doi.org/10.1016/j.eist.2019.04.004

Ayamolowo, O. J., Manditereza, P. T., & Kusakana, K. (2022). South Africa power reforms: The Path to a dominant renewable energy-sourced grid. *Energy Reports*, *8*, 1208–1215. https://doi.org/10.1016/j.egyr.2021.11.100

Babayomi, O. O., Dahoro, D. A., & Zhang, Z. (2022). Affordable clean energy transition in developing countries: Pathways and technologies. *iScience*, *25*(5), 104178. https://doi.org/10.1016/j.isci.2022.104178

Bart, I., Csernus, D., & Sáfián, F. (2018). Analysis of climate-energy policies and implementation in Hungary.

Berdysheva, S., & Ikonnikova, S. (2021). The Energy Transition and Shifts in Fossil Fuel Use: The Study of International Energy Trade and Energy Security Dynamics. *Energies*, *14*(17), Article 17. https://doi.org/10.3390/en14175396

Bohdanowicz, Z., Łopaciuk-Gonczaryk, B., Gajda, P., & Rajewski, A. (2023). Support for nuclear power and proenvironmental attitudes: The cases of Germany and Poland. *Energy Policy*, *177*, 113578. https://doi.org/10.1016/j.enpol.2023.113578

Bozsik, N., Szeberényi, A., & Bozsik, N. (2023). Examination of the Hungarian Electricity Industry Structure with Special Regard to Renewables. *Energies*, *16*(9), Article 9. https://doi.org/10.3390/en16093826

Cantarero, V. M. M. (2020). Of renewable energy, energy democracy, and sustainable development: A roadmap to accelerate the energy transition in developing countries.

Energy Research & Social Science, 70, 101716. https://doi.org/10.1016/j.erss.2020.101716

Cock, J. (2019). Resistance to coal inequalities and the possibilities of a just transition in South Africa. *Development Southern Africa, 36*(6), 860–873. https://doi.org/10.1080/0376835X.2019.1660859

de Zeeuw, M. (2014). *The Shale Influencing Strategy.* Quid Novi Foundation

Department of Minerals and Energy. (1998). *White Paper on the Energy Policy of the Republic of South Africa.*

Department of Minerals and Energy. (2003). White Paper on Renewable Energy November 2003.

Dogan, E., Chishti, M. Z., Karimi Alavijeh, N., & Tzeremes, P. (2022). The roles of technology and Kyoto Protocol in energy transition towards COP26 targets: Evidence from the novel GMM-PVAR approach for G-7 countries. Technological Forecasting and Social Change, 181, 121756. https://doi.org/10.1016/j.techfore.2022.121756

Gielen, D., Boshell, F., Saygin, D., Bazilian, M. D., Wagner, N., & Gorini, R. (2019). The role of renewable energy in the global energy transformation. *Energy Strategy Reviews, 24*, 38–50. https://doi.org/10.1016/j.esr.2019.01.006

Győri, Á., Huszár, Á., & Balogh, K. (2021). Differences in the Domestic Energy Consumption in Hungary: Trends between 2006–2017. *Energies, 14*(20), 6718. https://doi.org/10.3390/en14206718

Hanto, J., Schroth, A., Krawielicki, L., Oei, P.-Y., & Burton, J. (2022). South Africa's energy transition – Unraveling its political economy. *Energy for Sustainable Development, 69,* 164–178. https://doi.org/10.1016/j.esd.2022.06.006

IEA. (2022). *Hungary 2022, Energy policy review.* International Energy Agency (IEA).

IRENA. (2019). *Renewable Energy Statistics 2020.* The International Renewable Energy Agency.

IRENA. (2023a). *Energy profile, Hungary.* The International Renewable Energy Agency.

IRENA. (2023b). *Energy profile, South Africa.* The International Renewable Energy Agency.

IRENA. (2024a). *Energy profile, Hungary.* The International Renewable Energy Agency.

IRENA. (2024b). *Energy profile, South Africa.* The International Renewable Energy Agency.

ITA. (2022). *Country Commercial Guide, Hungary.* International Trade administration.

Janda, K., & Kondratenko, I. (2018). An Overwiew of Economic Impacts of Shale Gas on EU Energy Security. https://mpra.ub.uni-muenchen.de/83945/

KSH. (2023). *Primary energy consumption (2000 – 2021).* Energy – Hungarian Central Statistical Office (KSH).

Lebrouhi, B. E., Schall, E., Lamrani, B., Chaibi, Y., & Kousksou, T. (2022). Energy Transition in France. *Sustainability, 14(*10), Article 10. https://doi.org/10.3390/su14105818

Markard, J. (2018). The next phase of the energy transition and its implications for research and policy. *Nature Energy, 3*(8), Article 8. https://doi.org/10.1038/s41560-018-0171-7

Mata Pérez, M. D. L. E., Scholten, D., & Smith Stegen, K. (2019). The multi-speed energy transition in Europe: Opportunities and challenges for EU energy security. *Energy Strategy Reviews, 26,* 100415. https://doi.org/10.1016/j.esr.2019.100415

Ministry of National Development. (2015). *National Building Energy Performance Strategy.*

Ministry of National Development. (2017). *Seventh National Communication and Third Biennial Report of Hungary.*

Mohammed, S., Gill, A. R., Alsafadi, K., Hijazi, O., Yadav, K. K., Hasan, M. A., Khan, A. H., Islam, S., Cabral-Pinto, M. M. S., & Harsanyi, E. (2021). An overview of greenhouse gases emissions in Hungary. *Journal of Cleaner Production, 314,* 127865. https://doi.org/10.1016/j.jclepro.2021.127865

Müller, F., & Claar, S. (2021). Auctioning a 'just energy transition'? South Africa's renewable energy procurement programme and its implications for transition strategies. *Review of African Political Economy, 48*(169). https://doi.org/10.1080/03056244.2021.1932790

Müller, F., Claar, S., Neumann, M., & Elsner, C. (2020). Is green a Pan-African colour? Mapping African renewable energy policies and transitions in 34 countries. *Energy Research & Social Science, 68,* 101551. https://doi.org/10.1016/j.erss.2020.101551

Nkosi, N. P., & Dikgang, J. (2021). South African attitudes about nuclear power: The case of the nuclear energy expansion. International *Journal of Energy Economics and Policy, 11*(5), 138–146. https://doi.org/10.32479/ijeep.11343

Pathak, L., & Shah, K. (2019). Renewable energy resources, policies and gaps in BRICS countries and the global impact. *Frontiers in Energy, 13*(3), 506–521. https://doi.org/10.1007/s11708-018-0601-z

Rosch, L. B., & Epifanio, E. (2022). Just transition in 7 central and eastern European countries.

Sarkodie, S. A., & Adams, S. (2020). Electricity access and income inequality in South Africa: Evidence from Bayesian and NARDL analyses. *Energy Strategy Reviews, 29,* 100480. https://doi.org/10.1016/j.esr.2020.100480

Simionescu, M. (2023). The renewable and nuclear energy-economic growth nexus in the context of quality of governance. *Progress in Nuclear Energy, 157,* 104590. https://doi.org/10.1016/j.pnucene.2023.104590

Simoes, H. M. (2021). *Climate action in Hungary.*

Strambo, C., Burton, J., & Atteridge, A. (2019). The end of coal? Planning a 'just transition' in South Africa.

Szabo, J., Weiner, C., & Deák, A. (2021). Energy Governance in Hungary. In M. Knodt & J. Kemmerzell (Eds.), *Handbook of Energy Governance in Europe* (pp. 1–32). Springer International Publishing. https://doi.org/10.1007/978-3-319-73526-9_13-2

Uhunamure, S. E., & Shale, K. (2021). A SWOT Analysis Approach for a Sustainable Transition to Renewable Energy in South Africa. *Sustainability, 13*(7), 3933. https://doi.org/10.3390/su13073933

Van Wyk, J.-A. (2021). *Nuclear Energy in South Africa.* South African Institute of International Affairs.

Yergin, D. (2022). *Bumps in the Energy Transition.* International Monetary Fund (IMF).

Zygierewicz, A., & Sanz, L. S. (2021). *Renewable Energy Directive, Revision of Directive (EU) 2018/2001.* European Parliamentary Research Service.