

Review

State of Play for 100% Renewable Energy Futures for Cuba: Recent Changes and Challenges

Mika Korkeakoski

Finland Futures Research Centre, Turku School of Economics, University of Turku, 20014 Turku, Finland; mika.korkeakoski@utu.fi

Abstract: Over the last decades Cuba has been remarkably successful at revitalizing its energy sector by significantly increasing efficiency and reducing energy intensity and emissions. These achievements, made through a comprehensive approach targeting infrastructure, consumption habits and people's understanding of energy issues, can provide Cuba with fertile ground on which to tackle the policy challenges ahead in order to achieve its 2030 energy policy goals. This review carries out a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of the late 2010s until 2022 on the variety of changes that have taken place and the challenges still ahead. Overcoming critical challenges under the Political, Economic, Social, Technological, Environmental and Cultural (PESTEC) conditions is crucially important; how will Cuba be able to tackle the challenge of implementing the transition to renewable energy and find the resources to actualize the 2030 vision?

Keywords: Cuba; renewable energy; energy transformation; energy policy; PESTEC challenges; futures



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1. Introduction

Cuba is currently in a strategically important phase of its energy transition to address its fossil fuel trajectory, climate commitments and national development and sustainability goals. Although the Caribbean island is still heavily dependent on especially imported fossil fuels, the Cuban government has taken remarkable steps in its vision for renewable energy futures. The Cuban government has identified critical issues to be resolved through its energy transition: increasing energy security and independence, decreasing dependency on imported fuels and volatile oil prices, minimizing the impacts of the longest economic embargo in history, avoiding the influence of political turbulence in earlier trade partner countries and finding ways to fight against global climate change. These political, economic, social and environmental issues have already instigated various legal, policy and regulatory changes [1–3]. These include the provision of various decrees and resolutions to support and guide the implementation of the new constitution, supporting the decentralization of decision making to municipalities and facilitating a large transition towards renewable energy for the country's development efforts [4–7]. This review paper examines how Cuba can tackle the current energy transition challenges towards a more sustainable future energy sector. First, the review examines the most recent changes and challenges in detail through two analysis frameworks: Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of the current situation building on the past changes and challenges and the Political, Economic, Social, Technological, Environmental and Cultural (PESTEC) analysis differentiating the identified drivers and dimensions of the SWOT analysis. Secondly, the review discusses the implications of these changes and pinpoints the most critical ones to be addressed. Finally, the review provides recommendations on the most critical challenges for Cuba's 100% renewable energy future.

2. Background Materials and Methods Used

This review is based on desk review of existing literature by previous academic journals, books and studies as well as news and media updates on the Cuban energy transition towards renewables. The author focused on the latest developments in the area to provide an accurate picture of what changes have taken place, what have been and remain some of the challenges and what critical areas need to be focused on towards achieving a 100% renewable energy-based Cuba.

Review was structured as a Strengths, Weaknesses, Threats and Opportunities (SWOT) analysis commonly used since 1960s to identify internal and external dimensions of the study subject (e.g., organization, project, person) [8]. In internal dimension it means looking at the strengths and weaknesses of the study subject, while opportunities for and threats to the study subject are viewed by looking at external factors and attributes of the environment [9].

The identified issues were further divided into Political, Economic, Social, Technological, Environmental and Cultural (PESTEC) dimensions [10]. PESTEC is a tool allowing ideas to be structured across these six dimensions, providing the reader with a holistic way of examining the analysis [11,12]. PESTEC analysis has been developed for “promoting futures thinking, futures preparedness and provocative futures dialogue” [12] and is based on the evolution of commonly-known framework for Political, Economic, Social, Technological, Environmental, Cultural/ Customer, Value and Legal constituents such as PEST, PESTE, PESTEL, PESTLE, STEPE, PESTELV, ETPS, STEELV, STEEPV [12]. The harnessing of collaborative creativity for insights, innovative ideas and practical solutions can be further discussed with experts or relevant stakeholders for a more holistic approach to addressing emerging challenges. The Futures Clinique can be used to reorganize the (Political, Economic, Social, Technological, Environmental, Cultural/ Customer, Value, Legal) constituents for a more holistic way of approaching an issue or a challenge [10–12].

3. Results: Review of the Recent Developments in Cuba’s Energy Transition

3.1. Recent Changes in the Policy, Planning, Legal and Regulatory Framework

This section introduces the most relevant changes in policies, plans, laws, decrees and regulations in relation to possible future renewable energy transformation in Cuba.

In June 2017, the Cuban National Assembly approved three guiding policy and planning documents [4] that introduces directions aiming to modernize economic and social life in Cuba while fostering sustainable development:

- Conceptualization of the Cuban Economic and Social Model of Socialist Development (*Conceptualización del Modelo Económico y Social Cubano de Desarrollo Socialista*);
- The Economic and Social Development Plan until 2030: Vision of the Nation, Strategic axis and Sectors (Bases del Plan Nacional de Desarrollo Económico y Social hasta el 2030: Visión de la Nación, Ejes y Sectores Estratégicos); and
- Guidelines for the Economic and Social Policy of the Party and the Revolution for the Period 2016–2021 (*Lineamientos de la política económica y social del Partido y la Revolución para el periodo 2016–2021*) [4].

The Guidelines, especially, show a shift away from centralist state socialism and introduce new forms of ownership and management while aiming to reduce state bureaucracy, decentralizing authorities to provinces and municipalities, and expanding different forms of self-employment through small enterprises [4]. In addition, the National Plan for Economic and Social Development until 2030, (Plan Nacional de Desarrollo Económico y Social hasta el 2030, PNDES2030) highlights energy as a critically important factor for development in achieving the strategic priorities [5] set and was approved by the national assembly in 2017.

In addition, Cuba recently renewed its constitution acknowledging the role of municipalities in directing the economic development and allocation of resources to local development through decentralized decision making [6]. While the constitution refers to the central planning role as not being fully eliminated, it is diminished and the municipalities have been granted more autonomy in integrated management of the territory’s

resources. Thus, municipalities have become the primary political–administrative units for securing local needs and will play an essential role in the country’s development and aims to deepen democratic citizen participation. Municipalities have been granted autonomy and the faculty to decide on the use of their own financial resources and the exercising of their competencies [6].

Cuba is also moving towards a mixed economy including both private and state-run sectors, and foreign investments (supported by Laws 118 and 88 on Foreign Investment and, e.g., Investment Opportunities Portfolio for FDI) [13–15] have been given a more significant role in fueling Cuba’s economic development quoting the national socio-economic plan as “conceiving and promoting foreign direct investment as an essential part of the country’s development strategy and, in particular, of the economic sectors defined as strategic” [4].

The energy future envisioned in Decree-Law No. 345 “Prospective Development of Renewable Energy Sources and the Efficient Use of Energy for 2014–2030” aimed to achieve 24% penetration of renewable energies in electricity generation by 2030 [7]. This was later reevaluated and modified upwards by the government to 37% by 2030 with an aim to reach 100% in the future [16–18]. In specifics, Decree-Law No. 345 aims to increase the share of renewable energy sources in electricity generation and progressively substitute fossil fuels; diversify the structure of fossil fuels used in the generation of electricity; increase energy efficiency and savings; stimulate investment and research towards increased energy efficiency and the production and use of energy from renewable sources through incentives and other instruments; promote national development of the production of equipment, means and spare parts for use by renewable sources and energy efficiency; and establish working mechanisms and planning procedures at a state level to achieve the objectives set [7].

Furthermore, within Decree-Law No. 345, the government urges decentralized state business management organizations, provincial and municipal administrations, and all state-budgeted entities to exercise greater control over their energy use through energy management, efficiency, conservation and control (Resolutions 123/2019 and 124/2019). Similarly, in the decree, the Central Bank of Cuba also instructs the granting of credits to individuals for the acquisition of equipment to use renewable energy sources to accelerate the use of renewables [7].

In 2021, the Ministry of Energy and Mines resolutions approved the import of photovoltaic systems (Resolution 206/2021) [19] and the import of equipment and parts for renewable energy production and use (Resolution 208/2021) [20] to individuals for non-commercial use, while the Ministry of Finance and Prices exempted custom duties for individuals on the import of solar photovoltaic systems and their parts (Resolution 319/2021) [19] and certain equipment using renewable energy sources (Resolution 322/2021) [20], authorized fiscal benefits for fully foreign capital-operated companies carrying out electricity generation projects through renewable energy sources (Resolution 223/2021) [21] and initiated a feed-in tariff system (Resolution 359/2021) [22] that allows electricity produced through renewable sources to be sold to the National Electricity System (SEN) by larger entities (e.g., sugar mills) or even individuals. The Ministry of Internal Trade (MINCIN) also approved the commercialization of equipment that is energy efficient or the use of renewable energy by foreign exchange stores and provincial and municipal retail companies (Resolution 141/2019) [7].

3.2. Strengths, Weaknesses, Threats and Opportunities (SWOT) in the Path towards Renewable Energy Future in Cuba

Cuba has been and still is a special case due to its isolation from international trade and due to its geographical character, being an island. Hence, energy security and independence are crucial in fueling Cuba’s development. Although there have been recent changes and commitments towards renewables, the country is still heavily dependent on imported fuels, and despite the ambitious vision of reaching 37% of renewables by 2030 [16–18], the

current share of renewables in produced electricity remains at 4.5% in 2021 according to International Renewable Energy Agency (IRENA) statistics [23].

This section examines the drawbacks and opportunities through SWOT analysis based on the previous work of scholars on the issue, structures the aspects according to Political, Economic, Social, Technological, Environmental, and Cultural dimensions and discusses the main characteristics of the findings.

The identification of strengths is shown in Table 1 demonstrating the commitment of the Cuban government, and revisions of the regulatory and policy framework on the promotion of renewable energy (RE) have been discussed in the earlier section. Cuba has increased transparency in its legal framework and incentives geared towards increasing RE investments through, e.g., an investment portfolio showing over 100 opportunities in the energy sector, giving the benefit of tax exemptions to Renewable Energy Technologies (RETs), encouraging research and innovations, decreasing challenges in investment approval processes, e.g., by a Single Window for Foreign Investment (VUINEX), signed agreements with regional and international partners and the introduction of a feed-in tariff system to facilitate the purchase of electricity by the national electricity grid from independent power producers [13]. The constitution's direction on the decentralization of decisive economic power to municipalities shows the country is changing its approach on the centrally controlled powers by giving freedoms to local governments to be proactive in local development [6]. Cuba has an abundance of renewable energy sources, and has estimated it has the potential of reaching 100% renewable energy-based electricity production [24]. The most recent estimates by MINEM show that Cuba could well exceed their 24% goal in total by adding more renewables in to the energy mix: solar PV with an additional 13 GW, 1.8 GW from wind and 612 MW from biomass. Cuba has a high electrification rate and a highly distributed electricity generation system and could facilitate realization of the potential, resulting in electricity production of 26 TWh from renewable sources annually [25].

Cuba has created nationwide energy awareness through its energy revolution campaigns on renewable energy, energy efficiency and energy saving from 2006 onwards [2,3]. The highly educated, skilled and inexpensive workforce in a geopolitically strategic location as the largest Caribbean island between the Americas could fuel not only the transition towards renewables but support multiple sectors as the regional hub. The recent changes have created an enabling environment for the implementation of foreign and domestic renewable energy investments both by individuals and companies that can assist in Cuba's RE uptake.

Table 1. Strengths in transition towards 100% renewables.

Strengths	Dimension	Source
Renewable energy policy reforms and commitment	Political	[4]
Commitment from central level to renewable energy	Political	[24]
Governmental policy that prioritizes research and technological innovation	Political	[13]
Transparent legal framework	Political	[13]
Reforms in decentralization of decisive power	Political	[4,6,26]
Relatively stable political, social and legal conditions	Political/Social	[13]
Reforms in private investment promotion	Political/Economic	[13–15,20]
Agreements signed by Cuba in the region and internationally	Economic/Political	[13]
Sectoral policies identifying investment opportunities with foreign capital	Economic	[13]
Single Window for Foreign Investment (VUINEX) in 2020	Economic	[13]
Increased economic freedoms to municipalities	Economic	[4,6,26]
Tax benefits, import exemptions for renewable energy equipment	Economic	[19,20]

Table 1. Cont.

Strengths	Dimension	Source
Feed-in tariffs for companies and individuals	Economic	[21,22]
Geographical location in the center of an expanding market	Economic	[13]
Dialogue and cooperation agreement with the European Union	Economic/Political	[27–30]
History of energy revolutions (renewable energy and energy efficiency and savings)	Social/Cultural	[1–3,31]
Public awareness on demand side management	Social	[3,32]
Satisfactory social indicators on development (health, education)	Social	[27]
Skilled, educated and inexpensive workforce	Social	[27,31,32]
Basic infrastructure and communications networks throughout the country	Technological	[13]
High electrification rate (>99%)	Technological	[2,16,31,33]
Highly distributed system (40%)	Technological	[16,31]
Availability of renewable resources (solar, wind and biomass)	Environmental	[25,34]
Biomass/sugar co-location	Environmental	[31,35]

The identification of weaknesses is presented in Table 2. The weaknesses show the limitations of local government capabilities (knowledge, skills and tools), the lack of transparent energy data [2,3,32] for planning purposes and the lack of decisive freedom and tools for local actors to successfully implement renewable energy projects [36,37], echoing the historical centrally controlled state structures. Although the new constitution shows a clear decentralization of decisive power to local governments, the central state is still in control of trade, credit, foreign trade and foreign investment along with some strategic sectoral developments such as energy [27]. Similarly, to the central government control, the national electricity utility (UNE) is currently the sole offtaker in the electricity sector [31]. How the shift to municipal decision making in the energy sector translates into practice may necessitate a review of the current Electricity Law dating back to 1975 [38], although Decree-Law 345 provides guidance on renewable energy implementation [39].

Previous experience of and unfamiliarity with renewable energy (RE) projects affects the uptake of project implementation (arrastia, panfil, kākōnen). On the other hand, limited knowledge, inefficient energy utilization and energy saving and a lack of participation by the public in renewable energy decisions negatively affects the citizens' motivation to act as agents of change in promoting renewables [36,37]. The adaptive capacity of organizations on renewable energy has also been discussed in the energy transition; there is a dire need for skills and knowledge acquisition, training and practical experience to apply the renewable energy potential [40].

The high reliance on imported fuels and the aging grid and electricity production infrastructure negatively affects the operation and efficiency of the power plants, let alone the lack of funds for the maintenance and repair of the facilities and the lack of fuel [16,31,41]. Cuba's limitations on operating reserves of the electricity system and storing the energy produced by intermittent sources is also clearly hindering the wider adoption of renewables and remains a critical factor while examining the right balance of the installed capacity of renewables [41]. Currently the lack of automation and other challenges in controlling the electricity grid, together with high losses not only in the distribution networks but low efficiency throughout the value chain from production to distribution and consumption are clearly issues to be resolved [41–43]. Other demand side management issues include the low energy efficiency and savings culture from the consumer side. This may be a result of a highly subsidized electricity price historically to consumers, while, at the same time, the production costs from mainly imported fossil fuels for delivered electricity have been very high (energy being the highest cost category in the country's annual budgets with fuel representing 70–80% of total energy costs) [2,16,25,43,44]. The low share of RES

in electricity production is shown to lead to environmental pollution from outdated and inefficient fossil fuel-based power plants [42].

On the investment side, the absence of internal energy markets coupled with a single offtaker Unión Eléctrica (UNE), the low convertibility of the Cuban Peso (CUP) and the somewhat limited incentives for independent power producers (IPPs) has resulted in difficulties in attracting both domestic and foreign investments. [27,31,36,41,42].

Table 2. Weaknesses in transition towards 100% renewables.

	Dimension	Source
Quality, transparency and access to energy data (especially at community level)	Political/Technological	[2,3,32]
Highly subsidized electricity tariffs	Political/Social/Economic	[42]
State control over wholesale trade, credit, foreign trade and foreign investment	Economic/Political	[27]
Lack of finances for maintenance of power plants	Economic	[43]
Cumbersome investment processes and internal issues that hinder attracting foreign capital	Economic	[27,31,45]
Low share of RES in electricity production	Economic/Technological	[24,30,41]
Low competitiveness of goods and services	Economic	[27,30]
High average cost of delivered energy	Economic/Technological	[16,40,43]
Single offtaker (UNE)	Economic/Political	[31,41]
Lack of incentives and mechanisms for IPPs, energy service companies, local governments and cooperatives	Economic/Political	[36]
Problems of convertibility of the Cuban peso	Economic/Political	[27,42]
Limited market opportunities and legal framework due to state monopoly and black market	Economic	[46,47]
Weak investment and infrastructure environment	Economic	[27]
Limited public participation in the defining, implementation and evaluation of RE decisions	Social/Political	[36,37]
Limited instruments and freedom of the local government to manage the renewable energy investments	Social/Political	[36,37]
Insufficient knowledge and motivation of local stakeholders on energy issues	Social/Cultural	[1–3]
Limited absorptive capacity of organizations on renewable energy	Social/Cultural	[40]
Lack of experience and transparency in RE projects	Social/Technological	[31]
Inefficient use of energy related to low culture of energy saving	Social/Cultural	[36]
Shortages of necessities (electricity, goods)	Social/Economic	[16,27]
High reliance of imported fuels	Technological	[16,31,48–50]
Aging grid infrastructure and production facilities	Technological	[16,31,50]
Manual control of supply–demand balance in the electricity system (vs. automation, predictability)	Technological	[41]
Operating reserves of the electricity system are insufficient	Technological	[43]
High losses in distribution networks	Technological	[42]
Failure of several high-generation thermoelectric plants and the lack of fuel	Technological/Economic	[16]
Limited energy storage alternatives (especially for intermittent energy sources)	Technological	[41,50]
Low efficiency through the value chain from production to distribution and consumption	Technological/Social	[41]

Table 2. Cont.

	Dimension	Source
Environmental pollution by old thermoelectric power plants	Environmental	[41]
Lack of motivation and qualified staff for renewables' implementation	Cultural/Technological	[1,2]

Table 3 presents the opportunities in Cuba's energy transition including possibilities in financing the transition towards renewables via foreign direct investment (FDI), international banks and development and climate financing. The implementation of Cuba's Energy vision has been estimated by Cuban government to cost more than USD 4.0 billion to achieve their 2030 renewable energy target [2,51] of increasing the renewables share to 24% and USD 6.0 billion for the remodified target of 37% [44]. These investments are foreseen to come from mainly foreign investments, although should Cuba be able to reduce its spending to electricity from imported fuels, this could save a remarkable share of the USD 2.8 billion spent annually on the electricity sector, including the purchase of fuel (70–80% of the total cost), the operation and maintenance of the aging thermoelectric plants and the purchase of energy from independent producers [2,44]. Should Cuba be successful in moving away from fossil fuels and reaching the target of 37% renewables, there will be a reduction of more than nine million tons of carbon dioxide emissions every year [44]. With the implementation of its full renewable potential, the Cuban government estimates the production of 26 TWh (annually) of clean energy. This in turn would replace 6.5 million tons of fossil fuel per year and lead to a reduction of approximately 21 million tons of CO into the atmosphere per year [25]. Although Cuba has been able to direct USD 500 million of investments to renewables since 2014, the achievement of the government's vision is significantly lagging behind, resulting in only 4.5% of renewables contributing to electricity production in 2021 [23,33]. Should foreign investments flow through, aided by the investments of development and climate financing, Cuba could well advance its efforts. Currently, Cuba receives climate financing mainly through foreign direct investment, development cooperation grants and loans, the Green Climate Fund (GCF) and UN organizations, with the largest sectoral share in the energy sector (25.5%) [52–56]. Although there are various ongoing studies on Cuba's climate financing readiness, an important part of the mitigation financing currently still comes through foreign investments and credits [53]. Should Cuba be able access the climate financing potential from multilateral financial institutions in a better way and attract the right investments, it has all the potential of reaching its 100% renewable status not only in electricity but in the transformation of the energy sector. Such studies are increasingly receiving attention in Cuba [48,50,57,58].

Although Cuba is suffering from the sanctions set by the US government, there have been some recent changes made by the Biden administration to ease Cuban sanctions [59] and the increased interest and engagement by China [60] and the EU [28] in Cuba can speed up the transition. At the same time Russia has been an important ally and recently announced large joint investment projects in key sectors, especially in energy, transport, industry and agriculture followed by the USD 2.3 billion provided to Cuba earlier [30,61,62]. China has been strategically important to Cuba in four sectors: telecommunications, infrastructure, renewable energy sources and cutting edge technologies [63], while the European Union's approach is emphasizing the multi-bilateral approach and geoeconomics [14] with some recent drawbacks in the ties resulting from the incarceration of protestors and the political support to Russia in the Ukraine war [64]. Yet further potential can be realized through Cuban diaspora remittances into renewable energy sector development and this potential should not be ignored by the Cuban government [65,66]. With the right policy framework and new energy market mechanisms in place, Cuba now has the potential to support rural employment through renewables and harness companies and individuals to not only consume but also produce electricity for the national/local grid and generate income for both international and domestic energy entrepreneurs, cooperatives and individuals [22,41,67]. Cuba's energy (electricity) use per capita has increased in the last decade

and is considered average compared to developing countries in the Latin American and the Caribbean region despite the challenges in the recent years of power cuts and load shedding due to power plant failures, and a lack of fuel and maintenance [2,41]. This has had a significant effect throughout Cuba by rationing consumer use of electricity. Despite the electricity deficiencies, the use, however, is still highly inefficient and there is great potential in the demand side management for improvements [36,42]. Looking at the comprehensive set of both demand and supply management measures, Cuba has the potential to become a pioneer in showcasing a 100% renewable energy future while combating greenhouse gas emissions, abolishing the dependency on imported fossil fuels and increasing its energy security and independence.

Table 3. Opportunities in transition towards 100% renewables.

Opportunities	Dimension	Source
Increased interest and external engagement (EU, China, etc.)	Political/Economic	[14,28,30,31,59,60]
Potential ease of sanctions by the US	Political/economic	[59]
Transformation of the energy sector towards renewables (not only electricity)	Political/Technological/Economic	[48,50,55,56]
Availability of international/development/climate financing	Economic	[52–56]
High share of Cuban diaspora (remittances) interested in investing in Cuba	Economic	[65,66]
Prosumerism and energy entrepreneurship by stakeholders at different scales	Economic	[14,36,67]
Savings from imported fossil fuels	Economic	[2,25,41,44]
Rural employment creation through renewables	Economic/Social	[14,36,41,67]
Energy markets (local, national/regional)	Economic	[22,67]
Investment potential in various sectors and relatively low competition (in the energy sector alone over 100 investment opportunities identified)	Economic	[13,27]
Potential for demand side improvements in energy efficiency and energy saving	Social/Cultural	[36,42]
Sustainability image as a sustainable energy pioneer	Environmental	[40]
Reducing GHG emissions and environmental impacts of the energy sector	Environmental	[25,41,53]

Table 4 shows the threats identified. One of the most critical aspects is linked to the impact of the US embargo on Cuba since the early years after the Cuban revolution. The embargo imposed by the US government in 1962 and later the Helms–Burton act during the Clinton administration strengthened international sanctions penalizing foreign companies that traded with Cuba [16,68]. Although the embargo or the act itself does not compel other countries legally, it has had a drastic effect on cutting economic ties with the island nation. The significant disincentives for trade with Cuba heavily affected the investment flows to Cuba, especially after the collapse of the Soviet Union, and further limited Cuba’s access to international markets and the trade of goods and services [16,68,69]. Based on United Nations estimates, the US financial and trade embargo has cost the Cuban economy USD 130–147 Billion up to 2021 [70–72]. Between 2019 and 2020, the Cuban government estimated losses of USD 5.6 billion of which the energy and mining sector’s development suffered from losses of over USD 125 million due to the US restrictions [73]. This, coupled with banks being afraid of the US sanctions, strangled joint venture funding from Europe and other obvious sources, and definitely also had a negative impact on the renewable energy investments in the country [74,75].

The additional qualification of Cuba as a high-risk country by the US has limited the access and interest of foreign investors to open relations with Cuba [76–79]. The growing concerns of European investors, specifically on Cuba’s political stand with Russia during the Ukraine war, have presented Cuba with problems for initiating collaboration with the EU [64]. Russia and Cuba have recently agreed on collaboration in the promotion of large joint investment projects in key sectors, especially in energy, transport, industry and agriculture [61,62]. In contrast, the political loyalty to Russia also works against the wishes of the Cuban government to deepen relations with the European Union [64].

Cuba has, and still, failed to fulfill some of the criteria for multilateral international credits and financing (e.g., World Bank and the IMF) [56]. Cuba is still not a member of the major multilateral financial institutions, largely due to sanctions by the US [56]. According to various risk evaluations by credit risk rating agencies, Cuba’s political and business risks are in the highest categories with a high probability of Cuban companies failing to pay back loans [27,78]. The 2015 Paris Club agreement forgave USD 8.5 billion of the USD 11.1 billion in sovereign debt Cuba defaulted on in 1986, yet Cuba has continued to struggle to pay back its loans in recent years [80]. The Economist Intelligence Unit (EIU) predicted inflation of 399.6% in 2021 due to the weak Cuban peso and still the country suffers from two-digit if not from triple-digit inflation [64,81,82]. Global politics have also affected the high price of energy and the price volatility of fossil fuels, and Cuba’s heavy dependence on imported fuels coupled with only a few trading partners have increased Cuba’s energy vulnerability [16].

Cuba is gradually moving towards being a less centralized state [6,14,82], but the dynamics of the planned economy structure (information compartmentalization, lack of knowledge of standard market rules and excessive centralization of loan management for the entrepreneurial sector) [14,83], with somewhat cumbersome investment project approval processes [31], increase the project risk to investors. In addition, while the need for foreign investments is evident, Cuba’s challenge is to maintain the achievements of the socialist state (e.g., health, education, low level of income inequality) with environmental sustainability and the equal distribution of wealth while opening up the country to investors [14,82]. In recent times, Cuba, due to its geographical isolation, being an island state, has also suffered heavily from climate change-induced natural disasters (located in the main hurricane route) and the global pandemic. [27,53]. Cuba has also suffered for decades from the brain drain of its professionals throughout all sectors through outward migration [84–86]. All of the above has negatively affected the enabling environment for renewable energies in Cuba, further decreasing foreign capital flows and even leading to speculation about bankruptcy of the country [79].

Table 4. Threats in transition towards 100% renewables.

Threats	Dimension	Source
US embargo’s influence on investments and access to resources	Political/Economic	[16]
Qualification of Cuba as a state sponsor of terrorism and a high-risk country	Political/Economic	[27,76–78]
Growing concerns of investors (especially EU) on Cuba’s political support to Russia and opposition on NATO expansion (specifically due to Ukraine war)	Political	[64]
Limited access to multilateral and international credits and financing	Political/Economic	[14,27]
Cumbersome/extensive investment project approval process	Political/Economic	[31]
Maintaining socialist ideology while decreasing state control and increasing FDI	Political	[14,82]
Traditional planned economy dynamics structural challenges	Economic/Political	[14,41,83]
Price volatility of oil due to global political unrest	Economic	[16]

Table 4. Cont.

Threats	Dimension	Source
Increased project risk	Economic	[14,27,78]
High levels of indebtedness	Economic	[27,83]
High inflation	Economic	[81,82]
Cuba is highly vulnerable due to dependency on few partner countries (China, Venezuela, Russia and the EU)	Economic	[30,64]
Failure to meet requirements to access to international financing	Economic	[14,53,55,56]
Brain drain of qualified and skilled professionals due to outward migration	Social/Technological/economic	[84–86]
External vulnerabilities (natural and climate induced disasters, pandemics)	Environmental	[27,53]

4. Discussion: Critical Challenges on the Way to 100% Renewables

This section identifies the main critical junctures for Cuba's next energy revolution based on the analysis carried out on the internal and external advantages and disadvantages through the PESTEC dimension. It is critically important to systematically ensure the current strengths are maintained, weaknesses are decreased and minimized, opportunities are harnessed and threats are averted during the process towards the promotion of renewable energy transition. The recommendations are far from exhaustive and are based on the analysis carried out by the author. However, discussion on the challenges is a necessary process at this point to overcome the hurdles in renewables' integration.

- **Translating the alignment and flexibility of the revised regulatory and policy framework into action.** Although there are a lot of recent changes that support the renewables' implementation, there are barriers in project approval processes, and unclear interactions between the roles and responsibilities of the governmental and non-governmental entities at national and subnational levels. This could be targeted by streamlining project applications and approvals in a transparent manner for international and national energy developers alike. These may necessitate a revision and redesign of some of the existing regulatory and legal frameworks mentioned in Section 3 to further promote active implementation of the energy transition.
- **Tailor-fitting the RE investment possibilities for the right customers at different scales:** (1) private developers/investors (both foreign and national); (2) multilateral and development financing institutions (e.g., World Bank, Interamerican Development Bank, IMF); (3) climate-focused investors and financing organizations (e.g., GCF, UN); (4) bilateral partners (e.g., EU, China); (5) smaller scale entities (e.g., local governments, energy entrepreneurs, cooperatives and citizens). This could be conducted by active engagement and collaboration and by ensuring an enabling environment in Cuba, in the region and internationally. It is also of utmost importance to build upon the past experiences (with successful past partnerships) to upscale the implantation of renewables to their full extent in the future.
- **Improving the capacities, skills, understanding and tools on renewable energy** to facilitate the absorptive capacities of institutions and individuals to work as change agents. These could include closer partnerships of universities with the private and public sector and local stakeholders in skills and knowledge development, sharing the best practices and fostering innovations. Equally important is to engage and interact with the national energy sector actors such as UNE, La Oficina Nacional para el Control al Uso Racional de la Energía (ONURE), Empresa de Fuentes Renovables de Energía (EMFRE) and research organizations such as (Centro de Investigacion de Energia (CIES) and CubaEnergia.

- **Improving and modernizing the current energy infrastructure** to support the transition towards renewables. The increase in the share of renewables in electricity production poses significant technical and financial challenges; these include automation of the dispatch and predictability of energy behavior, the reserve storage capacities (e.g., pumped hydro, Power to Gas to Power P2G2P, battery storages, flywheels), reduction in the distribution losses and losses in the energy/electricity value chain and improving access to RE technologies. The Cuban government has increasingly shown its vision towards 100% renewables; however, this should be backed by a multitude of studies and roadmaps showing how to get there. Here the availability and transparency of data are of crucial importance to examine various paths to renewables.
- **Promoting incentives, subsidies and risk guarantees for RE investors.** The investment portfolios, tax exemptions and benefits already in place should be explored further to attract the right investments at different scales. Incentives and risk guarantees with correctly priced feed-in tariffs can motivate energy developers at all scales. These supporting mechanisms together with the redesign of regulatory and legal guidelines are especially needed to reduce project risk, especially now with the weak Cuban peso and high inflation pushing the return of investment further into the future. Cuba has the potential to introduce prosumerism at all scales should there be innovative mechanisms in financing RE projects. These could include fully foreign direct investments, joint ventures, municipal cooperatives, small energy entrepreneurs, remittances of diaspora, cooperatives to remittances from Cuban diaspora and individuals promoting the shift to renewables.
- **Accessing international investments, grants and loans.** Cuba has been excluded from international financing mechanisms since the US embargo and has had to navigate its way through bilateral collaboration and private investments until recently. There are, however, some promising signs of Cuba accessing, e.g., climate change readiness financing, and collaboration agreements with the EU and bilateral partners (e.g., China). Moreover, the geopolitical location of Cuba in the heart of the Caribbean, between the Americas, can offer new opportunities in regional collaboration. The recent addition to the challenges come from the announcement of the US including Cuba on its list of States supporting terrorism and the political support of Russia during the Ukraine war. While there are some sanctions Cuba can do little about, there are possibilities to continue engagement and pressure against the US embargo. The Biden administration was expected to continue on the path initiated during the Obama administration and some rays of light can be seen in the easing of the sanctions. Here the role of the US government is inevitably crucial in accepting Cuba as a member of international financing institutions and ending the six-decade-long embargo.

5. Conclusions

The review aimed to analyze the state of play of the Cuban energy transition towards renewables and map the most recent changes and challenges through the SWOT and PESTEC frameworks. The research question on how Cuba can overcome the hurdles on the way needs a holistic approach, and some of the hurdles are definitely easier to overcome than others. Cuba has been actively moving towards a renewable energy future with the government's commitment and policy and regulatory changes. There are, however, many challenges to overcome and Cuba is certainly in a special situation due to its isolation from economic trade, the unrestricted movement of people and goods and the lack of access to international credits and financing due to the US embargo. Despite the politically-motivated economic sanctions, Cuba may have what it takes to move to 100% renewables. This entails, however, innovative solutions and, most crucially, financing from all possible sources: international and domestic. It is, however, also important to examine the different pathways towards 100% renewables through a holistic analysis of the whole energy system instead of focusing on a single sector (e.g., electricity), exploring storage options, transport and other interconnected sectors. Further elaboration of the SWOT analysis prioritizing and weighing

the main challenges and solutions together with the relevant Cuban and international expert stakeholders can add value in guiding the energy transition roadmap process. Additionally, a Futures Clinique process prior to and(/or) post the SWOT elaboration can provide innovative, alternative and radical ways of encompassing the energy futures in a more holistic way. Currently, Cuba's biggest challenge, in addition to the decades long isolation, is financing. If Cuba can find ways in resolving it, other challenges can surely be addressed.

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