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PERSPECTIVE

Energy transition in a developing economy: Challenges, prospects and policy considerations

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ABSTRACT

Energy transition as a process of decarbonizing energy systems is considered a key mitigation strategy in the global effort to curb rising temperatures stemming from greenhouse gases. The main challenge with the energy transition process has to do with the social, economic, political and technological capacities of a country to undertake this transition process for which developing countries globally are lagging behind. The purpose of this study is the present a policy discussion paper looking at the pertinent social, economic and institutional challenges that developing countries need to consider in its energy transition process. As a case study, the paper also looked at the economy of Guyana, a country that is experiencing an oil and gas boom and also has committed to developing a low carbon development strategy. The paper implemented a narrative literature review and constructed the case study for Guyana utilizing secondary information on policy positions and directives for the energy sector in Guyana. Several pertinent issues within developing countries were identified including centralized and state dominated markets, poor infrastructure to support the transition process, availability of technology, energy justice and energy bullying and a lack of policies that foster community energy systems, energy sensitization and energy investments. These issues also reverberated with Guyana with policy recommendations emphasizing on collective actions needed to address the policy needs of developing countries in their transition process. The issues identified within the policy discussion of this paper can be used by policy makers globally as a potential framework for identifying the research gaps and priority areas to channel resources and technical skills to enhance the energy transition process in developing countries.

Keywords: developing countries; energy efficiency; energy transition; low carbon development strategy; renewable energy policy

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1. Introduction

Globally, an economy's ability to successfully transition its energy industry, whereby renewable energy sources are the primary drivers of economic growth, is now widely considered a critical component of sustainable development[1]. The underlying purpose of the energy transition is to foster low carbon industries, for which policymakers have argued is the marker of an energy-efficient economy[2]. The urgent need for energy efficiency is now well-documented in the literature as the world grapples with the global climate crisis exacerbated by fossil fuels combustion and the resultant greenhouse gas (GHG) emission[3]. According to Wimbadi and Djalante, the Paris Agreement on climate change has called for urgent and transformative actions across all sectors in society to reduce global

greenhouse gas emissions[3].

Stemming out of the Paris Agreement, signatories to the Paris Accord committed to a policy restructure within their economies that would contribute to national efforts (referred to as National Determined Contributions or NDCs) that reflect their highest possible ambitions to reduce GHG emissions[4]. These NDCs were widely incorporated into the developmental framework of many economies - many of which chose to implement a Low Carbon Development Strategy (LCDS) framework[4]. Zhang et al.[5] postulated that a clean energy transition is an effective way to achieve a Low Carbon Development agenda. Mundaca and Busch[6] outlined that the energy transition, particularly low carbon energy systems, has a positive role not only in the ecological dimension of sustainability but also in the context of poverty alleviation and economic prosperity.

Though, in principle, the literature on energy transition shows an idealistic goal in tackling the climate change issue, the reality of the transition process varies from country to country. There are several considerations that need to be accounted for in order to achieve an energy-efficient transition. Factors such as governance, technological and social systems, resource rents, technology spill-overs, legislation, and the policy environment can all impact the energy transition process[3]. Lee and Yang[7] outlined that political systems are direct determinants of energy transitions, with evidence showing several democratic countries unwilling to move away from fossil fuel-based energy. Lisin and Senjyu[8] demonstrated the relationship between financial and stock markets and access to green technologies within a country, having an impact on the renewable energy transition in the country.

The distinctive social and economic dimensions affecting the energy transition in a country are the underlying factors behind the global divide between developed and developing countries in such a process. The more developed economies are on the forefront of energy transition because of their higher capital, stable and well-designed policy environment, advanced technological societies, more diverse economic activities, and their geopolitical positions in international agreements[5,9,10]. According to Cantarero, developing countries presently are lagging behind in the energy transition process because of their unwavering dependence on fossil fuel-based resources, a lack of supporting and enabling policy and legislative frameworks, lack of understanding of societal needs, the level of investments made into renewable energy versus other economic priorities, and the notion of developing countries to look at a one-size-fits-all model without considerations for specific national needs[11]. It is well-documented in the literature that the energy transition process is multi-faceted[8].

This paper therefore intends to explore the breath of literature looking at the energy transition globally particularly for developing countries and present a narrative review on the various social, economic and policy considerations that are needed to effectively facilitate the transition process. The paper will also explore a case study, looking at the challenges and prospects of the economy of Guyana which have committed to a LCDS developmental framework that includes a plan for energy transition. The case study will outline markers of success and pressing policy and social issues in the energy transition process which can then be used to inform and guide other countries in their own transition process.

Through the discourse of this paper, the intention is to unravel the intricate complexities within the literature and how this corroborates with the case study of Guyana. The Guyana case study presented is a unique scenario that can guide policy makers as the country has enacted an LCDS policy, presented NDCs under the Paris agreement, committed to the United Nations Framework Convention on Climate Change (UNFCCC) and is currently experiencing an economic boom from its fossil fuel industry. Guyana from a geo-political standpoint globally is obligated to the energy transition process, however, navigating the relevant policy framework to achieve the gradual transition needs to be disentangled amidst the conflicting economic

and sustainability agenda. Additionally, despite the country recently being upgraded to a developed country status by the World Bank, prior to its oil boom, the country experienced high levels of poverty, institutional corruption, limited technical capacity, high energy costs and improperly maintained energy infrastructure. Therefore, despite this economic prosperity, the country's transition process will be affected by this historical position and thus, demonstrates a deeper complexity within the energy transition process whereby wealth and funding injected to an economy does not necessitate an immediate transition. This is a critical lesson for global policy makers that argue that the gap between the developed and developing countries in the energy transition process can be streamlined by the developed nations funding the developing nations. Though this policy action is still needed to bridge the energy transition gap, this paper will outline the deeper policy issues that needs to be implemented alongside it.

2. Theoretical perspectives and narrative review of the energy transition literature

The literature on energy transition alludes to the process being messy, disjointed, and extremely complicated, predominantly due to political resistance within the country[12]. It is due to this messy, disjointed process where the literature has expounded on several theoretical dispositions on the energy transition process. A study done by Pearson and Bardsley[2] integrated theories on complex adaptive systems and risks as part of the energy transition process, concluding that risk theory is an important guiding principle to understand the propensity for transformational changes within society, enabling the energy transition process. Biely et al.[11] also articulated the need to understand society's propensity for transformational change using socio-economic transition theory, concluding the need for analyzing the energy transition process with individuals being seen as agents of change. The traditional disposition on energy transition has predominantly focused on technology gaps, capital capacity, and infrastructural factors underpinning the transition process. The emergence of institutional and socio-technical factors is a recent development in the energy transition literature, which added new dimensions to the transition process by showing that there are multiple unexplored layers of the transition process[13].

As such, the literature on energy transition is constantly evolving. For instance, Heffron[14] outlined the need to apply the principles of energy justice within the transition policy framework to foster a more effective culture of practice in the energy transition process. Wahlund and Palm[15] conducted a comprehensive review of the role of democracy and citizenship in the energy transition process, adding another theoretical dimension to socio-technical theories that includes participatory engagement in the energy system. Leonhardt et al.[16] also conducted a review looking at government instruments that support community energy globally, with the authors concluding that there are many unanswered research questions, especially on the effectiveness of the various government instruments explored in the literature.

Considering the vast movement globally towards energy transition, the research on the many dimensions underpinning the transition process needs to keep up with the demand for evidence and knowledge to facilitate the policy environment for it. Many gaps exist in energy transition research particularly in the social and institutional dimensions of the transition process. It is on the basis of this knowledge gap that this paper intends to contribute too. Research on the social and institutional dimensions explored in the theory is lagging behind for the developing world and therefore, the narrative review presented here intends to present several policy arguments that developing countries can consider to deepen their understanding of the factors including the social and institutional factors underlying their energy transition process. As demonstrated with the research done by Leonhardt et al.[16] and Wahlund and Palm[15] , comprehensive literature reviews are a good academic stock-taking exercise that groups the existing literature in a manner that can dissect the literature gaps. The

reviews done on energy transition continue to show the multiple dimensions that research needs to fill in order to improve the transition process. As such, applying a literature review process for this study can give a comprehensive overview of the policy and research gaps needed for developing countries, which can then guide policymakers on areas they need to focus on developing to facilitate a more effective transition process.

In conducting the narrative review for this paper, the literature was gathered using online sources and databases including Google Scholar, Web of Science, Scopus and EBSCO. Through the literature search sources, the following search terms were entered; 1) energy transition theory; 2) energy transition policy; and 3) energy transition in developing countries. From these search terms, three categories of literature were compiled for the narrative review. The first category looked at the theoretical perspectives especially within the past five years. The second category looked at research on existing policies especially within developed countries and the third category explored the literature on energy transition issues within developing countries. Additionally, for the case study explored on Guyana, literature was sourced from public records and reports from the Guyana Energy Agency, Caribbean Community (CARICOM) energy reports and the International Renewable Energy Agency (IRENA) reports. The synthesis process then entailed constructed narrative policy arguments based on economic, social, institutional and legal factors in the energy transition process where the literature was used to demonstrate what is done with the current research on existing policies within these factors, what needs to be done with the limitations outlined in the research for developing countries and Guyana within these factors and the rational of various policy approaches based on the theoretical arguments presented in the literature. The synthesis of the literature was then presented in the subsequent sections as a narrative argument with potential policy recommendations and research gaps outlined for developing countries.

3. Economics considerations of the energy transition process

As outlined in the literature, the energy transition for any country is a complicated process often requiring the coordination of several moving parts within the economy. When a country commits to an LCDS framework that includes an energy transition initiative, as previously outlined, a thorough understanding of specific social, cultural, ecological, and economic issues is imperative. For instance, consideration has to be given to the capital requirements needed for this transition. Sareen and Haarstad[17] highlight that a low-carbon energy transition is not a matter of shifting from one regime to another but more of an intricate process of change that has to analyze societal costs, risks, and benefits accrued. Further delving into the points raised by Sareen and Haarstad[17], it is generally assumed in the literature that an increase in energy efficiency will reduce the price of energy[3]. However, during the transition process, the cost requirement is often high, and the benefits derived from the transition may not be recognized in the short run[18]. According to Hunt and Evans[19], the incremental capital costs to invest in a renewable energy technology can be substantial when compared to energy savings in the short run, and therefore, policymakers often look at the pay-back period to assess the economic feasibility of investing in this technology.

The literature on the economic considerations of energy efficiency was synthesized by Fowlie and Meeks[20], whereby they identified a bulk of research focusing on the private returns on energy-efficient investments, market failure and under investments, and cost-effective analysis on varying energy-efficient policy options[7,21–24]. The key principle observed in all the literature on the economics of energy efficiency is the concept of feasibility in the transition process. The feasibility process has two considerations. As standard economic theory would dictate, essentially if the net social benefits of the energy transition are maximized over time, then the transition process would be desirable. The second consideration is the status of the energy market. As outlined by Geraden et al.[23] market failure in the domestic energy market can be attributed to monopolistic behaviour or the market not capturing all marginal external costs associated with energy

production.

Synthesizing these economic perspectives from a developing country's viewpoint, considerations of feasibility must account for several key factors. Firstly, the domestic energy markets in many developing countries are often state-controlled and exhibit monopolistic behaviour. This centralization of control can impact the flexibility and efficiency of the energy sector[25,26]. Secondly, investments in the energy sector are frequently subsidized by state funding. Consequently, the opportunity cost of allocating resources to energy investments may compete with other crucial developmental needs, such as human capital development or poverty eradication[9]. Thirdly, the availability of capital for investments in developing countries plays a pivotal role. If the marginal cost of transitioning to low-carbon energy exceeds that of fossil fuel-based energy, the economic incentives for such a transition diminish[21,27]. Babayomi et al.[28] highlight that the initial stages of the energy transition involve high financial costs, potentially causing socioeconomic shocks, particularly for low-income countries. They underscore the need for further research on how developing countries can navigate the energy transition without compromising other critical developmental needs. Political systems are crucial in the techno-economic analysis of energy systems, as emphasized by Edomah[29]. Understanding the systemic implications, externalities, and network effects is essential for a comprehensive evaluation of the energy business[29]. Egli points out the significance of the weighted average cost of capital in assessing the feasibility of adopting low-carbon energy projects. Countries are more likely to shift towards low-carbon energy sources if the capital costs associated with these projects are lower than the alternatives[27,30]. Global projections indicate a decreasing gap between the marginal costs of fossil fuel and renewable sources. Studies demonstrate a reduction in the cost of renewable energy compared to fossil fuels, driven by international pressures to mitigate climate change[27,30].

The literature reveals energy transition in several countries, with countries documenting over one third of total energy generation done with low carbon technologies. According to Fabra[31], the rapid expansion of intermittent renewables is bringing new challenges for the performance of electricity markets under current structural designs. The arguments of Fabra[31] were based on the disposition presented by Joskow[32] who indicated that the current market design can raise questions about the long-term price signals that will support investments in energy-efficient portfolios that can generate and store energy consistent with public policy. Essentially, these arguments lead to the fundamental question of whether there is a regulatory and policy environment that can stimulate the investments needs particularly for the shift in infrastructure needed for the energy transition.

This is a pertinent challenge for developing countries as they need to find the mechanisms to attract investors into their energy markets. Additionally, several developed countries have piloted numerous energy projects since the early '90s, giving them a better understanding of how the energy transition can affect their energy market. For example, Cambini et al.[33] conducted a study on market and regulatory factors influencing smart grids in Europe, focusing on the pilot project done in Norway and how these projects impacted energy reform. In this study, Cambini et al.[33] outlined that the success of the pilot energy projects in Norway has seen a rapid integration of distributed energy resources, and Norway now can meet energy demands with a quality-adjusted revenue-based mechanism. The economic dynamics of the energy market are poorly understood for developing countries, and this can be an impediment to the capital investments needed for the shift in structures required for the energy transition. According to Babayomi et al.[28], many developed countries have highly inefficient grid structures, large rural populations unable to access a consistent grid supply, and a high capital cost recovery ratio. The conclusions of Babayomi et al.[28] can be attributed to the issue that developing countries have a state-operated energy market, which fosters energy provision more as a public good rather than a private commodity that can be incentivized. Developing countries, therefore, require energy transition

technologies that are affordable based on state-allocated resources, as the lack of private markets will not drive technology spill-overs through competitive market forces.

4. Social and community issues in the energy transition process

The literature on energy transition throughout the years has predominantly focused on understanding resource efficiency and the supply-side issues in energy distribution[34]. Of recent, researchers have started to recognize the importance of the demand side of energy, particularly the role of the community and civil society in the energy transition processes[10,35–37]. Understanding the community dynamics in energy transitioning is firstly hinged on the simple fact that energy production, particularly electrification, is primarily used by households. Communities comprise the largest share of the energy market. As a result of this, the transition process has to factor in two important issues; 1) consumption-related energy efficiency and 2) energy distribution and access.

According to Seyfang et al.[34], it is a well-established notion that sustainability processes such as energy transition necessitate community action and incorporating participatory and grassroots knowledge in any decision-making process. The community involvement in the energy transition process has now emerged as a force of change for the entire energy structure in some countries. The issues associated with consumption-related energy efficiency have evolved beyond the traditional viewpoint of energy-saving strategies (such as minimizing household use of electricity and energy-efficient appliances) at the household. Gui and MacGill[38], for instance, highlighted that electricity industries around the world have evolved from large-scale generation facilities with centralized transmission and distribution to a more decentralized system, with social innovations and community support for cleaner energy as the catalyst for this evolution. An example of this was documented by Mucha-Ku´s et al.[39], who highlighted that decentralization of large-scale energy, pro-ecological generation and distribution of energy, and the building of a civic dimension for the energy sector are the main objectives of the energy transformation process for the European Union. Energy directives in many developed countries are attempting to foster inclusivity and equality between consumers, producers, distributors, and energy communities shifting towards a legal and policy environment for a liberal energy market[40]. Policymakers in developed countries fostering social inclusion in the movement to a more liberal energy market understand the paradigm of opening the energy market across borders to communities within their country will drive competitive technological spillovers. According to Goldthau and Sitter[12], the gap between existing energy technologies from neighbouring territories and countries reaching the needs of communities in times when national energy suppliers struggled to address those needs caused major concerns across the European Union. Goldthau and Sitter[12] further emphasized that the liberal approach in the EU energy policy is sufficient and has proven its worth in managing the consequences of external shocks to energy supply and prices.

In addition to social and community involvement in energy transition policies and in the liberalization of energy markets, the demand-side factors are widely recognized in the literature as the catalyst needed for the technological innovations required for the energy transition. The literature shows that when communities are often proactive in adopting and utilizing low carbon energy technological innovations, this leads to further development and mass-market uptake, particularly in small-scale renewable technologies such as solar panels, solar heaters, and pumps[11,28,41]. There is a growing base of research on societal influence in technological innovation[41–43], but the literature also highlights that in energy transition policies, there has been a long neglect in recognizing citizen contributions to sociotechnical changes[20]. The research done by Hanke et al.[44] best encapsulates the role of communities in energy transition by outlining that renewable energy communities have become critical players in driving a citizen-led energy transition in Europe. The study done by Hanke et

al.[44] further postulates that these energy communities contribute to energy decentralization, energy democratisation, increased awareness of the energy transition, and create local economic value, develop skills, and build capacities. Hyysaloz[36] identified that energy decentralization based on renewable technologies is critical in transitioning away from fossil-fuel-based energy. Tomain[45] outlined that energy democratisation is needed for a sustainable energy environment as this empowers consumers with their energy choices, and therefore, assuming that most consumers are rational, they would seek efficiency-maximizing choices. De Pascali and Bagaini[46] outlined that participatory energy transition is vital in urban transformations and regeneration whereby good practices integrate energy with economic stimulus, mobility of skills, and overall sustainability.

The nexus in energy transition research involving the social dimension of sustainability is the focus on energy justice. This aspect of the energy transition focuses on applying the principles of justice to energy policies, energy production and consumption, energy systems, energy security, and activism and climate-smart energy technology[25,47]. According to Jenkins et al[48], energy justice concepts evaluate three things: a) where injustices emerge; b) which communities in society are ignored; and c) what processes exist for remediation. The literature has outlined several methods in exploring the social dimensions of energy supply with implications for applications in energy justice assessments[23,46]. Miller et al.[49] outlined three policy areas where energy justice research can contribute to more ethical energy transition policies. According to Miller et al[49], the three policy areas identified are: a) envisioning the practice and techniques for potential energy futures needs to be analyzed and modeled; b) public forums and consultations to deliberate, debate, and make energy choices; and c) the mandates of institutions to conceptualize, operate, and regulate the energy systems.

The complexity with energy justice considerations within the transition process is the depth of injustices that can arise from the energy market. Energy justice factors are not standard and vary from country to country. For instance, each source of energy itself is imbued with numerous social and environmental ethical issues[50,51]. Take, for example, implementing nuclear energy as a low carbon alternative energy source will also include the issues of radioactive waste and the potential threat of a nuclear disaster to the communities surrounding the nuclear facility as seen in Chernobyl, Ukraine, or Fukushima, Japan. Another example notable to countries such as China and Brazil is the development of mega Hydro Electric Plants along the course of large rivers, which often result in hydrological and ecological disruptions downstream and disturbances to the communities that depend on the river hydrology and ecology[37,52]. According to Rehner and McCauley[52], issues of morality reflected in national policies are powerful stimulators in shifting the energy market, as seen in Germany where the country moved away from nuclear energy after the nuclear disaster in Fukushima, Japan. The example presented by Rehner and McCauley[52] is a good demonstration as to the influence and depth of energy justice on energy markets. The potential linkages between justice and the energy transition are still in their infancy, but for an effective transition process, an assessment of energy justice is needed. Hefforn and McCauley[53] highlighted that understanding energy justice and its role in the economy has a significant impact on policymaking. The authors further outlined the role of including energy justice research conducted by scholars as a major part of the policy process. Jenkins et al.[48] best surmises the role and policy issues of energy justice by indicating that social justice must be part of the energy transition thinking; the question is how to conceptualize it to the context of the various energy systems.

5. Energy transition in developing countries

In exploring the literature on the energy transition, a notable observation made was the limited number of studies looking at the social dimension in the transition process for developing countries. Lacey-Barnacle et al.[54] was the first systematic review paper done looking at energy transition in the developing world, for which

the authors outlined the fundamental core and theoretical frameworks for energy justice originated from the work done in developed countries. Monyei et al.[55] outlined a clear demarcation of energy justice between the developed northern countries and the underdeveloped southern countries. The authors argued that the developing countries are victims of 'energy poverty' and energy 'bullying,' which essentially displaces their domestic energy markets through the competitive market forces created by the developed countries. Ambole et al.[9] outlined that the conversation on energy transition at the community level is going in different directions between the developed and developing world, with the more developed countries focusing on community-based mobilization and resources to secure alternative energy pathways, while developing countries are looking at low-carbon energy for energy-poor citizens. Our search through the literature did not show any empirical studies that outlined specific evidence-based conclusions for developing countries, and few papers sourced on the social dimension of the energy transition in developing countries were based on narrative or systematic review perspectives[18,34,56,57].

The majority of literature on the energy transition for developing countries focuses primarily on supply-side economic factors. Vanegas[58] outlined that the most common policies adopted by developing countries are renewable energy targets and tax incentives aimed at the power sector. Kim[59] indicated that the energy transition in developing countries depends on energy aid from donors in developed countries, and donor contributions are directly related to global climate policies such as the Kyoto Protocol. Ram et al.[60] acknowledged a clear disparity between the efforts of the energy transition between developed and developing countries, with the developing countries challenged by the financing mechanisms needed for the transition process. The literature outlined shows a limited scope in the energy transition process for developing countries. There are several case studies globally looking at specific energy transition challenges experienced by various developing countries. Shari et al.[61] outlined that there is a fluctuating process in the adoption of clean energy technologies at the household level in Nigeria, which is directly pinned to the price of liquefied petroleum gas. Additionally, this study in Nigeria concluded that the policy environment is not intervening sufficiently to see the steady transition process, especially in rural areas. Abdelbaki Mahmoud Abdelbaki Hamza[25] conducted a study in Egypt which outlined that socio-cultural and regulatory constraints are the main barriers to community renewable energy niche markets, and that the renewable energy transition process is led by large-scale technological developments that are centralized and void of civil society involvement. A study done by Lalnazov and Keeley[1] in Indonesia and Vietnam outlined that policymakers in developing countries are primarily concerned with energy security, energy access, and economic development through the existing energy markets, and the main barriers for the energy transition in these countries were the lack of technology, lack of financing, and lack of skilled human resources. Emodi et al.[62] found that Nigeria's preference for fossil fuel is shifting towards price inelasticity, which is triggering a reverse energy transition and limiting the uptake of clean energy at the household level. This study by Emodi et al.[62] concluded that the policy intervention needs to reduce the cost of living, increase household income, empower women, and improve clean energy access to alleviate the reversal of the country's energy transition process. Maswabi et al.[45] argued that the energy transition in Botswana can only be achieved through a regime-based reconfiguration driven by the country's political system.

In all the cases reviewed for this study, the general tone in the barriers and challenges in the energy transition for developing countries is similar. The dominance of a centralized system, concerns for economic and energy security, the price of the transition, and the lack of understanding of the community role and justice issues are the underlying factors observed in the literature. Another common theme found within the literature is the notion that the transition process means a total elimination of fossil-fuel-based energy. Nalule and Mu[24] argued that experts have often shamed countries with a desire to develop fossil-fuel-based systems, but it is a

process of decarbonization, and each country will undertake this process differently. Nalule and Mu[24] further outlined that European countries have spearheaded the decarbonization process through energy efficiency, energy decentralization, energy communities, and smart grids, whereas many developing countries, especially in rural areas, still depend on and progress economically from traditional carbon biomass sources of energy. Overall, the scholarly work on the energy transition issues was best summarized in the review done by Goldthau et al.[12]. This study demonstrated several novel research works that systematically outline the main energy transition issues faced by the developing world. The common themes in the study from Goldthau et al.[12] corroborate the evidence found in this review, whereby studies have demonstrated decentralization of energy systems as key to energy efficiency and the need to link economic development with off-grid energy solutions[4,13,63]. Additionally, the considerations of the sustainable development goals (SDGs) of countries and the role that individual stakeholders alongside the domestic political systems play in the energy transition process, especially in achieving SDG 7—affordable and modern energy[26,64,65].

6. Energy transition case study of Guyana

Guyana, as a developing country, is a unique case study on which to report. The country in recent times has committed to several international climate agreements and as part of their NDCs, the country has committed to reduce deforestation and to a low carbon development strategy[66]. Interestingly, the country is on the cusp of a major oil boom for which it has been projected that the country is expected to see as much as 40% growth in the economy. The country on paper has committed to an energy transition process as outlined in its Low Carbon Development Strategy but this transition process has been slow. Figures from 2019 show that 96% of Guyana's electricity generation is still fossil fuel based, with wind and solar amassing under 2% of contribution of generation. The country has an electrification rate of approximately 88% with 12% of the population having little to no access to an affordable and reliable energy services. According to Neil Gardner et al.[67], Guyana's transition to renewable energy is constricted by: 1) partial subsidies granted to the fossil-fuel energy market across Guyana to communities such as Linden where there are relatively lower tariffs in energy production; 2) high capital cost of renewables weighted against the fuel price risks; 3) capital market preferential treatment for the fossil-fuel energy market; 4) lack of technical skills in renewable energy systems though of recent, national institutions such as the Guyana School of Technology and University of Guyana have developed curriculums and programmes in renewable energy; and 5) poor market acceptance with perceived financial risks and high transaction costs by energy consumers. The conclusions drawn by Gardner et al.[21]align with the literature generally on the barriers of renewable energy transition in developing countries whereby the lack of investment and market willingness, lack of technical skills and fuel price signals have often impeded the transition process.

Despite these challenges, Guyana has made strides in their policy directive for decarbonizing their energy systems. The Guyana Energy Agency (GEA) has outlined a national mandate to provide affordable, stable and reliable energy for all in Guyana with an energy mix programme that includes hydropower, solar, wind, biofuels and biomass and natural gas. The policy directive outlined by the GEA includes 1) an interim production 300 MW from natural gas to compensate for energy supply shortfalls during the transition process; 2) urgent action to upgrade and improve the national grid; 3) complete hydropower facilities at outlined locations in Guyana; 4) invest in more solar and wind energy sources for off-grid areas to open electrification access across the country; and 5) develop micro-grids in the large interior area of the country to open energy access to indigenous and rural communities. Since 2012, Guyana has implemented a fiscal incentive whereby value added taxes and import duties have been removed on renewable electricity equipment, energy efficient lighting and solar appliances. There were several energy projects implemented which were targeted at boosting electrification especially in rural areas. In 2004, Guyana implemented the Unserved Areas Electrification

Programme which served 40,000 new connections to the electric grid and 1,750 solar systems installed in homes, schools and community buildings. The Hinterland Renewable Energy project was implemented in 2014 with an aim to support the energy needs of rural households who are not connected to the national grid. The project installed 11,540 home energy systems in nearly 200 rural communities and the project team also trained 400 indigenous people to install and maintain these systems. Guyana had also signed several agreements with Brazil and China to develop hydropower operation particularly in the areas of Amalia Falls and the Upper and Middle Mazaruni area. To date, these hydropower projects have not materialized and are still undergoing approval processes. The issue for the implementation of these hydropower projects are due to the changing scope of these projects under multiple administrations. Despite this, there are a few small hydropower project sin progress including the Kato project, the Moco Moco project and the Kumu Project.

Guyana's commitment towards a low-carbon development strategy is occurring at a point where the country is also increasing its domestic production of fossil fuel. The booming oil industry can result in the country being a positive net emitter of carbon primarily from the downstream industrial effects from the volume of petroleum products produced. Despite this contradictory perspective, the oil boom in Guyana can be seen as a vital means to enhance the energy transition process. A key challenge in energy transition as outlined in the literature for developing countries is the lack of capital investments needed to build the infrastructure required for the transition process. Guyana had started making renewable energy infrastructural investments even before the emergence of the oil industry. The oil industry can now provide the capital needs to expand upon the work already done. Shifting the resource rents from the oil industry towards investments in the renewable energy sector would see Guyana move towards a sustainability pathway based on the Hartwick's rule of sustainability as outlined in the study done by Mentis and Moonsammy[42]. In order to achieve this, Guyana's policy environment needs to be restructured in order to facilitate the shift in investments towards renewable energy. The study conducted by Mentis and Moonsammy[42] also measured the country's genuine savings which is used in weak sustainability literature as a measure for investments in renewable capital development[56,68]. The study outlined that prior to the oil boom, Guyana's policy environment did not facilitate a positive genuine savings trajectory and the country has little re-investments made from its resource rents into renewable capital industries. With the injection of rents from the oil industry, Guyana's investment policies cannot adopt a business as usual approach or else the energy transition process will be undermined. Guyana can learn from countries like Norway who invested a large proportion of their fossil-fuel rents into several renewable energy projects.

Guyana's low carbon development strategy aligns with the perspective of Nalule and Mu[24] where the country's process is focusing on economic development by reducing carbon output, but not totally eliminating it. In addressing the challenges of the energy transition process, Guyana is in a position to deal with the lack of capital investments for infrastructural needs, however, other key investments are also necessary. The country must invest in human capital development to enhance the technical skills capacity of the population to integrate the technologies needed for the energy transition. According to Dos Santos[69], human capital development through technical and vocational education training in Guyana is being impeded by a lack of investments in technological infrastructure, programme development and high energy costs. Additionally, the literature on the energy transition in Guyana has very little discussions on other key social dimensions such as energy justice and energy communities. One study done by Blair et al.[22] outlined a community based participatory approach entitled the Community Access Resource for Electricity Sustainability (CARES) which seeks to empower a rural energy community in Guyana. Aside from the study done by Blair et al.[22], most of the energy transition literature for Guyana focused on the potential of wind, biomass, biofuel and wave energy[47,70,71] and a few studies on energy efficiency monitoring and energy use across the country[72–74].

The energy policy environment for Guyana is predominantly centred on developing low carbon electrification available and accessible to the entire population. As such, the policy initiatives have focused on developing several renewable energy projects using the resource base of the country. For the short the medium term period, Guyana's energy mix will incorporate a gradual reduction of its fossil fuel based energy reduction but it most likely will not totally eliminate fossil fuel use. The policy environment for the demand side perspectives of the energy market in Guyana has focused on influencing consumer behaviour to reduce energy use or to choose more energy efficient options. Fiscal policies were developed to provide tax incentives for consumers and businesses using sustainable energy technology. Fiscal policies were also developed to subsidize the fossil-fuel based energy generation as the country still heavily depends on fossil fuel for its economic growth. The main areas in which Guyana needs to explore further to facilitate its low carbon energy transition goals are within the sphere of the multiple social dimensions that exist in the energy market. The country needs more inclusive energy policies that recognize energy justice, facilitate more rural energy communities, decentralize the energy market away from state affairs (though pragmatically for Guyana's context, this should be done as a hybrid process), and more investments in human capital development focused on technical capacity enhancement in the renewable energy field.

The stark reality for countries like Guyana is that the energy transition process is inevitable. Though the transition process aligns with the LCDS for the country, the shift towards decarbonisation has to come with the financial back drop of its oil and gas industry. It then raises the pertinent questions of the risks associated with transitioning and complying with the LCDS. Policy makers in Guyana now need to consider the country's state of readiness for transitioning and achieving the LCDS goals which therefore implies a comprehensive assessment of the state of readiness by the government and institutions.

7. Recommendations and policy considerations

As outlined in the literature reviewed, the gap between the energy transition of developed countries and developing countries is clear. Essentially, the developmental needs of the country directly impact how the country undertakes the transition process. The geopolitical influence, capital base and social capital strength of many developed countries have allowed the lateral freedom for these countries to explore very intricate social and economic issues that impacts the energy transition process. Developing countries, on the other hand, are very susceptible to shocks from the global energy market and have a lower risk bearing ability in their energy transition process. As such, developing countries are less inclined to make the necessary investments in exploring all the dimensions of the energy transition process. As outlined in the literature for developing countries and in the case study of Guyana, most developing countries focus on the supply side energy processes with a goal to reduce fossil fuel use. Generally, the literature on developing countries and case study for Guyana showed a slower uptake of renewable energy technologies when compared to the developed countries. The main reasons identified for this difference between developed and developing countries were the difference in capital, difference in technical capacity and the incorporation of community, social and cultural factors in energy policies.

The case study on Guyana has demonstrated some key policy areas whereby other developing countries can address the gaps in the renewable energy uptake. Green industrial fiscal policies such as tax incentives, duty free concessions and tax havens for sustainable energy technologies is a solid policy solution to promote consumer uptake of renewable technology by making it more affordable. Even so, the tax incentives are still not impacting all renewable technologies presently as some technologies like batteries are still costly to the average consumer. These policies though cannot exist in isolation or stand alone as a mechanism to solve the transition issues. Green industrial fiscal policies can only be effective if there are support services that can

provide the technical information needed for consumers to effectively adopt renewable technologies. The literature explored for Guyana did show this sort of service sector existing for the country but it is still in its infancy. Guyana Power and Lights (GPL) and the Guyana Energy Agency (GEA) are partnering with private sector companies in Guyana to advise customers on photovoltaic systems. The GEA also provides technical advice to private and public organizations in transitioning their energy systems to photovoltaic. These technical services need to be evaluated though to determine whether the information is provided in a manner that is useful to non-technical consumers Without understanding technocrat services effectiveness according to Roger's diffusion of innovation theory, the adoption process will be delayed as factors of technology complexity, technology compatibility and the relative advantage of technology use will not be fully understood by adopters[41].

Aligned with the absence or infant technocrat services sector for the energy transition process, many developing countries are often disadvantaged in the energy markets by having state owned centralized energy systems. As outlined in the economic theory literature, state owned centralized systems can treat energy generation as a public good which is a source of market failure. The reason why most developing countries have this state owned centralized system operating as a public good is to ensure a low energy cost to poor communities of the country. In the absence of capital injection or economic growth within the country, the state energy systems often lack capital to invest and diversify its energy operation and in some cases as outlined the literature for several developing countries including Guyana, the cost of energy production is too high when compared to the revenue from energy distribution. The revenues generated from energy distribution often only cover the recurring expenditures of the energy generation operation which therefore means that additional services, such as maintenance and upgrades are compromised. In order to move away from a state based centralized energy system, an investment policy framework is needed whereby developing countries can promote the ease-of-doing-business, foster public private foreign direct investment partnerships and explore competitive based bi-lateral energy trade agreements. The intent of an investment policy framework of this nature is to attract more privatized competitors in the energy market. Creating a privatized and competitive energy market can provide several social benefits including technology spill overs to consumers, improvement in energy maintenance, upgrades and services and a socially efficient energy price on the market.

The literature outlined for the developing countries including Guyana showed very little policy perspectives looking at social, cultural and community factors in the energy transition process. Majority of the literature outlined SDG 7 and improving electrification access especially to rural communities as the main tenets of social dimension in the energy transition process. The process of achieving energy access in developing countries focuses primarily on improving the infrastructure of the energy system. Though this is needed to improve electrification for poor and rural communities, the perspectives of the social dimension of the energy transition process needs to go beyond just the supply side factors. The literature on the energy transition for developed countries outlined several reasons why a country needs to understand factors such as energy justice, energy communities and adoption and diffusion factors of renewable technologies. For developing countries, energy justice, energy communities and understanding the adoption and diffusion factors of renewable technologies needs to be incorporated into their energy policy framework. Incorporation of energy justice into the policy environment can be a complicated process as injustices in the energy sector can occur nationally, regionally and internationally. Developing countries can therefore consider forming a national energy justice commission with the purpose of documenting energy injustices occurring at the community level and nationally and recommending the necessary mitigative or adaptive policies to address it. Another key mandate for the national energy justice commission should be to develop a participatory knowledge database that can be accessed by the public. This sort of knowledge database will be critical in

monitoring rural communities and empowering communities to make informed decisions about their choices in the energy system[51] . Empowering communities is the backbone for the formation of energy communities. As outlined in the literature, several developed countries have recognized the role of energy communities and have developed legislative frameworks to incorporate these energy communities within the energy transition process[75] .The formation of energy communities can benefit from the types of fiscal policies outlined for Guyana as this can foster the development of community based off-grid energy systems. Energy communities are also critical in the energy decentralization process and shifting away from the state-based energy system[76]. For developing countries, the inclusion of energy communities in the national energy policies needs to be considered[77–79]. Fostering the formation of energy communities is multifaceted and includes considering the socio-cultural landscape of the communities, the geographical landscape and the adoption and diffusion factors of renewable technology[80]. For instance, decentralization may be the only option in fully energizing Guyana as majority of the communities that lack adequate electricity in the country are due to their remoteness. As such, if the national energy policy outlines the formation of energy communities as an objective, then the policy actions needed to achieve this objective include; 1) investing and conducting community needs assessments (which is currently underway); 2) developing more technology transfer programmes; 3) fostering public and private energy boundary organizations; and 4) incorporating communities in pertinent national energy matters[81–84].

Specifically looking at the overall differences between developed and developing countries, a systematic issue with the several energy transition gaps outlined in this study between developed and developing countries is the potential of 'energy bullying' which in itself is a complicated matter. The position of developed countries in energy markets due to their technological and services advancements, higher skilled capacity and financing can result in developing countries being exploited. Energy services and suppliers from developed countries often monopolize renewable technology access to developing countries which can often lead to access issues[43,85–87]. Another argument in the literature looks at the responsibility of fossil fuel emissions being most prominent amongst developed countries with the impacts mostly felt by developing countries. Researchers have contentiously argued that the international organizations dealing with climate change are often funded and spearheaded by developed countries and advocate for energy transition to renewable energy globally while developed countries still maintain a high fossil-fuel use[43,55,61,88] Bridging the energy transition gap between developed and developing countries needs to be further explored especially given the sentiments of the World Energy Transition Outlook which highlighted the need for governments to fast-track the energy transition process in order to meet global carbon reduction targets. Further empirical work is needed on the policy gaps between developed and developing countries, the feasibility of implementing the policy practices of the developed countries in developing countries and understanding the risk bearing ability and injustices of developing countries to transition away from fossil fuels especially on their social and economic conditions[89–92].

8. Conclusion

The literature explored on the energy transition for developing countries shows that there are several empirical and policy considerations needed to improve their transition process. Majority of developing countries have recognized and initiated projects to decarbonize economic activities but the transition process has been generally slow. A narrative review of the literature on energy transition was presented with a comprehensive look at the energy transition process in the developing country of Guyana. The main gaps identified in the literature for developing countries were the limited inclusion of social issues such as energy justice, energy communities and participatory processes in energy policies. Several pertinent economic gaps were also identified including the lack of investment structures, price vulnerabilities and centralized energy

systems where energy is provided as a public good.

An energy transition case study was explored with the economy of Guyana. The energy situation in Guyana shows a country committed to the transitioning process but lack the capacity, infrastructure and unsure of its state of readiness to facilitate this transition process. The Guyana cases study also eludes to a larger transition issue for countries who are in the infancy of their transition process, which is the needed time frame to fully transition. Many countries are unaware of the timelines needed for transitioning which stems from a lack of understanding of the current status of their energy system and the areas of strengths and weaknesses that will guide the transition process. Guyana and the many other countries at the infancy stage of the transition process should conduct a SWOT (strength, weakness, opportunities and threats) assessment of its energy system to identify the areas needed to facilitate the transition process.

The myriad of policy gaps for developing countries needs further empirical work to explore the various causalities between their social and economic dimensions and energy transition process. Overall, developing countries are making the necessary steps towards a low carbon energy market by using the resources and capacity they have at their disposal. Fundamental to their pathway in the energy transition process is the role of new knowledge and research to inform their energy policy direction. This paper attempted to outlined the pertinent policy gaps and provide some policy insights that can potentially guide the energy policy makers from developing countries. The intention of this paper is to provide a narrative insight to bridge the transition gap between developed and developing countries and to guide developing countries in the areas to explore in order to improve their energy transition process. The discourse presented in this paper can benefit governments and firms by identifying priority areas in the energy sector to allocate resources to improve the efficiency of the energy transition process. As the energy transition process is seen as a necessity for an energy secure future globally, the collective actions needed to achieve energy and climate goals only underpins the importance of ensuring all developing countries has the means and capacity to make this transition effectively.

Conflict of interest

The authors declare no conflict of interest.

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