Expert Journal of Economics (2014) 2, 37-44
 ISSN 2359-7704
Economics.ExpertJournals.com

Achieving the Renewable Energy Target for Jamaica

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The high cost of energy in Jamaica, one of the highest in the Caribbean region, is usually cited as a hindrance to industrial development and efficiency, especially in the manufacturing sector. High energy cost is also considered to be a national energy security issue and the government is taking steps to ensure adequate supply of energy at affordable prices. In the current National Development Plan, the government has set a target for renewable energy sources to supply 20% of the country's energy need by the year 2030. Using a linear programing model of energy planning, we examine how realistically this target could be achieved. Our findings indicate that the 20% renewable energy target is technically achievable with the optimal plan showing a mixture of wind power, hydropower and bagasse power but no solar power. However, when the timeline for investment in new generating capacities that will ensure the attainment of the target is considered, it becomes highly improbable that the target will be met. This study fills the gap that exists in evidence-based analysis of energy policy in Jamaica.

Keywords: *energy planning; energy policy; renewable energy; linear programming; evidence-based policy analysis; Jamaica*

***JEL Classification**: C60; O21*

1. Introduction

Energy issues have dominated national discuss in Jamaica in recent times. Since the Government of Jamaica (GOJ) announced a plan in 2004 to introduce liquefied natural gas (LNG) into the country's energy mix as a way to diversify energy sources and reduce the price of energy, there has been a lot of excitement on energy-related issues in the island. With a population of about 2.7 million people, Jamaica is the largest English-speaking country in the Caribbean. The economy has been on the decline with negative growth in GDP for most of the last decade. Between 2008 and 2012, GDP value added declined, ranging from a low of 0.5% in 2012 to a high of 3.4% in 2009. The only growth (1.4%) recorded in that interval occurred in 2011. During this period, the manufacturing and construction sectors, both energy-intensive, recorded greater declines in GDP value added than the economy as a whole (BOJ, 2013). The potential for the manufacturing sector to drive economic growth and provide employment opportunities has always been sounded by the Jamaica Manufacturer's Association (JMA). Given that imports of manufactured goods constitute about 10% of all goods imported to the country compared to just 1% of exported goods (BOJ, 2013), the argument for import-substitution sounds tenable. However, JMA and other stakeholders have consistently cited high energy prices as a detrimental factor to industrialization in Jamaica. For example, industrial rate for electricity in

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Article History:
Received 18 June 2014 | Accepted 25 June 2014 | Available Online 27 June 2014

Cite Reference:
Abdulkadri, A.O., 2014. Achieving the Renewable Energy Target for Jamaica. *Expert Journal of Economics*, 2(1), pp. 37-44

Jamaica is US$0.31 per kWh compared to US$0.06 in Trinidad and Tobago (Makhijani et al., 2013), its major regional trading partner.

The energy issue has been paramount on the agenda of the GOJ and a number of initiatives have been floated and policy measures taken to tackle it. The government adopted a national energy policy in 2009 with the vision to attain "a modern, efficient, diversified and environmentally sustainable energy sector providing affordable and accessible energy supplies with long-term energy security and supported by informed public behaviour on energy issues and an appropriate policy, regulatory and institutional framework" (Ministry of Energy and Mining, 2009, p. 1). The national energy policy also feeds into the broader national development plan, Vision 2030 Jamaica, with the vision to make Jamaica, by the year 2030, "the place of choice to live, work, raise families, and do business" (Planning Institute of Jamaica, 2009, p. 1). Both the Vision 2030 Jamaica and the national energy policy have set specific goals for renewable energy (RE) sources to form an increasing share of the country's energy mix, reaching 20% by 2030. Although the government remains committed to this goal as outlined in policy statements, it remains uncertain if the targets will be achieved by the deadlines.

Lack of substantial progress towards energy diversification has called to question the reliability of the targets for renewables set by the government. In this paper, focusing on the electricity sub-sector, we examine the progress made so far in incorporating RE sources in the generation of electricity in Jamaica vis-à-vis the required progress that is needed if the targets are to be met. Using a linear programming model, we developed an energy plan that specifies the amount of electricity generation required to meet expected future demands, disaggregated by source. Our model suggests that a rather rapid investment in RE sources is necessary if the targets are to be met. Based on the optimal least-cost plan, only wind, hydro and bagasse power are the recommended RE sources that should be considered over the next 16 years. The results have implications for policy. Although Jamaica has abundant solar energy potential, based on current costs and already installed fossil-fuel generating capacity, solar power is not an economic investment for the country. Therefore, if the targets for renewable energy are to be achieved in the electricity sub-sector, greater emphasis should be placed on wind power and bagasse power as energy sources.

In the next section, an overview of the energy sector in Jamaica is presented. This is followed by the methodology section in which the linear programming (LP) model used to generate the optimal energy plan for Jamaica is presented and a description of the data and sources of data is provided. The results are then presented followed by a discussion of the findings. The paper concludes with implications for policy.

2. The Energy Sector in Jamaica

Petroleum is the major source of energy in Jamaica, accounting for 90% of the country's energy needs (Ministry of Mining, 2009). Electricity generation constitute the largest share of petroleum consumption (31% in 2010) and oil accounted for 95.3% of 4214 GWh of electricity generated in 2009 (Makhijani et al., 2013). The Petroleum Corporation of Jamaica, an executive agency of GOJ, has the sole authority for oil importation. In 2011, the government spent more on oil importation (US$2.2 billion) than the country's total export receipts (US$1.65 billion) (Makhijani et al., 2013). For a country experiencing a stagnant economy, such a mismatch erodes foreign reserves and further aggravates the domestic economic situation. Understandably, energy security and affordability are key goals of Jamaica's national energy policy and the introduction of renewable energy is seen as a critical factor in achieving these goals. To that end, the GOJ has set targets to increase the share of RE sources from 5% in 2008 to 12.5%, 15% and 20% by 2015, 2020 and 2030, respectively.

Diversification initiatives in the energy sector have mainly been focused on the electricity sub-sector, except for the introduction of ethanol fuel (E-10), in the earlier years, in the road transportation sub-sector. The energy mix diversification drive has been slow and hampered by many factors, including regulatory, financial and technical issues. The Jamaica Public Service Company Limited (JPSCo) is the dominant player in electricity generation in the country and has an exclusive right to power transmission and distribution. A private company with 20% government ownership, JPSCo accounts for about 70% of installed generating capacity of 925 MW. Four independent power producers (IPPs) account for the remaining capacity. One of the IPPs, Wigton Windfarm has a capacity of 38.7MW exclusively from wind. This and a 3 MW wind turbine operated by JPSCo represent all the wind power energy on the national grid and account for 1.4% of total energy generated in 2009. The only other renewable source of energy on the national grid is hydropower accounting for 3.3% of energy generated in the same year. The rest was generated from fuel-powered plants (Makhijani et al., 2013).

As a monopoly in power transmission and distribution, and a dominant player in power generation, the Office of Utilities Regulation (OUR) regulates JPSCo. The OUR Act of 1995 (amended in 2000), among others, stipulates that the office will encourage competition and the development and use of indigenous resources. However, the OUR has taken a lukewarm attitude towards, if not stymied, the development of RE sources in accordance with the national energy policy and its mandate. The office prepared an energy generation expansion plan for the country in 2010, a year after the national energy policy was adopted and the Vision 2030 Jamaica was implemented. The Generation Expansion Plan (OUR, 2010) provided three future energy demand forecasts (base, low and high) for the country. It also included three cases (scenarios) for energy expansion strategy. These involve natural gas, natural gas/coal and business-as-usual cases. Surprisingly, no case or strategy was provided for renewable sources. Instead, the plan included a brief narrative on the obstacles confronting RE projects in the country and indicated that the mid-term RE penetration target set by the national energy policy will not likely be achieved. As the government agency with the regulatory power and responsibility to effect energy diversification, the plan falls far short of a forward-looking strategy. At the minimum, the plan should have included a renewable energy case if only to indicate to the policy makers the magnitude of investment or the incentives needed to make the RE policy of the GOJ attainable.

Notwithstanding, international partners have conducted major studies on RE in Jamaica. In 2005, the United Nations' Economic Commission for Latin America and the Caribbean (ECLAC) sponsored a study on the RE potential in Jamaica (Loy and Coviello, 2005). The study concluded that there is an abundance of RE sources in the country and singled out the sugar processing industry as one of the largest sources of RE through the use of biomass for electricity generation. The study also indicated the need for better identification of existing potentials and on-site assessments and measurements as precursors for the achievement of long-term renewable energy goals.

The recommendations made by the ECLAC study were addressed in a recent study by the Worldwatch Institute (Makhijani et al, 2013). The study entailed a more comprehensive mapping of the RE potentials of Jamaica and provided scenarios for incorporating renewable energy sources in the country's energy mix. The study showed that not only is the 20% RE target achievable by 2030, a much higher target of 93% renewables by 2030 is also possible. That feat will entail investing in 3,500 MW of new renewable capacity, predominantly solar and wind power, over a period of 18 years. However, in a business-as-usual scenario, petroleum continues to dominate the energy source in a proportion similar to that of 2012.

On the practical side, the GOJ has been engaged in a protracted process of introducing LNG as an energy source in Jamaica. After signing a Memorandum of Understanding with the government of Trinidad and Tobago in 2004 to supply 1.15 million of metric tonnes annually, it was expected that two new combined cycle power plants will be built to run on LNG (Loy and Coviello, 2005). Ever since, the LNG project tender process has been mired in controversy resulting in numerous cancellations, with the most recent occurring in May 2014. A new process for selecting the preferred company to build a 380 MW plant that will run on LNG is now underway. Ten years after the idea was first floated as the ideal opportunity to cut the cost of electricity in Jamaica, a company to build and operate the proposed plant is yet to be determined. Meanwhile, consumers continue to endure high electricity price. Had the last tender process been successful, the winning bid would have guaranteed a price of US$0.13 per kWh which is just a third of the price currently paid by residential consumers. Delays in bringing the LNG project to reality has not only resulted in a jump in the projected investment cost, it has also progressively pushed the cost of electricity up as old and inefficient plants, a high proportion of which have outlived their useful economic life (OUR, 2010), continue to be operated and the cost passed on to the consumers.

Against this background, it is useful to determine what it will take to achieve a 20% target for renewable sources in the country's energy mix. Such information will be helpful to investors, regulators and policy makers in objectively and realistically assessing the renewable energy targets set in the national energy policy.

3. Methodology

3.1 Analytical Model

Linear Programming (LP) is an optimization model that has been used extensively for energy planning. Zeng et al. (2011) provided a review of an extensive list of studies using optimization models for energy systems planning. These studies include those using LP and other forms of optimization models for planning energy systems (Kavrakoglu, 1980; Smith, 1980; Beck et al., 2008), incorporating renewables in the energy mix (Cormio et al., 2003), and assessing decarbonisation targets (Kannan, 2009; Kannan and Strachan, 2009).

In the present study, we apply LP to generate optimal combination of energy sources for Jamaica that will ensure that the RE targets for 2015, 2020 and 2030 are met. The model is specified as follows:

$$\operatorname*{Min}_{\Delta X} Z = \sum_{i}^{k}\sum_{t}^{T} c_i \Delta X_{it}$$

Subject to:

$$\sum_i^k \bar{X}_i = \overline{GC}$$

$$\bar{X}_i + \sum_t^T \Delta X_{it} \leq maxX_i \qquad \forall\, i$$

$$\sum_i^k \Delta X_{it} \geq \Delta D_t \qquad \forall\, t$$

$$\overline{GC} + \sum_t^T \Delta D_t = D_T$$

$$\sum_i^k \bar{X}_i + \sum_i^k \Delta X_{it} \geq 0.125 \times (\overline{GC} + \Delta D_t)\, , when\ t = 2015\ \&\ k \in RE$$

$$\sum_i^k \bar{X}_i + \sum_t^{T-1}\sum_i^k \Delta X_{it} \geq 0.15 \times (\overline{GC} + \sum_t^{T-1} \Delta D_t), when\ t = 2015, 2020\ \&\ k \in RE$$

$$\sum_i^k \bar{X}_i + \sum_t^T \sum_i^k \Delta X_{it} \geq 0.20 \times (\overline{GC} + \sum_t^T \Delta D_t) \qquad \forall\, t\ \&\ i \in RE$$

$$\Delta X_{it} = 0 \qquad where\ applicable$$

$$x \geq 0$$

Where, ΔX_{it} is the change in electricity generation from energy source *i* by period *t*;
c_i is the unit cost of capital for generating a kWh of electricity from energy source *i*;
$\bar{X}_i$ is the initial generating capacity of energy source *i* in year 2009;
$\overline{GC}$ is the total generating capacity from all sources in year 2009;
ΔX_{it} is the change in generating capacity of energy source *i* in year *t*;
$maxX_i$ is generating potential of energy source *i*;
ΔD_t is the additional demand for electricity in year *t* from the previous period;
D_T is the forecast for electricity demand in year 2030;
$i = 1, \ldots, k$ represents k different sources of electricity generation;
$t = 1, \ldots, T$ represents time periods 2015, 2020 and 2030;
x represents any variable in the model;
RE is the set of renewable energy sources; and
Z is the minimum aggregate cost of investment.

The objective function represents the capital portion of the levelized costs of electricity generation (LCOE) in Jamaica as a proxy for the investment cost needed to build new generating capacities to meet future energy demands. This "investment cost" is minimized while ensuring that the target for renewable energy in the energy mix for each of the three time periods (2015, 2020 and 2030) is satisfied. This is done with due cognizance of the capacity limit for each energy source in the country and electricity demand forecast. Other timeline restrictions are incorporated to provide for realistic results that ensure that only technically feasible options are included in the optimal results for any time period. For example, since LNG is not a feasible option for 2015, a restriction is placed in the model not to generate electricity from natural gas in 2015. Other accounting restrictions are included to ensure model consistency. The optimal result from the LP model will indicate additional electricity generated for each period to meet the demand requirement and the source.

For ease of modelling and to normalize the variability in efficiency inherent in the different RE sources, energy capacity is modelled in GWh and not in MW. This will ensure that the renewable energy target is measured against the amount of electricity generated and not just in terms of capacity installed.

3.2 Data

The National Energy Policy (Ministry of Energy and Mining, 2009), OUR (2010) and Worldwatch (2013) were the main sources of data. The National Energy Policy served as the source for renewable energy targets for Jamaica. OUR (2010)'s base forecast for future electricity demand in Jamaica was used to set the minimum requirement for additional electricity generation by the three timelines. The existing capacity for oil-powered plants and potential capacities for RE sources were derived from Makhijani et al. (2013). The capacity for natural gas-fired plants was set at the original total capacity of 480 MW tendered by the OUR for the LNG project. Makhijani et al. (2013) reported a system loss (technical and non-technical) of 22.3% in 2011. To accommodate this reality in the optimal plan, a system loss of 20% was provided for in the input data. The capital portion of the levelized cost of electricity generation reported by Makhijani et al. (2013) represents the per unit cost of electricity generation attributable to the initial capital invested in the generation capacity. This value was used as a proxy for the unit cost of investment. Therefore, while it provides a realistic measure of the relative costs of investment for different energy sources, it does not represent the actual cost of upfront investment needed to build the new capacities.

4. Results

Current estimate from the Ministry of Science, Technology, Energy and Mining (formerly Ministry of Energy and Mining) indicates that the renewable energy share has increased from 5% in 2008 to about 8% in 2014. Using trend analysis, a linear and an exponential projection of the trend were compared to the policy targets (Figure 1). The analysis shows that if the current trend continues on a linear path, the renewable energy target will not be met for any of the timeline years. However, in the case of an exponential growth in renewable energy sources, the target will be met only for 2030, after investment in renewables would have been ratcheted up between now and 2025, at which time the growth in accelerated investment will be equivalent to the required growth in investment had the target been met all along.

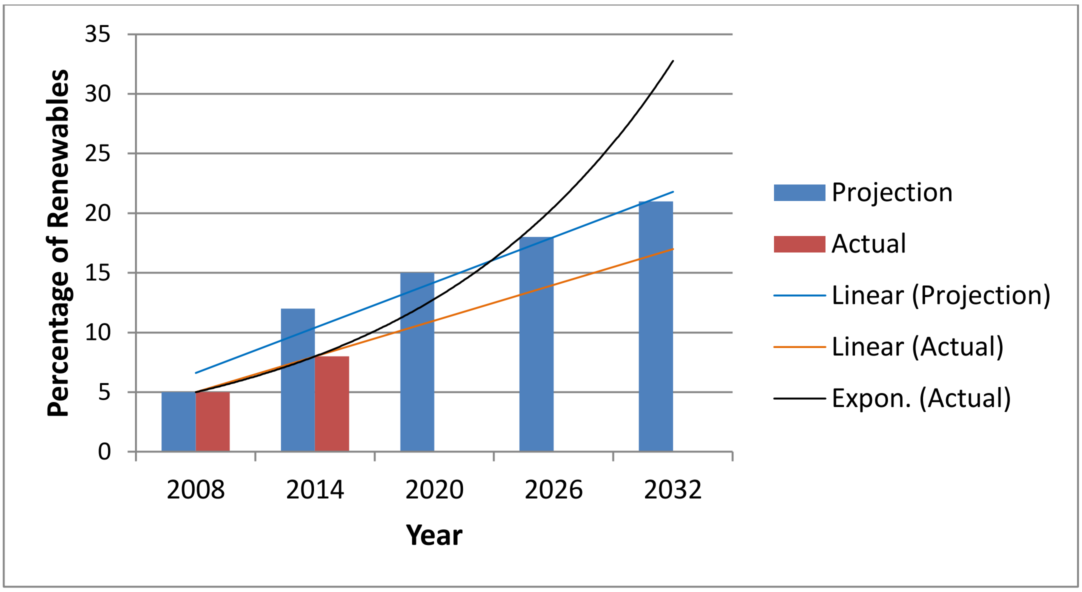

Figure 1. *Alternative Trajectories for Reaching Renewable Energy Targets for Jamaica*

The optimal LP result for achieving the renewable energy target for 2015, 2020 and 2030 is presented in Table 1. The result shows the optimal combination of renewable sources to include wind power, hydropower and bagasse power, but not solar power. By 2015, additional fuel-based capacity needs to be installed to produce 201 GWh of electricity. By the same year, major investments in wind power capacity must be made to produce 971 GWh of electricity. The only additional investment required between 2015 and 2020 is in natural gas plant(s) that have enough capacity to generate 1574 GWh of electricity. A more diversified energy-mix would be attained by 2030 with new investments in wind power (374 GWh), hydropower (126 GWh), bagasse power (596 GWh) and natural gas power (2631 GWh). Overall, the renewable energy target will be surpassed for 2015 and 2020, and met for 2030. In 2030, natural gas will account for one-third of electricity generation in addition to 20% produced from renewable sources.

Table 1. *Historical and Required New Electricity Generation to Meet Future Electricity Demand in Jamaica (2009-2030)*[1]

Historical (2009) Generation		**Recommended Additional Generation**			
Source	**Electricity (GWh)**	**Source**	**Electricity (GWh) by Year**		
			2015	**2020**	**2030**
Petroleum	4819	Petroleum	201		
Wind	71	Wind	971		375
Hydro	167	Hydro			126
		Solar			
		Bagasse			596
		Natural Gas		1574	2631
Total	**5057**		**1172**	**1574**	**3728**

[1] *Results incorporate a 20% system loss due to technical and non-technical losses.*

The composition of the different RE sources in the renewable energy share is shown in Figure 2. Wind power is the dominant RE source in the optimal mix for the three timelines accounting for at least 60% of renewables at any point in time. Hydropower remains fairly stable at about 13% across the periods while bagasse power accounts for about a quarter in 2030. The result provides evidence that the renewable energy targets are technically feasible and the attainment of the targets will facilitate the diversification of energy sources in Jamaica.

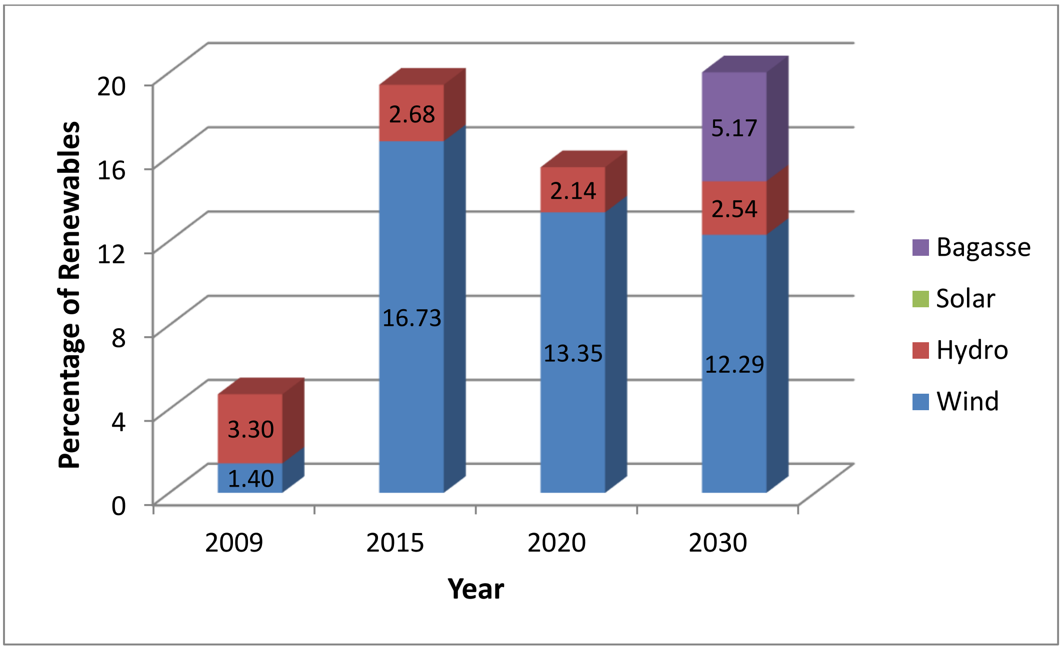

Figure 2*. Share of Renewable Sources of Energy in the Optimal Plan for Electricity Generation in Jamaica (2009-2030)*

5. Discussion

Although the optimal result shows technical feasibility, the practicality of this happening is highly improbable. For this to be a reality, major investments in wind farms need to be made in a period of a year and a half. At the moment, more attention is devoted to introducing LNG in the energy mix and that process has taken 10 years without any practical results. JPSCo has not shown any interest to invest in wind farms or any other forms of RE on a massive scale. The OUR has either shown lack of interest in pushing for RE or not offered any encouragement to JPSCo and other IPPs to invest in RE. This is against the backdrop of increasing public displeasure with high electricity prices and a more recent pronouncement by the government that the target for RE by 2030 is no longer 20% but 30%. This apparent discordant in the policy of the government on one hand and the action or inaction of the regulator and power generating companies on the other is troubling and brings to question the evidence-base for energy policy promulgation in Jamaica.

Although no real analysis has ever been provided as the evidence for setting the renewable energy target in Jamaica, anecdotal evidence suggests that the target is technically achievable. The recent report by Worldwatch Institute (Makhijani et al., 2013) showing that Jamaica could attain 93% RE in its energy mix by 2030 would have validated that perception and the recent shift in the target from 20% to 30% may not have been unconnected to that study. What will be more useful for policy makers and energy stakeholders in Jamaica, however, is an indicative plan or plans of what sort of investments need to happen and when for these targets to be achieved. To our knowledge, no such study has been done despite the need for it.

The current study fills the gap in evidence-based economic analysis that is required to inform practical energy planning, as it relates to RE, in Jamaica. Our findings indicate that the 20% RE target is technically achievable. Our study also reveals a rather surprising finding that investing in solar energy is not optimal for the country. Contrary to increasing popularity of solar panels in Jamaica, given current investment climate and costs, solar energy is not recommended as an energy option for electricity generation for the national grid. At first glance, this finding appears contrary to that reported in Makhijani et al. (2013) that showed solar energy as the major source of RE for a 93% RE penetration. A closer look at their results will show that a higher percentage of wind energy is indicated at lower RE penetration and the share of solar energy only increases at higher penetration. The current study provides evidence that at lower RE penetration target, solar power will not be an optimal choice. The inclusion of solar energy at lower levels of RE penetration, as shown by Makhijani et al. (2013), will only be economically justified if there are expectations and future plans to expand on solar energy, in which case early investments will drive down costs on future units as the scale of installation is increased significantly. A market for RE that is 73% larger will provide such an incentive and hence the reason for the difference in the results between this study and Makhijani et al. (2013).

The findings of this study should provide a basis for serious dialog in the energy sector of Jamaica on the reality of GOJ's RE target. As at present, this target is stated more conveniently as a slogan than pursued as a policy objective. It is high time the government realises that the target will not be achieved unless meaningful actions needed to actualize it take place. The first step in that line of actions is to know how the target can be achieved and what it will take to achieve it. This study has shown one of possibly several ways in which the target can be achieved. As more information is provided by stakeholders, the model can be applied to generate alternative plans under different scenarios. However, until such a time, this study provides a good starting point for instigating a much needed debate on the RE target policy in Jamaica.

6. Conclusions

Vision 2030 Jamaica, the national development plan for Jamaica, and the country's national energy policy have set a renewable energy target of 20% for the country by 2030. Previous studies (Loy and Coviello, 2005; Makhijani et al., 2013) have shown that Jamaica has great potentials for renewable energy and the government is now mulling a 30% target for renewables by 2030. Meanwhile, RE penetration in Jamaica remains at about 8% and is far short of 12% that it should have been had the country been on track to achieving the policy target. Many observers consider electricity prices to be too high in Jamaica and the introduction of renewable energy, among other benefits, is expected to lower cost of energy in the medium to long term. However, there are renewable energy sceptics within the energy sector and concrete large scale investments to actualize the target are yet to be made. Also, until this study, no economic analysis has been done to guide policy implementation in relation to the attainment of the RE target.

The results of this study indicate that the RE target is technically achievable. This will be done through investment in additional wind power, hydropower and bagasse power generating capacities between now and 2030. Surprisingly, solar power is not competitive and not recommended for the national grid for a 20% RE penetration. When the required investment for the target to be achieved is measured against actual growth in RE sources in Jamaica, it becomes highly improbable that the 20% target will be achieved talk less of a 30% target. Therefore, this study provides the much needed evidence-base analysis that is lacking in policy analysis in relation to the RE target in Jamaica. Unless the government gets serious about promoting RE, the prospects for a sustainable low-carbon feature for Jamaica are bleak and public concerns about high electricity prices and anaemic economic growth, in the face of government's inaction to meaningfully facilitate RE, may actually lead to popular support for using coal, a high CO_2-emitting energy source. This scenario is becoming increasingly likely as the government moves forward on its plan to engage the China Habour Engineering Company (CHEC) to build a logistic hub in Jamaica. The project is expected to result in a US$1.5 billion investment in Jamaica and create 10,000 new jobs. CHEC has signified its plan to generate its own energy using coal as it considers the price of electricity in Jamaica to be too high for its planned investment. This and other realities of the local setting suggest that a low-carbon future for Jamaica is, for the moment, unsustainable.

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