4-2024

Building a Cleaner, More Resilient Energy System in Cuba: Opportunities and Challenges

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APRIL 2024

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Acknowledgements: The authors would like to thank Stephanie Jones, Valerie Miller, Michael Panfil, Robert Muse, Michael O'Boyle, and Kaitlyn Bunker for their thoughtful review and comments. All conclusions and errors are the authors' own.

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BUILDING A CLEANER, MORE RESILIENT ENERGY SYSTEM IN CUBA

OPPORTUNITIES AND CHALLENGES

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EXECUTIVE SUMMARY

Cuba's energy sector is at a crossroads. The country's mostly fossil fuel-fired energy system faces a number of longstanding and serious challenges, including breakdowns at aging power plants, decreasing fuel imports and fuel shortages, and the growing threat of climate change-related disruptions. In recent years, Cuba has seen frequent electric blackouts and brownouts that have affected residents, businesses, and government institutions island wide.

Compounding these problems, Cuba is facing a severe economic crisis. In 2022, year-on-year inflation was 39% (down from 77% in 2021). While inflation is estimated to have dropped to 30% in 2023, the price of food increased 78%.[1] Residents of Cuba are expected to experience a new wave of inflation in 2024 following the government's announcement of a new austerity plan that will include price and tax increases and cuts in subsidies.[2] Further, according to Cuba's Minister of Economy and Planning, export earnings in 2023 were just $9.1 billion (down from $12 billion in 2019), missing the forecasted $9.9 billion.[3]

Overcoming Cuba's energy challenges amidst the economic crisis will be no small task, requiring substantial investments of capital, which have been hard to come by given real and perceived risks of investing in Cuba under current circumstances and other regulatory and legal obstacles. New policies and systemic changes, and an overall reimagining of the country's energy system, will be essential to attract the new investment needed to enable a clean energy future.

Over the past 10 years, Cuba has begun to embark on an energy transition. Recent shifts in law and policy create new and promising opportunities and indicate a desire on the part of Cuba's policymakers to transition to a cleaner, more climate resilient energy system. Cuba committed to generating 24% of its electricity from renewable energy sources by 2030 as part of the country's Nationally Determined Contribution (NDC) under the Paris Agreement. Policymakers have subsequently announced their intent to increase renewable electricity generation to 37% by 2030. Additionally, in 2019, Cuba updated its constitution to explicitly state that the government must respond to climate change and aims to promote foreign investment for economic development. Cuba's intention to transition to renewable energy generation is key, as renewables can provide climate change mitigation, reduced local air pollution, and resilience benefits over the current fossil fuel-fired power generation system.

This report provides detailed information on the current state of Cuba's energy sector and identifies opportunities to accelerate the deployment of renewables and advance climate resilience. The information provided is intended to help support future decisions on planning and policy in Cuba, foreign policy in the United States and other countries, and private and public investment in the country's clean energy transition.

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[1] NU.CEPAL, Economic Survey of Latin America and the Caribbean 2023: Financing A Sustainable Transition: Investment for Growth and Climate Action (2023), https://repositorio.cepal.org/items/d9e5dc2c-6d91-4adc-aca4-f4745a493016

[2] Marc Frank & Nelson Acosta, *Cuba's Economy Still Shrinking, Minister Says,* Reuters, Dec. 20, 2023, https://www.reuters.com/world/americas/cubas-economy-still-shrinking-minister-says-2023-12-20/

[3] *Id.*

The report begins with key data on Cuba's electricity sector, including the resource mix, generation capacity, transmission and distribution, and consumption. In 2022, fossil fuels accounted for about 95% of electric power generation, while renewables accounted for the other 5%. About 48% of the fossil fuels used in electricity generation in Cuba are imported. The rest are produced domestically, with the country's domestic oil production falling about 14% from 2014 to 2021. The domestic oil Cuba produces is high-sulfur crude, the burning of which can increase power plant breakdowns and have detrimental impacts on human health and the environment.

The country had 6,235 MW of installed generation capacity in 2022. However, actual generation capacity is likely significantly lower due to aging power plants, maintenance issues, and other equipment failures. As a result, according to some reports, less than 40% of installed capacity was operational at times in 2023. Like all electric grids, generation capacity in Cuba is made up of both large, centralized generation systems and smaller, distributed generation systems. Unlike most electric grids, however, Cuba's system has one of the highest percentages of distributed generation in the world, with approximately 36% of generation capacity in distributed systems.

The second section of the report provides information on the climate risks to Cuba's energy. As noted there, maximum temperatures on the island are expected to increase significantly in the coming decades, with direct impacts on Cuba's energy system, including both fossil fuel-based and renewable energy production. Extreme heat can cause the demand for electricity to surge. Higher temperatures can also reduce the efficiency of fossil fuel-based power plants and solar panels that supply power to meet this demand. As shown by the devastation to Cuba's energy grid caused by Hurricane Ian in 2022, increases in extreme weather events can reduce the supply of fossil fuels, damage generation and grid infrastructure, reduce output, and affect the security of supply. Further, rising sea levels can flood coastal energy infrastructure and limit the areas in which new power plants and other grid-related infrastructure can be constructed.

The third section of the report goes on to detail Cuba's relationships with countries that have a significant relevance to its energy sector. One example is Venezuela, which has been Cuba's primary source of imported oil since 2000. However, economic troubles in Venezuela have resulted in oil exports to Cuba falling by about half and led Cuba to increasingly seek oil imports from Mexico and Russia. Since 2018, Cuba has contracted with a Turkish power company to provide floating fuel oil-fired power plants that feed into the electric grid. Cuba has also worked with India, the Indian-based International Solar Alliance, and China to develop renewable energy projects.

U.S. policy also has a significant impact on Cuba's energy sector. The United States has maintained a trade embargo on Cuba since the early 1960s. During the Obama Administration, the United States initiated a policy shift away from sanctions and, in 2015, the administration rescinded Cuba's designation as a state sponsor of terrorism and restored diplomatic relations. The Trump Administration changed course and introduced new sanctions in 2017, before largely abandoning relations by 2019. The Biden Administration has announced several modest changes, including easing of travel restrictions, but has not yet taken significant steps to ease economic restrictions.

The fourth section of the report provides information on energy policy design in Cuba and highlights key developments over the last five years. During that period, Cuba implemented several measures that signal both a commitment to mitigate greenhouse gas emissions and a desire to advance a clean energy transition. These include the 2019

constitutional update discussed above. Also notable are the 24% and 37% renewable electricity generation by 2030 goals. Meeting those goals will require massive investments in renewable generation; it is estimated that 2,144 MW of newly installed renewable generation capacity will be required by 2030. Alongside the generation build-out, Cuba will also need to take steps to harden existing infrastructure, and otherwise protect against the impacts of climate change.

The fifth section of the report highlights lessons Cuba can draw from the Caribbean region broadly and particular jurisdictions within that region. Cuba can draw from the expertise of both the Caribbean Community (CARICOM) and the Alliance of Small Island States (AOSIS) to facilitate its energy transition. Cuba can also engage with, and learn from, the Bahamas and Puerto Rico, both of which have seen widespread damage from hurricanes, and both of which have committed to an energy transition towards renewables.

The report concludes with recommendations to help facilitate Cuba's energy transition. The recommendations span three key areas: Cuba Policies and Programs, Regional Cooperation, and U.S. Policy. The recommendations are:

Cuba Policies and Programs

- Codify the higher renewable electricity generation figure (37% by 2030) into law;
- Prioritize solar and wind development to meet the 2030 renewable energy goal;
- Incentivize private energy development and provide protections for investors; and
- Incorporate resiliency planning into infrastructure development.

Regional Cooperation

- Step up dialogue and cooperation in the region on clean energy transition.

U.S. Policy

- Ease rules further to allow more exports of clean energy technology to Cuba from the United States and other countries and allow U.S. investment in Cuban energy projects;
- Utilize an existing bi-lateral agreement to initiate government to government dialogue with Cuba on clean energy, including discussions on access to financing and Cuba's participation in PACC 2030; and
- The U.S. government should align its foreign policy goals in Cuba with its climate and clean energy objectives.

I. CUBA'S ELECTRICITY SECTOR

Cuba's electric power grid is largely reliant on fossil fuels (crude oil, fuel oil, diesel, and natural gas). In 2022, fossil fuels accounted for 5,393 Megawatts (MW) of Cuba's generating capacity (86%), renewable energy (solar, wind, and hydro) accounted for 328 MW (5%), and Independent Power Producers (IPPs)[4] accounted for 514 MW (8%).[5]

About 48% of the fossil fuels[6] used in electricity generation in Cuba are imported.[7] The rest of the fuels are produced domestically. Cuba's domestic oil production fell to about 43,000 barrels per day in 2021, down 14% from 2014.[8] The domestic oil that Cuba produces is high-sulfur crude,[9] the burning of which increases the risk of power plant breakdowns and generates air pollution that is particularly harmful to human health and the environment.[10] Ingesting sulfur oxides emitted from the burning of high-sulfur fuels can lead to heart and lung problems and is a leading cause of childhood asthma. It also contributes to acid rain and other environmental problems.

In terms of electric power generation (in gigawatt hours (GWh)), fossil fuels, renewables, and IPPs generated 15,732 GWh in 2022. KPS Powerships (see *Section I.8*) produced an additional 2,591 GWh, resulting in a combined total of 18,323 GWh for the year. Table 1 below provides a breakdown of generation by fuel type.

Fuel Type	Electric Power Generation (GWh)	Percent of Total
Fossil Fuels	14,979	95.2%
Renewables	477	3.1%
Sugarcane Bagasse	276	1.6%

Table 1. Breakdown of generation (GWh) by fuel type and the relevant percentage of total annual electric power generation in 2022.

[4] IPPs produce nickel oil and sugarcane bagasse.
[5] ONEI, ANUARIO ESTADÍSICO DE CUBA 2022 (2023), http://www.onei.gob.cu/sites/default/files/publicaciones/2023-11/aec-2022_1.pdf
[6] For more on Cuba's fossil fuel imports, see *Section III* below.
[7] Randy Alonso et al., *Modifican tarifas eléctricas para el sector residencial y precios del gas licuado de petróleo*, CUBADEBATE (Dec. 26, 202), http://www.cubadebate.cu/noticias/2020/12/28/modifican-tarifas-electricas-para-el-sector-residencial-y-precios-del-gas-licuado-de-petroleo/.
[8] Canute James, *Cuba's Oil Production to Fall for Seventh Year,* ARGUS MEDIA, (Aug. 11, 2021), https://www.argusmedia.com/pt/news/2243420-cubas-oil-production-to-fall-for-seventh-year
[9] *Id.*
[10] Abdurrashid Haruna et al., *Sulfur Removal Technologies from Fuel Oil for Safe and Sustainable Environment*, 329 FUEL 125370 (2022).

I.B. GENERATION CAPACITY

Nameplate generation capacity (i.e., installed capacity) in Cuba has grown modestly in recent years, from roughly 6,190 MW in 2014 to 6,235 MW in 2022—a less than 1% increase.[11] However, actual generation capacity is likely significantly lower than this figure due to aging thermoelectric power plants, increased maintenance from burning high-sulfur fuel oil, and other equipment failures that have hampered electricity generation from fossil fuel-fired power plants.[12]

Like all electric grids, generation capacity in Cuba is made up of both large, centralized generation systems (e.g., thermoelectric oil-fired power plants), and smaller, distributed generation systems (e.g., fuel oil and diesel-fired generators). However, unlike most electric grids, Cuba's system has one of the highest percentages of distributed generation in the world, with approximately 36% of generation capacity in distributed systems. [13]

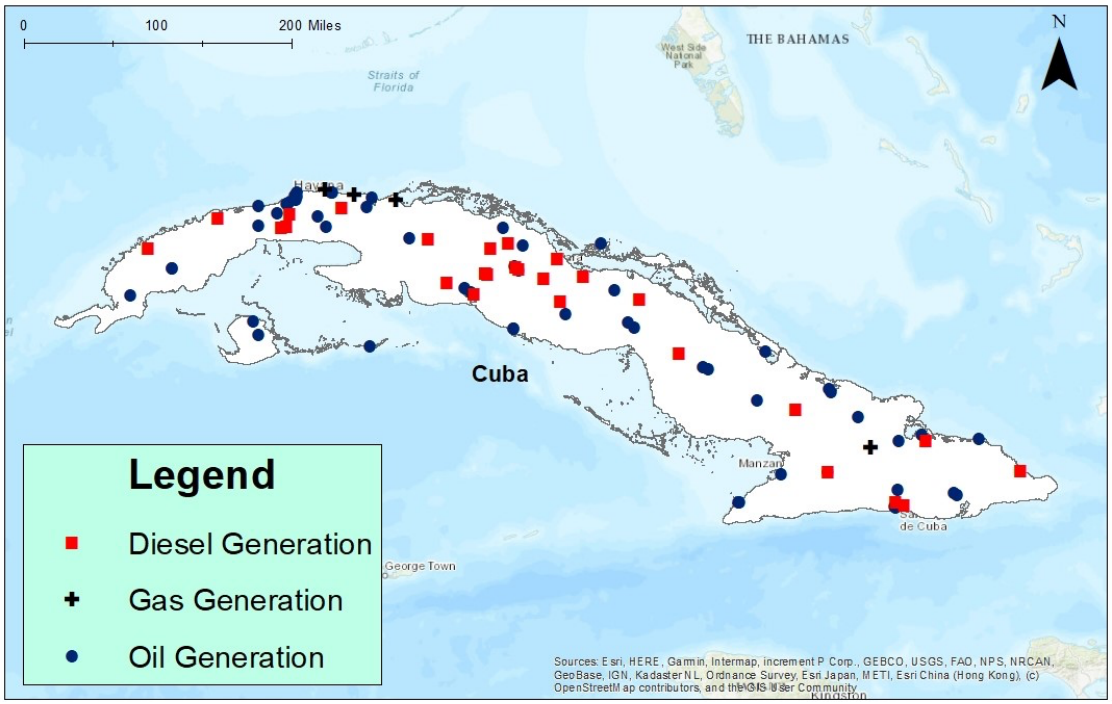

Figure 1. Distribution of fossil -fuel--based power generation in Cuba. According to data from OpenStreetMap[14], there are 55 oil, 32 diesel, and three gas-fired power plants across the island.

[11] Onei, *supra* note 5; Electricidad en Cuba Indicadores Seleccionados 2022, *supra* note 5.
[12] Amaury Perez Sanchez, *Thermal Power Plants in Cuba Struggle to Meet Demand*, POWER MAGAZINE (Aug. 1, 2023), https://www.powermag.com/thermal-power-plants-in-cuba-struggle-to-meet-demand/
[13] Michael Panfil et al., *The Cuban Electric Grid*, 30 ELECTR. J. (2017), https://www.edf.org/sites/default/files/cuban-electric-grid.pdf
[14] Open Infrastructure Map, *Stats: Cuba*, https://openinframap.org/stats/area/Cuba (last visited Apr. 11, 2024).

I.C. CENTRALIZED GENERATION

Eight fossil fuel-fired power plants comprise the majority (2,593 MW) of Cuba's centralized generation.[15] However, government reports and research by one outside expert suggest that, due to maintenance and aging issues, only 72% of this capacity is operational under normal conditions.[16] Further reports by Unión Eléctrica (UNE), Cuba's vertically integrated electric utility, suggest that less than 40% of fossil fuel generating capacity was operational throughout 2023.[17] Several of Cuba's fossil fuel-fired plants are more than 40 years old and have seen operational issues stemming from boiler fires and boiler deterioration due to lack of maintenance.[18]

Plant Name	Location	Installation Years	Installed MW[2]	Nominal MW[3]	Operation (% of Capacity)	Fuel Type
Maximo Gomez	Mariel	1977 - 1982	370 MW	330 MW	89%	Crude Oil
Otto Parellada	Tallapiedra, L. H.	1972	60 MW	0 MW	0%	Fuel Oil
Ernesto Guevara	Santa Cruz del Norte	1987 - 1996	295 MW	260 MW	88%	Crude Oil
Antonio Guiteras	Matanzas	1988	317 MW	290 MW	92%	Crude Oil
10 de Octubre	Nuevitas	1985 - 1996	375 MW	174 MW	46%	Crude Oil
Lidio Ramon Perez	Felton, Mayari	1997 - 2000	480 MW	225 MW	47%	Crude Oil
Antonio Maceo (RENTE)	Santiago de Cuba	1978 - 1984	380 MW	320 MW	84%	Fuel Oil
Carlos M. de Cespedes	Cienfuegos	1978 - 1979	316 MW	280 MW	89%	Crude Oil
Total (8)			2,593 MW	1,879 MW	72%	
[2] Maximum capacity for which Block was designed.						
[3] Estimated annualized output under current operating conditions.						

Table 2. Major thermoelectric power plants operating in Cuba.[19]

[15] See *Table 1*
[16] See *Table 1*
[17] Jorge Piñon & Ricardo Torres, *The National Electric Grid and the Future of the Cuba Economy,* Columbia Law School Cuba Capacity Building Project, https://horizontecubano.law.columbia.edu/news/national-electric-grid-and-future-cuban-economy (last visited Feb. 21, 2024).
[18] Sanchez, *supra* note 12.
[19] Onei, *supra* note 5.

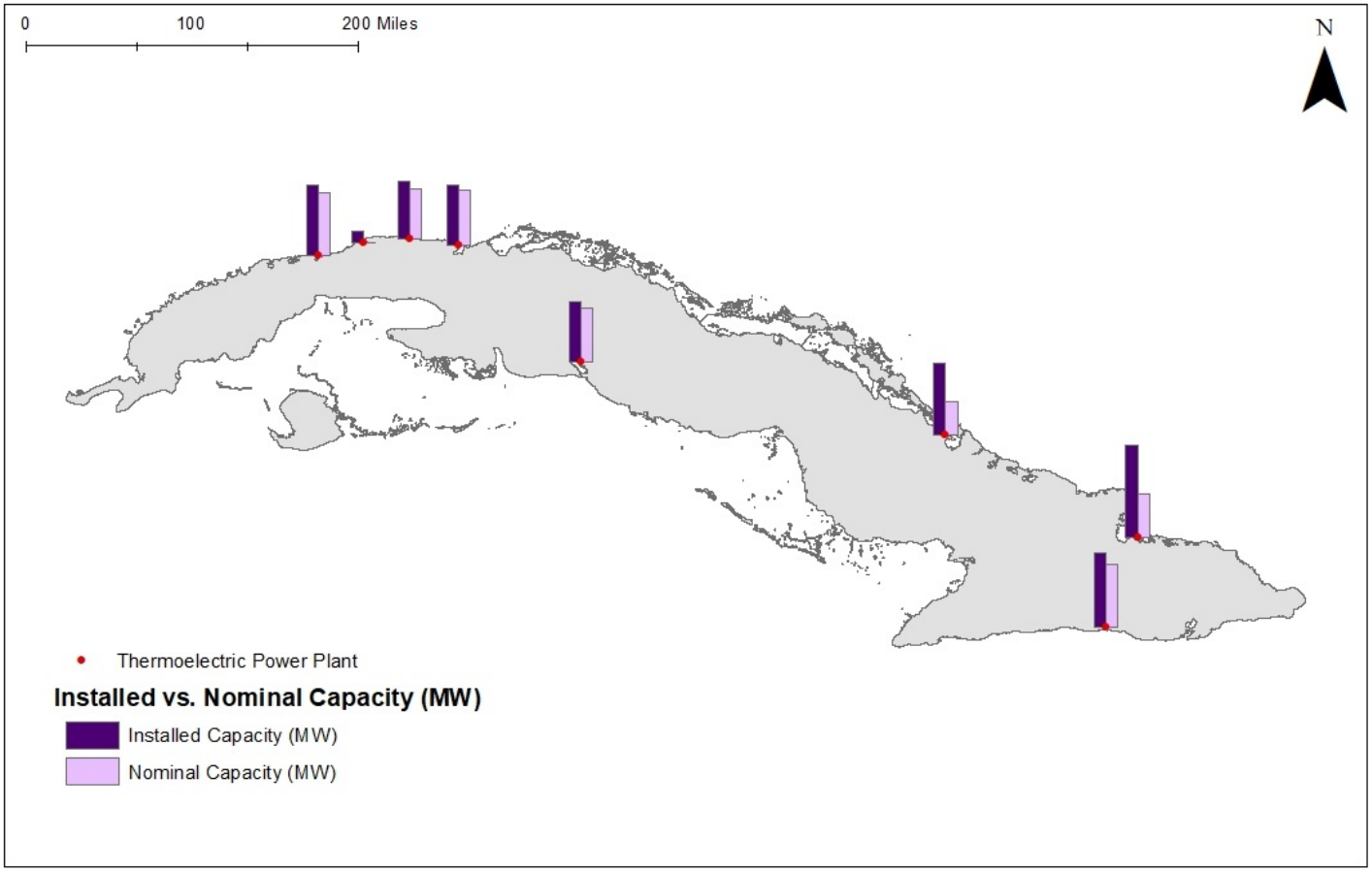

Figure 2. Installed versus nominal capacity, in MW, across all eight major thermoelectric power plants included in **Table 2** above. These power plants met just 72% (1,879 MW) of their combined installed capacity (2,593 MW).

I.D. DISTRIBUTED GENERATION

As discussed in Section I.B. above, 36% of electricity generation capacity in Cuba is in distributed generation systems.[20] The majority of this capacity is in diesel generators (about 1,065 MW) and fuel oil motors (1,200 MW).[21] These systems are distributed widely throughout the country, with large installations in Moa, Mariel, and Havana.[22] Cuba also has distributed combined heat and power and renewable systems.[23]

[20] Panfil et al., *supra* note 13.
[21] Onei, *supra* note 5.
[22] There is a large nickel plant located in Moa, Mariel is the most important port, and Havana is the largest city and capital. *See* Panfil et al., *supra* note 13.
[23] *Id.*

Similar to its centralized thermoelectric power plants, Cuba's fossil fuel-fired distributed generation systems saw significant operational challenges in 2023. Generation data reporting from UNE suggests that, at certain points in 2023, 59% of installed capacity at these systems was out of service due to equipment failures and diesel fuel shortages.[24]

I.E. RENEWABLE ENERGY GENERATION

Renewable energy sources made up around 5% of electric power generation in 2022. Cuba notably considers biofuels[25] to be renewable—nearly 2% of total generation was from the burning of sugarcane bagasse.

Cuba's National Social and Economic Development Plan (Plan Nacional de Desarrollo Económico y Social) aims to increase the proportion of clean energy output to 37% by 2030.[26] However, financial constraints on Cuba's energy sector have set these plans roughly 40% behind the intended schedule—with only 303 MW installed in 2021 compared to a 506 MW goal.[27] In 2022, Cuba had 84 solar photovoltaic plants, with an estimated 252 MW capacity in operation, producing roughly 2.2% of daily electricity.[28] The country also had four wind farms in operation in 2022, with generation capacity of roughly 11.8 MW.[29]

I.F. TRANSMISSION AND DISTRIBUTION

At present, there are 7,700 kilometers of installed transmission lines across Cuba.[30] In February 2022, Cuba announced plans to expand its electricity infrastructure by constructing 131 steel towers for high-voltage power transmission lines across the country.[31] Cuba is also looking to expand transmission capacity through foreign investment in combined generation and transmission projects. For example, in 2022, Cuba signed a deal with the Kuwait Fund for Arab Economic Development (KFAED) that provided the country with 30 million USD in financing for the construction of 34 small

[24] Piñon and Torres, *supra* note 17.
[25] For more on the climate and environmental impacts of biofuel generation, see *Section IV* below.
[26] Den Extremera et al., Bioenergía, otra alternativa en el cambio sostenible de la matriz energética cubana, CubaDebate (Apr. 1, 2021), http://www.cubadebate.cu/especiales/2021/04/01/bioenergia-otra-alternativa-en-el-cambio-sostenible-de-la-matriz-energetica-cubana/; James, *supra* note 8.
[27] René Tamayo, *Sesión del Consejo Nacional de Innovación: Vamos a trabajar con todas las energías,* CubaDebate (Oct. 16, 2021), http://www.cubadebate.cu/noticias/2021/10/16/sesion-del-consejo-nacional-de-innovacion-vamos-a-trabajar-con-todas-las-energias/
[28] Randy Alonso, Unión Eléctrica ejecuta ambicioso proceso inversionista y apuesta por las fuentes renovables de energía, CubaDebate (March 16, 2021), http://www.cubadebate.cu/noticias/2021/03/16/union-electrica-ejecuta-ambicioso-proceso-inversionista-y-apuesta-por-las-fuentes-renovables-de-energia-video/.
[29] Extremera, *supra* note 26.
[30] David Urra, *Cuba's Strategy for Electricity Generation,* Cuba Business Report (Mar. 31, 2021), https://www.cubabusinessreport.com/cubas-strategy-for-electricity-generation/ For comparison, Puerto Rico has about 5,000 km of transmission lines to transmit generation from an ~5,800 MW capacity system (Cuba generated 6,235 MW in 2022). *See* Frederico Sotomayor, *Puerto Rico's Electric System: An Analysis of Contemporary Failures and the Opportunity to Rebuild a More Resilient Grid, including the Development of a Utility-Scale Solar Farm on the Island Municipality of Culebra*, Int'l Dev., Community, & Envtl. (2020).
[31] *Cuba Announces Manufacture of High-Voltage Electricity Pylons*, teleSUR (Feb. 21, 2022), https://www.telesurenglish.net/news/Cuba-Announces-Manufacture-of-High-Voltage-Electricity-Pylons-20220221-0015.html

hydropower projects, with a combined generation capacity of 14.6 MW.[32] This deal also includes the construction of three linking substations that will transmit to Cuba's national grid, along with the build-out of approximately 75 kilometers of transmission lines.

I.G. CONSUMPTION

According to Cuba's National Statistics Office (ONEI), total power consumption decreased between 2018 and 2022.[33] This drop in consumption was the result of decreased generation—during this same time period, total electricity generated declined 12.4%, resulting in less electricity available to meet the needs of consumers.[34]

In 2020, facing economic unrest and high energy premiums, the Cuban government piloted a program to reduce electricity rates in the residential sector.[35] These modified rates varied by 'consumption segments' and included lower rates for consumers with lower monthly consumption.[36] In Cuba, over 90% of consumers use less than 350 kWh/month, and this group of consumers represents nearly 80% of residential electricity consumption.[37] In contrast, the average U.S. residential consumer used 889 kWh/month in 2022.[38]

In 2023, Cuba's Ministry of Finance and Prices announced a resolution aimed at setting rates for the sale of electricity produced by various forms of renewable generation.[39] The resolution set separate rates for the purchase of electricity generated by bagasse power plants, non-residential sector renewables, and residential sector renewables.[40] The resolution also aimed to incentivize renewable energy production by ensuring that such projects are exempt from income tax during recovery of investment for up to eight years.[41]

[32] Int'l Hydropower Association, *Region Profile: North and Central America,* https://www.hydropower.org/region-profiles/north-and-central-america (last visited Feb. 23, 2024); Michael Harris, *Kuwaiti Agency Financing Small Hydro Development in Cuba*, HydroReview (Apr. 26, 2017), https://www.hydroreview.com/business-finance/finance/kuwaiti-agency-financing-small-hydro-development-in-cuba/#gref
[33] Anuario Estadístico de Cuba 2022, *supra* note 5; Electricidad en Cuba Indicadores Seleccionados 2022, *supra* note 5.
[34] *Id.*
[35] Randy Alonso Falcôn et al., Modifican tarifas eléctricas para el sector residencial y pecios del gas licuado de petróleo, CubaDebate (Dec. 28, 2022), http://www.cubadebate.cu/noticias/2020/12/28/modifican-tarifas-electricas-para-el-sector-residencial-y-precios-del-gas-licuado-de-petroleo/comentarios/pagina-3/.
[36] *Id.*
[37] *Id.*
[38] U.S. Energy Information Administration, *Frequently Asked Questions (FAQs)*, https://www.eia.gov/tools/faqs/faq.php (last visited Mar. 4, 2024)
[39] Resolution 238, Cuba Ministry of Finance and Prices (2023). *See* Andrea Rodriguez, *Cuban Government Defends Plans to Either Cut Rations or Increase Prices*, AP News (Dec. 23, 2023), https://apnews.com/article/cuba-economy-ration-cuts-prices-1d429722219bff732846d38cb6d4edde.
[40] *Id.*
[41] *Id.*

I.H. KEY PLAYERS IN CUBA'S ELECTRICITY SECTOR

Ministry of Energy and Mines. Energy policy in Cuba is state driven and is directed by the Ministry of Energy and Mines. The agency is responsible for all activities related to the energy sector, including oversight of Unión Eléctrica, the state-run utility.[42]

Unión Eléctrica (UNE). UNE is Cuba's vertically integrated utility that provides power throughout most of the country. Established in 1960, UNE serves Cuban households and other end-users of electricity. UNE is responsible for the entire electric sector, including generation, transmission, and distribution.[43]

Ministry of Science, Technology, and Environment (CITMA). CITMA oversees Cuba's environmental policy and was originally established in 1994 based on the government's decision to make sustainable development and environmental protection a policy priority and to provide a clearer and more integrated mandate for environmental governance.[44]

Cuba's National Statistics Office (ONEI). ONEI provides economic, energy, and other data for Cuba. ONEI publishes annual reports about Cuba's electricity sector.[45]

Cupet. As Cuba's vertically integrated state-run oil company, Cupet is responsible for exploration, production, and refining domestic oil, and may enter into third party contracts with private parties.[46]

Energoimport. Energoimport is Cuba's state-owned import company for electricity generation, transmission, and distribution equipment. In October 2018, Energoimport signed a contract with the Turkish company Karpowership to deploy powerships to boost generation capacity in Cuba.[47]

Energas. Energas is a joint venture of Sherritt (a Canadian company), Cupet (the Cuba state-owned oil company), and UNE (Cuba's electric utility). Each party holds a 33% stake in the joint venture. Energas is responsible for electricity generation at natural gas-powered plants in Varadero, Boca de Jaruco, and Puerto Escondido. These plants, taken together, have a total generating capacity of 506 MW.[48]

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[42] Dennis Desgain & James Haselip, *Barriers to the transfer of low-carbon electricity generation technologies in four Latin American countries*, 10 ENERGY SOURCES: PART B: ECONOMICS, PLANNING, AND POLICY 348, 356 (2015).
[43] Manuel Cereijo, Republic of Cuba: Power Sector Infrastructure Assessment 48, University of Miami (2010).
[44] Olivier A. Houck, *Environmental Law in Cuba*, 16 J. LAND USE & ENVIRONMENTAL L. 1 (2000).
[45] Library of Congress, *Oficina Nacional de Estadística e Información (Cuba)*, https://www.loc.gov/item/lcwaN0038271/ (last visited Mar. 15, 2024).
[46] Unión Cuba-Petróleo (CUPET), https://web.archive.org/web/20160323151727/http://www.cupet.cu/es (last visited Feb 13, 2024).
[47] El Toque, *Turkish Powerships in Cuba, a Plan We Know Little About*, HAVANA TIMES (Dec. 8, 2022), https://havanatimes.org/features/turkish-powerships-in-cuba-a-plan-we-know-little-about/.
[48] Sherritt, 2015 Annual Report, Sherritt International Corporation

Cubasolar. Cubasolar, which was created in 1994 to promote the use of renewable energy in Cuba, is a quasi-independent organization which operates under the auspices of CITMA.[49]

AzCuba. AzCuba is a state-run entity focused on the production of sugarcane bagasse to produce electricity. AzCuba consists of 25 provincial and service companies, including two research institutes on sugarcane.[50]

International Solar Alliance (ISA). The ISA is a collaborative platform with the goal of increasing deployment of solar energy technologies in its member countries. The ISA was originally conceived in 2015 at the 21st Conference of Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) by India and France. Today, 116 countries have signed on to the ISA Framework Agreement, 94 of which are recognized as fully ratified members.[51] As a member country, Cuba has partnered with the ISA in setting a goal to install 1,150 MW of solar generating capacity on the island. Across member countries, the ISA seeks to install 1,000 GW of solar energy capacity.[52]

National Thermal Power Corporation (NTPC). The NTPC, founded in 1975, is an Indian energy corporation owned and operated by India's Ministry of Power. With an electric power generating capacity of 72,304 MW, the NTPC has quickly become the largest power company in India. The ISA has been working with the NTPC, Cuban officials, and engineers to install solar power plants that would help Cuba reach its renewable energy goals. This project is considered a priority and has received support from the Cuban legislature to ensure that relevant procedures and permissions are met to secure foreign investment.[53]

Deltro Energy Solutions, S.A. Deltro Energy Solutions, a 100% foreign capital, Canadian company registered in Barbados, announced plans to develop, construct, install, manage, and commercialize electrical energy for at least 19 solar parks throughout Cuba in 2021.[54]

Kuwait Fund for Arab Economic Development (KFAED). The KFAED is the State of Kuwait's agency for the provision and administration of financial and technical assistance to the Global South. KFAED extends loans on concessionary terms to finance development projects in the Global South, as well as providing technical assistance to finance the costs of projects. The Fund's operations are focused primarily on the sectors of agriculture and irrigation, transport and communications, energy, industry, water, and sewage.[55]

[49] RedSolar, *RedSolar – Cubasolar*, http://www.cubasolar.cu/ (last visited Feb 13, 2024).
[50] Ecured, *Grupo Empresarial de la Agroindustria Azucarera*, https://www.ecured.cu/Grupo_Empresarial_de_la_Agroindustria_Azucarera (last visited Apr. 11, 2024).
[51] International Solar Alliance, https://isolaralliance.org/about/background (last visited Feb 13, 2024).
[52] *Id.*
[53] NTPC Limited, A*bout Us*, https://www.ntpc.co.in/about-us (last visited Feb 13, 2024).
[54] Urra, *supra* note 29.
[55] Kuwait Fund for Arab Economic Development, *Partners in Development,* https://www.kuwait-fund.org/en/web/kfund/general-information (last visited Feb. 13, 2024).

Karpowership. Karpowership, a Turkish business group that specializes in electricity generation, started its energy investments in 1996 and now owns and operates 6,000 MW of installed capacity globally. The company owns the fleet of floating power plants that, in partnership with Energoimport, were deployed to Cuba in October 2018.[56]

[56] Karpowership, https://www.karpowership.com/ (last visited Feb 13, 2024).

II. CLIMATE RISK AND CUBA'S ENERGY SYSTEM

The consequences of climate change, in the form of changing weather patterns and increased, more intense extreme weather events, are being felt around the globe. The physical risks of climate change can be either event-driven (acute) or associated with longer term shifts in climate patterns (chronic). In Cuba, like other countries, the impacts of climate change take a variety of forms. Acute physical risks can arise from, among other things, increased severity of extreme weather events such as hurricanes, heat waves, and flash flooding. Chronic physical risks may result from rising average temperatures, sea-level rise, and changes in precipitation patterns. Both acute and chronic physical risks can affect the entire energy system: fuel mining and production, fuel transportation to power plants, electricity generation, transmission through high voltage grids, and low voltage distribution to customers.

II.B. CUBA'S CLIMATE

Cuba's climate is defined as tropical with both maritime and semi-continental influences. The rainy period, which coincides with the majority of the Atlantic hurricane season, runs from May to October, and the dry season covers November to April. Between 1991–2020, Cuba's mean annual temperature was 25.8° Celsius (78.4° Fahrenheit (F)) and mean annual precipitation was 1375.77 mm (54.16 inches).[57] Cuba's summer months can be particularly hot, with maximum temperatures reaching up to 33° Celsius (91.4° F), leading to high energy demand as residents and businesses across the island rely on air conditioners for cooling.[58]

Cuba's geographical location in the Caribbean Sea makes the island nation particularly vulnerable to tropical cyclones. Indeed, a review of NOAA's Historical Hurricane Tracks database reveals that the country has been directly impacted by more than 180 tropical cyclones since 1851.[59] This includes 66 tropical storms, which the National Hurricane Center defines as a tropical cyclone with maximum sustained surface winds between 39 to 73 miles per hour (mph), and 80 hurricanes with wind speeds of 74mph or more.[60]

II.C. CUBA'S FUTURE CLIMATE

The World Bank's Climate Change Knowledge Portal provides development practitioners and policymakers with access to historical climate data as well as future projections based on various shared socioeconomic pathways (SSP) and representative concentration pathways (RCP) combinations. RCPs define a set of pathways for greenhouse gas emissions and the resultant warming that could occur by the end of the century, whereas SSPs encompass socioeconomic factors

[57] World Bank, *Climate Change Knowledge Portal*, https://climateknowledgeportal.worldbank.org/ (last visited Feb 14, 2024).
[58] Nelson Acosta, *Cuba Says Blackouts to Return as Aging Power Plants Overhauled*, Reuters (Feb. 17, 2023), https://www.reuters.com/world/americas/cuba-says-blackouts-return-aging-power-plants-overhauled-2023-02-17/
[59] Ramon Miro & Peter J Meyer, Cuba: U.S. Policy Overview (2023), https://sgp.fas.org/crs/row/IF10045.pdf. According to NOAA data, there have been 40 tropical depressions, 66 tropical storms, 27 Category 1 hurricanes, 23 Category 2 hurricanes, 17 Category 3 hurricanes, 11 Category 4 hurricanes, and two Category 5 hurricanes. *See* Nat'l Ocean Service, *NOAA Historical Hurricane Tracks*, https://oceanservice.noaa.gov/news/historical-hurricanes/ (last visited Feb. 23, 2024).
[60] *Id. See also* National Hurricane Center, *Tropical Cyclone Climatology,* https://www.nhc.noaa.gov/climo/?text (last visited Feb. 14, 2024).

(e.g., population, economic growth, education, urbanization, and the rate of technological development) that could determine whether emission reductions will be achieved.[61]

This report assesses several key climate variables across two potential modeling outcomes: the middle of the road (i.e., SSP2-4.5) and worst-case scenarios (i.e., SSP5-8.5). SSP2-4.5 is described as a scenario wherein historical development patterns are continued throughout the 21st century but mitigation efforts keep warming to between 2.5–2.7° C by 2100.[62] SSP5-8.5 is described[63] as a high-emissions scenario wherein economic and social development are driven by the exploitation of fossil fuel resources resulting in between 4.6–5.2° C of warming by 2100.[64]

1. Temperature

Climate change is likely to increase the mean air temperature in Cuba. By 2100, SSP2-4.5 and SSP5-8.5 ensemble models show that the projected mean temperature in Cuba could reach almost 28° C and 30° C, respectively. The incidence and severity of heatwaves is also projected to increase. The higher temperatures are likely to lead to increased demand for electricity for air-conditioning and could reduce the operating efficiency of fossil fuel power plants, potentially leading to supply shortages. Globally, cooling accounts for about 10% of the demand for electricity. According to the International Energy Agency's (IEA) Electricity Market Report, grid capacity in the world's hottest regions needs to cover a doubling of electricity demand compared to milder months, where cooling can account for more than 70% of peak electricity demand.[65] Likewise, a recent study on the electricity consumption in the Yangtze River Delta found that the annual electricity consumption and the annual peak electricity use increases by 9.2% and 36.1%, respectively, per one degree Celsius increase in annual global mean surface temperatures (GMST).[66] According to Cuba's 2012 census data, about 15% of households in the country had air conditioning.[67] However, this number has likely increased[68] due to a series of reforms in 2013 that allowed Cubans to import air-conditioning units after eight years of prohibitions.[69] Warmer temperatures, in tandem with increased proliferation of air-conditioning, could result in continued stress on Cuba's

[61] Zeke Hausfather, *Explainer: How 'Shared Socioeconomic Pathways' Explore Future Climate Change*, CARBON BRIEF (Apr 19, 2018), https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change/
[62] *Id.*
[63] Keywan Riahi et al., *The Shared Socioeconomic Pathways and Their Energy, Land Use, and Greenhouse Gas Emissions Implications: An Overview*, 42 GLOB. ENVIRON. CHANGE 153 (2017).
[64] Larissa S. Nazarenko et al., *Future Climate Change Under SSP Emission Scenarios With GISS-E2.1*, 14 J. ADV. MODEL. EARTH SYST. e2021MS002871 (2022).
[65] Nicholas Howarth et al., *Keeping Cool in a Hotter World Is Using More Energy, Making Efficiency More Important than Ever,* IEA COMMENTARY (July 21, 2032), https://www.iea.org/commentaries/keeping-cool-in-a-hotter-world-is-using-more-energy-making-efficiency-more-important-than-ever
[66] Yating Li et al., *Climate Change and Residential Electricity Consumption in the Yangtze River Delta, China*, 116 PROC. NATL. ACAD. SCI. 472 (2019).
[67] *Turn Off the Cuban Summer and Turn on the AC*, TRANSLATING CUBA (July 16, 2019), https://translatingcuba.com/turn-off-the-cuban-summer-and-turn-on-the-ac/.
[68] According to recent estimates, approximately 35% of households have air conditioners. Net total number of air conditions is estimated at 1,360,000. Communication with Madelaine Vazquez, Cubasolar (Oct. 17, 2023).
[69] *Turn Off the Cuban Summer and Turn on the AC*, TRANSLATING CUBA (July 16, 2019), https://translatingcuba.com/turn-off-the-cuban-summer-and-turn-on-the-ac/.

electricity grid. Indeed, studies in Texas and India found that every 1°C increase in the average daily temperature above 24°C results in an increase in electricity demand of about 4% and 2%, respectively.[70]

In addition to driving up electricity demand for air-conditioning, increases in average and maximum daily temperatures can also directly impact the efficiency of fossil fuel-based power plants and solar panels that supply power to meet this demand. When air temperatures and/or water temperatures get too hot, operators of these plants can be forced to curtail electricity output due to the systems' inability to dissipate heat fast enough to cool down.[71] One recent study found that climate change has "increased average thermal power plant curtailment[72] in nuclear, coal, oil, and natural gas-fired plants by 0.75–1 percentage points."[73] This study also found that for each degree Celsius of additional warming, power plant curtailment is projected to increase by 0.8–1.2 percentage points during peak demand.[74]

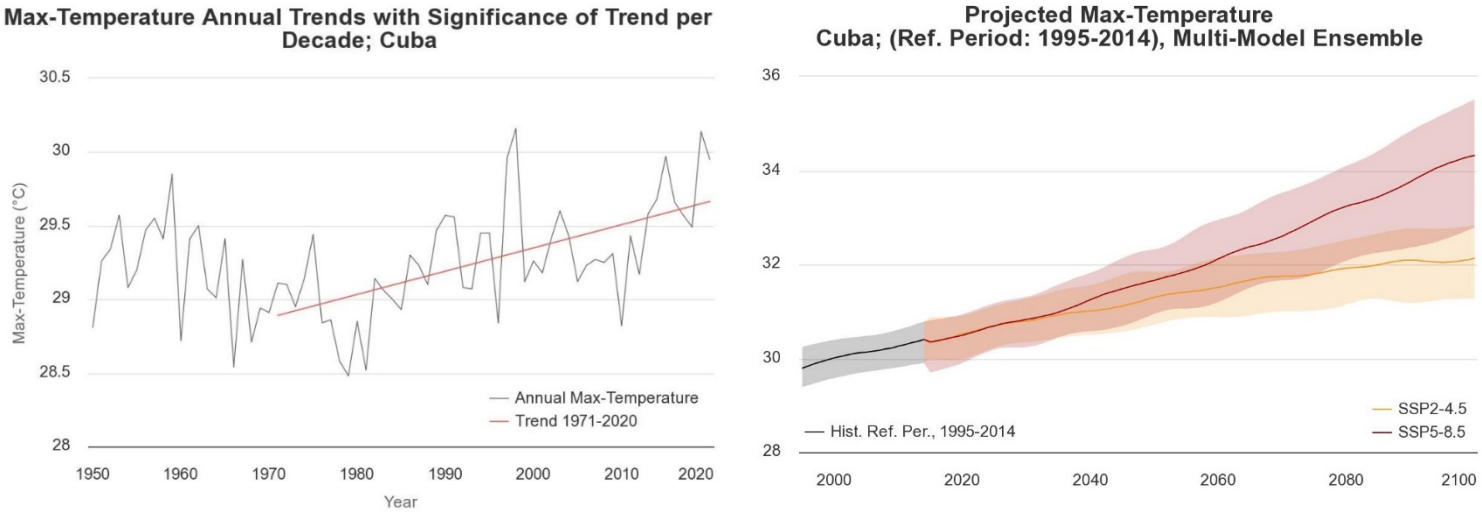

Figure 3 on the left shows time-series data of annual maximum temperatures in Cuba from 1950 to 2020 with a trendline fit to the data spanning 1971-2020.[75] The slope of the trendline (0.16° C/decade) is statistically significant, indicating that the change in annual maximum temperatures over this time period was the result of anthropogenic forcing and cannot be explained by natural variability alone.[76] **Figure 4** on the right shows orange (SSP2-4.5), red (SSP5-8.5), and black (historical) shading that represents the 10th–90th percentile range of results produced by an ensemble of CMIP6 climate models, while the orange, red, and black lines indicate the 50th percentile (or median) for projected

[70] Howarth et al., *supra* note 65.
[71] Ethan D. Coffel & Justin S. Mankin, *Thermal Power Generation Is Disadvantaged in a Warming World*, 16 ENVIRON. RES. LETT. 024043 (2021).
[72] The study was not specific to Cuba. it is possible that Cuba could see the same level of curtailment or possibly more given the age and condition of their power plants.
[73] Coffel and Mankin, *supra* note 71.
[74] *Id*.
[75] World Bank, *Cuba*, CLIMATE CHANGE KNOWLEDGE PORTAL, https://climateknowledgeportal.worldbank.org/country/cuba/trends-variability-projections (last visited Feb. 23, 2024).
[76] *Id*.

maximum temperatures using multi-model mean calculations through 2100 and a 1995–2014 historical reference period, respectively.[77] Historically, the average maximum temperature has fluctuated between 27° C and 32° C. Both scenarios project an increase in the maximum temperature through the end of the century.[78]

Higher temperatures could also reduce the amount of energy produced by solar arrays by slowing the speed of the electrical current in each panel.[79] The optimal temperature (i.e., where solar panels are tested and rated) for solar panel performance is around 25° C, and each panel will have a temperature coefficient that indicates performance under hotter temperatures.[80] For example, if a solar panel's temperature coefficient is *X* per degree Celsius, its energy production would be reduced by *X* should the temperature increase from 25° C to 26° C.[81]

2. *Precipitation*

Generally, increasing the temperature of air also increases its capacity to retain water; indeed, for every 1° C increase in temperature, air can hold about 7% more moisture.[82] At the same time, warmer temperatures can result in greater evaporation and surface drying, potentially impacting the intensity and duration of drought.[83] While a warmer atmosphere can result in more extreme precipitation events, climate models show that some regions may see an increase in average precipitation,[84] while other areas may see a decline as a result of shifting wind patterns and changes in ocean currents.[85] For example, a recent analysis using the high-end warming scenario (RCP8.5) across all climate models available in CMIP5[86] showed that high-latitude areas could see more precipitation in the future, while much of the tropical Atlantic—including Cuba—could experience a decrease in precipitation.[87] Some forecasts indicate that, due to these changes in precipitation, water availability around the country could be reduced by more than 35% by 2100.[88] Reduced rainfall and water availability could also result in the curtailment of power from thermal power plants.[89]

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[77] *Id*.
[78] *Id.*
[79] Ilum Energy Solutions, *How Does Temperature Affect Solar Panel Energy Production?* https://ilumsolar.com/how-does-temperature-affect-solar-panel-energy-production/ (last visited Feb. 14, 2024).
[80] *Id.*
[81] *Id.*
[82] Hausfather, *supra* note 61.
[83] *Id.*
[84] *Id.*
[85] US EPA, *Climate Change Indicators: U.S. and Global Precipitation*, https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-precipitation (last visited Feb. 14, 2024).
[86] The Coupled Model Intercomparison Project (CMIP) is a framework for climate model experiments, allowing for scientists to compare and assess climate models in a systematic way. The Working Group on Coupled Modelling committee, which is part of the World Climate Research Program (WCRP) based at the World Meteorological Organization, oversees CMIP. CMIP5 represents the fifth phase of this project, and the Intergovernmental Panel on Climate Change incorporated CMIP5 into their fifth assessment report (AR5). *See Q&A: How Do Climate Models Work?* CarbonBrief (Jab, 15, 2018). https://www.carbonbrief.org/qa-how-do-climate-models-work/
[87] Hausfather, *supra* note 61.
[88] Luis Brizuela, *Cuban Farmers Fight Land Degradation with Sustainable Management,* ReliefWeb (May 23, 2022), https://reliefweb.int/report/cuba/cuban-farmers-fight-land-degradation-sustainable-management
[89] Asia Dev. Bank, Climate Risk and Adaptation in the Electric Power Sector (2012), https://www.adb.org/sites/default/files/publication/29889/climate-risks-adaptation-power-sector.pdf.

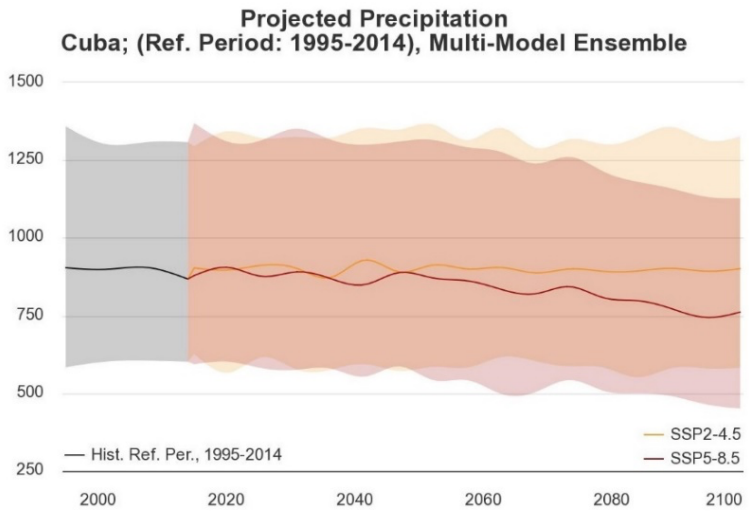

Figure 5. The orange (SSP2-4.5), red (SSP5-8.5), and black (historical) shading represents the 10th–90th percentile range of results produced by an ensemble of CMIP6 climate models, while the orange, red, and black lines indicate the 50th percentile (or median) precipitation projections using multi-model mean calculations through 2100 and a 1995–2014 historical reference period, respectively.[90] The median projections for precipitation under SSP2-4.5 do not show too much variability through the end of the century, while SSP5-8.5 shows a gradual decrease in precipitation compared to the historical reference period by 2100.

3. Tropical Cyclones

While there is less scientific consensus[91] on how climate change will impact the *total* number of tropical cyclones in a given year, the effects of climate change on tropical cyclone intensity are well documented. Recent research shows "that the proportion of major hurricanes (Category 3 or above) in the Atlantic Ocean has doubled since 1980."[92] A warming climate can also fuel wetter storms—increases in air and ocean temperatures cause evaporation rates to go up, resulting in more water availability in the atmosphere, and therefore heavier rainfall rates. For example, climate change is estimated to have increased Hurricane Ian's accumulated rainfall by 18%.[93] More intense hurricanes can reduce fuel supplies, disrupt energy imports, reduce energy inputs (e.g., destroying yields of sugarcane), damage or destroy critical generation and grid infrastructure, and reduce energy outputs.[94]

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[90] World Bank, *Cuba*, CLIMATE CHANGE KNOWLEDGE PORTAL, https://climateknowledgeportal.worldbank.org/country/cuba/trends-variability-projections (last visited Feb. 23, 2024).
[91] Mathew Barlow & Suzana J. Camargo, *Here's What We Know About How Climate Change Fuels Hurricanes,* STATE OF THE PLANET (Oct. 3, 2022), https://news.climate.columbia.edu/2022/10/03/heres-what-we-know-about-how-climate-change-fuels-hurricanes/
[92] Envt'l Defense Fund, *How Climate Change Makes Hurricanes More Destructive*, https://www.edf.org/climate/how-climate-change-makes-hurricanes-more-destructive (last visited Feb. 14, 2024).
[93] Kevin A Reed & Michael F Wehner, *Real-Time Attribution of the Influence of Climate Change on Extreme Weather Events: A Storyline Case Study of Hurricane Ian Rainfall*, 2 ENVIRON. RES. CLIM. 043001 (2023).
[94] Asia Dev. Bank, *supra* note 89.

Additionally, since 1970, global sea levels have risen nearly four inches due to melting land ice and the expansion of warmer ocean waters.[95] With higher sea levels, not only can hurricane-driven storm surges push water further inland and flood coastal energy infrastructure, but also limit the areas where grid-related infrastructure can be constructed.[96] Understanding these impacts today can help ensure adequate preparation for stronger storms in the future.

Climate Risk Case Study—Hurricane Ian

On September 26, 2022, Tropical Storm Ian was upgraded by the National Hurricane Center to a hurricane. A day later, Ian rapidly intensified and made landfall in western Cuba as a major Category 3 hurricane. Ian's destructive winds and storm surge knocked out power to the entire island. Even 10 days later, only 15% of the western Pinar del Rio province had electricity restored and all 7,000 residents of the town of La Coloma—located 125 miles southwest of Havana—remained without power. The power outages caused by Hurricane Ian prompted protests in the streets as residents demanded that power be restored. In October, the Cuban government implemented 10-hour average blackouts, and, from February through May 2023, Cuban officials scheduled three-hour average blackouts to conduct repair and maintenance work on its oil-fired power plants.

Ian's rapid intensification (RI) from a tropical storm to a major hurricane joins a growing list of hurricanes that strengthen rapidly right before and leading up to landfall. Indeed, a recent study found that "offshore areas within 400 km of the coastline have experienced a significant increase in RI events, with the count tripling from 1980 to 2020."[97]

[95] Envt'l Defense Fund, *supra* note 92.
[96] Asia Dev. Bank, *supra* note 89.
[97] Yi Li et al., *Recent Increases in Tropical Cyclone Rapid Intensification Events in Global Offshore Regions,* 14 NATURE COMMUNICATIONS 5167 (2023).

III. ENERGY RELATIONS WITH OTHER COUNTRIES

This section covers Cuba's relationships with countries that have significant relevance to its energy sector. Venezuela has been Cuba's primary source of imported oil since 2000. However, in response to declining oil imports from Venezuela in recent years, Cuba has increasingly sought imports from both Russia and Mexico. Cuba has also engaged with Turkey, India, and China, primarily for renewables and not liquid petroleum fuels. This section concludes with a discussion of Cuba's relationship with the United States.

III.A. VENEZUELA

Since 2000, Venezuela has been Cuba's primary source of imported crude oil, which, combined with domestic oil production, is used to power about 85% of Cuba's electric grid. Venezuela has historically provided oil to Cuba under a barter agreement initially signed between the two countries in 2000: Venezuela agreed to provide Cuba with 100,000 barrels per day (b/d) of oil at subsidized prices in exchange for Cuba sending doctors and other professionals to work in Venezuela.[98] In the mid-2010s, economic troubles in Venezuela put this agreement at risk.

In 2016, Venezuela supplied 90,000 b/d of oil to Cuba.[99] The amount of imported oil dropped to 80,000 b/d in 2020 and, in 2023, reached about 55,000 b/d—nearly a 40% decline from 2016.[100] In addition to lower volumes, Venezuela has also started to deliver heavier crude that is more difficult for Cuban refineries to process. In response, Cuba has looked to find oil supplies from other sources, including Mexico and Russia, discussed further below.[101]

III.B. RUSSIA

Cuba and Russia have recently entered into a series of agreements aimed at bolstering economic ties and increasing trade between the two countries. For example, in May 2023, Cuba and Russia agreed to thirty trade agreements covering tourism, agriculture, and energy.[102] One such agreement provides that Russia will, on an annual basis, supply Cuba with 1.64 million tons of oil and hydrocarbons.[103] Cuba agreed to pay for this oil using a new, bilateral financial system of payments that has yet to be disclosed.[104] Russia has already started shipments of oil to Cuba, but at least one

[98] Circles Robinson, *Cuba Hopes Russia Will Supply 32,000 Barrels of Oil Per Day*, HAVANA TIMES (Jun. 21, 2023), https://havanatimes.org/news/cuba-hopes-russia-will-supply-32000-barrels-of-oil-per-day/
[99] Panfil, *supra* note 13.
[100] Marianna Parraga et al., *Unable to Process Venezuela's Heavy Oil, Cuba Turns to Russia, Mexico,* REUTERS (Apr. 26, 2023), https://www.reuters.com/business/energy/unable-process-venezuelas-heavy-oil-cuba-turns-russia-mexico-data-sources-2023-04-26/
[101] *Id.*
[102] *Cuban Officials Return from Russia with Promises of Oil, Renewed Tourism*, REUTERS (Jun. 20, 2023), https://www.reuters.com/world/cuban-officials-return-russia-with-promises-oil-renewed-tourism-2023-06-20/.
[103] 1.64 million tons of oil is roughly equivalent to 32,000 barrels of oil per day.
[104] *Cuban Officials Return from Russia with Promises of Oil, Renewed Tourism*, REUTERS (Jun. 20, 2023), https://www.reuters.com/world/cuban-officials-return-russia-with-promises-oil-renewed-tourism-2023-06-20/

expert questions Cuba's ability to continuously pay for the oil given the estimated cost of $58/barrel, meaning that Cuba would owe $676 million per year.

The trade agreements between Cuba and Russia build on the historical relationship between the two countries. From the 1960s through the early 1990s, Cuba imported nearly 90% of its fuel from the Soviet Union. After the collapse of the Soviet Union in 1991, imports of Russian fuel declined precipitously, resulting in Cuba's eventual fuel agreements with Venezuela. However, in the years following the Soviet Union's collapse, Russia and Cuba maintained relations; Russia even forgave roughly $32 billion of Cuba's debt in 2014. Since then, bilateral trade has increased between Cuba and Russia, reaching $450 million in 2022 (more than triple the total from 2021).[105] About 90% of this trade, or roughly $400 million, was in the sale of petroleum products and soybean oil. [106]

Cuba and Russia have also increased ties in response to sanctions imposed by the United States against both countries. The continuation of sanctions against Cuba has limited the country's ability to import goods and services from other countries,[107] while new sanctions against Russia following its invasion of Ukraine have resulted in the country seeking new importers of its oil.[108]

III.C. MEXICO

In recent years, Cuba has increasingly relied on oil imports from Mexico to fill supply gaps. In July 2021, Mexico's state-run oil company Petroleos Mexicanos (Pemex) sent a cargo ship carrying 100,000 barrels of diesel to Cuba, as part of a larger shipment of aid sent from Mexico.[109] Mexico has periodically sent further shipments of fuel since then, including two shipments in April 2023.[110] Over four months in summer 2023, Mexico delivered around 2 million barrels of oil to Cuba, averaging roughly 13,000 barrels per day.[111] One report states that Mexican light crude oil is easier to process by Cuba's aging refineries compared to Venezuelan crude oil.[112] Mexico has not disclosed financial terms of the shipments, and the country's officials have made conflicting statements about whether oil shipments are being sent as donations or humanitarian assistance.[113]

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[105] Dave Sherwood & Nelson Acosta, *Cuba Rolls out Red Carpet for Russian Business in Push to Deepen Economic Ties*, Reuters (May 17, 2023), https://www.reuters.com/world/americas/cuba-rolls-out-red-carpet-russian-business-push-deepen-economic-ties-2023-05-17/.
[106] *Id.*
[107] Frank Jack Daniel et al., *Mexican Fuel Cargo for Cuba Is Sovereign Decision, President Says*, Reuters (Jul. 27, 2021), https://www.reuters.com/world/americas/mexican-fuel-cargo-cuba-is-sovereign-decision-president-says-2021-07-27/.
[108] Nidhi Verma, *Exclusive: India Refiners Start Yuan Payments for Russian Oil Imports*, Reuters (Jul. 3, 2023), https://www.reuters.com/business/energy/india-refiners-start-yuan-payments-russian-oil-imports-sources-2023-07-03/.
[109] *Mexico President: Sending Fuel Cargo for Cuba is their Sovereign Decision*, NBC News (July 28, 2021), https://www.nbcnews.com/news/latino/mexico-president-sending-fuel-cargo-cuba-sovereign-decision-rcna1533.
[110] Parraga et al., *supra* note 100.
[111] Marianna Parraga, *Cuban Oil Tankers Becoming Regular Visitors to Mexican Ports*, Reuters (Aug. 19, 2023), https://www.reuters.com/world/americas/cuban-oil-tankers-becoming-regular-visitors-mexican-ports-2023-08-10
[112] Parraga et al., *supra* note 100.
[113] *Mexico Denies Energy "Donations" to Cuba but mum on Financial Details,* Reuters (Oct. 9, 2023), https://www.reuters.com/world/americas/mexico-denies-energy-donations-cuba-mum-financial-details-2023-10-09/

III.D. TURKEY

Cuba has increased energy trade with Turkey over the last five years. Starting in 2018, Cuba and the Turkish company Karpowership signed three contracts under which Karpowership agreed to provide seven floating power plants to Cuba.[114] The financial details of the agreements have not been made public, but one estimate suggests Cuba may owe around $100 million per year to the company.[115] These ship-based power plants combust high sulfur fuel oil or heavy fuel oil and, in aggregate, provide Cuba with 500 MW in generation capacity.[116] The plants provided 7% of electricity generation in Cuba in 2022 and are expected to provide 18–20% in 2023. [117] The floating power plants may have the advantage of quickly powering up, but pose significant environmental, health, and cost concerns. The high sulfur fuel oil used to power the turbines creates pollution concerns for nearby communities and emits high volumes of greenhouse gases. In South Africa, growing worries over the environmental impacts of similar floating power plants have resulted in currently unresolved litigation regarding permits to operate the plants in the country.[118]

Though there is no indication that the Turkish government is directly involved with the Karpowership contract, there appear to be strengthening ties between the Turkish and Cuban governments. In November 2022, Cuba and Turkey signed six agreements covering media, communication, and culture, and discussed ways to develop energy cooperation.[119] The two countries aim to quadruple bilateral trade to $200 million per year. [120]

III.E. INDIA

Cuba has worked with India and the India-based ISA to develop solar power generation. In August 2022, the partners announced a Request for Qualification for a 1,150 MW solar project in Cuba.[121] Additionally, in June 2023, ISA helped launch an auction for an initial 60 MW solar project in Cuba.[122]

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[114] In October 2018, the first three floating power plants came online through a contract between Energoimport, Cuba's state-led generation and transmission company, and Karpowership, a Turkish company that owns the power ships. The initial contract provided for four years of generation from three ships with a combined total of 110 MW capacity. The contract has been updated three times to add generating capacity, and, in November 2022, Karpowership agreed to provide the 7th power plant, increasing total capacity to 500 MW. See El Toque, *Turkish Powerships in Cuba, a Plan We Know Little About*, HAVANA TIMES (Dec. 8, 2022), https://havanatimes.org/features/turkish-powerships-in-cuba-a-plan-we-know-little-about/.

[115] *Id*.

[116] *Id.*

[117] *Id.*

[118] *Id.*

[119] *Türkiye, Cuba Sign 6 Agreements, Vow to Enhance Cooperation*, DAILY SABAH (Nov. 24, 2022), https://www.dailysabah.com/politics/diplomacy/turkiye-cuba-sign-6-agreements-vow-to-enhance-cooperation

[120] Selcan Hacaoglu, *Erdogan Says Sanctions on Cuba Hamper Its Trade With Turkey*, BLOOMBERG.COM (Nov. 23, 2022), https://www.bloomberg.com/news/articles/2022-11-23/erdogan-says-sanctions-on-cuba-hamper-its-trade-with-turkey.

[121] Press Release, *ISA, Cuba and NTPC issues a Request to set up 1150 MW solar project in Cuba* (Aug. 10, 2022), https://isolaralliance.org/uploads/docs/dc2d7cb86de07ff272688ba5020783.pdf.

[122] *Cuba to hold 60 MW solar tender*, PV MAGAZINE INTERNATIONAL (June 12, 2023), https://www.pv-magazine.com/2023/06/12/cuba-to-hold-60-mw-solar-tender/.

III.F. CHINA

China and Cuba have engaged in billions of dollars of trade in recent years, with important implications for Cuba's energy system. Total trade between the two countries declined from $2 billion USD per year in 2017 to $1.3 billion in 2021.[123] However, in 2022, China agreed to restructure Cuban debt, paving the way for the two countries to sign a series of trade agreements, including an agreement for China to build wind and solar energy projects in Cuba.[124] Cuba has also partnered with Chinese financing and Goldwind, a Chinese wind turbine manufacturer, to build the La Herradura 1 wind farm, which has been in development since at least 2016[125] and was still under construction according to the latest reports at the time of writing.[126]

III.G. UNITED STATES

The United States has maintained a trade embargo on Cuba since the early 1960s, essentially eliminating trade between the two countries. During the Obama Administration, the United States initiated a policy shift away from sanctions and, in 2015, reestablished diplomatic relations and rescinded Cuba's designation as a state sponsor of terrorism.[127] The Trump Administration changed course and introduced new sanctions in 2017, before largely abandoning dialogue with Cuba by 2019. In January 2021, the Trump Administration redesignated Cuba as a state sponsor of international terrorism. [128]

The Biden Administration conducted an initial review of U.S. foreign policy on Cuba in early 2021 and indicated that it might reverse or relax restrictions put in place by the Trump Administration. But after Cuba's crackdown on public protests in July 2021, the Biden Administration imposed additional, targeted sanctions on Cuban officials and security entities.[129] In May 2022, the Biden Administration announced several modest changes to U.S. policy, including the easing of some restrictions on travel and remittances (i.e., the ability to send money to individual Cuban nationals).[130] At the time of this report, the Biden Administration had yet to take any significant steps toward easing economic sanctions on Cuba.

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[123] Marc Frank, *Cuba wins China Debt Relief, New Funds,* REUTERS (Nov. 27, 2022), https://www.reuters.com/world/americas/cuba-wins-china-debt-relief-new-funds-2022-11-27/

[124] *Id.*

[125] *Cuba promotes wind power with Chinese turbines to protect environment*, ENGLISH.NEWS.CN (June 20, 2016), http://www.xinhuanet.com//english/2016-06/20/c_135452005.htm.

[126] Ministerio De Energía y Minas, Energías Renovables y Efficiencia Enérgetica, https://www.minem.gob.cu/es/actividades/energias-renovables-y-eficiencia-energetica (last visited Feb. 23, 2024).

[127] RAMON MIRO & PETER J MEYER, CUBA: U.S. POLICY OVERVIEW (2023), https://sgp.fas.org/crs/row/IF10045.pdf.

[128] *Id.*

[129] *Id.*

[130] MARK P. SULLIVAN, CONGR. RES. SERV., BIDEN ADMINISTRATION'S CUBA POLICY CHANGES (2022), https://crsreports.congress.gov/product/pdf/IN/IN11937/4.

Though this report does not set out to provide an in-depth analysis of the history of U.S. law and foreign policy toward Cuba, we posit that if the U.S. government were to take modest actions to support mitigation of and adaptation to the impacts of climate change *in Cuba,* such actions would be in line with the Biden Administration's objectives on environmental protection and climate change and consistent with its stated focus on support for the Cuban people.[131]

For example, in his first week in office, President Biden signed an executive order indicating that the United States would rejoin the Paris Agreement and that his Administration would put "the climate crisis at the center of United States foreign policy and national security."[132] The order stated that "[t]he United States will also immediately begin to develop a climate finance plan, making strategic use of multilateral and bilateral channels and institutions, to assist developing countries in implementing ambitious emissions reduction measures, protecting critical ecosystems, building resilience against the impacts of climate change, and promoting the flow of capital toward climate-aligned investments and away from high-carbon investments." The order also directed the Department of Treasury to "develop a strategy for how the voice and vote of the United States can be used in international financial institutions, including the World Bank Group and the International Monetary Fund, to promote financing programs, economic stimulus packages, and debt relief initiatives that are aligned with and support the goals of the Paris Agreement."[133]

Supporting Cuba's clean energy transition would also be in line with the Biden Administration's U.S.-Caribbean Partnership to Address the Climate Crisis 2030 (PACC 2030), announced by Vice President Harris at the Summit of the Americas in April 2022.[134] PACC 2030 is the principal initiative for supporting Caribbean countries in climate adaptation and energy security and has four principal pillars:

- Improving access to development financing;
- Facilitating clean energy project development and investment;
- Enhancing local capacity building; and
- Deepening collaboration between the United States and Caribbean partners.[135]

PACC 2030, led by the U.S. State Department, does not include Cuba among the Caribbean countries it is working with and, as of the date of this report, the State Department has not indicated an intention to include Cuba within the initiative.

Although current U.S. regulations and policies may restrict the ability of non-governmental U.S. actors (e.g., non-governmental organizations (NGOs), the private sector, and philanthropies) to sell or donate clean energy equipment,

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[131] *See e.g.,* U.S. Dep't of State, *Biden Administration Expands Support to the Cuban People,* https://www.state.gov/biden-administration-expands-support-to-the-cuban-people/ (last visited Feb. 23, 2024).
[132] The White House, *Executive Order on Tackling the Climate Crisis at Home and Abroad* (2021), https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/.
[133] *Id.*
[134] The White House, *Fact Sheet: Vice President Harris Launches the U.S.-Caribbean Partnership to Address the Climate Crisis 2030 (PACC 2030)* (2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/09/fact-sheet-vice-president-harris-launches-the-u-s-caribbean-partnership-to-address-the-climate-crisis-2030-pacc-2030/ (last visited Feb 13, 2024).
[135] *Id.*

technology and services to Cuba state and private entities, they do not entirely prohibit them.[136] In some instances, U.S. restrictions extend to third countries; for example, since the U.S. government put Cuba back on the list of State Sponsors of Terrorism in January 2021,[137] foreign companies may not sell or donate to Cuban entities goods that contain 10% or more of U.S.-made components. Nonetheless, there is an exception to this rule. Under the Export Administration Act of 1979 there is a general policy of denial for exports and reexports of most items to Cuba, but there is a *general policy of approval* for the exports or reexports of several items, including "[i]tems necessary for the environmental protection of U.S. and international air quality, waters and coastlines, including items related to renewable energy or energy efficiency."[138] Thus, foreign companies and NGOs that wish to provide Cuba with clean energy technology that contains more than 10% of U.S.-made components, may do so with a license from the U.S. Department of Commerce's Bureau of Industry and Security (BIS). The Bureau is strongly predisposed to grant such an export license by reason of the aforementioned codified policy of approval.

Notwithstanding the rigors of the embargo on Cuba, the United States has long supported the activities of U.S. NGOs and philanthropies that promote protection of Cuba's and the transition to clean energy. The U.S. also pursues policies that are ameliorative of the hardships endured by the Cuban people. An example is the authorization of cash transfers to Cuban nationals in the form of remittances.[139] Ample, reliable, and environmentally friendly electrical power is less and less available to the average Cuban as the national grid falls into ever deeper disrepair. U.S.-origin clean energy equipment and project funding can help offset the hardships associated with Cuba's energy deficits, while at the same time promoting a clean energy transition in the country. Several current U.S. export regulations authorize some U.S. support of clean energy development in Cuba.[140]

[136] Bureau of Industry and Security, *Cuba*, https://www.bis.doc.gov/index.php/policy-guidance/country-guidance/sanctioned-destinations/cuba (last visited Feb. 16, 2024)
[137] U.S. Dep't of State, *State Sponsors of Terrorism,* https://www.state.gov/state-sponsors-of-terrorism/ (last visited Feb. 16, 2024).
[138] 15 C.F.R. § 746.2(a)(1).
[139] Sullivan, *supra* note 130.
[140] *See e.g.* 15 C.F.R. 746.2(b)(2) (establishing a general policy of approval for exports "necessary for the protection of U.S. and international air quality, waters, coastlines (including items related to renewable energy nervy or energy efficiency");15 CFR 746.2(b)(3) (authorizing the export of U.S.-origin items to Cuba to "meet the needs of the Cuban people, including exports to Cuban governmental agencies that provide goods or services to the Cuban people" including "facilities for supplying electricity or other energy to the Cuban people"); 15 CFR 740.21(b) (authorizing the export of U.S.-origin items for use by the Cuban private sector for private sector economic activity - e.g., the development of alternative energy sources for private agricultural and hospitality sector use)**;** 15 CFR 740.21(c)(1) (authorizing the use of donated items of U.S. origin in "ecological activities").

Under the general license provisions of the Department of Treasury's Cuba-related OFAC regulations, U.S. persons may have some ability to provide services in Cuba for infrastructure development.[141] For example, a U.S. private company or NGO could provide technical assistance on the development of a wind farm, a residential solar project, or the like.[142]

[141] U.S. Dep't of the Treasury, Office of Foreign Assets Control, *Cuba Sanctions*, https://ofac.treasury.gov/sanctions-programs-and-country-information/cuba-sanctions (last visited Feb. 13, 2024).

[142] *See* 31 CFR 515.591 ("Persons subject to the jurisdiction of the United States are authorized to provide to Cuba or Cuban nationals services related to developing, repairing, maintaining, and enhancing Cuban infrastructure that directly benefit the Cuban people...[I]nfrastructure means systems and assets used to provide the Cuban people with goods and services produced or provided [by] non-nuclear electricity generation, and electricity distribution sectors… This authorization includes projects related to the environmental protection of U.S., Cuban, and international air quality, waters, and coastlines); 31 CFR 515.570(g)(1) (authorizing cash transfers in the form of unlimited remittances to Cuban non-governmental entities and individuals to "support humanitarian projects in or related to Cuba that are designed to directly benefit the Cuban people).

IV. ENERGY POLICY DESIGN IN CUBA

In the last five years, Cuba has implemented several measures that signal both a commitment to mitigate greenhouse gas emissions and a desire to advance a clean energy transition. The section below discusses the details of a constitutional change, multiple domestic laws, and submissions to the Paris Agreement relevant to Cuba's energy future.

IV.A. 2019 CONSTITUTIONAL UPDATE

Following ratification through a national referendum, Cuba's updated constitution entered into force on April 10, 2019.[143] Cuba's previous constitution was drafted and approved by referendum in 1976. The government launched a process to revise that constitution, in part, to transition towards a mixed economy that includes a state-run sector alongside a bolstered private sector.[144] A governmental drafting commission released a first draft of the revised constitution in July 2018. This was followed by a three-month public comment period. After that, the government released an updated draft and held the referendum in February 2019.[145]

The 2019 constitution explicitly states that the government will respond to climate change.[146] In Chapter II, on international relations, the constitution states that Cuba:

> Promotes the protection and conservation of the environment as well as responding to climate change, which threatens the survival of the human species, through the recognition of common, yet differential, responsibilities; the establishment of a more just and equitable international economic order as well as the eradication of irrational patterns of production and consumption.[147]

In including this provision, Cuba became one of only 11 countries in the world to have a dedicated climate clause in its constitution, according to a 2021 analysis by the Grantham Institute.[148] By including the climate clause in the international relations section of the constitution, Cuba may be signaling the importance of the UNFCCC and Paris Agreement processes. The climate clause also recognizes that climate change presents an existential threat to human survival—signaling the importance with which the country views the threat. The clause ends by calling for the eradication of irrational patterns of production and consumption—signaling the need for an energy transition to deal with the climate threat.

The climate clause in Cuba's constitution notably does not include actionable duties. This is in line with the way most other countries address climate change in their constitutions.[149] One notable exception is Ecuador, which has a

[143] Geoff Thale & García Castro, *Cuba's New Constitution, Explained*, WOLA, https://www.wola.org/analysis/cubas-new-constitution-explained/ (last visited Feb. 13, 2024).
[144] *Id.*
[145] *Id.*
[146] Cuba's Constitution of 2019, https://faolex.fao.org/docs/pdf/cub184086E.pdf.
[147] *Id.*
[148] Karla Martinez Toral, *The 11 Nations Heralding a New Dawn of Climate Constitutionalism,* COMMENTARY, GRANTHAM RESEARCH INSTITUTE ON CLIMATE CHANGE AND THE ENVIRONMENT (Dec. 2, 2021), https://www.lse.ac.uk/granthaminstitute/news/the-11-nations-heralding-a-new-dawn-of-climate-constitutionalism/
[149] *Id.*

constitutional provision explicitly stating that the country "shall adopt adequate and cross-cutting measures for the mitigation of climate change."[150] Even without an analogous explicit call to governmental action, Cuba's climate clause could serve as the basis for strong climate action through implementing domestic law.

The 2019 constitution includes a number of provisions further aimed at environmental protection. Article 75 states that "All persons have the right to enjoy a natural environment that is healthy and stable. The State protects the environment and the country's natural resources."[151] Article 90 states that Cuban citizens have duties, including "[t]o comply with the requirements established for the protection of environmental health and hygiene" and "to safeguard the preservation of a clean environment."[152] And Article 191 states that the Municipal Assembly of People's Power, or the authoritative local legislative bodies in Cuba, have a responsibility to organize and supervise "environmental protection."[153] Together, these provisions establish a right to a healthy environment and a citizen-based duty to safeguard the environment. In addition to the climate clause, these environmental provisions could be used to bolster legislation aimed at combating climate change.

The constitution includes a number of other changes relevant to Cuba's energy transition. Important in these are provisions regarding foreign investment. Article 28 states that:

> The State promotes and provides guarantees to foreign investment as an important element for the economic development of the country, which is based upon the protection and the rational use of the natural and human resources as well as respect for national sovereignty and independence. The law establishes regulations with respect to foreign investment within the national territory.[154]

This provision appears squarely aimed at ensuring that foreign investments are protected, emphasizes the importance of protecting natural resources with that investment, and calls for regulations to establish the rules around such investment. Article 122 directs the Council of State—the governing body consisting of the president, vice-presidents, and 27 additional members—to "approve the methods of foreign investment."[155] Article 137 directs the Council of Ministers—the highest-ranking executive and administrative body—to "direct and to monitor foreign commercial relations as well as foreign investment" and to "approve or to authorize the appropriate forms of foreign investment."[156] These provisions are aimed at foreign investment broadly. But given Cuba's energy challenges and climate-related goals, they are likely to be highly relevant to the country's future energy sector development.

[150] *Id.*
[151] Cuba's Constitution of 2019, https://faolex.fao.org/docs/pdf/cub184086E.pdf.
[152] *Id.*
[153] *Id.*
[154] *Id.*
[155] *Id.*
[156] *Id.*

IV.B. UPDATED NDC

In 2020, Cuba submitted an updated NDC to the UNFCCC Secretariat pursuant to its obligations under the Paris Agreement.[157] The updated NDC includes detailed information on changes to Cuban domestic law to implement climate mitigation and adaptation measures. These will be discussed further in the next subsection on the emerging legal framework. The NDC also provides context for challenges in meeting Cuba's energy goals, including those stemming from U.S. trade sanctions.

The NDC identifies five mitigation efforts that the Cuban government plans to undertake, namely:

- By 2030, increasing electricity generation from renewable energy sources (RES) to 24%
- Increasing forest coverage across the country to 33% by 2030;
- Increasing energy efficiency and energy savings;
- Reducing the amount of carbon-intensive ground transportation; and
- Reducing the amount of greenhouse gas emissions associated with Cuba's swine industry.

While Cuba had previously enacted domestic legislation that set a goal of 24% renewable electricity generation by 2030, the updated NDC marks the first time that the country has made such a goal explicit in its NDC under the Paris Agreement. The NDC further breaks down the projected makeup of renewable sources—14% of total generation from sugarcane bagasse and 10% of total generation from wind, solar, and hydro. [158]

It is important to note that Cuba's classification of biomass generation as renewable and its reliance on biomass more than other renewables to meet its climate goals is controversial. Some studies classify biomass burning as carbon neutral, since regrowing plants can uptake carbon dioxide that was released in previous biomass burning.[159] Others argue that replacing coal with wood can temporarily increase carbon dioxide in the atmosphere and leave a carbon debt for decades before new biomass can be grown.[160] Further, the burning of sugarcane biomass releases aerosols that can cause local environmental and health impacts, such as changes in the composition and acidity of rainwater and increased rates of respiratory disease.[161]

[157] Primera Contribución Nacionalmente Determinada (Actualizada) República de Cuba 2020-2030 (n.d.), https://unfccc.int/sites/default/files/NDC/2022-06/Cuban%20First%20NDC%20%28Updated%20submission%29.pdf
[158] *Id.*
[159] Energy Information Admin., *Biomass explained,* https://www.eia.gov/energyexplained/biomass/biomass-and-the-environment.php (last visited Feb. 23, 2024).
[160] John D. Sterman et al., *Does Replacing Coal with Wood Lower CO2 Emissions? Dynamic Lifecycle Analysis of Wood Bioenergy*, 13 ENVIRON. RES. LETT. 015007 (2018).
[161] José E.D. Cançado et al., *The Impact of Sugar Cane–Burning Emissions on the Respiratory System of Children and the Elderly*, 114 ENVIRON. HEALTH PERSPECT. 725 (2006).

Officials estimate that Cuba will need to install 2,144 MW of renewable capacity in order to achieve its renewable energy goals. According to Cuba's updated NDC, it will cost an estimated USD $7.723 billion[162] to achieve this goal. The NDC also provides information on Cuba's updated energy efficiency goals, including plans to install more than 800,000 solar water heaters, 5,000 solar pumping systems for livestock farming, and 15 million LED bulbs, and replace two million stoves with more energy efficient induction models.[163]

IV.C. EMERGING LEGAL FRAMEWORK

Over the past decade, Cuba has enacted several laws and policies aimed at updating its energy system and mitigating the impacts of climate change. In July 2016, Cuba's National Assembly approved the *Guidelines of the Economic and Social Policy of the State and the Revolution* ("the Guidelines") in order to "[tackle] the issues related to climate change and state…".[164] This law established a number of guidelines, including:

- Guideline 107, which aims to accelerate both the implementation of these guidelines overall, as well as the implementation of science, innovation, and technology programs focused on confronting climate change by all entities and agencies; and
- Guideline 237, which aims to continue the development of a hydraulic program to mitigate the impacts of climate change and to help materialize adaptation measures, including the reuse of water, rainwater harvesting, seawater desalination, "and the sustainability of all associated services that allows [Cuba] to achieve and exceed the sustainable development goals." [165]

Following the approval of the Guidelines, the Cuban government also adopted the "State Plan to Confront Climate Change", also known as "Tarea Vida" (Life Task), in April 2017.[166] This plan includes five strategic actions and eleven tasks aimed at confronting climate change. Of these eleven tasks, *Task 2* and *Task 8* focus on developing a legal framework to address climate change and adopting mitigation and adaptation measures, respectively. In addition to the industrial and agricultural sectors, the energy sector was identified as a key area "in which the main tasks of adaptation and mitigation are implemented [under] *Task 8* from the State Plan."[167]

[162] $4.713 billion USD needed to cover imported technology, remaining $3.01 billion from the state budget. *See* Primera Contribución Nacionalmente Determinada (Actualizada) República de Cuba 2020-2030 (n.d.), https://unfccc.int/sites/default/files/NDC/2022-06/Cuban%20First%20NDC%20%28Updated%20submission%29.pdf
[163] The World Bank, *World Bank Open Data*, https://data.worldbank.org/ (last visited Feb. 23, 2024).
[164] Primera Contribución Nacionalmente Determinada (Actualizada) República de Cuba 2020-2030 (n.d.), https://unfccc.int/sites/default/files/NDC/2022-06/Cuban%20First%20NDC%20%28Updated%20submission%29.pdf
[165] *Id.*
[166] *Id.*
[167] *Id.*

The National Economic and Social Development Plan (PNDES 2030),[168] released in 2015,[169] further emphasizes the Cuban government's climate objectives. In its NDC to the Paris Agreement, the country identified this law as the "main tool to achieve prosperous development, that is economically and socially sustainable, resilient, and less intensive in carbon emissions."[170] The law also includes a number of specific objectives that are relevant to the country's energy future, such as:

- Reducing Cuba's vulnerability to the impacts of climate change through the gradual implementation of the State Plan;
- Increasing energy efficiency in the country and developing renewable energy sources; and
- Implementing programs and actions (i.e., economic incentives, such as taxes, tariffs, credits, etc.) to fight pollution and combat climate change efficiently and effectively. [171]

Together, these objectives represent codified ambitions aimed at reducing carbon emissions, promoting renewables, implementing economic incentives, and ultimately achieving the country's climate goals.

Decree Law No. 345, also known as "Prospective Development of Renewable Energy Sources and the Efficient Use of Energy for 2014–2030," sketches out more specifics on Cuba's plans for its energy future. The law codifies Cuba's 24% renewable generation by 2030 goal.[172] It also aims to increase energy efficiency, stimulate investment in renewable energy, promote domestic production of renewable sources, and diversify fossil fuel generation sources. The law urges local governments to exercise greater control over their energy use and instructs the Central Bank of Cuba to grant credits to individuals to acquire renewable energy equipment.[173]

In implementing Decree Law No. 345, Cuban ministries have issued regulations aimed at further developing renewable energy. The Ministry of Finance and Prices adopted, among other provisions, a feed-in tariff for rooftop solar projects.[174] According to PV magazine, Cubasolar's president estimated the tariff amount at $0.06/kWh for non-residential solar installations.[175] The Ministry of Finance and Prices further exempted some imported solar PV systems from custom

[168] Ministerio de Economía y Planificación de Cuba, *Plan Nacional de Desarrollo Económico y Social (2030)*, https://www.mep.gob.cu/es/pndesods-2030/plan-nacional-de-desarrollo-economico-y-social-2030 (last visited Feb 13, 2024).
[169] London School of Economics, *National Plan for Economic and Social Development towards 2030 (PNDES 2030)*, Climate Change Laws of the World, https://climate-laws.org/document/national-plan-for-economic-and-social-development-towards-2030-pndes-2030_ed8c (last visited Feb 13, 2024).
[170] Primera Contribución Nacionalmente Determinada (Actualizada) República de Cuba 2020-2030 (n.d.), https://unfccc.int/sites/default/files/NDC/2022-06/Cuban%20First%20NDC%20%28Updated%20submission%29.pdf.
[171] *Id.*
[172] Mika Korkeakoski, *State of Play for 100% Renewable Energy Futures for Cuba: Recent Changes and Challenges*, 14 SUSTAINABILITY 13825 (2022).
[173] *Id.*
[174] *Id.*
[175] Emilio Bellini, *Cuba Introduces New Rules, Fiscal Incentives for Solar Prosumers*, PV MAGAZINE INTERNATIONAL (Nov. 29, 2019), https://www.pv-magazine.com/2019/11/29/cuba-introduces-new-rules-fiscal-incentives-for-solar-prosumers/.

duties. The Ministry of Energy and Mines approved the import of solar PV systems and other renewable equipment. And the Ministry of Internal Trade approved the commercialization of equipment aimed at improving energy efficiency.[176]

Since the adoption of Decree Law No. 345 in 2019, Cuban officials have increased their renewable energy ambitions. In its updated National Economic and Social Development Plan, the government identified a goal of 37% renewable electricity generation by 2030, with a long-term goal of 100% renewable generation.[177] Cuba included the updated 37% goal in its 2021 national voluntary review of its sustainable development goals submitted to the UN.[178] However, for the purposes of the Paris Agreement, the goal remains 24% until the country reviews its NDC again in 2025.

Technology	2021	2030 Objectives Announced in 2014	2030 Objectives Announced in 2022	Estimated Total Capital Investment ($MM)
Solar	230 MW	700 MW	2104 MW	$2.792
Wind	11 MW	633 MW	807 MW	$1.386
Biomass	302 MW	755 MW	612 MW	$1.867
Small Hydro	64 MW	56 MW	56 MW	NA
Total Renewables	608 MW (9%)	2144 MW (24%)	3579 MW (37%)	$6.045
Fossil Fuels	6059 MW (91%)	6700 MW (76%)	6071 MW (67%)	$7.205
Total	6667 MW	8844 MW	9650 MW	$13.320

Table 3. Cuba's 2021 power generation capacity (across renewable energy and fossil fuel sources) compared to the 2030 objectives announced in 2014 (which set the 24% renewable energy goal) and the new, updated 2030 objectives announced in 2022 (which set a 37% renewable energy goal). The final column provides an estimate of the total capital investment needed to achieve 2030 goals (in millions of dollars).[179]

[176] Korkeakoski, *supra* note 172.
[177] Government of Canada, *Renewable Energy Sector Profile – Havana, Cuba,* https://www.tradecommissioner.gc.ca/cuba/market-reports-etudes-de-marches/0006689.aspx?lang=eng (last visited Feb. 23, 2024).
[178] Voluntary National Review: Sustainable Development Goals progress report at the High Level Political Forum: Cuba (2021), https://digitallibrary.un.org/record/4002691.
[179] Onei, Electricidad en Cuba, Indicadores Seleccionados. Enero-Diciembre 2022, Edición Mayo 2023.

V. LESSONS FROM THE CARIBBEAN REGION

The Caribbean is particularly vulnerable to the impacts of climate change; for this reason, countries within the region have been organizing to identify shared climate-related issues and coordinate mitigation measures through the Caribbean Community (CARICOM). Founded in 1973 to promote economic integration and cooperation, CARICOM currently consists of 15 member states that face similar challenges—both in the form of electrical grid issues and the threats of climate change—as Cuba.[180] To address some of these challenges, island nations across the Caribbean are prioritizing a transition away from fossil fuels and towards more renewable energy sources in order to increase the independence and resilience of their grids. Though Cuba is not a member, its government has maintained bi-lateral ties with CARICOM since 1972 and has maintained a close working relationship with CARICOM members and other Caribbean Island nations.

In addition to their partnership through CARICOM, sixteen Caribbean countries—including Cuba—are members of the Alliance of Small Island States (AOSIS). Since 1990, AOSIS has represented small island and low-lying coastal developing states in international negotiations and processes on climate change, sustainability, and other issues. The AOSIS countries and others regularly take part in the UN-led International Conference on Small Island Developing States (SIDS). Participants in the International Conference on SIDS work to develop shared priorities for promoting sustainable development.[181] Current priority areas for the Caribbean region were identified at the most recent SIDS conference in consultation with stakeholders across three geographical regions: the Caribbean, the Pacific, and the Atlantic, Indian Ocean and South China Sea (AIS). The policy recommendations synthesized from this diverse set of stakeholders demonstrate a clear focus on implementing proactive climate change measures. According to the most recent *Caribbean Regional Snapshot*[182] report, engaged stakeholders identified climate change adaptation and mitigation as a priority area and outlined three recommendations for action, namely:

- Fostering international collaboration and knowledge sharing between SIDS, academic and research institutions, and international organizations;
- Establishing a comprehensive financing mechanism and/or strengthening the financing mechanisms that have already been established (e.g., the Loss and Damage Fund[183] established during COP27) to help fund climate adaptation projects; and
- Building the required capacity by enhancing institutional and technical expertise to ensure that climate change considerations are incorporated into all sectors of development planning.

[180] Global Edge, CARICOM Memo, https://globaledge.msu.edu/trade-blocs/caricom/memo.
[181] UNITED NATIONS, REGIONAL SNAPSHOT: CARIBBEAN REGION (n.d.), https://sdgs.un.org/sites/default/files/2023-08/Caribbean%20Regional%20Snapshot.pdf
[182] *Id.*
[183] The Loss and Damage fund "aims to provide financial assistance to nations most vulnerable and impacted by the effects of climate change." *See What you need to know about the COP27 Loss and Damage Fund*, UNITED NATIONS ENVIRONMENT PROGRAM (Nov. 29, 2022), https://www.unep.org/news-and-stories/story/what-you-need-know-about-cop27-loss-and-damage-fund

SIDS face unique economic vulnerabilities due to their remote geographies (e.g., high import and export costs of goods) and often experience high levels of debt,[184] which can present a challenge in acting upon their sustainable development goals.[185] Compounding these issues, SIDS also face disproportionate harms from the impacts of climate change. A variety of financing mechanisms have been proposed to address these challenges. One such mechanism aimed at increasing capital for sustainable development activities in SIDS is the Bridgetown Initiative. This initiative—an outline of development financing created in collaboration with the United Nations and the government of Barbados—calls for increased funding from international development banks, debt restructuring, increased lending for sustainable development goals, increased private sector investment, and more equitable government and financial structures and international trade systems.[186] Implementing these steps could help SIDS in the Caribbean to overcome issues posed by debt and help advance the ambitious climate and renewable energy goals set forth in their NDCs.

There are also several examples in the Caribbean of progress being made at the national and local levels on the transition to clean energy. The sections below provide brief case studies of how Puerto Rico and The Bahamas are advancing their sustainable development and energy transition goals and describe ways in which Cuba may draw lessons from them.

V.B. PUERTO RICO

Like Cuba, Puerto Rico's location in the Caribbean makes the island particularly vulnerable to tropical cyclones. On September 20th, 2017, Hurricane Maria made landfall in Puerto Rico's Yabucoa municipality as a strong category 4 storm. Hurricane Maria's extreme winds, heavy rains, and storm surge[187] decimated Puerto Rico's aging and poorly maintained electrical infrastructure that had previously been damaged by Hurricane Irma,[188] eliminating power to most of the island's 3.7 million residents. Five months after Hurricane Maria hit, a quarter of Puerto Rico's population was still without power.

Hurricane Maria exposed just how fragile Puerto Rico's electric grid had become, after years of neglect from the publicly owned utility that was deeply in debt and had failed to maintain and modernize generation, transmission, and distribution assets. In the words of The Center for a New Economy, a think tank based in San Juan, Puerto Rico, because of the utility's mismanagement, negligence, and corruption, even before Maria hit the island's electricity system was an

[184] United Nations, *Small Island Developing States*, https://www.un.org/ohrlls/content/about-small-island-developing-states (last visited Feb. 14, 2024).
[185] *Id.*
[186] *Id.*
[187] According to the Federal Emergency Management Authority, preliminary peak wind gusts in Puerto Rico were over 140 mph (225 kph), over 35 inches (89 centimeters) of rainfall was recorded, and storm surge of over 6 feet (2 meters) was estimated. *See* FEMA, MITIGATION ASSESSMENT TEAM REPORT: HURRICANES IRMA AND MARIA IN PUERTO RICO (2018), https://www.fema.gov/sites/default/files/2020-07/mat-report_hurricane-irma-maria-puerto-rico_2.pdf.
[188] Less than two weeks before Maria's landfall, the eye of category 5 Hurricane Irma passed within 30 miles of the Puerto Rican island of Culebra. Despite avoiding a direct landfall, Puerto Rico still experienced wind gusts over 120 mph, which left ⅔ of the island's population without electricity.

"old, unreliable, fossil fuel-based generation fleet connected to a functional but fragile and unstable transmission and distribution grid."[189]

While devasting, the destruction of Puerto Rico's grid presented new opportunities to rebuild an energy system that is more independent, financially sustainable, cleaner, and more resilient to extreme weather events. Following Hurricane Maria, Puerto Ricans launched an all-hands effort to dismantle the utility monopoly, modernize the grid, provide resilient, reliable, and affordable power to the island's residents, and deploy new technologies to increase electricity generation from distributed, renewable sources.

Just two months after Maria struck, the independent Resilient Puerto Rico Advisory Commission was established with the support of several U.S.-based philanthropies with the goal of identifying pathways to rebuild Puerto Rico and to ensure that the island is better prepared to confront future hurricanes and other challenges. The Commission engaged in a lengthy, stakeholder driven process and produced a report, Reimagine Puerto Rico, that included recommended principles, strategies, and actions for mitigating the impact of future disasters and addressing unmet needs.[190]

In the years immediately following, the U.S. government approved billions of dollars for Puerto Rico's recovery and reconstruction. For instance, in 2020, the Federal Emergency Management Agency (FEMA) authorized nearly $9.5 billion for the reconstruction of Puerto Rico's grid, including for generation, transmission and distribution.[191] FEMA works closely with Puerto Rico's Central Office for Recovery, Reconstruction and Resilience, or COR3, on identifying and approving recovery projects. Despite the large amount of government funding authorized for recovery, only a fraction of the money has been spent to date.[192]

In 2019, Puerto Rico's legislature passed the Puerto Rico Energy Public Policy Act (Act 17). Act 17 established a "goal for the commonwealth to meet 100% of its electricity needs with renewable energy by 2050, with interim targets of 40% by 2025, 60% by 2040, the phase-out of coal-fired generation by 2028, and a 30% improvement in energy efficiency by 2040."[193] The Puerto Rico Energy Bureau reaffirmed the goals set forth in Act 17 when it approved the utility's Integrated Resources Plan (IRP) in 2020, which limits the expansion of fossil fuel-based generation and includes pathways towards cleaner, more resilient sources of energy.[194] While Puerto Rico's clean energy transition efforts are still in the early stages, there has been progress on several fronts from which Cuba could learn.

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[189] Sergio M. Marxuah, CNE, *A Short History of the Demise of Puerto Rico's Electric System,* https://grupocne.org/2021/10/21/a-short-history-of-the-demise-of-puerto-ricos-electric-system/ (last updated Oct. 21, 2021).
[190] CNE, *Fostering a Better and Stronger Puerto Rico for all*, https://grupocne.org/reimagina-puerto-rico/ (last visited Apr. 8, 2024).
[191] *See e.g.,* FEMA, FEMA Authorized Statements on PREPA Projects, https://www.fema.gov/press-release/20220408/fema-authorized-statements-prepa-projects (last visited Apr. 8, 2024).
[192] *See* Gov't Accountability Off., Peurto Rico Disasters: Progress Made, but the Recovery Continues to Face Challenges (2024), https://www.gao.gov/products/gao-24-105557.
[193] U.S. Dep't of Energy, *Puerto Rico Grid Recovery and Modernization*, https://www.energy.gov/gdo/puerto-rico-grid-recovery-and-modernization (last visited Feb 14, 2024).
[194] Final Resolution and Order on the Puerto Rico Electric Power Authority's Integrated Resource Plan, https://energia.pr.gov/wp-content/uploads/sites/7/2020/08/AP20180001-IRP-Final-Resolution-and-Order.pdf.

Notably, much of the push toward clean energy is coming from those communities that are most affected by chronic power outages. After Hurricane Maria, a growing number of Puerto Ricans, "fed up with the unstable electric grid, high electricity bills and the state-owned utility's reliance on fossil fuels", installed solar panels and batteries on their homes and businesses.[195] An analysis of the island's net metering program revealed that the number of installed rooftop solar systems in 2022 (40,830 residential, 1,340 commercial, and 29 industrial[196]) was more than eight times the number installed by the end of 2016.[197] In addition to rooftop solar, efforts to install solar at critical facilities, such as hospitals, schools, and fire stations, have created a competitive market for solar companies on the island. The Puerto Rico Energy Bureau is currently considering six tranches to build-out utility-scale solar farms.

Over the last couple of years, the federal government has strengthened its commitment to helping Puerto Rico achieve its renewable energy mandates. In February 2022, the U.S. Department of Energy's Grid Deployment Office, along with six national laboratories, launched a two-year study to model scenarios under which Puerto Rico could meet its renewable targets and achieve long term energy resilience. The study, called Puerto Rico Grid Resilience and Transitions to 100% Renewable Energy Study (PR 100), was a participative process that included an advisory group of over 100 members from academia, community groups, NGOs, private solar energy companies, local governments, and other stakeholders. A top priority of the study was to analyze ways in which to achieve an equitable energy transition by ensuring access to renewable energy and storage by the island's lowest income and most vulnerable residents. In April 2024, PR 100 released its final results including the conclusion that, "Puerto Rico can feasibly transition to 100% renewable energy by 2050, but significant system upgrades and investments—guided by meaningful community participation—are needed to get there."[198] The PR 100 study could provide a useful model for Cuba to assess the challenges to a clean energy transition and to model scenarios for achieving it.

Pursuant to legislation passed by the U.S. Congress in December of 2022, the U.S. Department of Energy (DOE) established the Energy Resilience Fund that will provide up to $440 million to support residential rooftop solar and battery energy storage systems on tens of thousands of low-income homes across the archipelago. DOE will provide an additional $560 million to support community solar and other activities aimed at advancing and accelerating an equitable energy transition.[199]

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[195] Maria Galluci, *Puerto Ricans Are Powering Their Own Rooftop Solar Boom*, CANARY MEDIA, https://www.canarymedia.com/articles/solar/puerto-ricans-are-powering-their-own-rooftop-solar-boom (last visited Feb. 14, 2024).

[196] JACQUELINE GLATTARD, GERSON BEAUCHAMP & ARTURO MASSOL DEYÁ, THE ENERGY INSURRECTION: ANALYSIS OF NET METERING IN PUERTO RICO (2014-2022), (2022), https://casapueblo.org/wp-content/uploads/2022/05/scientific-technical-report.pdf.

[197] Thousands of additional systems are said to be operating but are not officially included in the final total because they are not connected to the grid. *See* Galluci, supra note 195.

[198] Dep't of Energy, *Peurto Rico Grid Resilience and Transitions to 100% Renewable Energy Study (PR100)*, ENERGY.GOV, https://www.energy.gov/gdo/puerto-rico-grid-resilience-and-transitions-100-renewable-energy-study-pr100 (last visited Apr. 8, 2024).

[199] Dep't of Energy, *DOE Announces Up to $440 Million to Install Rooftop Solar and Batteries in Puerto Rico's Most Vulnerable Communities*, ENERGY.GOV, https://www.energy.gov/articles/doe-announces-440-million-install-rooftop-solar-and-batteries-puerto-ricos-most-vulnerable (last visited Feb. 14, 2024).

Recent experience with community solar projects in Puerto Rico shows what can be achieved through public-private partnerships. One example is the Culebra solar project, led by the Environmental Defense Fund and Fundación Colibri in collaboration with Genesis Solar. Culebra—an island municipality with a population of 1,700 located off Puerto Rico's western coast—has historically received its electricity from underground cables that connect to fossil fuel-based power plants on the mainland. Following Hurricane Maria's landfall, residents of Culebra were without reliable power for 18 months, limiting access to critical medical and communication resources.

The Culebra solar project leveraged private funding to install solar energy and battery energy storage systems in the homes of 45 residents from low- and middle-income households that had the greatest need for reliable power (i.e., residents reliant on electrical medical equipment and/or refrigerated medications). These solar systems provided residents with power for essential services even after Hurricane Fiona knocked out 100% of the grid in September 2022. Additionally, these systems have significantly cut the monthly energy bills of many residents. The success of rooftop solar in Culebra is serving as a model for other NGO-backed and privately and publicly financed solar projects. In fact, in November 2023, the U.S. DOE announced its intent to award a total of $40 million to five community-based rooftop solar projects in Puerto Rico, including a grant to EDF to expand its project in Culebra. Under this award, EDF will partner with two community groups to provide solar panels and batteries for up to 250 very-low-income households on the island. Community leaders hope that with this new project, and several others, Culebra will become the first solar-powered island in the Americas.

While Cuba does not yet have access to this type of public and private financing to help it achieve its renewable energy goals, Puerto Rico's experience with community-led projects offers lessons for Cuba on how it could design and implement the transition if financing can be identified and obtained.

V.C. THE BAHAMAS

Much as Hurricane Maria was a catalyst for action in Puerto Rico, the destruction caused by Hurricane Dorian in 2019 prompted government and private sector efforts in The Bahamas to modernize the electric grid and to accelerate the transition to clean energy. For nearly two days, Dorian—the strongest hurricane ever to hit The Bahamas—brought catastrophic wind and storm surge to the country. The Abaco Islands were hit particularly hard—more than 75% of structures were either damaged or destroyed—and the island's power grid was knocked out. According to estimates from the Inter-American Development Bank (IDB), Dorian caused $3.4 billion in damages, which is equivalent to roughly a quarter of The Bahamas' Gross Domestic Product (GDP).[200]

Since Dorian, The Bahamian government has committed to producing 30% of its energy from renewables by 2030.[201] As part of this commitment, the government is incentivizing rooftop solar for households and transitioning to 100% solar on

[200] OCHA, *The facts: Hurrican Dorian's devastating effect on the Bahamas,* https://reliefweb.int/report/bahamas/facts-hurricane-dorian-s-devastating-effect-bahamas (last visited Feb. 14, 2024)
[201] Govt. of The Bahamas, *An Initiative to Develop Solar Energy Microgrids Across the Family of Islands Launched,* https://www.bahamas.gov.bs/wps/portal/public/gov/government?1dmy&urile=wcm%3Apath%3A/mof_content/internet/all+news+press+release/an+initiative+to+develop+solar+energy+microgrids+across+the+family+islands+launched (last visited Feb. 14, 2024)

less populated islands.[202] In April 2022, the Bahamian government announced its plans "to become the first country in the world to sell blue carbon credits to finance renewable energy and climate-resilient infrastructure."[203] These energy transition efforts are supported by grants from the European Union and the IDB.

In addition to these large-scale government initiatives, NGOs are also aiding the clean energy transition in The Bahamas. For example, Rocky Mountain Institute (RMI)—through its Islands Energy Program—has led several renewable energy projects in The Bahamas. Recently, RMI worked with the public utility Bahamas Power and Light to design, develop, and install a 390-kW solar microgrid[204] on Ragged Island, providing every home on the island with a renewable and resilient source of power. RMI also helped complete a community-scale project involving the installation of solar energy and storage systems in three primary schools in the Abaco Islands. These systems will not only cover 90% of the energy needs for these three schools but also function as shelters and resilience hubs during future hurricanes by providing power, heat, light, and other resources.[205]

V.D. MAIN TAKEAWAYS AND PARALLELS FOR CUBA

Efforts in Puerto Rico and The Bahamas to transition to more renewable energy sources and modernize their grids were spurred by the devastating impacts of major hurricanes. The damage caused by Maria and Dorian illustrated the weaknesses of aging electrical grids that are reliant on imported fossil fuels for power generation. Cuba faces even more severe generation challenges that have been exacerbated by destructive hurricanes, including Hurricane Ian. Cuba would benefit from taking a close look at the clean energy successes in Puerto Rico, The Bahamas, and other Caribbean islands and initiating further dialogue on how models elsewhere might be adapted for use in Cuba. With neighboring SIDS pioneering innovative methods to foster a clean energy transition, combined with its own ambitious renewable energy goals, Cuba has plenty of examples to learn from and ample opportunity to implement renewable energy projects that can create a cleaner, more resilient grid.

[202] Int'l Trade Administration, *Bahamas – Country Commercial Guide*, https://www.trade.gov/country-commercial-guides/bahamas-energy (last visited Feb. 14, 2024).
[203] *Id.*
[204] A microgrid can be detached from the main grid and is a small network that produces electricity for local consumption, even when the grid is down. *See* Lauri Stone, *How the Storm-Ravaged Bahamas Can Be a Model for Resilient Energy*, RMI (July 26, 2024), https://rmi.org/how-the-storm-ravaged-bahamas-can-be-a-model-for-resilient-energy/
[205] RMI, *The Bahamas Bolsters Hurricane-Resilient, Clean Energy at Three Primary Schools and Lays Foundations for Scaling*, https://rmi.org/press-release/bahamas-bolsters-hurricane-resilient-clean-energy-and-lays-foundations-for-scaling/ (last visited Feb. 14, 2024).

VI. RECOMMENDATIONS

VI.A. CUBA POLICIES AND PROGRAMS

1. Codify the higher renewable electricity generation figure (37%) into law

Cuban officials have announced two separate renewable energy goals for 2030—one to generate 24% of electricity from renewables and another to generate 37% of electricity from renewables. The 24% figure was announced first, and that figure has subsequently been codified into Cuban law in Decree Law No. 345[206] and included in Cuba's NDC submission to the Paris Agreement.[207] Although Cuban officials have announced the higher 37% figure and included it in a voluntary review of sustainable development goals submitted to the UN,[208] the government has not formally codified the higher 37% figure into law nor submitted an updated NDC incorporating it. The Cuban government should consider doing both.

Codifying the higher 37% renewable energy by 2030 goal and including it in Cuba's NDC submission under the Paris Agreement would demonstrate that Cuba is fully committed to the higher target. That would send important signals to foreign investors and government officials to drive investment and development of renewable energy infrastructure. Codifying the higher figure would also help clarify internal Cuban government goals. Cuban officials would have a clear benchmark to gear domestic policy towards achieving this goal. Of course, there is a risk that reaching this higher figure could be difficult, and that not meeting the goal will undermine Cuba's climate ambitions. To guard against these risks, we further recommend the actions below.

Cuban officials should concretize the higher figure with interim goals, energy mix goals, and finance plans, which would help Cuban officials measure progress toward the 2030 goal. Setting clear energy mix goals would provide a further benchmark to measure whether individual technologies are doing their part to meet the goals. Cuba set renewable energy mix goals for the 24% figure in its NDC. The country should update these figures, as explained below. Further, clear finance plans would help reassure Cuban officials and outside companies that Cuba has a plan to pay for the build-out. Financing the renewable energy transition may be one of the most difficult aspects of meeting the overall energy goals. As such, further recommendations on options to finance these projects are discussed below.

[206] Korkeakoski, *supra* note 129.
[207] Naranjo, *supra* note 114.
[208] Voluntary National Review, *supra* note 135.

2. Prioritize solar and wind development to meet the 2030 goal

Cuban officials had identified four technologies that would be used to meet the original 2030 renewable energy goal—biomass, wind, solar, and hydro. Cuba's 2020 NDC indicates that 14% of overall energy generation in 2030 will come from biomass, while 10% will come from solar, wind, and hydro combined.[209] We recommend revising these percentages to prioritize wind and solar and to deprioritize biomass.

Wind and solar have climate, local pollution, and cost advantages over biomass burning. As explained above, bioenergy production from biomass burning releases greenhouse gas emissions that may not be fully offset by biomass growing.[210] Further, biomass burning can cause local environmental pollution, which can in turn lead to serious health problems, including respiratory disease and death.[211] Solar and wind energy production offer alternatives with fewer concerns around climate and local environmental pollution. According to the United Nations Economic Commission for Europe's *Life Cycle Assessment of Electricity Generation Options* report, life cycle greenhouse gas emissions for wind power vary from 7.8 and 16 g CO2 eq/kWh and 12 and 23 g CO2 eq/kWh for onshore and offshore wind, respectively, and photovoltaic technologies produce life cycle greenhouse gas emissions that range from 8 and 83 g CO2 eq/kWh.[212] While this report does not calculate life cycle greenhouse gas emissions for biomass "due to the complexity of modeling various feedstock-agricultural practices-conversion-technology combinations",[213] one study found that bioenergy's ecological impact due to land occupation is "of similar magnitude to the impact of GHG emissions from coal power."[214]

Although costs vary region to region, the International Renewable Energy Agency found that the global weighted average localized cost of electricity was lower for both utility scale solar (0.049/kWh) and onshore wind ($0.033/kWh) than for biomass burning (0.061/kWh) in 2022.[215] Given the cost and environmental pollution advantages of solar and wind, we recommend prioritizing solar and wind over sugarcane biomass where possible.

3. Incentivize private energy development

Cuban officials should, where feasible, incentivize private energy development to help meet renewable energy goals. This is not to say that private development is the only path forward for Cuban officials, as public-owned enterprises can also help Cuban officials meet energy goals. But private development can help leverage international finance to overcome high initial capital costs and to take advantage of efficiencies developed by renewable energy companies.

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[209] Naranjo, *supra* note 114.
[210] Sterman et al., *supra* note 160.
[211] Cançado et al., *supra* note 161.
[212] United Nations Economic Commission for Europe, Life Cycle Assessment of Electricity Generation Options (2021), https://unece.org/sites/default/files/2021-11/LCA_final.pdf
[213] *Id.*
[214] Thomas Gibon et al., *Health Benefits, Ecological Threats of Low-Carbon Electricity*, 12 Environ. Res. Lett. 034023 (2017).
[215] IRENA, *Renewable Power Generation Costs in 2022*, https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022 (last visited Feb. 14, 2024).

Cuban officials have already taken steps to incentivize renewable energy development by private companies. The 2019 constitutional update enshrined in Cuban constitutional law guarantees for private company investments in Cuba.[216] In 2021, Cuba passed a resolution to allow 100% foreign ownership of solar and wind farms, in addition to exemptions from taxes for such projects for eight years.[217] And in November 2023, the country passed a resolution aimed at establishing favorable prices for land to be used by foreign companies in renewable energy development.[218] These developments are a good sign that the government aims to incentivize renewable energy development by private companies. Cuban officials should continue to look for opportunities to further incentivize such development, including through government guarantees of contracts, subsidies, and further tax breaks.

4. Incorporate resiliency planning into infrastructure development

Climate change impacts will continue to threaten Cuba's ability to reliably generate and deliver electricity. When planning new electricity infrastructure projects and upgrading existing facilities, Cuban officials should consider the risks posed by climate change and develop strategies to mitigate and manage those risks. The full range of expected climate impacts, both chronic and acute, should be evaluated using forward-looking projections rather than historical data, since historical data is no longer an adequate predictor of future climate conditions.[219] Each energy infrastructure asset should be assigned a risk profile based on the overall likelihood of it being impacted by a given climate-related risk, as well as the extent of potential consequences from that impact. When assessing risk, it is important to not only consider the vulnerability of individual assets to climate impacts and the importance of the assets to system operation and reliability as a whole, but also to consider the inter-relationships between assets and the potential for compounding impacts. While this sort of climate resilience planning may involve up-front costs, such investments should reduce future storm damage and recovery costs, resulting in lifetime savings for both electric providers and their customers.

As Cuban officials consider ways to adapt to climate change, care should be taken avoid maladaptive outcomes. Maladaptation occurs when attempts to address the symptom of a particular risk inadvertently exacerbate its underlying cause. In the climate context, the World Bank describes maladaptation as "actions…that (unintentionally) constrain the options or ability of other decision-makers now or in the future to manage the impacts of climate change, thereby resulting in an increase in exposure and/or vulnerability to climate change."[220] Maladaptation can also be used as a metric to capture the extent to which adaptation measures fail, or when such efforts have been conducted in a

[216] Cuba's Constitution of 2019, *supra* note 103.
[217] Gaceta Oficial Extraordinaria No. 49, June 18, 2021, Resolución 223, June 16, 2021, Ministerio de Finanzas y Precios.
[218] Havana Live, *Land Sale Value Approved for Foreign Investments in Renewable Energy*, https://havana-live.com/land-sale-value-approved-for-foreign-investments-in-renewable-energy/ (last visited Feb. 14, 2024).
[219] Romany M. Webb et al., Climate Risk in the Electricity Sector: Legal Obligations to Advance Climate Resilience Planning by Electric Utilities (2020), https://scholarship.law.columbia.edu/sabin_climate_change/44/.
[220] Jane Ebinger & Walter Vergara, World Bank, Climate Impacts on Energy Systems: Key Issues for Energy Sector Adaptation 90 (2011), https://openknowledge.worldbank.org/entities/publication/dfd1eb14-dfb0-528a-959c-8d9fbc2c3e78 Maladaptation could, for example, occur where electric utilities invest in elevating or hardening infrastructure against sea level rise in areas where "retreat" is more appropriate. *See generally* Beatriz Azevedo de Almeida & Ali Mostafavi, *Resilience of Infrastructure Systems to Sea-Level Rise in Coastal Areas: Impacts, Adaptation Measures, and Implementation Challenges*, 8 Sustainability 1115 (2016).

manner that is unsustainable.[221] In order to guard against maladaptation, planning and investment processes should be designed in a way that not only acknowledges the critical importance of mitigating greenhouse gas emissions to reduce climate risk, but also incorporates local knowledge and expertise throughout the process.[222] For example, in this context, Cuban officials should consider investments that support the deployment of distributed renewable energy resources instead of the hardening of existing fossil fuel infrastructure.[223]

VI.B. REGIONAL COOPERATION

1. Step up dialogue and cooperation in the region on clean energy transition

Cuban officials should engage with partners in the region to facilitate its clean energy transition. This report highlights two jurisdictions—Puerto Rico and The Bahamas—that Cuba can learn from in setting and meeting ambitious climate goals. Cuban officials could reach out to representatives from both Puerto Rico and the Bahamas to set up dialogues and share information on best practices. While dialogue with government officials in Puerto Rico might be difficult at this time, as Puerto Rico is a U.S. territory, it could engage in dialogue with non-governmental and private sector actors in Puerto Rico. Cuba can learn from these and other jurisdictions to accelerate and smooth its energy transition.

Cuba can also advance its energy transition by joining regional efforts aimed at facilitating clean energy buildouts and climate resilience. For example, Cuba could strengthen its engagement with CARICOM, and learn from its efforts to respond to climate challenges. Cuba has a history of engaging with CARICOM through trade agreements,[224] and specific engagement on the climate transition could help strengthen regional bonds. Cuba could also lead new regional efforts aimed at fostering climate mitigation and adaptation, and support more ambitious efforts across the region.

Cuba could also engage in global dialogues, for example, through the Renewable Energy Transition Accelerator (RETA).[225] Launched at COP26 in 2021, RETA is a joint initiative of the UK energy regulator Ofgem, the International Energy Agency, International Renewable Energy Agency, RMI, and the World Bank. It aims to "enhance the capacity of energy regulators to contribute to" energy system decarbonization "through enhancing exchanges and communicating best practices."[226] Cuban officials do not currently participate in RETA but, by joining, would have the opportunity to engage with and learn from energy regulators from more than 30 countries around the world.

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[221] Orr Karassin, *Mind the Gap: Knowledge and Need in Regulating Adaptation to Climate Change*, 22 GEO. INT'L ENV'T L. REV. 383, 389 n.31 (2010).
[222] Webb et all., *supra* note 219.
[223] *Id.*
[224] Barbados Ministry of Foreign Affairs and Trade, *The CARICOM-Cuba Trade and Economic Cooperation Agreement,* https://www.foreign.gov.bb/the-caricom-cuba-trade-and-economic-cooperation-agreement/ (last visited Feb. 14, 2024).
[225] Regulatory Energy Transition Accelerator, *Accelerating the Energy Transition*, https://retatheaccelerator.org/ (last visited Feb. 14, 2024).
[226] *Id.*

VI.C. U.S. POLICY

1. Initiate government to government dialogue with Cuba on clean energy

During the Obama Administration, the U.S. and Cuban governments signed a number of bi-lateral agreements, including the *Joint Statement Between the United States of America and the Republic of Cuba on Cooperation on Environmental Protection*, signed on November 24, 2015.[227] This and other agreements provide a platform and framework for dialogue and cooperation on a range of issues, including addressing the "causes and effects of climate change."[228]

As noted above, a transition to clean energy in Cuba is in the interests of the United States and squarely consistent with the Biden Administration's commitment to address the climate crisis globally. It is also in line with the objectives of PACC 2030, which include improving access to development financing, facilitating project development and investment, and deepening collaboration with countries in the Caribbean. Given this, the United States should consider resuming bi-lateral talks with Cuba on environmental protection, with a specific focus on actions that can be taken to support Cuba in addressing the climate crisis and accelerating the clean energy transition. Such a dialogue could identify potential steps each country could take to facilitate the flow of clean energy technology and investment in Cuba. These might include, for example, policy reforms in Cuba to further allow and incentivize private sector development of clean energy generation. The United States could further ease rules to allow the export of clean energy technology to Cuba and allow private businesses in the U.S. to invest in Cuban projects. Removing Cuba from the list of State Sponsors of Terrorism would result in lifting the "10% rule" and allow freer flow of clean energy technology into Cuba from other countries. The United States could also formally include Cuba in PACC 2030.

As access to capital may be Cuba's greatest challenge in pushing forward a clean energy transition, both countries could encourage the World Bank and other International Financial Institutions (IFIs) to provide grants and loans to Cuba. Additionally, Cuba and the United States should find a political solution that addresses the restrictions put in place by the Cuban Democracy Act, which was codified in 1992, and the Helms-Burton Act of 1996, which limits U.S. trade and investment in Cuba.[229] Although Cuba withdrew from the principal global IFIs, IFIs have developed mechanisms for supporting projects involving non-members. For example, trust fund arrangements have been adopted whereby third parties—such as the United Nations Development Program (UNDP)—manage monies for projects in nonmember countries. A trust fund arrangement (e.g., involving the UNDP which has long been established in Cuba) would not trigger sanctions under the Helms-Burton Act or other Cuba-related restrictive U.S. legislation. Of course, IFIs and other sources of capital would require some measure of assurance that Cuba can repay its obligations in the future. Given the country's current economic situation and the inability of most Cubans to afford the actual costs of electricity, future access to capital remains a central challenge.

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[227] U.S. Dep't of State, *Joint Statement Between The Republic of Cuba and The United States of America on Cooperation on Environmental Protection,* https://2009-2017.state.gov/e/oes/rls/pr/249946.htm (last visited Feb. 14, 2024).
[228] *Id.*
[229] Piñon and Torres, *supra* note 17.

Cuba's energy crisis is severe and the road to recovery will be a long one. Nonetheless, taking bold and aggressive steps now can result in enormous benefits for the Cuban people not only in the present, but in the future as well. Benefits will extend beyond Cuba's borders and serve the interests of the United States in fostering climate resilience and energy security throughout the Caribbean region. As outlined in this report, Cuba has the science and data needed to understand the scope and depth of the problem and to inform future decisions on how to modernize the grid and to build out renewables in its electricity sector. Key to success will be ambitious and innovative policies, strong political will, incentives to the private sector, and access to capital. Greater cooperation between Cuba and its neighbors, including the United States, can facilitate and expedite the transition. To this end, renewed dialogue between the Cuba and the United States on climate and clean energy is needed in order to find mutually beneficial pathways for cooperation.