Energy Strategy Reviews 52 (2024) 101357

Contents lists available at ScienceDirect

Energy Strategy Reviews

journal homepage: www.elsevier.com/locate/esr

Decarbonising the power sector of the Dominican Republic: An approach from electric mobility transition

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ARTICLE INFO

Handling editor: Xi Lu

Keywords:
Decarbonisation
Energy modelling
Energy transition pathways
OSeMOSYS
Renewable energy
SIDS

ABSTRACT

The electrical power and land transportation systems of the Dominican Republic are facing significant challenges due to growing demand in both sectors. These two systems are responsible for around 62% of greenhouse gas (GHG) emissions. With the deployment of electric mobility, the power and transport sectors can synergise and contribute significantly to long-term sustainable planning. This article analyses the impact of the penetration of electric mobility programmed by the Dominican Republic's National Institute of Transit and Land Transport (INTRANT), the country's goal of reducing GHG emissions by 27% by 2030 and the decarbonisation process. Using the open-source modelling system OSeMOSYS, four scenarios are built to explore strategies that contribute to sustainable development in the long term. Meeting climate change commitments necessitates that all coal-fired plants in the country will be closed or transformed by 2040. Despite the positive role of electric mobility in reducing GHG, decarbonising the electricity sector while facing the energy crisis requires investments totalling around 16 billion USD. Failing to make these investments will incur expenses of approximately 6 billion USD on the user's side in the period from 2024 to 2030 to cover energy needs; this figure represents more than 270% of the amount that should be invested in the electrical power system to supply these users' needs.

1. Introduction

The electrical power sector and the transport sector each have a significant impact on greenhouse gas (GHG) emissions [1–3]; to reduce GHG emissions, countries are developing medium- and long-term planning based on energy models [4] that comprehensively depict intricate systems, aid in structuring vast quantities of data and establish a uniform contextual framework for assessing hypotheses [5]. Long-term planning must be developed in Small Island Developing States (SIDS) [6], including the Dominican Republic. Curto et al. [7] explained that SIDS have common characteristics hindering their ability to achieve sustainable development, such as that they are importers and highly dependent on fossil fuels, their use of renewable energy sources is limited although they have high potential, their cost of electricity production is higher than in large or continental countries and they are highly vulnerable. Based on long-term energy systems modelling, it is possible to alter public policies to achieve the Dominican Republic's objectives [8], the goals raised in the nationally determined contribution (NDC) [9] and sustainable development.

The objectives of this study are to analyse the impact of electric mobility penetration programmed by the Dominican Republic's INTRANT, the country's goal of reducing 27% of GHG emissions by 2030 and the decarbonisation process amid the current state of national energy poverty wherein the marginal cost of energy is equal to the cost of shortages for at least 8% of hours in the year. Industry, residential,

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https://doi.org/10.1016/j.esr.2024.101357
Received 10 October 2023; Received in revised form 1 February 2024; Accepted 29 February 2024
Available online 9 March 2024

Nomenclature

ARIMA	Autoregressive integrated moving average
BAU	Business as usual
CCGT	Combined cycle gas turbine
CLEWS	Climate land energy water systems
DOMRETS	Dominican Reference Energy and Transport Systems
EV	Electric vehicle
GHG	Greenhouse gas
HFO	Heavy fuel oil
IC	Internal combustion
ICE	Internal combustion engine
INTRANT	National Institute of Transit and Land Transportation
IRENA	International Renewable Energy Agency
LFO	Light fuel oil
LPG	Liquefied petroleum gas
NDC	Nationally determined contribution
NGS	Natural gas
PV	Photovoltaic
SIDS	Small Island Developing States

commercial and public services users are usually forced to supply their own energy needs during shortages, so they bear high shortage costs. Using the open-source modelling system OSeMOSYS, four scenarios are built to explore strategies that will contribute to sustainable development in the long term.

The main contributions of this study are long-term planning based on feasible scenarios, including electrical power and land transport systems; evaluation of the country's capacity to achieve the reduction of GHG declared in the Nationally Determined Contributions (NDC-2020); an open model adhering to U4RIA recommendations [10]; and analysis of the electric mobility transition's impact on the electrical power system and its decarbonisation. This paper is structured as follows. Section 2 presents the modelling methodology, input data and scenario analysis; section 3 presents the results; section 4 discusses the main findings, limitations and future work opportunities; and section 5 summarises the main conclusions.

1.1. Context

The electrical and land transportation systems of the Dominican Republic face significant challenges due to growing demand in both sectors. These systems are responsible for around 62% of GHG emissions, but integrating electric mobility will allow the systems to synergistically contribute to long-term sustainability. The International Renewable Energy Agency (IRENA) reports that the transport sector consumes the most significant portion of energy in the Dominican Republic. Long-term planning for the transport sector must reduce its externalities (such as environmental pollution) and integrate technologies such as liquid biofuels to replace secondary carriers like gasoline and diesel. IRENA also proposes integrating different forms of electric mobility, the infrastructure of which will affect the electric power sector [11]. As presented by the Dominican Ministry of Energy and Mines [12], the fleet in the Dominican Republic in 2018 encompassed 4.3 million land vehicles and emitted 7.76 Mt CO_2eq. A proper plan to control GHG for sustainable energy development is needed [13,14].

1.2. Literature review

Studies on islands such as Favignana Island, Iceland, Flores Island and Ireland have analysed the role of electric mobility in the decarbonisation process through various scenarios of electric mobility penetration and have identified its relevance from economic and environmental points of view for sustainable energy transition [15–18]. Multiple sources [19,20] state that including electric mobility is vital to achieving carbon neutrality.

In a recent study, Aryanpur [18]represents the specific regional characteristics of transport technologies and infrastructures using the TIMES tool. This study concludes that decarbonisation is likely impossible without demand-side strategies such as reducing mobility control in conventional vehicles, which is why electric mobility can play an essential role in decarbonisation. In Ref. [21], it is proposed that electric mobility has the potential to participate in auxiliary intermittent flattening services to support the integration of the solar photovoltaic grid. Other studies such as [22,23]examine the underlying concerns of global warming in the context of SIDS and the consequent action of phasing out coal to keep global temperature rise below 1.5 °C, as stipulated in the Paris Agreement, focused solely on the electricity system.

The analyses mentioned in this section were carried out with tools such as EnergyPLAN, HOMER, TIMES, MESAP-PLANET, REMIX and the one used in present study, OSeMOSYS, which is a widely used, open-source, easy-to-use optimisation modelling framework for medium-to long-term energy planning [24]. An advantage of this long-term bottom-up optimisation model is its capacity to consider the domestic availability of energy supplies and the techno-economic characteristics of centralised and decentralised technologies. Furthermore, the model accounts for the energy system's architecture, encompassing the supply technologies, transmission and distribution networks and energy trade connections to end-user demands. OSeMOSYS uses linear optimisation methods to meet pre-determined energy demand. The objective function sums the discounted operational and capital costs. The conventional setup assumes the presence of perfect foresight and complete competition in the energy market [25].

OSeMOSYS has been used to visualise the impacts of economic, environmental and social factors on long-term sustainability [22,26,27]. In Costa Rica, OSeMOSYS was used to evaluate plans to decarbonise the transport and power sectors [27]. The Genesys-MOD model was developed based on OSeMOSYS and was used to assess the long-term planning of ten world regions in the power, heat and transport sectors, considering climatic constraints and the integration of renewable energy technologies [28]. In the European Union, OSeMOSYS was used to analyse planning for the isolated electrical network of Cyprus and determine which investments in the transport sector and renewable generation technologies will best mitigate climate change [29].

2. Methodology

2.1. Modelling the electrical power and transport systems

This study's methodology consists of ten stages: (1) modelling review for transport systems decarbonisation; (2) data management and processing of the electrical and transport system; (3) development of the reference energy framework for the Dominican electrical system using OSeMOSYS ver.4.2.0, 20,221,030 release, which is usually applied to developing CLEW systems; (4) electrical demand projection and power generation expansion of the model; (5) efficiency calculations of system components; (6) selection of the most relevant scenarios focused on by the emission reduction goals and the Nationally Determined Contributions (NDC-2020) for long-term sustainability; (7) determination of the maximum renewable capacity available for power generation based on the limits of natural resources; (8) determination of the lowest achievable level of CO_2eq emission; (9) determination of the Gross domestic product fraction required to implement the alternatives; and (10) estimation and valuation of the energy not served in the scenarios.

2.1.1. Dominican Reference Energy and Transport System

Fig. 1 presents the Dominican Reference Energy and Transport System (DOMRETS), which includes fuel inputs, conversion technologies, the transmission and distribution network and the electricity demand of

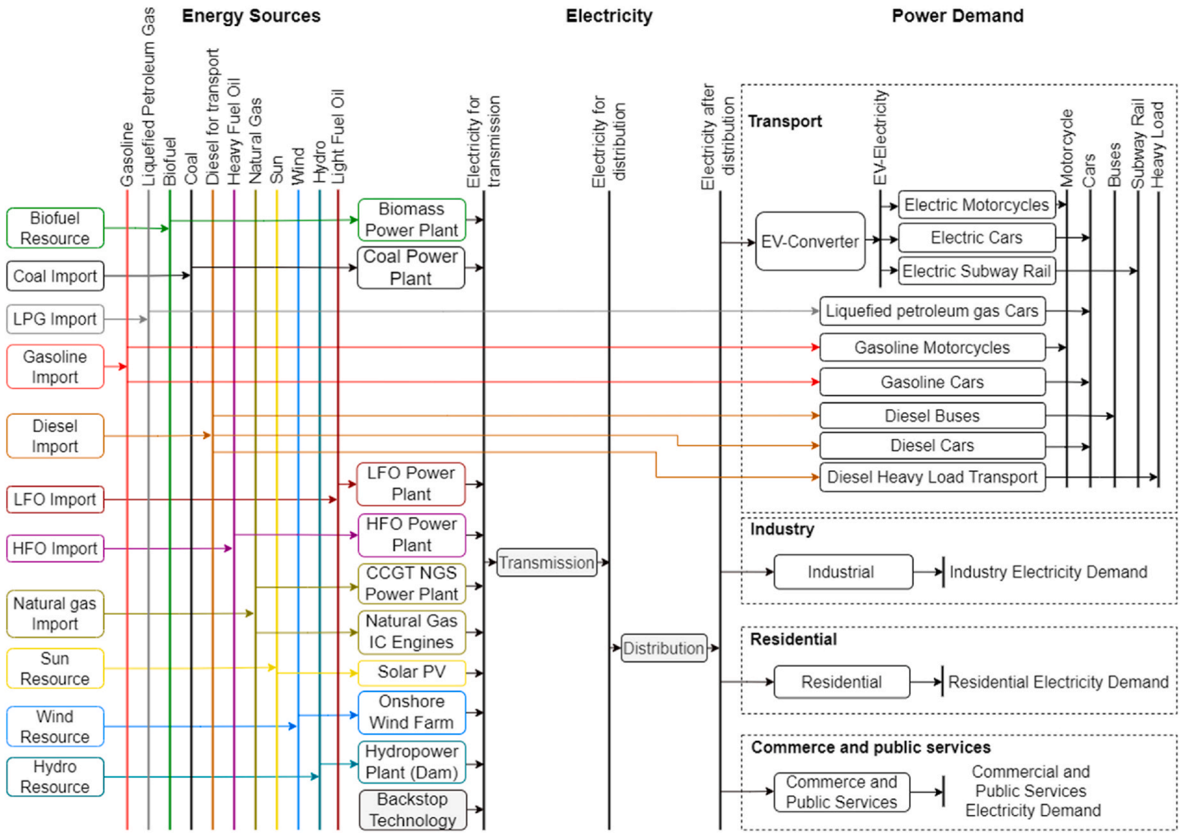

Fig. 1. Dominican reference energy and transport system (DOMRETS).

end users. This model is developed with the configurations applied to the OSeMOSYS system [30]. The power plants in DOMRETS result from the combination of National Interconnected Electric System plants with similar characteristics in terms of technology and fuel used for combustion. In the case of a plant that operates in more than one modality, its modality is considered to be the modality in which it operated for more than 75% of all hours in 2022 [25].

2.1.2. Transport demand

Table 1 shows the demand of the transport sector, expressed in 10^9 km/year, constructed from the information available in the National Strategic Plan for Electric Mobility [31], Energy Consumption of the Transportation Sector Ministry of Energy and Mines [12] and Annual Vehicle Statistics [32]. Table 2 shows the demand for the country's metro and cable car rail system, expressed in petajoules (PJ). In both tables, the data is shown in triennially averages. An autoregressive integrated moving average (ARIMA) model is used to elaborate on the forecast model of the projection of the vehicle fleet until the year 2050.

2.1.3. Electrical power system demand

The demand for the electricity sector stratified by sectors is obtained from the National Energy Commission through the National Energy Information System [33]. Table 3 shows the triennially averages of electricity demand by sector.

2.1.4. Installed capacity

The installed capacity of the business as usual (BAU) scenario is composed of the capacity currently installed in the system [34] plus the capacity of those projects that are supposed to enter into operation, according to the long-term programme of the dominican system operator [35]. It is assumed that The Expansion Plan of the dominican Hydroelectric Generation Company will begin in 2028 [36]. Table 4 shows the changes in the total installed capacity of the BAU scenario.

2.2. Scenario selection and assumptions

Techno-economic data such as emission factors, efficiencies, operational lifetimes, capacity factors, capital cost, fixed cost and variable cost are available in Ref. [37]. The technologies of the transport sector have

Table 1
Transport demand by technology, expressed in 10^9 km/year.

Technology	2024–2026	2027–2029	2030–2032	2033–2035	2036–2038	2039–2041	2042–2044	2045–2047	2048–2050
Gasoline Cars	8.3	9	9.6	10	10.3	10.5	10.5	10.4	10.2
Liquefied Petroleum Gas Cars	28.9	33.2	37.5	41.7	46	50.3	54.6	58.8	63.1
Diesel Cars	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3
Electric Cars	0.6	1.2	2	2.8	3.8	5	6.3	7.7	9.2
Diesel Buses	22.8	25.2	27.6	30	32.4	34.7	37.1	39.5	41.9
Diesel Heavy Load Transport	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9
Gasoline Motorcycles	35.8	39.7	43.2	46.5	49.4	52	54.2	56.2	57.8
Electric Motorcycles	1.5	3	4.8	7	9.4	12.2	15.3	18.7	22.5
Total	99.8	113.4	127.1	140.7	154.2	167.9	181.4	195	208.6

Table 2
Subway rail demand, expressed in petajoules.

Technology	2024–2026	2027–2029	2030–2032	2033–2035	2036–2038	2039–2041	2042–2044	2045–2047	2048–2050
Electric Subway Rail	0.3	0.8	1	1.1	1.2	1.2	1.2	1.2	1.2

Table 3
Electrical power system demand by sector, expressed in petajoules.

Power Demand	2024–2026	2027–2029	2030–2032	2033–2035	2036–2038	2039–2041	2042–2044	2045–2047	2048–2050
Residential	21.3	23.5	25.8	28	30.5	33.2	36	38.9	41.7
Commerce and Public Services	18.7	20.6	22.6	24.5	26.7	29	31.4	33.7	36.1
Industrial	35.9	40.2	45	50.2	56	62.5	69.5	77.1	85.2
Total	75.9	84.3	93.4	102.7	113.2	124.7	136.9	149.7	163

Table 4
Installed capacity by technology, expressed in gigawatts.

Technology	2024	2025	2026	2028	2034	2036	2050
Biomass Power Plant	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Coal Power Plant	1.09	1.09	1.09	1.09	1.09	1.09	1.09
CCGT NGS Power Plant	1.33	1.91	2.72	2.72	2.72	2.72	2.72
Natural Gas IC Engines	0.29	0.29	0.29	0.29	0.29	0.29	0.29
LFO Power Plant	0.10	0.10	0.10	0.10	0.10	0.10	0.10
HFO Power Plant	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Hydropower Plant (Dam)	0.62	0.62	0.62	0.63	0.73	0.92	0.92
Onshore Wind Farm	0.66	0.71	0.71	0.71	0.71	0.71	0.71
Solar PV	1.48	1.77	1.82	1.82	1.82	1.82	1.82
Total	6.57	7.49	8.35	8.36	8.46	8.65	8.65

no associated costs since, in this study, they are not expected to compete. The present study is based on the construction of four scenarios built with OSeMOSYS to explore strategies that will contribute to sustainable development in the long term. These scenarios are described in the four following subsections.

2.2.1. Business as usual scenario

In the BAU scenario, the characteristics of the National Interconnected Electric System are modelled to represent the best trend approximation of the system's current state, including those projects that to date have a definitive concession for their construction and the projects considered in the Dominican Hydroelectric Generation Company Expansion Plan [36], assuming its projects will start in 2028. A representation of the trend growth of demand in the transport sector and the industrial, residential, commerce and public services sectors is also provided, according to the National Energy Commission's forecast [33].

2.2.2. E-shortage

The Dominican Republic is dealing with an energy crisis that dates back to the inception of the national electrical system [38,39]. This reality is reflected in the BAU scenario, given that for its execution, it is necessary to invest more than 2 billion USD to install 2.15 GW based on natural gas in the first year of planning. This investment is not viable because of the economic burden and the time that would be required to construct a power plant that would add 2.15 GW to the National Electric System. Hence, the E-Shortage scenario wherein the country may make traditional cuts in demand is more feasible for the Dominican Republic [34,35].

2.2.3. EV-transport

This scenario evaluates the impact of electric mobility penetration from the 'trend scenario' established by the INTRANT in its National Strategic Plan for National Electric Mobility [31]. It is considered that the country would have difficulties implementing the moderate and ambitious scenarios established in this plan. The 'trend scenario' established by INTRANT assumes that, in the long term, 70% of the replacement of conventional vehicles with electric vehicles will be carried out for public fleets and 30% for private vehicles. Table 5 shows the penetration goals established for each year and the rate of increase in each period [31].

Based on the difficulties of the country in executing the National Strategic Plan for Electric Mobility [31], a displacement at the beginning of the implementation is considered. In 2024, the conditions established for 2021 are considered and so on in the following years. With this displacement, the INTRANT plan extends until 2053; however, in the present study, the values are considered until 2050, when the public vehicle fleet reaches 61% and the private vehicle fleet reaches 25.5%. It is considered that 'Diesel Buses' and 'Diesel Heavy Load Transport' technologies will continue to consume liquid fuels.

2.2.4. Low-Carbon

The document 'Nationally Determined Contributions (NDC-2020)' aims to eliminate 13,853.71 Gg of CO_2eq, which represents 27.16% of the 51,000 Gg CO_2eq estimated for 2030 [9]. The actions proposed in NDC-2020 to achieve this goal focus on the electrical power sector, energy efficiency and land transport. Based on the assumptions of the EV-Transport scenario and considering the expected emission reduction in the NDC-2020, for the Low-Carbon scenario, an 'Annual Emission Limit' of 37.15 Mt is established in the model.

3. Results

This section presents the results of four strategically defined scenarios to generate knowledge for the long-term planning of the Dominican Republic.

3.1. Energy production

Fig. 2 shows the annual energy production comparison by scenario for 2030, 2040 and 2050.

In the BAU scenario, between 83% and 92% of the energy produced annually comes from fossil fuels, with natural gas contributing between 55% (2024) and 80% (2050). Renewables contribute an average of 12%,

Table 5
Penetration goals for each year and the rate of increase by period.

Years	Public vehicle fleet penetration (%)	Public vehicle fleet increase rate (%)	Private vehicle fleet penetration (%)	Private vehicle fleet increase rate (%)
2021	1	1	0.5	0.5
2030	10		5	
2031	13	3	6	1
2040	40		15	
2041	43		16.5	1.5
2050	70		30	

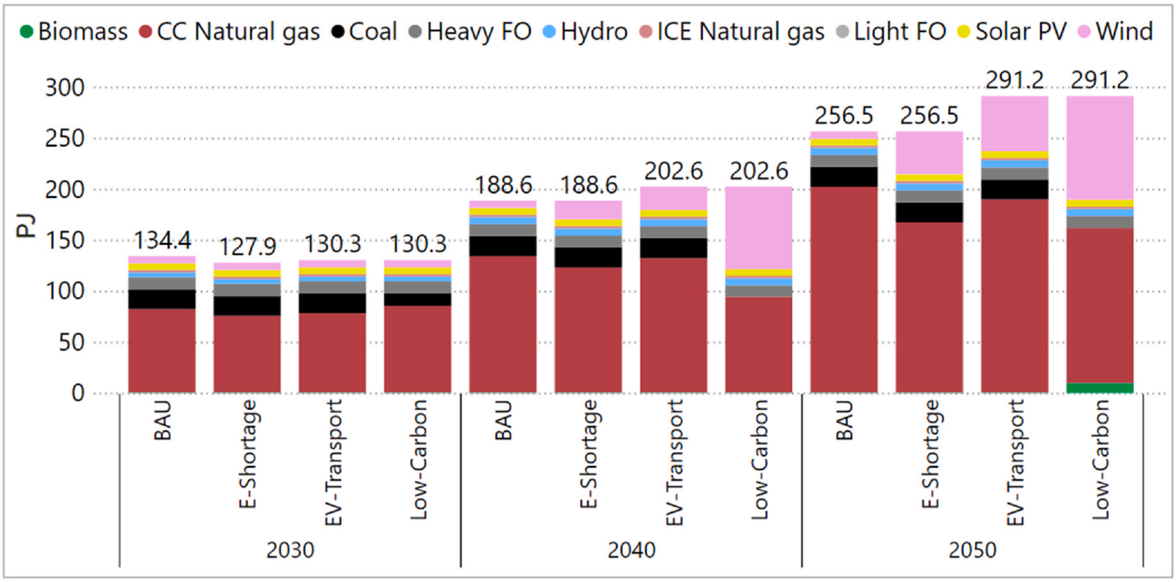

Fig. 2. Energy production by scenario.

with a maximum of 17%. The reduction in the contribution of renewable energies is due to the increase in the installed capacity of natural gas plants; see Fig. 2. Individually, solar and wind technologies contribute an annual average of 3.9% and 4.4%, respectively; see Fig. 2. In the E-Shortage scenario, the share of fossil fuels ranges from a minimum of 76% to a maximum of 86% and wind technology contributes between 5% and 16%, with a pronounced increase from 2040. Solar technology contributes an average of 4.2%. In total, renewable energies contribute an average of 18%, with a maximum of 24%. The reduction in the use of natural gas compared to the BAU scenario is covered by wind energy; see Fig. 2. In 2024–2030, there are downwards cuts in demand ranging from 35% to 5%; see Fig. 2.

In the EV-Transport scenario, the share of fossil fuels ranges from a minimum of 76% to a maximum of 87% and wind technology contributes between 5% and 19%, with a pronounced increase from 2040. Solar technology contributes an average of 4.1%. In total, renewable energies contribute an average of 19%, with a maximum of 24%. According to Fig. 2, the increase in demand due to the penetration of electric mobility is covered by wind and natural gas-based technologies (Onshore Wind Farm, CCGT NGS Power Plant).

3.2. Technology deployment

Fig. 3 shows the new installed capacity by scenario over the entire study period; in the BAU scenario, 9.73 GW (100%) from natural gas are installed. In the E-Shortage scenario, the matrix is diversified by installing 7.6 GW (60%) from natural gas and 3.4 GW (31%) from wind. In the EV-Transport scenario, diversification is based on natural gas and wind combined cycle technologies, installing 9 GW (66%) from natural gas and 4.6 GW (34%) from wind. In the Low-Carbon scenario, the diversification of the matrix also supports solar and biomass technologies and 6.7 GW (40.47%) from combined cycle natural gas, 9.3 GW (56.48%) from wind, 0.08 GW (0.48%) from solar and 0.42 GW (2.57%) from biomass are installed.

In the E-Shortage scenario, on average, 67% (8.94 GW) of annual installed capacity corresponds to technologies that operate with fossil

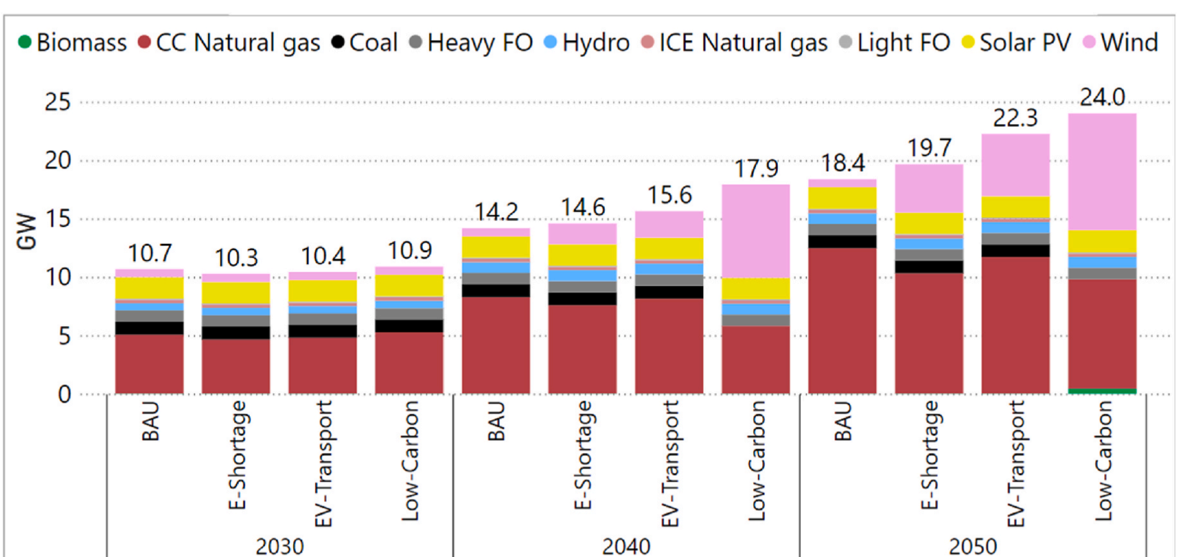

Fig. 3. Installed capacity by scenario.

fuels, especially natural gas, whose average share is 49% (6.8 GW). The installed capacity of solar photovoltaic sources, on average, is 15% (1.8 GW) and that of wind technology is 12% (1.76 GW); see Fig. 3. In the EV-Transport scenario, on average, 66% (9.4 GW) of annual installed capacity corresponds to technologies that operate with fossil fuels, especially natural gas, whose average share is 49% (7.27 GW). The average installed capacity of solar photovoltaic sources is 14% (1.8 GW) and that of wind is 14% (2.17 GW); see Fig. 3

3.3. GHG emissions

Fig. 4 shows the total emissions by scenario. Considering the reduction of 56.64 Mt from the BAU scenario to the E-Shortage scenario, a reduction of 39.60 Mt occurs due to the diversification of the energy matrix with the installation of 3.4 GW of wind from 2032 and a reduction of 17.04 Mt occurs due to the implementation of the 110.25 PJ cut in demand between 2024 and 2030. From the E-Shortage scenario to the EV-Transport scenario, due to the shift in demand for land transport to the electricity sector while maintaining the limits of energy that can be dispatched with natural gas technologies, emissions from the transport sector are reduced by 91.92 Mt. In comparison, emissions from the electricity sector increase by 30.54 Mt, for a net reduction of 61.38 Mt. The lowest emissions correspond to the Low-Carbon scenario, which exhibits a 206.03 Mt reduction compared to the EV-Transport scenario; 100% of this reduction is due to the diversification of the energy matrix given the restriction of the limit of 37.15 Mt of CO_2eq. The emissions corresponding to the transport sector in this scenario remain unchanged.

3.4. Socioeconomic assessment

Fig. 5 shows total system cost by scenario. The BAU scenario has the lowest cost. However, this scenario requires that 24% of its investment capital be executed in 2024, so it is considered an unviable scenario. In the E-Shortage scenario, the total cost of the system is 24 billion USD, of which 39% corresponds to investment capital, 14% to annual variable operating cost and 47% to annual fixed operating cost. In the EV-Transport scenario, the total cost of the system is 27,342.53 million USD, which is 12.8% (3 billion USD) higher than in the E-Shortage scenario; this cost is composed of 43% capital investment, 13% variable operating cost and 44% fixed operating cost. The Low-Carbon scenario is the scenario with the most diversified energy matrix and the highest cost, with a total amount of 32 billion USD, composed of 49% capital investment, 7% variable operating cost and 43% fixed operating cost. The variable cost is approximately 50% lower than in the other scenarios due to the high penetration of renewable energy sources.

Fig. 6 presents the annual capital investment for the E-Shortage, EV-Transport and Low-Carbon scenarios. The execution of the E-Shortage scenario requires starting with an investment of 0.6 billion USD in 2028 and maintaining an average investment of 0.4 billion USD per year. The EV-Transport scenario begins with an investment of 0.03 billion USD in 2027, an annual average of 0.6 billion USD between 2028 and 2031 and an average yearly investment of 0.5 billion USD from 2032. The most significant investment is made in the Low-Carbon scenario, which starts with 0.03 billion USD in 2027, an annual average of 1 billion USD between 2028 and 2031 and 0.7 billion USD from 2032.

Fig. 6 shows two peaks in required investment within the Low-Carbon scenario. The first peak correlates with the demand increase and the stabilisation of CO_2eq emissions during the post-investment period up to 2044. Investments in CCGT NGS Power Plant and Onshore Wind Farms in 2030 and 2031 are required to meet the demand increase and reduce CO_2eq emissions. The second peak in Fig. 6 correlates with the demand increase, the exit of coal power plant technology from 2040 established in the Low-Carbon scenario and the limits of natural wind (10 GW), solar (1.9 GW), hydro (2.1 GW) and biomass (0.5 GW) potentials available on the island, according to the REmap 2030 [11] and Energy Diagnosis 2015 [40].

In the Low-Carbon scenario, the restriction of the 'Annual Emission Limit' is configured at 37.15 Mt for the entire period of 2024–2050; however, the diversity, capacity and available potential of renewable sources in the energy matrix of the Dominican Republic are insufficient to maintain this objective beyond 2044. After reaching the limits of the capacities of all renewable sources, the model suggests the installation of conventional natural gas technologies to achieve the least emissions possible. For this reason, emissions rise significantly despite the investment peak in 2043 and 2044.

3.4.1. Valuation of energy not served in the period 2024–2030

Table 6 shows the valuation of energy not served, considering the needs not covered due to a system's power capacity deficit in 2024–2030. The cost of the generation deficit results from the projection of the shortage cost annual average, established by the Superintendence of Electricity. This projection is carried out with monthly data from January 2007 to June 2023 using the Holt–Winters model.

4. Discussion

4.1. Findings and policy insights

In this study, OSeMOSYS is used to build a model of the electric power and transport sectors of the Dominican Republic. Data for model construction are obtained from local institutions that run the electric power and transport sectors and international references when the information is not freely accessible. In our case study of SIDS, scenarios are established wherein the penetration of variable renewable energy sources does not exceed 25% of energy production. The exception is the Low-Carbon scenario, which corresponds to a country's objective to

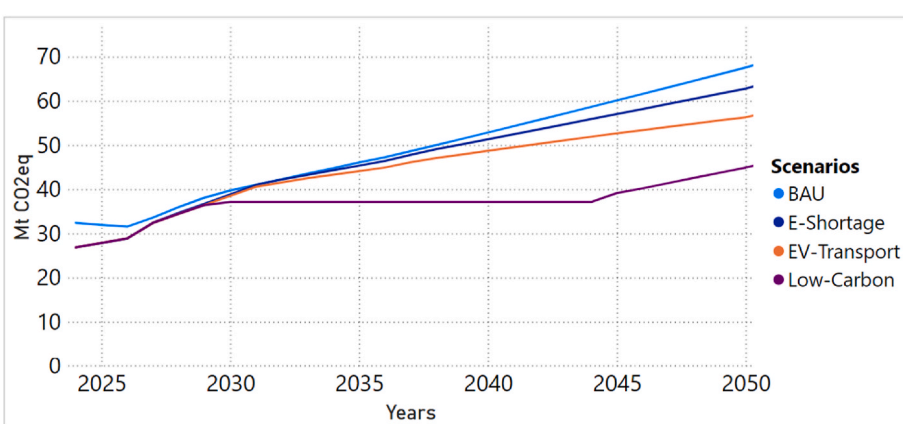

Fig. 4. Total system emissions by scenario.

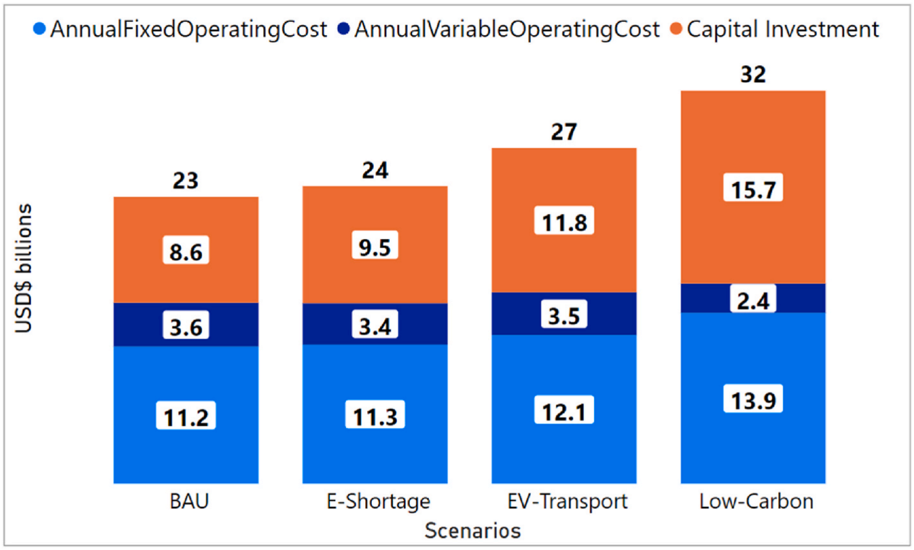

Fig. 5. Total system costs by scenario.

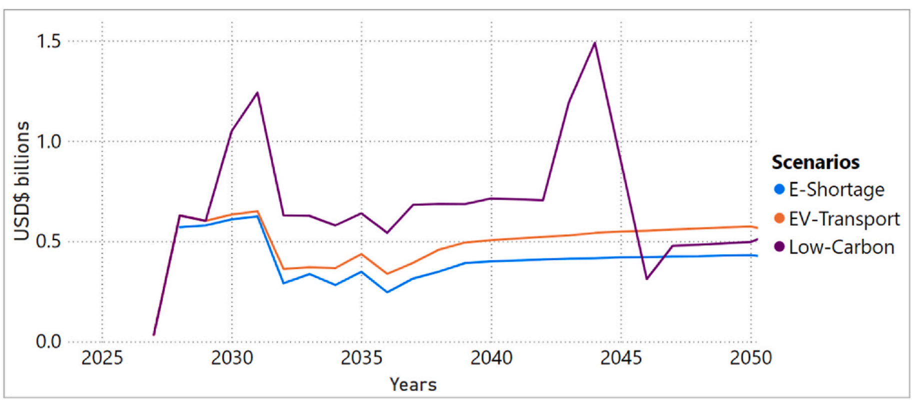

Fig. 6. Annual capital investment by scenario.

Table 6
Valuation of not-served energy in the period 2024–2030.

Year	2024	2025	2026	2027	2028	2029	2030	Total
Not-Served Energy (GWh)	7,149	6,313	5,453	4,520	3,512	2,424	1,254	30,625
Shortage Cost (USD/MWh)	199	208	174	190	209	196	168	192
Billion USD	1.4	1.3	1	0.9	0.7	0.5	0.2	6

limit GHG emissions; an average of 36% penetration of variable renewable sources is reached in this scenario.

The BAU scenario is the least expensive, but it is not viable for the Dominican Republic [34,36]. To execute this scenario, it is necessary to invest more than 2 billion USD to install 2.15 GW of natural gas in the first year of planning. Considering both the money and time required to construct a power plant capable of adding 2.15 GW to the National Electric System, the BAU scenario is not viable. Therefore, alternative scenarios such as the E-Shortage scenario allow the Dominican Republic to continue implementing traditional cuts in demand, at least until 2030. If the country implements transport electrification, scenarios requiring a first significant investment of just around 0.6 billion USD in new capacity in 2028–2031 and a rate of 0.5 billion USD yearly are possible. These investments are likely to be feasible considering that the gross domestic product of the Dominican Republic in 2022 was 114 billion USD [41].

From the economic point of view, it is desirable for the country to encourage the investment of 2 billion USD suggested in the BAU scenario. The total cost imposed upon the industrial, residential, commercial and public services sectors by the 30,625,556 MWh (110,252 PJ) of energy not served in the period 2024–2030, valued based on the prognosticated shortage cost for each year (Table 6), is equivalent to about 6 billion USD, which is more than 270% the investment that should be made in the national electricity system in the same period. This extra cost is detrimental to social welfare because it raises electricity prices and does not contribute to infrastructure development.

Despite the increase in GHG emissions due to the shift of cargo from the transport sector to the electricity sector, the net effect of this displacement is positive, given that GHG emissions from the consumption of transport fuels are higher. Comparing the E-Shortage scenario with the EV-Transport scenario, emissions from the electricity sector increase by 30.54 Mt, whereas those from the transport sector decrease by 91.92 Mt: the net effect is a reduction of 61.38 Mt (Fig. 4).

As can be seen in Fig. 4, from 2044, it is not possible to maintain the emission limit to reduce GHG emissions by 27% by 2030. Due to the increase in electrical demand, it is necessary to have the support of technologies other than onshore wind and solar photovoltaic to maintain this goal until 2050 and achieve carbon neutrality, as expressed in the NDC-2020 for the Dominican Republic.

This study's results validate the 'Planning of Investments in Electricity Generation of the Dominican Republic 2040" [42], which recommends new combined cycle natural gas plants, as well as the 'National Energy Plan 2022–2036' [43], which recommends diversifying the energy matrix by increasing natural gas and other renewable energy sources to reduce GHG emissions. The results also show that to achieve carbon neutrality by 2050, a necessary but insufficient step is to close or transform all coal-fired power plants by 2040.

Unfortunately, there have not been enough publications on long-term energy planning or analysis in the Dominican Republic. Beyond the 'Investment Planning in Electricity Generation of the Dominican Republic 2040' published by the Ministry of Energy and Mines [42], the 'National Energy Plan 2004–2015' [44] and 'National Energy Plan 2022–2036' published by the National Energy Commission [43], our literature review only identified two relevant studies: one by Quevedo and Moya, entitled, 'Modelling of the Dominican Republic energy systems with OSeMOSYS to assess alternative scenarios for the expansion of renewable energy sources' [45] and one published by the Inter-American Development Bank, entitled, 'Economic Evaluation of the Decarbonisation of the Electricity Sector in the Dominican Republic' [46]. The present study is relevant for developing similar studies and generating knowledge about the energy future of the Dominican Republic and other SIDS.

4.2. Limitations and opportunities of future works

The main limitations in the methodology applied are discussed here.

Data and assumptions: In this study, some data from energy technology are adopted from reports of similar applications due to the lack of local records. For the transport sector, the performance by technology is established based on the type of technology, but the year of exploitation and its effect on efficiency is not captured.

Limited Technology Details: OSeMOSYS uses a technology-rich representation of the energy system but may not capture all the complexities of specific technologies. The ARIMA model is used to elaborate on the forecast model of the projection of the vehicle fleet until the year 2050; the records on fleet composition are moderated and may induce some uncertainties.

Limited consideration of environmental impacts: While some energy models incorporate environmental factors, such as greenhouse gas emissions or air pollution, the level of detail and accuracy can vary. Models may not fully capture the ecological consequences of different energy pathways or adequately account for energy production and consumption externalities. In this analysis, only environmental impact is considered.

It is essential to consider these limitations when interpreting energy modelling results and to recognise that models provide valuable insights but are not infallible predictors of the future. The limitations do not necessarily invalidate the study's findings but rather highlight areas that should addressed in future research to enhance the robustness and applicability of the results.

In future work, it is recommended to include technologies from renewable sources that include storage in the model. It is also recommended to extend this model to evaluate the climate, land (food), energy and water (CLEWs) systems, focusing on assessing the interrelationships between resource systems, locating pressure points and minimising trade-offs while enhancing the synergies of these systems.

5. Conclusion

Meeting climate change commitments and national goals embodied in NDC-2020, not including carbon neutrality by 2050, requires that all coal-fired plants in the country will be closed or transformed by 2040. Decarbonising the electricity sector of the Dominican Republic while facing the energy crisis necessitates investments of around 16 billion USD.

The development of electric mobility positively impacts the net reduction of greenhouse gas emissions. Shifting cargo from the transport sector to the electricity sector while maintaining the diversification of the energy matrix (as in the EV-Transport scenario) demands additional investments of up to 2 billion USD in the electricity sector.

The lack of investment in the electric power generation sector causes users in the industrial, residential, commercial and public services sectors to bear costs of up to 6 billion USD in 2024–2030 to cover their energy needs. These costs are equal to more than 270% of the amount that should be invested in the electrical power system to supply these users' needs.

This study provides valuable insights into how electric mobility affects the Dominican Republic's efforts to decarbonise its power sector. Policymakers can use these results to formulate policies and strategies that promote transition to a more sustainable energy system and contribute to achieving global and national targets for reducing greenhouse gas emissions.

U4RIA compliance statement

This work adheres to the U4RIA recommendations [10], which offer a list of high-level objectives for carrying out energy system evaluations in nations. U4RIA implies universally Retrievable, Repeatable, Re-constructible, Reproducible, Interoperable and Auditable.

Financing

The Government of the United Kingdom of Great Britain and Northern Ireland acting through the Foreign, Commonwealth & Development Office ('FCDO') and Loughborough University. FCDO Project Name: Climate-Compatible Growth. FCDO Project Number: 300,125.

CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Supplementary data to this article can be found online at https://data.mendeley.com/datasets/tk8ndsp9wt/2.

Acknowledgement

This material has been produced under the Climate Compatible

Growth (CCG) programme, which brings together leading research organisations and is led out of the STEER centre, Loughborough University. CCG is funded by UK aid from the UK government. However, the views expressed herein do not necessarily reflect the UK government's official policies. This work was developed with the Energy Transition Council (ETC), which assisted in identifying needed research areas and connected to relevant stakeholders for a discussion on essential aspects of research. This paper was reviewed and edited by Simon Patterson (CCG, Loughborough University).

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