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Conversion of Different Units of Measurement

1 MW	1.000 kW
1 GW	1.000 MW
1 TW	1.000 GW
1 MWh	1.000 kWh
1 GWh	1.000 MWh
1 TWh	1.000 GWh
1 TWh	3.600 TJ

1. Introduction

“The usual definition of energy security is clear: sufficient supplies at affordable prices”¹ - Daniel Yergin, Pulitzer Prize winner and author on energy, geopolitics, and the global economy.

The research goal of this paper is to examine the energy security of Hungary and Cuba from 2014 to 2024, while the overall objective is to draw attention to the importance of developing and maintaining energy security and to emphasize that this is an area of constant change and therefore worth looking at in its dynamics. 2014 marks a notable year. Since the annexation of Crimea in 2014, more serious questions have arisen about Russia's energy export reliability, and therefore energy security issues have come to the forefront. Both states were dependent on the Soviet Union, and Hungary still imports a large portion of its natural gas, and crude oil from Russia. Also, 2014 is the year when oil prices dropped drastically on a global scale, contributing to an extreme crisis for Cuba's main energy supplier, Venezuela, leading to a decrease in crude oil exports.

Specifically, the paper examines energy indicators, including net energy import, total final consumption, total final supply, electricity generation, and the progress in renewable energy initiatives in line with future energy policies. This research excludes examining other countries' energy security, to provide an efficient comparison of Cuba and Hungary, which are similar in size and population, and additionally, in the second half of the 20th century, they maintained close relations with each other and were both dependent on energy imports from the Soviet Union.

In the past decade, both Hungary and Cuba have remained reliant on energy imports. Still, some steps have been taken to improve diversification and reduce their carbon footprint. Renewable energy initiatives can lead to many improvements, especially regarding the acceptability pillar, however, currently, both countries face challenges that make completing these projects more difficult.

The research paper aims to provide an analysis of how energy security has changed in Hungary and Cuba from 2014 to the present. In this paper, two research questions are examined.

¹ Yergin, D. (2019). A küldetés: Energia, biztonság és a modern világ újraalkotása. Antall József Tudásközpont. 226.

1. What changes and trends have been observed in Hungary's and Cuba's energy security situation in the past ten years?
2. What opportunities and challenges do the development of renewable and alternative energy sources bring to Hungary and Cuba?

In my research, I included secondary qualitative and quantitative data as well. The qualitative analysis includes energy reports, articles, books, and journals, while for the quantitative part, statistics (Hungarian Central Statistical Office) and international energy databases, such as the International Energy Agency (IEA) performed as the primary data source. From this data, diagrams and charts have been created as visualization tools. The "Four As" definition; availability, accessibility, affordability, and acceptability introduced by the Asia Pacific Energy Research Centre in 2007 provided the main framework for the comparative analysis.

The research paper contains six chapters. Following the introduction, the reader will gain insight into Cuba's energy landscape in Chapter 2, and in Chapter 3 into Hungary's energy landscape, covering the historical overview, challenges they face, various recommendations, and notable recent activities. Chapter 4 presents renewable energy initiatives, first focusing on Cuba and then on Hungary. A comparative analysis based on the four pillars: availability, accessibility, affordability, and acceptability with an Author-edited comparative table at the end, that shows the key differences and similarities between the two countries is included in Chapter 5. The conclusion in the last chapter contains a SWOT analysis and the reaches back to the research questions.

1.1. Defining Energy Security

There are several definitions, with different aspects being highlighted. One reason for the diversity of definitions for energy security is the various stakeholders' points of view. In the

definition of energy security by K. Sovacool² and Ishani Mukherjee³ five basic elements are included: availability, affordability, technology development, sustainability, and regulation. In contrast, Emily Cox⁴ represents the ideas of availability, affordability, reliability, and sustainability. Other definitions include the one introduced by Mitchell et al.,⁵ focusing on dimensions such as stability, resilience, durability, and robustness, while Christian Winzer⁶ suggests narrowing the definition, to energy supply continuity considering technical, human, and nature-based risks while focusing on long-term discontinuities.⁷

The definition introduced by the Asia Pacific Energy Research Centre (APERC) known as the “four As” of energy security (availability, accessibility, affordability, and acceptability) is mentioned in most of the scientific papers. The APERC was established in July 1996 under the framework of the Asia-Pacific Economic Cooperation (APEC), hosting its headquarters in Tokyo. The centre’s primary goal is to help the 21 APEC members understand regional energy outlook, trends, and policies.⁸ The comparative analysis in Chapter 5 of this paper is also based on this model because of its comprehensive approach.

² Benjamin K. Sovacool is a professor, researcher, and consultant. He holds a position at Boston University, the University of Sussex in the United Kingdom, and Aarhus University Denmark. He has over 740 publications and 52,000 citations. One of his most popular publications is “An agenda for sustainability transitions research: State of the art and future directions” published in 2019 and cited by 2631.

Sovacool, B. K. (n.d.). Benjamin Sovacool profile. ResearchGate.

<https://www.researchgate.net/profile/Benjamin-Sovacool>

Sovacool, B. K. (n.d.). Benjamin Sovacool profile. Google Scholar.

<https://scholar.google.com/citations?user=wKHreQ0AAAAAJ&hl=en&oi=sra>

³ Ishani Mukherjee is a scholar from Singapore. She works as an assistant professor of public policy at Singapore Management University. She received many awards, including the “2016 Best Article Prize, Routledge/ Asia Pacific Journal of Public Administration (2017)”, and “Behavioral Experts in Policy Design: Lessons for Sustainability from Singapore”. Mukherjee, I. (n.d.). Bio. <https://www.ishanimukherjee.com/about-me>

⁴ Emily Cox is a research associate at Cardiff University and the University of Oxford in the fields of environmental policy and social psychology. As an energy security expert, she also works for the UK Energy Research Centre. Cox, E. (n.d.). Staff profile. Cardiff University. <https://profiles.cardiff.ac.uk/staff/coxe3>

⁵ Mitchell et al., is a collaborative work, including John V. Mitchell and other energy researchers. John V. Mitchell is a research adviser at the Oxford Institute of Energy Studies and an associate research fellow at Chatham House. Mitchell, J. V. John V. Mitchell. (n.d.). Brookings Institution. <https://www.brookings.edu/people/john-v-mitchell/>

⁶ Christian Winzer has 24 publications according to ResearchGate. He is a lecturer at the Center for Energy and Environment, after his PhD at Cambridge University.

Winzer, C. Christian Winzer. (n.d.). ResearchGate. <https://www.researchgate.net/profile/Christian-Winzer>

Winzer, C. Christian Winzer. (n.d.). ZHAW Zurich University of Applied Sciences.

<https://www.zhaw.ch/en/about-us/person/winc/>

⁷ Jones, O., & Dodds, P. E. (2017). Definitions of energy security. *Energy Policy*. 23-24.

https://discovery.ucl.ac.uk/id/eprint/10087004/6/Dodds_IMPJ5213-H2FC-Supergen-Energy-Security-032017-Chapter%202.pdf

⁸ Asia Pacific Energy Research Centre. Japan. Devex.

<https://www.devex.com/organizations/asia-pacific-energy-research-center-institute-of-energy-economics-japan-38804>

ASEAN Centre for Energy. (n.d.). Asia Pacific Energy Research Centre (APERC).

<https://aseanenergy.org/post/asia-pacific-energy-research-centre-aperc/>

U.S. Department of Energy. (n.d.). Asia-Pacific Economic Cooperation (APEC).

David A. Baldwin⁹ “defines security as a “low probability of damage to acquired values”, building on a half-century tradition of security studies starting with [Arnold] Wolfers”¹⁰. He also claimed that at least three questions should be responded. “Security for whom, security for which values, and from what threats”¹¹. The question security for which values, deals with the exploration of which important values, such as economic welfare and social stability, need the protection of energy security systems. It involves finding linkages between energy systems and important social values so that policymakers can decide which area needs to be protected the most.¹²

The word affordability is included in many definitions but used in different contexts. For instance, APERC (2007) used it in the context of the profitability of energy investments, Kruyt et al.,¹³ (2009) and Larry Hughes¹⁴ (2012) saw it as a concept that consumers could afford energy because of its low price. Regarding the term acceptability (in the case of Kruyt et al. and Lynne Chester it is sustainability) Hughes, Winzer, Kruyt et al., and Chester¹⁵ all related the concept to the environmental impacts of energy systems. The expansion of previous definitions was also needed because a variety of possible risks and threats to energy security changed over the years. Classic energy security studies focused on geological, geopolitical, and economic threats evolved around oil supply, while today vulnerabilities like ageing infrastructure also need to be taken into consideration. An energy security concept cannot include every risk or

<https://www.energy.gov/ia/asia-pacific-economic-cooperation-apec>

⁹ David A. Baldwin is an American senior political scientist at Princeton University and Wallach professor of Political Science Emeritus at Columbia University. His book titled “Economic Statecraft” received the Gladys M. Kammerer Award in 1985.

Baldwin, D. A. (n.d.). David Baldwin. Princeton University.

<https://dbaldwin.scholar.princeton.edu/>

¹⁰ Cherp, A., & Jewell, J. (2014). The concept of energy security: Beyond the four As. Energy Policy. 416.

<https://www.researchgate.net/publication/267634608>

¹¹ Cherp & Jewell. (2014). 416.

¹² Cherp & Jewell. (2014). 416.

¹³ Including, Bert Kruyt, Detlef P. van Vuuren, H.J.M. de Vries, and Heleen Groenenberg, who are Dutch scholars. Their famous publication is the “Indicators for Energy Security” 2009, about the “Four As” definition.

Kruijt, B., van Vuuren, D. P., de Vries, H. J. M., & Groenenberg, H. (2009). Indicators for energy security. Energy Policy. https://is.muni.cz/el/fss/podzim2019/IRE111/um/project_readings/Kruijt_Indicators_ES_2009.pdf

¹⁴ Larry Hughes is a Canadian researcher in energy and environment and holds a position as a professor at Dalhousie University.

IEEE Xplore. (n.d.). Author profile: Larry Hughes.

<https://ieeexplore.ieee.org/author/37269304200>

¹⁵ Lynne Chester’s research fields are energy and heterodox economics. She is an associate professor at the University of Sydney and is considered as a leading scholar in the country.

University of Sydney. (n.d.). Applied economics (energy), public policy (energy), and heterodox economics.

<https://www.sydney.edu.au/research/opportunities/3224.html>

vulnerability, but it should offer a framework for locating, assessing, and controlling weaknesses.¹⁶

According to Owain Jones and Paul E. Dodds¹⁷ “Availability ensures that energy supplies are available in sufficient amounts, affordability aims to have these resources available at sufficiently-low prices, accessibility focuses on ensuring all citizens have access to energy, [...]. Acceptability is concerned with the negative impacts of energy, such as pollution and environmental damage, and ensuring that these impacts are minimised”.¹⁸ It is important that through future energy policies, regulations, and infrastructure improvements, these four pillars of energy security function well and stably.

2. Cuba’s Current Energy Landscape

2.1. Historical Overview

In the 1990s, the dissolution of the Soviet Union with ending the trade ties caused a severe economic crisis in Cuba. During the “Special Period”¹⁹ the island’s GDP fell by 22% (1990: \$28.65 billion, 1993: \$22.37 billion).²⁰ Consequently, the main task was to revitalize its energy sector. Additionally, the United States enforced its trade embargo, tying foreign trade opportunities with other countries. During this period, citizens’ everyday life was characterized by using bicycles as a fossil-free replacement, experiencing 20-hour blackouts, restrictions on available bread per person, food shortages, and health issues. The Cuban Government took drastic steps and modified the Constitution of 1976 in 1992 focusing on economic reforms, such

¹⁶ Cherp & Jewell. (2014). 415-420.

¹⁷ Owain Jones and Paul E. Dodds are British researchers. Owain is an Emeritus Professor and is currently the deputy director of the Research Centre for the Environmental Humanities at Bath Spa. His projects are mainly based on water and society. Paul E. Dodds is a Research Associate at University College London. His main research field is bioenergy, climate change, and energy systems.

Jones, O. (n.d.). Professor Emeritus Owain Jones. Bath Spa University.

<https://www.bathspa.ac.uk/our-people/professor-emeritus--owain-jones/>

Dodds, P. (n.d.). Paul Dodds. ResearchGate. <https://www.researchgate.net/profile/Paul-Dodds>

¹⁸ Jones & Dodds (2017). 23

¹⁹ Arrastía-Avila, M. A., & Glidden, L. M. (2017). Cuba's Energy Revolution and 2030 Policy Goals: More Penetration of Renewable Energy in Electricity Generation. 74-76.

<https://www.jstor.org/stable/10.13169/intejcubastud.9.1.0073>

²⁰ World Bank. (n.d.). Cuba GDP (current US\$). World Bank Data.

<https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=CU>

as to control foreign investment, make state-owned companies profitable, legitimize the use of US dollar, and recognizing new types of properties, mainly in the agriculture sector.²¹

The 2005 Energy Revolution in Cuba was the next significant milestone. The inability of the power grid to reliably supply electricity was a major source of the energy crisis, which the Energy Revolution campaign sought to solve. The solution involved the decentralization of the production of electricity, so they quickly installed distributed generation (DG) plants which were small-scale power plants made up of diesel and fuel oil generator sets. The purpose of this system was to supply the nation's need for electricity, which had a successful result, as 110 municipalities of the 168 had implemented DG systems by 2006.²² This construction demonstrates Cuba's willingness to adopt creative solutions, despite a shortage of funding. However, because the DG plants depend on fossil fuels, Cuba will still have difficulties in transitioning to renewable energy.

According to the international journal article by Mario Alberto Arrastía-Avila and Lisa M. Glidden, the Energy Revolution is defined as a combination of “policy, technological, environmental, social and educational”²³ initiatives. The Revolution's policies aim to guarantee social and economic advancements, such as to safeguard the nation, increase its resilience to natural disasters, - especially hurricanes - shift to a diversified energy economy with energy efficiency, introduce Distributed Generation (DG), work with other nations to implement energy efficiency measures, and establish an environmentally conscious energy culture.²⁴

The *Convenio Integral de Cooperación* - signed by Hugo Chávez and Fidel Castro in 2000, contains that Venezuela will export 53,000 barrels of oil per day to Cuba, which was one third of Cuba's energy consumption, however for Venezuela this was only a very small percentage of their annual output. Part of the agreement, in exchange, Cuba sent assistance in the areas of science, technology, sports, education, and healthcare. However, a new agreement was signed by Hugo Chávez and Fidel Castro in April 2005, expanding the healthcare workers to 30,000. Cuba developed healthcare initiatives, and provided training programs for Venezuelan

²¹ Cuba 101. (n.d.). The special period.

<https://static1.squarespace.com/static/5a137d8aedaed807de3a77b3/t/5bb67912e79c70664782e757/1538685202297/SpecialPeriod-Cuba101.pdf>

Constitución de la República de Cuba, 1992. <https://www.acnur.org/fileadmin/Documentos/BDL/2001/0511.pdf>

²² Arrastía-Avila & Glidden (2017). 77-79 and, Levinson, S. H., & Knight, F. W. (2024). Cuba. Encyclopedia Britannica. <https://www.britannica.com/place/Cuba/Local-government>

²³ Arrastía-Avila & Glidden (2017). 78

²⁴ Arrastía-Avila & Glidden (2017). 78

healthcare professionals. Meanwhile, oil exports grew to 90,000 barrels per day.²⁵ Although, Venezuela has had to face an economic collapse since 2014, one year after Hugo Chávez passed away in 2013, which has also had a negative influence on the two countries' international trade relations. The global price of oil fell by 70% between 2014 and 2016,²⁶ which forced Venezuela to reduce oil exports to Cuba, resulting in electricity shortages on the island. To reduce import dependency, in 2014 the Cuban government introduced future energy policy goals for 2030, which included developing renewable energy sources, particularly biomass, wind, and solar energy. These initiatives emphasize important aims, such as reducing crude oil dependency by over 10% and guaranteeing that from total electricity generation 24% is sourced from renewables.²⁷ These are considered as positive approaches toward a more sustainable future, however, due to the lack of financing, foreign aid and partnership opportunities, they are unlikely to materialize.

2.2. Energy Sources and Infrastructure

Cuba imports its oil mainly from Venezuela. Net energy import was 62.8% of 2022's total energy supply. It was in 2010 the highest in the examined period (377,014 TJ), however, after the economic crisis in Venezuela – that also caused energy shortages in Cuba – the percentage of imports and exports decreased each year. In 2014 from the total energy supply, oil generated 342,700 TJ, followed by biofuels and waste (69,259 TJ), natural gas (39,910 TJ), geothermal, solar, wind and other small-scale renewable energy (133 TJ), hydro (374 TJ), and coal (54 TJ). Eight years later, oil accumulated 81% of the total energy supply, with 304,563 TJ, followed by biofuels and waste (43,697 TJ), natural gas (28,055 TJ), geothermal, solar, wind, etc. (869 TJ), hydro (432 TJ), and coal (55 TJ). The figures also show that it is challenging for Cuba to reduce its reliance on fossil fuels and adjust to global energy trends toward sustainability.

²⁵ Erikson, D. (2005). Castro's Chávez strategy. *Inter-American Dialogue*. 7-8.
<https://web.archive.org/web/20161129151659/http://archive.thedialogue.org/PublicationFiles/CubaVenezuelaandtheAmericasAChangingLandscape.pdf>

²⁶ World Bank. (2018). *Global Economic Prospects*. 51.
<https://openknowledge.worldbank.org/server/api/core/bitstreams/da2c5a6b-5650-576b-8e43-add85378e6bd/content>

²⁷ Arrastía-Avila & Glidden (2017). 74,85

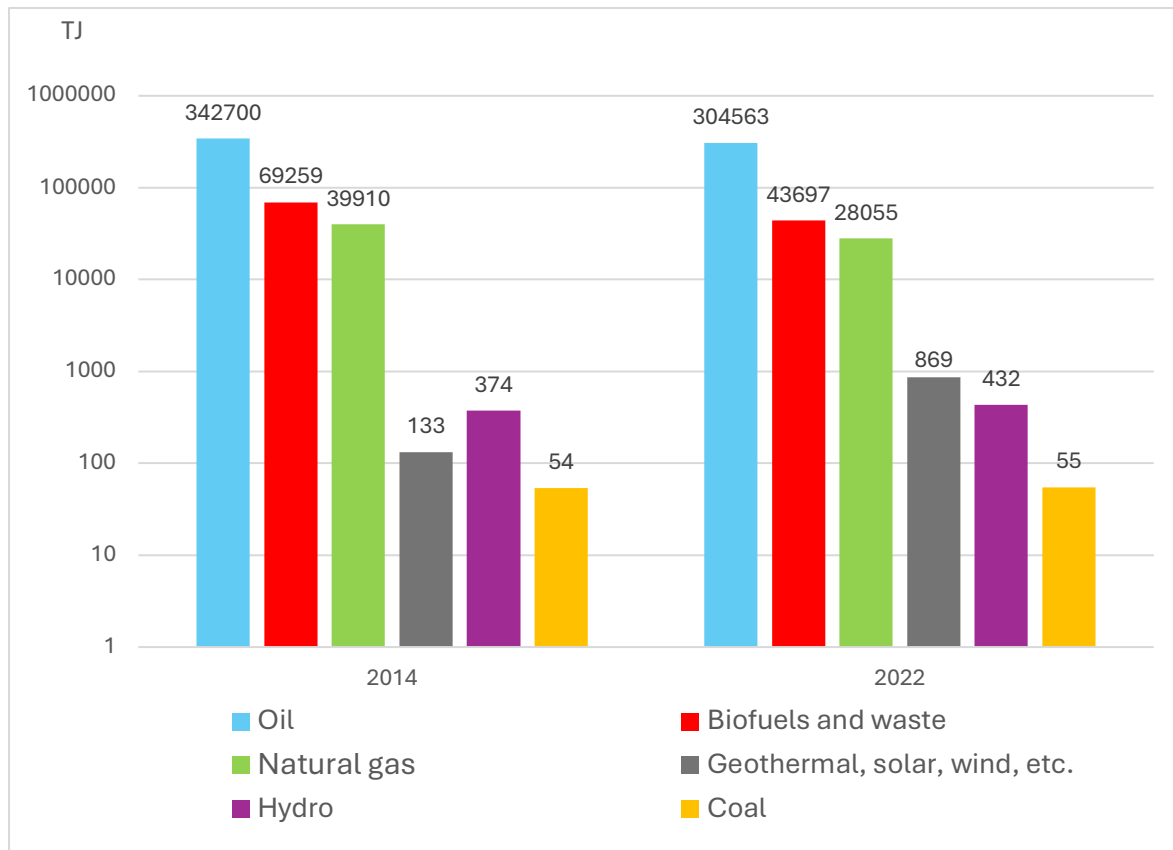


Figure 1. Total energy supply, comparing 2014 with 2022. Source of data: International Energy Agency. (n.d.). Cuba: Country profile. <https://www.iea.org/countries/cuba>. Edited by the Author 2025.

Electricity generation is dominated by oil, accumulating 13,032 GWh in 2022, however, it was the highest in 2019 (17,359 GWh) within our investigated period. Natural gas was the same year 1,946 GWh, biofuels 276 GWh, and wind, solar and, hydro together 361 GWh. However, it is worth noting that solar PV increased drastically since 2013,²⁸ as that year marked the opening of the first solar farm in Cantarrana and the Santa Teresa plant at Guantanamo. Furthermore, in the region of Cienfuegos, the government constructed a manufacturing facility that has produced 14,000 photovoltaic solar panels.²⁹

²⁸ International Energy Agency. (n.d.). Cuba: Country profile. <https://www.iea.org/countries/cuba>

²⁹ Kolopic, S. (2016). Solar energy outlook in Cuba. Havana Times. <https://havanatimes.org/features/solar-energy-outlook-in-cuba/>

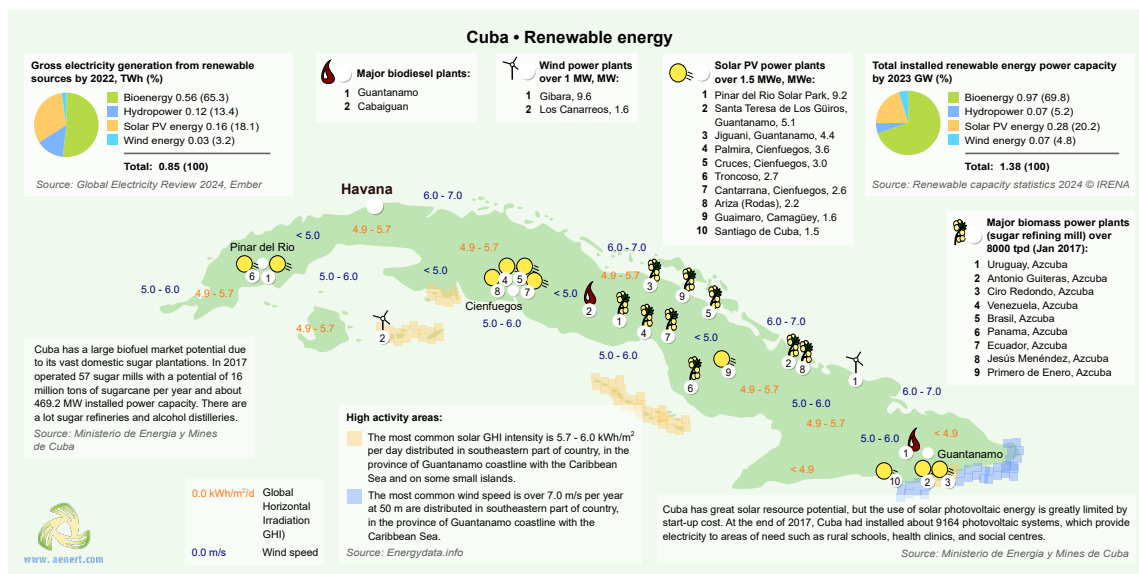


Figure 2. Source: Aenert. (2024). Energy Industry in Cuba.
https://aenert.com/fileadmin/default/templates/images/Cuba/aenert_Cuba-.pdf

The industry sector made up 50.7 % of the total final energy consumption in 2022, followed by the residential (22.5%) and transport sectors (8.6%). Due to economic issues and the ageing infrastructure, the industry sector's share fell by almost 60% (from 250,505 TJ to 103,858 TJ) in comparison with the statistics of 2000. In 2022, 14,978 GWh of energy generation came from non- renewable sources (oil and natural gas), while 637 GWh came from hydro, biofuels, wind, and solar PV. Within our investigated timeframe, the share of renewable energy only increased by a very small portion- except for solar PV -, and biofuels even decreased by 57%. These numbers show the slow transformation toward the utilization of more natural sources.³⁰

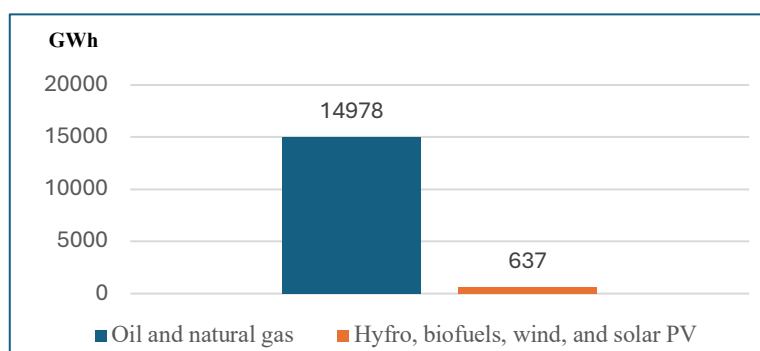


Figure 3. Electricity generation in 2022. Source of data: International Energy Agency. (n.d.). Cuba: Country profile. Edited by the Author 2024.

³⁰ International Energy Agency. (n.d.). Cuba: Country profile.

There are eight oil power plants on the island, which each generate more than 100 MW. The largest is the 10 de Octubre in Neuviatas with a capacity of 503 MW. The other seven plants have a total capacity of 2596 MW.³¹



Figure 4. Source: Aenert. (2024). *Energy Industry in Cuba*.

https://aenert.com/fileadmin/default/templates/images/Cuba/aenert_Cuba-.pdf

2.3. Challenges and Strategies

Cuba's energy security situation is affected by the dependence on imported fossil fuels (in 2022, 95% of the electricity was generated from fossil fuels and 48% of the fossil fuels were imported).³² Further challenges include ageing infrastructure, that harms energy stability. In response, the government established an energy policy for 2030, aiming to utilize more renewable energy sources in electricity production.³³ The financial investment needed for these projects is expected to exceed \$3.5 billion. The project to build two solar photovoltaic power plants in Las Tunas, plans to reduce CO₂ emissions by 26,000 tonnes and preserve

³¹ Aenert. (2024). *Energy Industry in Cuba*. 7.

https://aenert.com/fileadmin/default/templates/images/Cuba/aenert_Cuba-.pdf

³² Silverman-Roati, K., Whittle, D., Webb, R.M., & Fralick, J. P. (2024). Illuminating a path to a cleaner and more resilient energy system in Cuba. *Columbia Law School Blog on Climate Change*.

<https://blogs.law.columbia.edu/climatechange/2024/04/17/illuminating-a-path-to-a-cleaner-and-more-resilient-energy-system-in-cuba/>

³³ Japan International Cooperation Agency. (2024). Completion ceremony for the project for the improvement of power supply in the Isle of Youth: Contributing to electricity system stabilization and climate change solutions for Cuba's largest remote island.

https://www.jica.go.jp/english/information/press/2024/20240524_41.html

approximately 8,900 tonnes of fossil fuels, and by that contribute significantly to an environmentally friendly energy transition.³⁴

2.4. Notable Activities During the Past Few Years

Cuba demonstrated a positive approach to improve its energy sector, and comply with global standards, through the approval of the Paris Agreement in 2015, which had been adopted globally one year before, under the United Nations Framework Convention on Climate Change.³⁵

Additionally, the updated Nationally Determined Contribution (NDC) was submitted on 17 September 2020, highlighting the importance of the energy and the AFOLU (Agriculture, Forestry, and Other Land Use) sectors. Concerning the energy sector, the aim is that 24% of electricity generation should come from renewables by 2030, to cut emissions by 30.6 million kilotons of carbon dioxide equivalent, boost energy efficiency, and eliminate fossil fuel use in ground transportation by 50%.³⁶ In 2017, Cuba also set a new project for the Havana Energy biomass plant, investing more than \$186 million, to generate renewables from sugarcane bagasse, and diversify its energy mix.³⁷

In the past years, Cuba also focused on developing foreign partnerships with traditional partners Russia and Venezuela and with India, the Indian-based International Solar Alliance, and China through renewable energy projects.³⁸ Within the Latin American region, Mexico is featuring as an old – new partner. In the Cold War context, it is important to note, that compared to other countries of the region, Mexico's enjoyed more independence from the U.S in its foreign and trade policies, as a strategy to make the Mexican government more popular among its citizens and therefore contribute to its stability. This flexibility of Mexican foreign policy made it possible to strengthen ties with Cuba and when for example the question was raised about

³⁴ Ilaria-Mayrhofer, A. (2018). Solar project fuels Cuban energy policy. OPEC Fund for International Development. <https://opecfund.org/news/solar-project-fuels-cuban-energy-policy>

³⁵ Granma. (2016). Cuba ratifies the Paris Agreement on climate change. <https://en.granma.cu/mundo/2016-12-12/cuba-ratifies-the-paris-agreement-on-climate-change>

³⁶ Antonich, B. (2020). Cuba's 2020 NDC update prioritizes energy, agriculture, forestry, and other land use sectors. SDG Knowledge Hub. <https://sdg.iisd.org/news/cubas-2020-ndc-update-prioritizes-energy-agriculture-forestry-and-other-land-use-sectors/>

³⁷ New Energy. (2017). Cuba breaks ground on first Havana Energy biomass project. New Energy Events. <https://newenergyevents.com/topic/havana-energy/>

³⁸ Silverman-Roati, Whittle, Webb, & Fralick. (2024). Illuminating a path to a cleaner and more resilient energy system in Cuba. Columbia Law School Blog on Climate Change.

Cuba's expulsion from the Organization of American States (OAS), Mexico actually abstained from voting.³⁹ Due to its geological closeness, oil exporting capabilities, and the fact that since 2018 it has had progressive presidents (new left): Andrés Manuel López Obrador (AMLO) and Claudia Scheinbaum it has led to further collaboration with the island. Between January and September 2024, Mexico exported approximately 20.000 barrels per day of crude to Cuba.⁴⁰

The BRICS partnership involving Brazil, Russia, India, China, and South Africa was established in 2009. In October 2024, Cuba applied to the alliance as a "Partner Country" submitting the formal request to this year's President of the Group, Russian President Vladimir Putin.⁴¹ This opportunity may result in enhanced supply chains, and help bring much-sought stability.

Concerning regional cooperations, Cuba's participation in the Caribbean Community (CARICOM), and the Alliance of Small Island States (AOSIS) also provide further benefits.⁴² In 2022, during the eighth CARICOM-Cuba Summit taking place in Barbados, Cuba established closer ties in the agriculture sector, to accomplish the goal of reducing food imports by 25% by 2025. Furthermore, Cuba also provided disaster management support, considering the threat of climate change that affects all the member states.⁴³ Moreover, the 2024 United Nations Climate Change Conference (COP29) will take place in Baku, Azerbaijan, between November 11-12, where Cuba is likely to participate, because of its active engagement in previous COP Conferences representing the interests of the small island states. During this conference key topics that are going to be discussed are clean energy, sustainability, climate finance, and collaboration.⁴⁴

³⁹ Familiar Avalos, J. (2018). Contradiction and ambivalence: Mexico's Cold War and the United States. The Yale Review of International Studies. <https://yris.yira.org/essays/contradiction-and-ambivalence-mexicos-cold-war-and-the-united-states/>

⁴⁰ Parraga, M., & Barrera, A. (2024). Oil cargo from Mexico en route to Cuba amid power crisis, data shows. Reuters. <https://www.reuters.com/business/energy/oil-cargo-mexico-en-route-cuba-amid-power-crisis-data-shows-2024-10-28/>

⁴¹ Jochecová, K. (2024). Cuba to Putin: Let us join BRICS club. Politico. <https://www.politico.eu/article/cuba-request-join-brics-partner-country-vladimir-putin-carlos-miguel-pereira-emerging-economies/>

⁴² Silverman-Roati, Whittle, Webb, & Fralick. (2024). Illuminating a path to a cleaner and more resilient energy system in Cuba. Columbia Law School Blog on Climate Change.

⁴³ Ministry of Foreign Affairs and Foreign Trade Barbados. (2022). 8th CARICOM-Cuba summit described as productive. <https://www.foreign.gov.bb/8th-caricom-cuba-summit-described-as-productive/>

⁴⁴ The Nature Conservancy. (2024). COP29: Your guide to the 2024 UN climate conference. https://www.nature.org/en-us/what-we-do/our-priorities/tackle-climate-change/climate-change-stories/cop-climate-change-conference/?en_txn1=p_g.gd.cg.cop.en.fca_lf&gad_source=1&gclid=CjwKCAjw-JG5BhBZEiwAt7JR65zdxQqQdqsU-i4BSR0CCkPZcmcZ4DMeThOrjJnMI84KPUNdD

3. Hungary's Energy Landscape

3.1. Historical Overview

During the Cold War, Hungary was under the influence of the Soviet Union, which has left lasting marks: its energy landscape is mainly dominated by import dependency, especially crude oil and natural gas from Russia. In 2020 energy import dependency was 56.6%. This indicator was the lowest at the beginning of 2010 at 50.1% and the peak was 69.7% in 2019.⁴⁵ Besides fossil fuels, Hungary's energy mix includes a high share of nuclear energy.⁴⁶

Hungary's historical overview of its energy landscape is mostly shaped by joining international organizations (such as the Organisation for Economic Co-operation and Development and the International Energy Agency) in the last almost three decades. Hungary became a member of the European Union in 2004, which marked the beginning of a change in the strategy planning phase, focusing on that its energy strategies are in line with the EU guidelines. The growth of oil prices and the challenges caused by climate change led to the publication of a Green Book: A European strategy for sustainable, competitive and secure energy, followed by the Energy Efficiency Action Plan (2006) and the EU Energy Action Plan (2007), which contained a solution for recent issues via improving energy efficiency by 20%. According to the National Energy Strategy (NES) report, "The quickest and most cost-efficient way to achieve the energy and climate policy objectives, particularly in heat utilisation, is the improvement of energy efficiency and saving".⁴⁷

It is possible to examine the overall energy efficiency by measuring the total energy supply per unit of GDP in Hungary. In 2007 this was 2604 MJ/ thousand 2015 USD, however because of the EU policies, in 2022 it already decreased by 30% in comparison with 2007 levels, meaning that the goal had a successful outcome. Due to the establishment of the new renewable energy tenders (METÁR) on 1 January 2017 ⁴⁸ the evolution of renewable electricity generation by

⁴⁵ Hungarian Central Statistical Office (KSH). (2022). Sustainable development indicators. <https://ksh.hu/s/kiadvanyok/fenntarthato-fejlodes-indikatorai-2022/3-22>

⁴⁶ International Energy Agency. (n.d.). Hungary: Country Overview. <https://www.iea.org/countries/hungary>

⁴⁷ Ministry of National Development (2012). National energy strategy 2030. 21. <https://2010-2014.kormany.hu/download/7/d7/70000/Hungarian%20Energy%20Strategy%202030.pdf>

⁴⁸ Etienne. (2022). Minden egy helyen, a megújuló támogatási rendszer (METÁR tender) kapcsán. <https://etienne.hu/megujulo-tamogatasi-rendszer-metar-tudnivalok/>

solar PV increased drastically. In 2023, it was 6,960 GWh, which is an increase of nearly twenty times compared to 2017 numbers.⁴⁹

3.2. Energy Sources and Infrastructure

In 2023, total energy supply included 32.309% of oil, 30.756% natural gas, 3.822% coal, 18.1% nuclear energy, geothermal 3.976%, hydro 0.083% and 10.953% biofuels and waste. Compared to 2014 statistics, there was a rise of 11,867 TJ, from 949,529 TJ to 961,396 TJ.

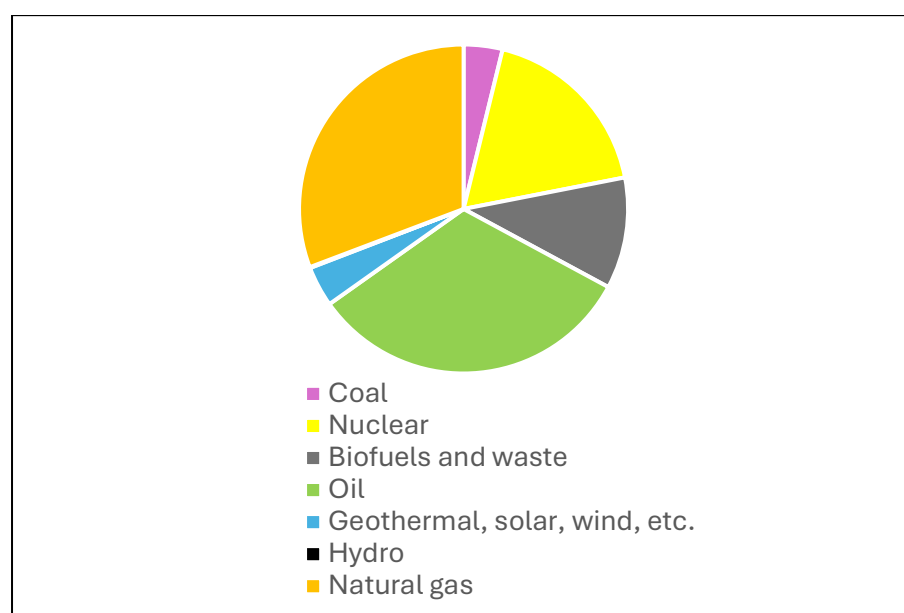


Figure 5. Total energy supply, 2023. Source of data: International Energy Agency. (n.d.). Hungary: Country Overview. <https://www.iea.org/countries/hungary>. Edited by the Author 2025.

Concerning total final energy consumption, in 2014 oil products were the highest with 249,717 TJ followed by natural gas with 230,183 TJ, mainly due to the imports. Crude oil, coal, heat, electricity, geothermal, solar, wind and other small-scale renewables, and biofuels and waste were a total of 261,745 TJ. Five years later, all the sources increased, which highlights Hungary's rising dependence on imported fuels. Between 2000 and 2022 the largest sector was always the residential sector ranging between 229,683 TJ (2014) and 291,622 TJ (2005), followed by the transport, industry, and commercial and public services sectors.

⁴⁹ International Energy Agency. (n.d.). Hungary: Country Overview.

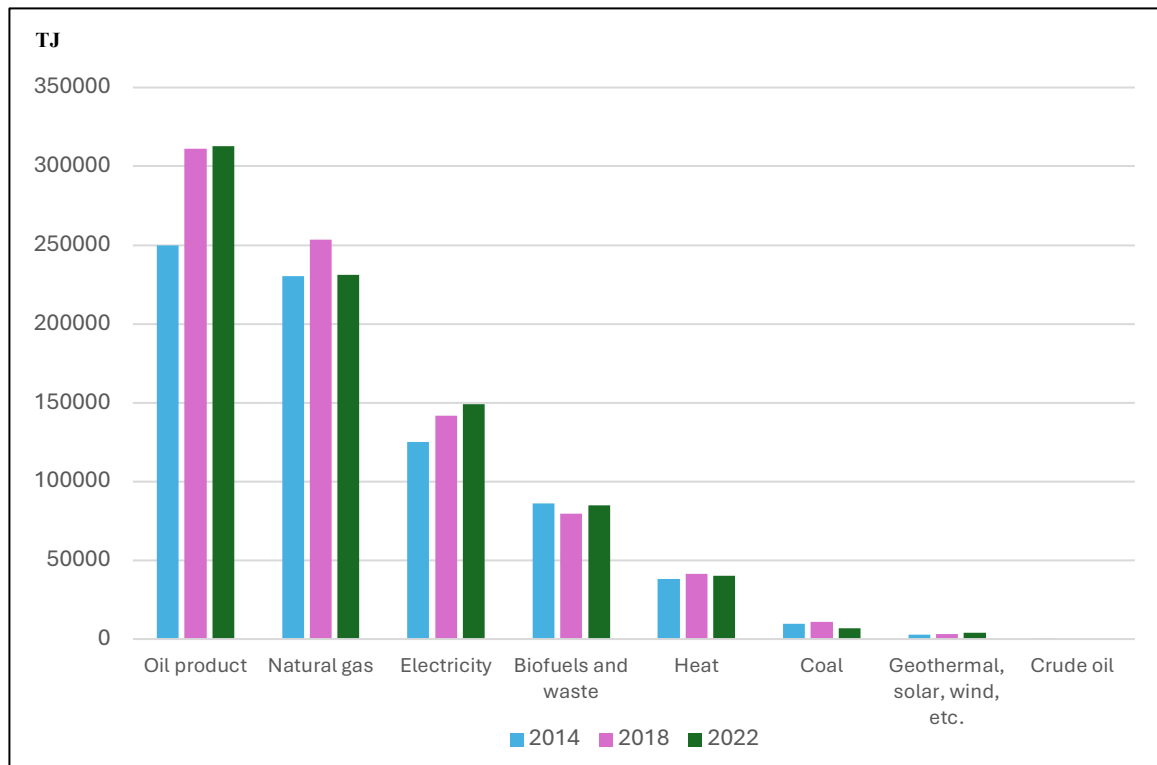


Figure 6. Total final consumption. Source of data: International Energy Agency. (n.d.). Hungary: Country Overview. Edited by the Author 2025.

In 2023, net energy imports (coal, natural gas, and oil) accumulated 62.5% of the total energy supply and the amount increased by 16% between 2000 and 2023. The highest number was in 2019, with importing 975,859 TJ of energy.⁵⁰

“Electricity can be generated in two main ways: by harnessing the heat from burning fuels or nuclear reactions in the form of steam (thermal power) or by capturing the energy of natural forces such as the sun, wind or moving water.”⁵¹ In 2023, Hungary’s electricity generation, was mainly from nuclear energy (45%), followed by natural gas (20%). The same year, hydro, wind, geothermal, and solar PV generated totally 7843 GWh. Due to the nuclear powers’ low-carbon emissions, it contributes significantly to Hungary’s electricity supply. Although, the small percentage of electricity generated by renewables still signifies that further commitment to sustainable energy sources will be essential in the future.⁵²

During the last ten years, there has been an emphasis on improving energy security by expanding the amount of renewable energy, especially by implementing future energy policies and investments. The Paks Nuclear Power Plant (NPP) consists of four reactors, with a capacity

⁵⁰ International Energy Agency. (n.d.). Hungary: Country Overview.

⁵¹ International Energy Agency. (n.d.). Hungary: Country Overview.

⁵² International Energy Agency. (n.d.). Hungary: Country Overview.

of 2000 MW, however, there are future goals for 2030 to extend it with two new reactors. The second generating plant is the Mátra coal power plant, providing 950 MW.⁵³ The plan to further develop nuclear energy demonstrates Hungary's readiness to stable, low-emission energy, however, reliance on nuclear power also brings risks, particularly if nuclear waste is not managed effectively, furthermore, in the future if anything happens to the NPP, it will affect a significant percentage of Hungary's energy sources.

As bioenergy and solar energy are the main renewable energy sources, between 2019 and 2021, several new solar plants were established, encompassing the Paks Solar Park, 20.6 MW, Kapuvár Solar Park, 25 MW, and Kaba Solar Park, 43 MW. However, regarding wind farms, only a few reach 20 MW, from which the Ács wind farm possesses the largest ability, generating 74 MW.⁵⁴

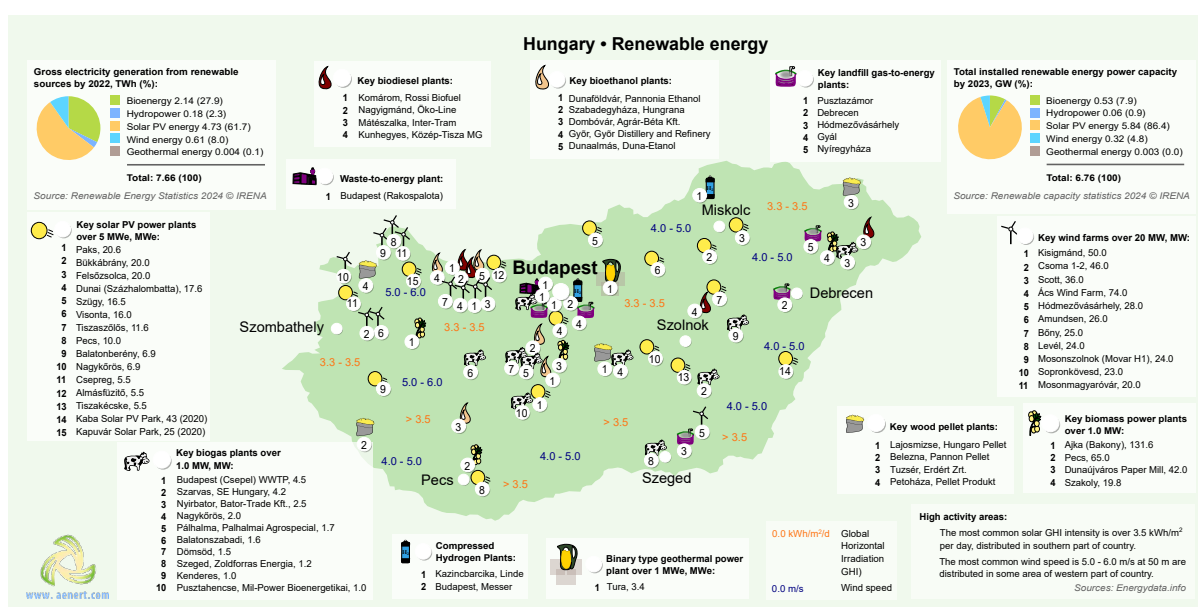


Figure 7. Source: Aenert. (2024.) Energy Industry in Hungary.
https://aenert.com/fileadmin/default/templates/images/Hungary/aenert_Hungary-.pdf

3.3. Challenges and Recommendations

The first challenge is the dependence on crude oil, reflected by the high percentage of import, particularly from Russia. Hungary imported on average 420,57 thousand tonnes of crude oil

⁵³ Aenert. (2024). Energy Industry in Hungary. 8.
https://aenert.com/fileadmin/default/templates/images/Hungary/aenert_Hungary-.pdf

⁵⁴ Aenert. (2024). Energy Industry in Hungary. 8.

from Russia between 2008 and 2023.⁵⁵ Moreover, there is a shortage of energy professionals in the country, which slows down the successful implementation of construction projects – such as Paks II.⁵⁶

The International Energy Agency (IEA) 2022 report mentions various recommendations that Hungarian officials should take into consideration and address as soon as possible. A well-defined road map should be part of the development pathway, which will result in a more effective examination of the emission results concerning the NECP goals. Moreover, modernizing its energy infrastructure, especially energy generation and transmission is essential, as electrification's role in the economy is rising. A modification in the legislative environment would encourage households and small businesses to participate in the country's energy landscape.⁵⁷ Although, it is important to emphasize that developments and reforms alone will not guarantee success, therefore, public education and fostering confidence in these programs are also essential suggestions.

3.4. Notable Activities in the Past Few Years

Hungary and the Russian corporation Rosatom signed a contract in 2014 to construct the Paks Nuclear Power Plant II. The plan suggests that by 2030-2032, these two new investments will produce 1200 MW of electricity each. The list of benefits regarding this construction include for example, energy independence, supply security, competitiveness, energy sovereignty, and climate-friendly solutions (Paks II will save 17 million tonnes of CO₂ annually, which is 5 million tonnes more than that Hungary's transport sector emits on average). This project achieved a major milestone in August 2024, with the successful completion of the soil stabilisation works under the nuclear island of unit five and the same works for unit six have already started. Moreover, almost one-third of the piles (24,000) had already been placed into the ground during the soil preparation stage.⁵⁸

⁵⁵ Trading Economics. (n.d.). Hungary Crude Oil Imports from Russia.

<https://tradingeconomics.com/hungary/crude-oil-imports-from-russia>

⁵⁶ Ministry of Innovation and Technology (2022). National Energy and Climate Plan, chapter 2.3.

https://energy.ec.europa.eu/system/files/2022-08/hu_final_necp_main_en.pdf

⁵⁷ International Energy Agency (2022). Hungary 2022 Energy Policy Review. 31-157.

<https://iea.blob.core.windows.net/assets/9f137e48-13e4-4aab-b13a-dcc90adf7e38/Hungary2022.pdf>

⁵⁸ International Trade Administration. (2024). Hungary - Country Commercial Guide: Energy.

<https://www.trade.gov/country-commercial-guides/hungary-energy>

Paks II. (n.d.). 10 év Paks II. mellett. <https://www.paks2.hu/10-%C3%A9rv-paks-ii.-mellett>

Paks II. (2024). Szijjártó Péter: újabb fontos mérföldkőhöz ért el a paksi építkezés.

In 2017, Hungary established a renewable energy scheme called METÁR, aiming that “solar plants above one MW capacity need to sell their electricity on the market, but they can apply for a so-called ‘green premium’, which is granted through a tendering process for a maximum period of 15 years.”⁵⁹ This way, Hungary's energy sector is developing into a more market-driven but sustainable energy sector because of the financial assistance provided by green premiums.

In June 2020, Hungary set energy policy targets about net-zero emissions to be achieved by 2050, along with mid-term goals for 2040 emphasizing “clean, smart, and inexpensive energy”⁶⁰ Furthermore, it aims to achieve 21% of final energy consumption from renewables and to guarantee that by 2030, 90% of its electricity production comes from low-carbon sources.⁶¹

On 4 September 2020, Hungary signed a six-year purchase contract with Shell, about supplying 250 million m³ of liquefied natural gas (LNG) annually from LNG Terminal Krk.⁶² One year later, Hungary also signed a contract with Gazprom for fifteen years, supplying 4.5 billion m³ of gas annually.⁶³ This agreement with the Russian company is important because it will ensure more stability in the energy sector - particularly essential during the winter period when demand increases drastically - and storing a greater amount of natural gas will possibly reduce the chance of unforeseen increases in heating prices.

The 2022 European Union decree considering underground gas storage requirements specifies that member states need to have 80% of their storage filled, before the heating season comes, but in 2023 this percentage has even increased by 10%, now requiring 90% of storage filled up before November 1st. Hungary's task was to achieve 86% by 1 September 2024, however, they already met these goals two weeks before the deadline. There is approximately 5.8 billion m³ of gas stored,⁶⁴ which is 3.3 billion m³ more than consumed during the 2023 heating season.⁶⁵

<https://paks2.hu/web/guest/w/szijjarto-peter-ujabb-fontos-merfoldkohoz-ert-el-a-paksi-epitkezes>

⁵⁹ International Trade Administration. (2024).

⁶⁰ International Trade Administration. (2024).

⁶¹ International Trade Administration. (2024).

⁶² Szőke, E. (2020). Hungary signs historic long-term gas supply agreement with Shell. CE Energy News.

<https://ceenergynews.com/oil-gas/hungary-signs-historic-long-term-gas-supply-agreement-with-shell/>

⁶³ Institute for the Study of War (ISW). (2021). Russia in review. 5.

<https://www.understandingwar.org/sites/default/files/RIR%20September%2022%20-%20October%205%202021%20formattedv3.pdf>

⁶⁴ About Hungary. (2024). Hungary's gas storage facilities are at 90 percent.

<https://abouthungary.hu/news-in-brief/hungary-s-gas-storage-facilities-are-at-90-percent>

⁶⁵ Hungary Today. (2024). Domestic gas consumption has fallen sharply in the last two years.

<https://hungarytoday.hu/domestic-gas-consumption-has-fallen-sharply-in-the-last-two-years/>

This positive result not only reduces the chance of unexpected energy price fluctuations, but also provides greater reliability and security.

4. Renewable Energy Initiatives

4.1. Cuba

The energy policy of 2030 aims to reduce import dependency, improve energy efficiency and energy security, and mitigate global climate change through a reduction of greenhouse gases. In December 2012, Raúl Castro – between 2011 and 2021 Cuba’s president – signed Presidential Decree No. 3 stating the establishment of a Governmental Commission responsible for the development of the policy proposals for the advancement of renewable energy sources on the island. The energy policy was presented at the meeting of the Council of Ministers in 2014. “It proposes to incorporate 633 MW of wind potential in 12 high-capacity factor wind parks, 755 MW with sugar cane biomass, 56 MW of hydropower from the construction of 75 hydroelectric plants taking advantage of already existing dams, 700 MW PV, 47 MW non-sugar cane biomass, and 27 MW biogas electricity generation. In addition, around 16,500 windmills will be installed.”⁶⁶ The project, as part of the Nationally Determined Contribution (NDC) under the Paris Agreement, suggests that by 2030 Cuba will generate approximately 30,000 GWh of electricity, of which 24% (7,200 GWh) will be from renewables.⁶⁷ As a comparison, in 2022 total electricity generation was 15,615 GWh, with a 4% share of renewables (hydro, biofuels, wind, and solar) generating 637 GWh, meaning that in the upcoming years, the amount of the total electricity generation must double, and the renewables must increase tenfold.⁶⁸

According to the IRENA article about expanding the energy sector, the government intends to allocate about \$3.5 billion toward the renewable energy industry. Experts have a positive outlook, stating the following opinions: “Accelerating domestic renewable energy production will not only improve energy security and strengthen economic development but also reduce emissions that contribute negatively to public and the changing climate”, said IRENA Director-General Adnan Z. Amin.⁶⁹ Moreover, “Cuba has excellent technical potential for renewable

⁶⁶ Arrastía-Avila & Glidden (2017). 8.

⁶⁷ Arrastía-Avila & Glidden (2017). 85-87.

⁶⁸ International Energy Agency. (n.d.). Cuba: Country profile.

⁶⁹ International Renewable Energy Agency (IRENA). (2016). Cuba seeks to expand role of renewable energy. <https://www.irena.org/news/pressreleases/2016/Aug/Cuba-Seeks-to-Expand-Role-of-Renewable-Energy>

energy to meet its ambitious government targets, particularly for solar, wind and biofuel, said Dolf Gielen, Director of IRENA's Innovation and Technology Centre “.⁷⁰ Nonetheless, if we take into account the current economic and energy crisis on the island, the outlooks are much bleaker.

In 2019, Cuba modified its constitution to encourage foreign investment for economic development required to move toward a more sustainable future with greater reliance on renewables, thereby mitigating climate change, reducing local pollution, and prompting greater resilience compared to the current fossil-fuel-fired power generation system.⁷¹ Despite Cuba's willingness to contribute to global environmental improvements, various external influences, such as the lack of foreign markets, the U.S. embargo, and outdated infrastructure, make this pathway more challenging. In October 2024, these issues lead to the collapse of the power grid system twice within two days, leaving 10 million citizens without electricity. The crisis started on 18 October, with the malfunctioning of the Antonio Guiteras power plant. During this period of ‘energy emergency’ Prime Minister Manuel Marrero Cruz closed schools, workplaces, and non-essential industries to conserve energy.⁷²

4.2. Hungary

Since 2011, Hungary has developed future renewable energy strategies, emphasizing both mid-term and long-term goals. Firstly, the National Energy Strategy (NES) published in the Official Gazette focusing on 2030. Secondly, the National Clean Development Strategy (NCDS) established on 10 September 2021 setting targets for the period from 2020 until 2050. Thirdly, the National Energy and Climate Plan (NECP) introduced in 2020, containing key targets to achieve total decarbonization by 2050.⁷³ However, to implement these strategies regular adjustments are required.

⁷⁰ International Renewable Energy Agency (IRENA). (2016).

⁷¹ Silverman-Roati, K., Whittle, D., Webb, R. M., Fralick, J. P., & Harmer, L. (2024). Building a cleaner, more resilient energy system in Cuba: Opportunities and challenges. 33.

⁷² Green, E. (19 October 2024). Cuba's power grid collapses again. Why does this keep happening? OPB. <https://www.opb.org/article/2024/10/19/cuba-s-power-grid-collapses-again-why-does-this-keep-happening/>

⁷³ Hungarian Official Gazette. (2011). National Energy Strategy 2030. https://njt.hu/document/5d/5df020114130000077_1.PDF

Government of Hungary. (2021). National Clean Development Strategy.

<https://kormany.hu/dokumentumtar/nemzeti-tiszta-fejlodesi-strategia>.

European Commission. (2023). Hungary – Draft updated National Energy and Climate Plan.

According to the IEA country report of 2022, the NES and NECP focus on energy independence, and taking steps toward cleaner, smarter, and more affordable energy. The future targets include reducing greenhouse gas⁷⁴ emissions by 40% compared to 1990 levels, producing 90% of the domestic electricity from carbon-neutral sources, installing 6.5 GW of solar PV by 2030 and ten years later increasing this to 12 GW, installing 40,000 household solar panels, 1 million smart meters (in 2022 this was 100,000) and 1000 MW of storage capacity by 2026 which will contribute to the goal of ensuring that the share of renewable energy sources from the final energy consumption increases to 21%. In order to achieve the target of net-zero carbon emission, the project of implementing two new reactors at the Paks NPP by 2030 and ensuring that the Mátra lignite-fired plant is ready for hydrogen or carbon capture utilization and storage (CCUS) technology would be crucial. Furthermore, in addition to focusing on solar energy, investments in wind and geothermal energy constructions would lead to achieving the 21% goal more effectively.⁷⁵

The NCDS emphasizes full carbon neutrality, based on the Climate Protection Law of 2020. The strategy is built upon three scenarios based on the change in greenhouse gas emissions over the years. First, the “business-as-usual” scenario states that emissions would only decrease a small portion, and by 2050 it would be around 8.4 million tonnes of CO₂ equivalent. Second, in the “late action” scenario emissions will decrease slowly until 2045, and in the last five years, the reduction would be faster. Third, in the “early action” scenario emissions would decrease rapidly until 2030, followed by a more linear decline during the next two decades.⁷⁶

The above-mentioned policies are also in line with the goals written down in the EU Green Deal report. It is important to note, that if Hungary accomplishes the goals outlined in the NES, NCDS, and NECP it will significantly contribute to national and the European Union efforts to develop a more secure and sustainable energy landscape

https://commission.europa.eu/system/files/2023-09/HUNGARY%20-%20DRAFT%20UPDATED%20NECP%202021-2030%20_HU.pdf

⁷⁴ The indicator of greenhouse gas emissions includes seven gases: CO₂, CH₄, N₂O, HFCs, PFCs, SF₆, and NF₃. In 2020 it was 66.2% measured in CO₂ equivalent (1990=100%).

Hungarian Central Statistical Office (KSH). (2022). Fenntartható fejlődés indikátorai. Az üvegházhatású gázok kibocsátása.

<https://ksh.hu/s/kiadvanyok/fenntarthato-fejlodes-indikatorai-2022/3-38>

⁷⁵ International Energy Agency (2022). Hungary 2022 Energy Policy Review. 24, 29, 106-108.

⁷⁶ International Energy Agency (2022). Hungary 2022 Energy Policy Review. 22.

5. Analysis based on the ‘Four As’

For this chapter, the reader will gain insight into a comparative analysis of Cuba and Hungary’s energy security based on the “Four As”; *availability, accessibility, affordability, and acceptability*.⁷⁷

Availability

Cuba faces lots of challenges regarding availability, however, it is also trying to survive by working on a more sustainable future. Cuba’s electricity generation is mainly dominated by imported fossil fuels (in 2022, 48% of the fossil fuels were imported), moreover, the ageing infrastructure together with the current economic crisis causes frequent blackouts on the island. The year-on-year inflation was in 2021, 77%, in 2022, it decreased to 39%, and in August 2024, it was 30.12%. Decreasing exports have rendered conditions worse. To address these challenges, Cuba is focusing on renewable energy initiatives and moving toward a more sustainable future.⁷⁸

Hungary’s energy security policies (NES, NCDS, NECP) are focusing on increasing availability, mainly through the development of nuclear reactors, and the net-zero emission carbon plan for 2050. However, Hungary remains heavily dependent on imported oil and natural gas from Russia, with an import dependency rate of 87% in 2020.⁷⁹

Accessibility

In response to restricted foreign partnership opportunities, and limited accessibility to secure energy resources and technology, the island is focusing on the development of solar PV parks, aiming to implement 2,012 MW through 92 new facilities, generating 3,400 GWh in order to increase energy independence.⁸⁰

⁷⁷ Bert Kruyt, D.P. van Vuuren, H.J.M. de Vries, H. Groenenberg (2009). Indicators for energy security, *Energy Policy* 37. 2167.

⁷⁸ Silverman-Roati, Whittle, Webb, Fralick, & Harmer. (2024). Building a cleaner, more resilient energy system in Cuba: Opportunities and challenges. Environmental Defense Fund, Columbia Law School, Columbia Climate School, Sabin Center for Climate Change Law. 4-5.

Trading Economics. Cuba Inflation Rate. <https://tradingeconomics.com/cuba/inflation-cpi> (2024 data).

⁷⁹ International Energy Agency. (n.d.). Hungary 2022 executive summary: Maintaining energy security during the transition.

<https://www.iea.org/reports/hungary-2022/executive-summary>

⁸⁰ Angulo Leiva, J. E. (2024). Electricity generation with photovoltaic solar panels will multiply several times over. *Granma*. <https://en.granma.cu/cuba/2024-07-16/electricity-generation-with-photovoltaic-solar-panels-will-multiply-several-times-over>

Hungary faces some challenges regarding the accessibility of energy security, especially heavy reliance on energy imports, because of geopolitical and infrastructural factors. However, in 2024 the government allocated 160 billion Hungarian forints for “building new substations, expanding existing ones and developing transmission lines,”⁸¹ thereby, providing long-term energy security.

Affordability

The Cuban government declared at the beginning of 2024 that, due to growing economic problems, the price of a liter of gasoline would rise from 25 to 132 pesos.⁸² This represents a more than fivefold increase. In 2024, in Cuba, the minimum monthly salary is 2100 Cuban peso (CUP), and on 28 October 2024, the price of gasoline per liter even increased to 156 Cuban Peso per liter,⁸³ meaning that the price of one liter of gasoline costs 7.4% of the minimum monthly wage. Without outside assistance or investment, energy prices may become a greater burden for Cuba’s economy, negatively impacting citizens’ everyday lives, which will lead to increased dissatisfaction and immigration. In order to make foreign money to purchase fuel on international markets, Mr. Regueiro added that the government would also open 29 additional gas stations that would only accept US dollars as payment.⁸⁴

In 2021, the Hungarian government established a decree, about implementing a price cap of 480 HUF per liter for euro-super 95 gasoline and diesel. The price-cap was planned to last for

⁸¹ Szöke, E. (2024). Hungary’s grid modernisation takes a major leap in 2024, says State Secretary. CE Energy News.

<https://ceenergynews.com/electricity/hungarys-grid-modernisation-takes-a-major-leap-in-2024-says-state-secretary/>

⁸² Latin America Advisor. (12 January 2024). Energy Advisor. 2.

<https://www.thedialogue.org/wp-content/uploads/2024/01/LEA240112.pdf>

⁸³ Jiménez, R. (2024). ¿Qué se puede comprar con el salario mínimo en Cuba en 2024? Directorio Noticias.

<https://www.directoriocubano.info/panorama/que-se-puede-comprar-con-el-salario-minimo-en-cuba-en-2024/>

Global Petrol Prices. (28 October 2024). Cuba gasoline prices, liter.

https://www.globalpetrolprices.com/Cuba/gasoline_prices/

⁸⁴ Atkinson, E. (2024). Fuel in Cuba to become five times more expensive. BBC.

<https://www.bbc.com/news/world-latin-america-67922246>

After excluding the use of the Cuban Convertible Peso (CUC) in 2021, Cuba’s only official currency is known as the Cuban Peso (CUP), and 1 CUP equals 15.7 HUF (31 October 2024). However, US dollars and Euros are also widely accepted on the island mainly in tourism, therefore they have the Moneda Libremente Convertible (MLC) card, with 1 MLC = 1 USD, bought from foreign currency and it can be used for purchases on imported goods in MLC stores.

Locally Sourced Cuba Tours. (n.d.). Money and currency in Cuba.

<https://locallysourcedcuba.com/currency-in-cuba/>

Cuba Unbound. (n.d.). Money in Cuba.

<https://www.cubaunbound.com/money-cuba>

Xe. Cuban peso to Hungarian forint exchange rate chart.

<https://www.xe.com/currencycharts/?from=CUP&to=HUF&view=1D>

a three-month period starting on 15 November, although it was extended multiple times, lasting for more than a year, until 6 December 2022.⁸⁵ Despite the decrease of inflation to 3.4% in August 2024,⁸⁶ many households still have difficulties in paying for the cost of energy. Besides gasoline, there are also government regulations for natural gas and electricity. If households consume below a certain limit (1,729 m³ of natural gas and 2,523 kWh of electricity per year) they need to pay only 102 HUF/m³ and 36 HUF/ kWh. However, if they exceed the limit, the price is much higher, 747 HUF/ m³ and 70.1 HUF/kWh.⁸⁷

Acceptability

Cuba's energy security acceptability is mainly impacted by renewable energy projects, such as the plan to install 2,012 MW of solar PV. The aim is to reduce the dependency on imports, decrease greenhouse gas emissions, and enhance domestic energy generation.⁸⁸ Not only will the future initiatives rise sustainability, but they will also ensure the acceptance of energy sources from a social and environmental point of view. However, there are also several challenges, causing significant delays in the projects, such as the lack of financial aid, economic recession, and ageing infrastructure.

Hungary is also improving the acceptability from an environmental point of view by implementing policies such as the NES, NECP, NCDS, or the grid modernization project, which aims to increase renewable energy production while reducing environmental risks.

⁸⁵ Berezvai, Z., & Helfrich, D. (2024). The impact of a short-term fuel price cap on market prices after its removal: Evidence from Hungary. 1. <https://doi.org/10.1016/j.esr.2024.101472>

⁸⁶ Hungarian Central Statistical Office (KSH). (2024). Homepage. <https://www.ksh.hu/>

⁸⁷ Officina (n.d.). <https://officina.hu/gazdasag/311-gaz-ara-rezsicsokkentes-gaz-limit>
Officina. (n.d.). <https://officina.hu/gazdasag/312-aram-ara-rezsicsokkentes-aram-limit>

⁸⁸ Angulo Leiva, J. E. (2024). Electricity generation with photovoltaic solar panels will multiply several times over. Granma.

Aspects	Cuba	Hungary
Availability	Reliant on imported fossil fuels, old infrastructure, frequent blackouts, but trying to move toward renewable energy initiatives	Dependent on imported oil, but future energy policies focusing on net-zero emission and nuclear power development
Accessibility	Limited accessibility due to lack of foreign partnerships	Heavy reliance on imported energy
Affordability	Increasing prices	Government decree about implementing price-caps
Acceptability	Seeking for future solutions to make energy sources environmentally and socially acceptable, however, delays are expected in these projects	NES, NECP, NCDS, and the grid modernization projects aiming to increase renewable energy production

Table 1. Comparative table based on the “Four As”. Edited by the author 2024.

6. Conclusion

For this section the SWOT analysis: *Strengths, Weaknesses, Opportunities, and Threats* will provide an overall analysis of Hungary’s and Cuba’s energy security during our investigated timeframe.

Strengths

Cuba’s progress has been significant but limited by the financial and economic crisis. Nonetheless, it is important to mention the increase in solar PV. The announcement of Lázaro Guerra Hernández, general director of Electricity of the Ministry of Energy and Mines reported on 15 October 2024, claimed that the photovoltaic solar energy project of 26 solar parks will add 1,000 MW by 2026, and with further developments, another 1,000 MW by 2031, that shows Cuba’s strong commitment to renewable energy. Additionally, the participation of scientists in the National Innovation Council meeting demonstrates a commitment to further development. The President of the Photovoltaic Research Laboratory of the University of Havana stated that almost one million solar panels have already been installed with the aim of generating 12% of 2031’s total energy.⁸⁹ Hungary’s strengths include the Paks Nuclear Power Plant, the Mátra Coal Power, solar parks, wind farms, and the METÁR. Moreover, its membership in

⁸⁹ Puig Meneses, Y. (15 October 2024). Photovoltaic solar parks in Cuba: A project based on science and innovation. Granma. <https://en.granma.cu/cuba/2024-10-15/photovoltaic-solar-parks-in-cuba-a-project-based-on-science-and-innovation>

international organizations provides frameworks for implementing strategies. Hungary also has stable underground gas storage, and this way capable of improving its energy supply.

Weaknesses

Cuba faces many electricity shortages (for example, 18-19 October 2024), affecting citizen's everyday life. The sector is negatively affected by outdated infrastructure, economic crisis, and the dependence on imported fossil fuels. Another weakness is the lack of diversity in its energy mix and possible delays of future projects due to the shortage of money, experts and competency. In case of Hungary, in October 2024, MOL, the country's largest oil company, announced that the country would keep depending on Russian crude oil until the end of 2026. The further delay is a consequence of complications in the implementation of alternative energy sources.⁹⁰

Opportunities

Besides the energy policy for 2030 and the 2017 project of the Havana Energy biomass plant, the Cuba Energy Summit in Havana, taking place between 4 and 6 December 2024 is also a great opportunity. 150 expected participants, such as investors, interested in getting involved with Cuba's energy projects will take part in this event. The major sessions involve networking and discussions with government ministers and directors.⁹¹ This summit is an important milestone for Cuba, because it facilitates enhanced cooperations, necessary for a more stable energy security. Hungary aims to implement two new reactors at Paks, and has outlined the NCDS and NES for 2030 and the NECP goals for 2050 to achieve net-zero emissions - significant steps taken to strengthen its energy sector.

Threats

Cuba's main threat is limited foreign partnership opportunities. Moreover, \$3.5 billion is needed to accomplish the project related to renewable energy improvement, which is a huge amount causing issues for its economy. Both countries, as heavily dependent on energy imports, are threatened by external events, such COVID-19 pandemic, or the Russian-Ukrainian War

⁹⁰ Krisztina Than. (10 October 2024). Exclusive: Oil group MOL's refineries shift to non-Russian crude faces delay. Reuters. <https://www.reuters.com/business/energy/oil-group-mol-refineries-shift-non-russian-crude-faces-delay-2024-10-10/>

⁹¹ The Cuba Energy Summit. (n.d.). Your gateway to investment in Latin America and the Caribbean. The Net-Zero Cycle. <https://www.netzerocircle.org/articles/latin-america-and-the-caribbean-the-next-prime-destination-for-energy-investment>

causing negative effects on import opportunities due to geopolitical risks. A recent threat that was due to this kind of external factors, happened in June 2024, when Ukraine imposed sanctions on transiting crude oil exported by Russian corporation Lukoil, via its territory to Hungary and Slovakia.⁹² After some months, in September, the agreement included the allowance of MOL Group to take ownership of crude oil near the Belarus-Ukraine border, and this way not breaching the limitations imposed on Russia.⁹³

The first research question mentioned in the paper is: What changes and trends have been observed in Hungary's and Cuba's energy security situation in the last ten years? Over the past decade, both countries remained dependent on imported fossil fuels, especially oil and natural gas. Hungary made some significant investments and projects to accomplish diversification, for example, the 2030 project of a new construction at Paks, the net-zero emission by 2050, or the improvement of renewables, however, the country still struggles with reliance on Russian crude oil, and natural gas, with external factors making things more difficult, whereas the island is experiencing its worst crisis since the collapse of the socialist bloc.

What opportunities and challenges do the development of renewable and alternative energy sources bring to Hungary and Cuba? The development of renewable and alternative energy sources brings both opportunities and challenges. For Hungary, the solar PV farms, wind farms (Ács), and the Paks Nuclear Power Plant provide a path toward greater energy safety and decreased carbon emissions, however, these projects demand financial expenditures and modernized infrastructure. Differences in weather conditions affect the outcome of solar and wind power in electricity generation. The number of imports would decrease as a result of Cuba's renewable energy initiatives, mainly related to solar, wind, and biomass improvement projects, however, a lack of access to financial markets makes it more difficult to achieve them (in 2014 and 2022, the renewable share of electricity generation was 4% and 4.1%).⁹⁴ Additionally, a lack of resources (money, time, and people) necessary for modernizing its infrastructure is a huge burden. Cuba is frequently hit by hurricanes (until November 2024 there

⁹² Jack, V., & Gavin, G. (20 July 2024). Hungary facing fuel crisis as Ukraine turns up heat on Russian oil supplies. Politico. <https://www.politico.eu/article/hungary-fuel-crisis-ukraine-sanctions-russian-oil-imports-lukoil-central-europe/>

⁹³ Melkozerova, V., & Gavin, G. (10 September 2024). Ukraine backs Russian oil loophole for Hungary. Politico. <https://www.politico.eu/article/ukraine-russian-oil-hungary-mol-lukoil-sanctions/>

⁹⁴ International Energy Agency. (n.d.). Cuba. Country Overview.

were five in total)⁹⁵ and other natural disasters, which also damage solar and wind farms, affecting the total share of renewables negatively.

The outcomes of the SWOT analysis support the idea that Hungary and Cuba have remained reliant on imported fossil fuels, however, they have taken steps to reduce greenhouse gas emissions,⁹⁶ mitigate climate change, and diversify the energy mix in terms of future policies and renewable installations. These renewable energy initiatives, furthermore, can lead to improved acceptability of energy security from an environmental and social point of view as well. Although, it is true that both countries face challenges in connection with financing, providing the right expertise, and extreme weather conditions.

In conclusion, the SWOT analysis demonstrates that Hungary and Cuba are both facing weaknesses and threats, however, they have shown a strong commitment to improved energy security. Renewable energy increased, and the acceptability of energy security improved. For further research, looking back at the roots and examining the 1990s and 2000s would give a more comprehensive and detailed approach. Moreover, by the beginning of 2050, after accomplishing the mid-term and long-term goals, we would see if these countries overcame geopolitical, economic, and infrastructure obstacles in order to take full advantage of renewable energy and move toward sustainability.

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⁹⁵ World Data. (2024). Hurricanes in Cuba. <https://www.worlddata.info/america/cuba/hurricanes.php>

⁹⁶ In Cuba in 2014, CO₂ emission per population was 2.3 tonnes of carbon dioxide per capita while in 2022 it was 1.7 tCO₂/capita. In Hungary, it was in 2014, 4.1 tCO₂/capita and in 2023 3.9 tCO₂/capita.
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