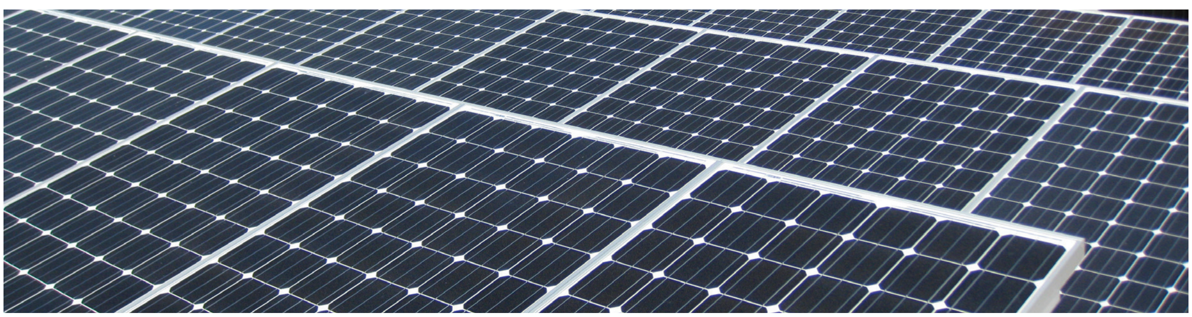
ROADMAP TO A SUSTAINABLE ENERGY SYSTEM

Harnessing the Dominican Republic's Sustainable Energy Resources



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On the cover: Los Cocos Wind Farm, Pedernales, Dominican Republic; Jatropha Processing Plant, Elias Piñas, Dominican Republic; Monte Plata Solar Farm, Monte Plata, Dominican Republic. Photos courtesy of Mark Konold.

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Preface

Two years ago, Worldwatch Institute completed its first-ever Sustainable Energy Roadmap, which focused on solar and wind resources in the Dominican Republic. That pilot study was followed by enormous demand from other countries and regions for similar analysis. Just as our work in the Dominican Republic became a prototype for analysis elsewhere, we believe that the country itself will become a model for the transition to sustainable energy systems in other parts of the world.

The solar and wind Roadmap also set the basis for the extended and advanced research presented here. Throughout the country, it became an importance reference guide in the conversation about the wide-reaching impacts that could come from implementing smart and substantive policies in the energy sector—policies that would be able to clear the way for sustainable energy investments and thus unleash the Dominican Republic's enormous renewable energy potential, achieve significant efficiency gains, and reduce carbon emissions.

The expanded Roadmap presented here makes the case for the social and economic benefits of sustainable energy solutions even clearer. With an abundance of solar, wind, hydro, and biomass resources, the Dominican Republic has the potential to revolutionize the way it produces and consumes electricity. The country has witnessed a surge in the uptake of small-to medium-scale renewable energy deployment; it has reformed energy sector governance with a new Ministry of Energy and Mines; it has begun addressing in earnest the pervasive challenge of electricity theft; and the government has made unequivocal calls for drastic reductions in greenhouse gas emissions and highlighted the important role that energy efficiency must play.

But much more remains to be done. Although liquefied natural gas (LNG) is playing an increasing role in the country's energy matrix to supplant old and inefficient oil-burning units, renewable energy (excluding existing large-scale hydropower) still comprises less than 10% of the country's electricity generation. Restrictive banking practices and high levels of government debt—driven largely by the poor management and financial performance of the electricity sector—stymie renewable energy investment. System losses from theft are still significant and are compounded by system inefficiencies due to a lack of maintenance and investment, leading to chronic power blackouts and reliance on expensive and polluting diesel generators.

We believe that this Roadmap provides decision makers and stakeholders in the Dominican Republic with the sound technical, socioeconomic, financial, and policy analysis needed to guide the country's further transition to an electricity system that is socially, economically, and environmentally sustainable. The report includes key recommendations for institutional, regulatory, and legal reform. If implemented, they will usher in a new era of energy security, economic development, social opportunity, and environmental integrity.

Like many small-island developing states, the Dominican Republic is on the front lines of global climate change. The country faces threats from increasing storm intensity, erratic rainfall patterns, rising temperatures, and rising sea levels. Reducing costly fossil fuel reliance through the transition to an efficient energy system based on renewable electricity generation will result in more resources for climate adaptation. It will bring increased economic vitality through new jobs in the growing sustainable energy business with enormous positive impact on the country's existing economic sectors, including tourism, agriculture, and manufacturing.

Presented here is a plan that can lead to an affordable, reliable, low-emission electricity system that facilitates climate-compatible development in the Dominican Republic. But it is just a plan. What is needed now is action. Manos a la obra!

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Washington, D.C., July 2015

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While the authors of this study take full responsibility for its overall content and ultimate findings, this Roadmap would not have been possible without the input and dedication of hundreds of individuals and organizations. Indispensable input was provided through interviews and by participants in our stakeholder consultations and workshops. The list of experts who have supported this project by sharing ideas, data, contacts, and general encouragement is too long to include here, but we remain indebted to all of them. They may not agree with all of our conclusions, but we would be gratified to know that they consider the results of our work worth their active support, and that they are proud of what could be achieved only with their help.

We give special thanks to Julian Despradel for his collaboration while he was working at the National Energy Commission (CNE) and later at the Ministry of Energy and Mines (MEM). From the very beginning, Julian kept us informed about all important developments in his home country, provided necessary introductions in and outside of government, and mastered in-country logistics and technical details while immersing us in Dominican culture. We are grateful for his professionalism, his technical capacity, and his extensive knowledge of the energy sector both in the Dominican Republic and in the wider Latin American region.

We also are very grateful to Moisés Alvarez, Rüdiger Fleck, Francisco Gómez, Federico Grullón, Demarys Marte, Milton Morrison, Francisco Ortega, Yeulis Rivas Peña, Hinya de Peña, Omar Ramirez, and Pelegrín Castillo Semán, who met with us regularly (and patiently) throughout the project to ensure that we understood the nuances of the Dominican electrical, financial, and political systems.

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List of Abbreviations

AC	alternating current
ADIE	Dominican Electricity Industry Association (Asociación Dominicana de la Industria Eléctrica)
AOSIS	Alliance of Small Island States
BAU	business as usual
CAES	compressed air energy storage
CAF	Development Bank of Latin America (Corporación Andina de Fomento)
CCDP	Climate-Compatible Development Plan
CDEEE	Dominican Corporation of State Electricity Companies (Corporación Dominicana de Empresas Eléctricas Estatales)
CDM	Clean Development Mechanism
CEPM	Consorcio Energético Punta Cana-Macao
CER	certified emissions reduction
CFL	compact fluorescent lightbulb
CIM	construction, installation, and manufacturing
CNCCMDL	National Council for Climate Change and the Clean Development Mechanism (Consejo Nacional para el Cambio Climatico y el Mecanismo de Desarrollo Limpio)
CNE	National Energy Commission (Comision Nacional de Energía)
CO_2	carbon dioxide
CoP	coefficient of performance
COP	Conference of the Parties
CPI	U.S. Consumer Price Index
CRI	cost recovery index
CSP	concentrating solar thermal power
DBJ	Development Bank of Jamaica
DGRS	General Directory of Norms and Systems (Dirección General de Reglamentos y Sistemas)
DHI	diffuse horizontal irradiance
DIGECOOM	General Directory of Multilateral Cooperation (Direccion General de Cooperacion Multilateral)
DNI	direct normal irradience
DOP	Dominican peso
EE	energy efficiency
EEU	Energy Efficiency Unit
EGEHID	Empresa de Generación Hidroeléctrica Dominicana

EPBD	European Energy Performance in Buildings Directive
ESMAP	Energy Sector Management Assistance Program
ETED	Empresa de Transmisión Eléctrica Dominicana
EU	European Union
FDI	foreign direct invesment
GCF	Green Climate Fund
GCI	Global Competitiveness Index
GDP	gross domestic product
GDS	gross domestic savings
GEF	Global Environment Facility
GHI	global horizontal irradience
GW	gigawatt
GWh	gigawatt-hour
HFO	heavy fuel oil
HVAC	heating, ventilation and air conditioning
IDB	Inter-American Development Bank
IEA	International Energy Agency
IECC	International Energy Conservation Code
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Finance Corporation
INDC	Intended Nationally Determined Contribution
INDOCAL	Dominican Institute for Quality (Instituto Dominicano de la Calidad)
INDRHI	National Institute for Hydraulic Resources (Instituto Nacional de Recursos Hidraulicos)
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ITBIS	Industrialized Goods and Services Transfer Tax
kV	kilovolt
kWh	kilowatt-hour
LCOE	levelized cost of electricity
LED	light-emitting diode
LNG	liquefied natural gas
MEM	Ministry of Energy and Mines (Ministerio de Energía y Minas)
META	World Bank Model for Electricity Technology Assessment
MSW	municipal solid waste
MW	megawatt
NAMA	Nationally Appropriate Mitigation Action
NaS	sodium-sulfur battery
NGO	non-governmental organization
NO_x	nitrogen oxide

NYISO	New York Independent System Operator
O&M	operation and maintenance
OAS	Organization of American States
OC	Organismo Coordinador del Sistema Eléctrico Interconectado
OLADE	Latin American Energy Organization (Organización Latinoamericana de Energía)
OSHA	U.S. Occupational Health and Safety Administration
OTEC	ocean thermal energy conversion
PAEF	Anti-Fraud Program
PECASA	Parques Eólicos del Caribe
PM	particulate matter
PoA	plan of action
PPA	power purchase agreement
PV	photovoltaic
RCC	Regional Collaboration Centre
RE	renewable energy
SBA	standby agreement
SeNaSa	Seguro Nacional de Salud
SENCO	National Energy Efficiency Committee
SENI	National Interconnected Electrical System (Sistema Eléctrico Nacional Interconectado)
SGP	GEF Small Grants Program
SIDS	small-island developing state
SIE	Electricity Superintendent (Superintendencia de Electricidad)
SMES	superconducting magnetic energy storage
SO_x	sulfur oxides
SRI	Solar Reflectance Index
SWAC	sea water air cooling
TCO	total cost of ownership
UERS	Unidad de Electrificacion Rural y Suburbanas
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USAID	U.S. Agency for International Development
USD	U.S. dollar
VEEI	Value of the Energy Efficiency of an Installation
VRBB	vanadium redox battery
WPK	Wei, Patadia, and Kammen
ZBB	zinc-bromine flow battery

Executive Summary

The Dominican Republic's energy sector is at a crossroads. Currently, the country depends on fossil fuel imports for 86% of its electricity generation, bringing enormous economic and environmental costs and necessitating a transition to a more sustainable energy system.

In 2011, the Dominican Republic spent 8.6% of its GDP on fossil fuel imports. Electricity prices in the country are low for the region, at about 21 U.S. cents per kilowatt-hour in the commercial and industrial sectors and 27 U.S. cents per kilowatt-hour in the residential sector. In 2011, an estimated 85% of Dominican citizens received a subsidized electricity billing rate, which was projected to cost the government USD 1 billion. Transmission and distribution losses are very high, at 32%, leading to significant financial losses for the Dominican power system. The reliance on fossil fuels for power generation also results in high local pollution and healthcare costs and contributes to global climate change.

The Dominican government is considering phasing out the use of petroleum for electricity—which currently accounts for over 40% of generation—by increasing imports of coal or liquefied natural gas. Although these energy sources could provide much-needed electricity cost reductions, the potential for energy efficiency measures and renewable energy generation deserve much greater consideration. In this *Roadmap to a Sustainable Energy System*, the Worldwatch Institute conducts the technical, socioeconomic, financial, and policy assessments needed to create a smooth transition to an energy system that is socially, economically, and environmentally sustainable.

Seizing the Potential of Energy Efficiency

The first element of Worldwatch's technical assessment is an analysis of key sectors for energy efficiency. Overall, the five least-cost ways to mitigate greenhouse gas emissions in the Dominican Republic are related to what is sometimes called "the fifth fuel." The country's high transmission and distribution losses and expensive electricity mean that energy efficiency improvements can result in significant cost savings, especially for power distributors. Improving the efficiency of power generation and reducing grid losses—both of which are far short of international standards—are a first step to reducing electricity prices for consumers.

End-use improvements and standards for key sectors can achieve significant additional energy savings. Efficiency upgrades in the hotel and tourism industry provide a largely untapped opportunity for more-efficient energy use, bringing demonstrated cost savings. HVAC systems and building envelope improvements could save the commercial and public services sector significant energy and money. In the residential sector, lighting and refrigeration show the most potential for energy savings. Despite the economic motivation for energy efficiency improvements, lack of awareness of these benefits and upfront financing costs still pose a barrier to implementation. Although some pilot projects exist, particularly through the efforts of the National Energy Commission (CNE), more could be done to increase the public's awareness of such programs and to encourage residents and businesses to investigate similar solutions.

Harnessing Renewable Energy Resources

Improving energy efficiency will help curb the growth in energy demand in the Dominican Republic, but new power capacity will still be needed to meet the country's needs. The country has very strong renewable energy potential, and the lion's share of that new power capacity can, and should, be met with renewable resources. The country's solar energy resources are particularly strong: average global horizontal irradiance (GHI)—the measurement used to determine potential for solar photovoltaic (PV) development—ranges from 5 to 7 kilowatt-hours per square meter per day (kWh/m^2/day) throughout most of the country.

For perspective, Germany, which has nearly half of the world's installed solar PV capacity, has an average GHI of just 2.9 kWh/m^2/day and very few locations above 3.5 kWh/m^2/day. Distributed solar PV generation at the household and commercial level can play an especially important role in the Dominican Republic's energy mix.

Several locations in the Dominican Republic have extremely strong wind energy potential. The successful experience of the country's Los Cocos wind farm could be replicated at other sites that have high wind speeds. Just 15–20 medium-sized wind farms (60 megawatts each) could provide half of the country's current power demand. Wind energy potential varies throughout the day and year, but several locations could still support economical wind power generation even during relative lows.

By developing small hydropower potential at the Dominican Republic's remaining viable sites, and improving the efficiency of existing sugarcane bagasse power generation, the country can round out a diverse, renewables-based electricity system.

A More Reliable Electricity Grid

To reduce grid losses and accommodate growing energy demand, the Dominican electricity grid will require significant upgrades and expansion. Distributed generation, especially from household and commercial-scale rooftop solar PV systems, can reduce power system inefficiencies by lowering the amount of electricity that the grid must accommodate, which in turn reduces grid losses. The technical challenges associated with distributed generation, such as unintentional islanding and voltage fluctuations, can be addressed using well-established technologies, operating standards, and regulatory best practices. Furthermore, a distributed electricity system based on renewable energy will be more resilient than centralized fossil fuel generation is to climate change impacts, such as more-frequent and intense hurricanes, to which the Dominican Republic is particularly vulnerable as a small-island state.

Important grid modernization measures, such as closing the national grid through Manzanillo, better utilizing the high-voltage line connecting Santo Domingo and Santiago, and improving operations and forecasting practices, can go a long way to addressing challenges associated with the variability of renewable energy. In many cases, the cost of grid connection for solar, wind, and small hydro installations will be minimal and should not serve as a deterrent to renewable energy planning.

The Dominican Republic's current electricity system is well suited to renewable energy integration, as existing liquefied petroleum, fuel oil, and natural gas power plants can be fired up and down quickly in response to fluctuations in solar and wind generation. Plans for new natural gas plants, if installed, would similarly complement variable renewable power production.

Integrating multiple renewable energy sources can further reduce renewable intermittency issues. In the Dominican Republic's case, combining solar and wind capacity on the grid can help particularly in smoothing out seasonal variability. In addition, electricity storage options, especially batteries and pumped hydro systems, can be paired with renewable energy capacity to store power produced during periods of high production and low demand, to be fed into the grid at peak hours. Building biomass power plants, which can be fired up and down quickly, next to solar power plants can collectively generate baseload power as well.

Energy Scenarios Through 2030

If the necessary grid strengthening measures are implemented, renewable energy can reliably meet up to 85% of the Dominican Republic's electricity demand while lowering energy costs. Worldwatch developed several scenarios for scaling up renewable energy in the country's electricity sector through 2030. These scenarios present technical realities of the different energy pathways that the Dominican Republic is currently considering, including expanding its imports of LNG or coal for power generation. Worldwatch's analysis shows that a transition to an energy system based on renewable energy is best achieved through integration with the currently existing and already planned coal, natural gas, and petroleum-fueled power plants.

Worldwatch's analysis challenges the need for tendering additional coal power. The construction of new coal power plants is redundant and will lock in a technology for the next 35 years that puts the Dominican economy on an unsustainable growth path. In contrast to petroleum and gas power, investments in new coal plants ultimately will limit the amount of renewable energy that the system can integrate. Because coal plants are relatively inflexible and, unlike petroleum and gas power, cannot be fired up or down rapidly in response to renewable power fluctuations, new coal power in the Dominican Republic would result in much higher curtailment at times of peak renewable production.

Assessing the Socioeconomic Impacts of Alternative Electricity Scenarios

Worldwatch built on its technical resource assessments to model the costs of electricity production from various energy sources from 2013 through 2030. Based on findings from this socioeconomic assessment, renewable energy can enable the Dominican Republic to lower electricity prices, save scarce resources on fossil fuel imports, decrease its trade deficit, increase energy security, and reduce greenhouse gas emissions and local pollution at negative costs.

At generation costs of 7.6 and 8.8 U.S. cents per kWh, respectively (not including financing costs), new wind and hydro power facilities already are competitive energy sources in the Dominican Republic. Coal, natural gas, and petroleum generation cost 9.4, 11.3, and 20–23 U.S. cents per kWh, respectively. Solar energy will become the cheapest source by 2030 if the country is able to benefit from experience and economies of scale. The economic case for all renewable energy sources becomes even stronger once external health, environmental, and climate change costs of fossil fuel generation are included.

Applying electricity cost assessments to Worldwatch's scenarios through 2030 for the Dominican Republic demonstrates that a higher share of renewable energy reduces overall energy costs across all scenarios. A continued reliance on the current coal, gas, and oil-based generation infrastructure during the shift to renewable energy requires less upfront investment and results in greenhouse gas emission savings over time, but also leads to high fuel costs and overall generation costs in the transition period.

The results also show the role of coal in driving emission increases. For example, greenhouse gas emission projections for Scenario 1 (a 30% renewable energy share) even marginally exceed estimates under business as usual (BAU, a 12.8% renewable share). Moreover, Scenario 2 results show that a 50% renewable energy share cannot lead to substantial emission reduction savings if combined with new coal power investments.

Worldwatch also sought to assess the rising environmental costs from electricity generation, thinking in new paradigms that make the societal costs of electricity generation more transparent. Coal plants in the Dominican Republic are the most injurious to human health and the environment. The costs of local pollution alone increase the costs of coal power by around 170%.

Once these estimates are added to the traditional levelized cost of energy (LCOE) analysis, coal power becomes the most expensive technology for the country. Once local pollution and climate change costs are accounted for, generating 1 kWh of wind power is less than one-seventh the generation cost of coal plants and around one-sixth that of diesel generators and oil combined-cycle plants. Solar photovoltaics (PV) is substantially less expensive than all conventional power apart from natural gas. It is about half the price of oil combined-cycle power generation and more than 25 U.S. cents below coal power generation.

Transitioning to an electricity system powered 85% by renewables can decrease the average cost of electricity by 40% by 2030 in comparison to 2010. The transition also can create up to 12,500 new additional jobs and reduce greenhouse gas emissions in the electricity sector to a mere 3 million tons annually. Although an accelerated expansion of renewables requires higher upfront investments, it reduces the total cost of electricity generation and can save the country up to USD 25 billion by 2030, freeing up public money to be spent on more pressing social and economic concerns.

Sustainable Energy Finance

Worldwatch's scenario cost analyses demonstrate that the Dominican Republic could reach 85% renewable electricity generation by 2030 with less than USD 47 billion in investment costs between 2013 and 2030 (compared to more than USD 71 billion under BAU). However, persistent high interest rates, a lack of access to long-term loans needed for the upfront capital costs of energy efficiency and renewable energy projects, and a perception as a high-risk investment environment have hampered development of the country's sustainable energy market.

Low cash recovery by electricity distributors constrains their ability to pay generators, necessitating government support to make up the revenue gap. High losses and artificially low electricity prices challenge their financial viability. The high debt accrued by the electricity sector puts a strain on the nation's overall credit rating and discourages new investments in the sector. Petrocaribe has long been a significant contributor to the debt burden. By the end of 2014, Petrocaribe's debt load totaled USD 4.1 billion, although it has since been lowered substantially because of a write-down by the Venezuelan government and a significant payment on the outstanding balance. Despite this improvement, there was no change to the agreement regarding import levels.

Perceived risk and the need for capacity building impede domestic investment in sustainable energy. Private international finance institutions continue to view the Dominican Republic's sustainable energy market as risky, and for the most part they will not provide loans without assurance through a sovereign guarantee from the Dominican government that debts will be repaid. On occasion, the government has offered sovereign guarantees in exchange for ownership of an electricity generating asset, which has proven problematic in project development.

The lack of long-term loans also poses a major barrier for financing sustainable energy projects. Renewable energy projects face a difficult hurdle of a seven-year payback window and an inability to refinance as easily as conventional energy projects. An energy credit line disbursed through Banco BHD, supported by the International Finance Corporation (IFC), provides low-interest medium-term loans for sustainable energy projects, especially for small and medium-sized enterprises. This is the only finance stream available through a domestic private bank.

Outside of private financial institutions, traditional development assistance from bilateral and multilateral agencies is targeted increasingly toward sustainable energy. The Dominican Republic can harness these resources to establish energy efficiency and renewable energy programs. Climate financing—including through Nationally Appropriate Mitigation Actions (NAMAs), Climate Investment Funds, and the Green Climate Fund—also has the potential to provide major support for the country's sustainable energy transition.

Although a high share of renewable energy will be more cost-effective than fossil fuels over the entire lifecycle of new power installations, the relatively high installment costs for renewables remains an important challenge. Further improvements in the financial sector thus will be necessary to make use of the Dominican Republic's full renewable energy potential. These include capacity building for banks and project developers, creation of new loan products, and financial guarantees to improve investment security in the sustainable energy market.

Policy Recommendations

Although creative financing solutions and capacity building can overcome some challenges, the most significant barriers to achieving a sustainable energy transition in the Dominican Republic must be overcome through targeted policy reform. The country should establish a long-term energy plan that clearly states its intention to establish a modern, sustainable electricity sector that fully utilizes the country's abundant natural renewable resources, aggressively reduces greenhouse gas emissions, and improves the lives of its citizenry through more affordable and reliable electricity along with health and environmental improvements. To date, loose goals have been stated; however, based on Worldwatch's renewable resource potential assessments and energy scenario cost analyses, we conclude that the country can strengthen its renewable energy target for the electricity sector to 85% or more by 2030 while also reducing electricity prices for consumers.

Overarching national energy plans and targets are just one part of the planning and policy framework necessary for a sustainable energy transition; they alone are not enough to ensure that all goals will be met. Institutional and regulatory barriers stand in the way of achieving a significant share of renewable energy in the Dominican Republic. The creation of a new Ministry of Energy and Mines is a strong first step to coalescing the myriad energy-related resources that had been spread across competing government ministries and agencies. And while energy efficiency is prioritized and elevated to a vice-ministry level, renewable energy is not, which could jeopardize the full impact that renewable energy can have in the Dominican electricity system. Further, the initial exclusion of the state-owned utility, CDEEE, from the broader structure of the new ministry may cause unnecessary delays in sector reform.

A new, formal electricity policy and accompanying legislation are necessary to strengthen the new Ministry's authority over the electricity sector. In addition, clearer directives for the electricity sector regulator, the Electricity Superintendent (SIE), are necessary to improve overall sector accountability and to see that established electricity prices accurately reflect generation costs and enable access to reliable, affordable energy for consumers and businesses.

Time-consuming administrative procedures for energy projects also are a major deterrent to renewable development in the Dominican Republic. Although effective permitting is essential to limit the negative environmental and social impacts of energy projects, long and bureaucratic permitting processes can result in significant risk and expense, discouraging developers and investors from undertaking renewable projects. Streamlining permitting procedures and ensuring that necessary inspections and assessments happen in a timely manner would eliminate a major source of renewable energy investment risk.

The Dominican Republic currently has policies proposed or in place to promote renewable energy, including net metering and various fiscal incentives. Further initiatives such as competitive tendering processes can take this progress further. In addition, new programs targeting energy efficiency have been developed and are expanding to include enhanced building codes and appliance standards. In the near term, these measures should be implemented to their fullest potential to demonstrate the government's commitment to sustainable energy.

In the longer term, policies that have been proven successful in other countries should provide additional support for the Dominican Republic's energy transition. Equally important to addressing systemic challenges is a revised and strengthened electricity theft law. Further, the government should work with CDEEE, the Ministry of Energy and Mines, and international supporters to improve metering and bill collection, especially among large-scale consumers.

Moving Forward

The Dominican Republic's government, private industry, and civil society have acknowledged the important role of energy efficiency, renewable energy, loss reduction, and intelligent grid solutions in reducing energy costs, bolstering the national economy, and contributing to a healthier environment. The country is now at a crucial point where it must implement targeted measures and reforms in order to achieve the full benefits of a sustainable energy system in the coming years. This Roadmap provides the information necessary to create a national consensus on the most suitable energy path forward. It ends with a list of recommended next steps to make this transition a reality.

1 | A Sustainable Energy Roadmap for the Dominican Republic: An Integrated Approach

Key Findings

- The Dominican Republic—including its energy sector—is highly vulnerable to the impacts of climate change. Renewable energy, energy efficiency, and intelligent grid solutions are a means to both mitigate and adapt to climate change.
- International support for climate change mitigation and sustainable energy access can provide an opportunity for the country to deploy energy efficiency measures, harness its strong renewable energy potential, and build a reliable, flexible grid.
- The Dominican Republic's electricity sector is dominated by fossil fuels, with oil (46.0%), natural gas (24.9%), and coal (14.2%) accounting for 85% of the country's power generation in 2014.
- The Dominican Republic spent USD 4.4 billion on petroleum imports in 2013—equivalent to 7.3% of its GDP.
- Renewable energy now accounts for 15% of electricity generation in the Dominican Republic, with hydropower (13.2%) and wind (1.7%) accounting for nearly all renewable generation.
- The country has a National Energy Plan and a Climate Compatible Development Plan and has committed to halving emissions, from 2010 levels, by 2030. Despite the government's commitment to increasing renewable energy, the country's energy diversification strategies are focused mainly on coal and natural gas. Recent visions and plans do not align with current energy sector activities.
- Accomplishing renewable energy goals is stymied by a confusing make-up of electricity sector actors, laws, and mandates and a lack of adherence to established laws and mechanisms for running the sector.
- To enable the Dominican Republic to transition to a sustainable energy system, this report provides a holistic approach that
    - assesses technical barriers and potential for energy efficiency, renewable energy, and grid improvements;
    - analyzes socioeconomic costs and benefits of alternative energy development pathways;
    - studies the investment environment for sustainable energy projects and identifies opportunities and areas for improvement; and
    - recommends concrete policies and measures for how to implement the shift to a clean, reliable, and affordable energy system.

This Roadmap aims to lay out concrete strategies that enable the Dominican Republic to transition to an energy system that is economically, socially, financially, and politically sustainable.* If implemented, the resulting electricity system would better enable the country to meet its development needs while mitigating and adapting to global climate change. This chapter provides the international context and methodology for this Sustainable Energy Roadmap. It overviews the country's current electricity system and its key challenges and defines the role that a sustainable power system can play in fostering greater independence and security.

1.1 Climate Change and Sustainable Energy: The Dominican Republic in the Global Context

At the 2009 and 2010 Conferences of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), held in Copenhagen, Denmark, and Cancún, Mexico, advanced economies pledged to provide developing countries with USD 30 billion in financial and technical assistance for climate change adaptation and mitigation by 2012, and USD 100 billion annually by 2020.[1†] These efforts are supported by the international development community, including the World Bank, regional development banks, and other international and bilateral mechanisms.

These assistance measures reinforce earlier agreements made at the 2007 UN Climate Change Conference in Bali, Indonesia. According to the *Bali Action Plan* (commonly known as the Bali Roadmap), developing countries are to consider "[n]ationally appropriate mitigation actions…in the context of sustainable development, supported and enabled by technology, financing and capacity-building." The activities of developing countries, as well as the technology transfer and financial assistance efforts of industrial countries, are to be implemented in a "measurable, reportable and verifiable manner."[2]

The Dominican Republic is a so-called small-island developing state (SIDS). SIDS have played a proactive role in international climate negotiations. At the Copenhagen conference in December 2009, member countries of the Alliance of Small Island States (AOSIS)—including the Dominican Republic—launched a sustainable energy initiative known as SIDS DOCK, designed as a "docking" station to connect the energy sectors in these countries to wider markets for finance, carbon, and sustainable energy sources. SIDS DOCK commits small-island states to work together to develop renewable energy and energy efficiency options and to seek funding from international carbon markets to implement their low-carbon energy strategies. As one of the five founding members from the Caribbean, the Dominican Republic has taken a leading role in this initiative.

Additionally, UN Secretary-General Ban Ki-moon launched the Sustainable Energy for All initiative in 2012, with three central objectives through 2030: "providing universal access to modern energy services; doubling the global rate of improvement in energy efficiency; and doubling the share of renewable energy in the global energy mix."[3] The Sustainable Energy Roadmap for the Dominican Republic provides the country with a clear pathway to meeting these goals and accessing opportunities under the initiative.

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* This Roadmap constitutes part of a Worldwatch series of Sustainable Energy Roadmaps. Portions of the analysis and text in each Roadmap follow a similar model, reflecting the Institute's knowledge base and methodology.

† Endnotes are numbered by chapter and begin on page 173.

Historically, developing countries have contributed comparatively little to the world's climate crisis. Yet these nations are profoundly vulnerable to the impacts of climate change, which include water shortages, reduced food production, and escalating disasters due to increased storm intensity and rising sea levels. The threat to SIDS continues to intensify as the risk of climate change grows. The Intergovernmental Panel on Climate Change's (IPCC's) *Fourth Assessment Report*, released in 2007, anticipates a global temperature increase of between 1.8 and 4 degrees Celsius by the end of the century, causing extensive damage to ecosystems worldwide.[4] The IPCC's *Fifth Assessment Report*, released in 2014, paints an even more worrying picture, including heightened projections for expected sea-level rise of 26 to 82 centimeters by the late 21st century.[5]

Meanwhile, emissions from developing countries are growing rapidly, and the developing world's share of global greenhouse gas output is expected to soar in the coming decades unless new approaches are taken to develop low-emissions energy, building, and transport systems. Most developing countries, including small-island states, lack the full range of technologies and policies needed to pursue an alternative, less emissions-intensive path.

In addition to providing environmental benefits, low-emissions development strategies can deliver socioeconomic benefits by taking advantage of indigenous renewable energy resources such as solar, wind, hydro, geothermal, and biomass, rather than relying on imported fossil fuels. Small-island states can serve as ideal showcases for low-carbon development strategies due to the congruence of their national economic and security interests with the global climate agenda, as well as to their relatively small sizes and the homogeneity of their economies. With adequate support, they can demonstrate on a small scale what needs to be done globally in the long run.

Technologies that are available today, and those that are expected to become competitive in the next few years, can permit a rapid decarbonization of the global energy economy if they are deployed properly.[6] Modern sustainable energy systems are built on an advanced degree of energy efficiency, a high share of renewable energy in the overall electricity mix, and a strong and flexible grid. Additional key components to increasing energy and economic security include the diversification of energy sources and suppliers, a decrease in the level of energy imports, and greater infrastructure resilience during natural disasters.

As a country particularly vulnerable to destructive weather events and sea-level rise, the Dominican Republic needs to develop a resilient energy infrastructure that can withstand natural disasters, particularly hurricanes and tropical storms. An energy system dependent on fossil fuel imports is particularly vulnerable to the impacts of extreme events on fuel supply and coastal infrastructure. Coastal flooding, storm surges, and sea-level rise can also disrupt fossil fuel transport infrastructure and power generation facilities. Further, thermal power generation requires considerable water supplies for fuel processing, cooling, and power generation, and thus can be affected by a decrease in water availability due to climate change. Decentralized power generation can increase the flexibility, resiliency, and reliability of an energy system.

Coal and nuclear power pose serious environmental and safety risks, especially in a disaster-prone region like the Caribbean. Electricity from natural gas can be fed into the electricity grid with much greater flexibility than coal and nuclear baseload power, and it has the benefits of greater efficiency and lower carbon emissions than electricity generated from oil. Therefore, natural gas could potentially play an important role as a natural ally of renewable power by compensating for the variability and storage challenges that currently exist with renewables.[7] Natural gas should continue to be used in the Dominican Republic and should be used as a part of a larger strategy to transition to renewable energy; however, a reliance on gas as the centerpiece of the energy sector will prolong dependence on fossil fuel imports.

All countries in the world have renewable energy resources at their disposal; those of the Dominican Republic are tremendous. In order to harness them, however, an intelligent framework of policies and regulations is needed. Low-carbon energy strategies require the implementation of solutions that are physically available, economically viable, and politically feasible.

1.2 The Dominican Republic's Current Electricity System and the Role of Sustainable Power in Building the Future

The Dominican Republic is the third largest energy consumer in the Caribbean, after Cuba and Puerto Rico. Approximately 92% of the country's towns and villages are connected to the grid, and about 96% of the population has access to electricity.[8] Yet the existing grid system also has one of the highest rates of distribution losses in the world, at around 32%.[9]

Despite the country's growing power capacity and production, electricity shortages are a regular occurrence. In 2012, 2,598 gigawatt-hours (GWh) of additional electricity demand, equal to 1,614 hours or 18.4% of annual electricity demand, went unmet.[10] The industrial sector is the largest electricity consumer (accounting for 46% of demand), followed by the residential sector (42%) and commercial and public services (11%).[11]

In 2013, there were 16 power companies operating in the Dominican Republic, with a total of 67 power plants producing 14,093 GWh of electricity—representing average annual increase in production of 2.8% from 2000 to 2012.[12] This production includes a number of industrial installations and many private individuals that generate their own electricity independently—mostly from oil products, with a small but increasing share coming from solar photovoltaics (PV).

Until 1997, all electricity generation, transmission, and distribution in the Dominican Republic was state-owned. That year, under the Public Sector Enterprises Reform Law (Law 141-97), the government unbundled the electricity sector and privatized most of it by selling half of its electricity generation capacity and divesting all of its distribution services to private companies. By 2009, citing their poor financial and operational situation, the government re-acquired all three distribution companies, but left half of the generation capacity in the private sector.[13]

National energy demand far exceeds existing domestic traditional energy resources, leaving the Dominican Republic highly dependent on fossil fuel imports. Approximately, 85% of the country's electricity production is fossil fuel-based, the majority of which (46%) is heavy fuel oil (HFO).[14] (See Figure 1.1.) A combination of fuel oil products is used, including fuel oil No. 6 (35.6%), a mix of fuel oil No. 6 and natural gas (5.9%), a mix of fuel oil No. 6 and fuel oil No. 2 (3.7%), and fuel oil No. 2 (2.7%).[15] HFO is a particularly polluting energy source, as it is a residual fuel that is left after more valuable types of crude oil are separated out. In addition to high carbon emissions, it has a higher concentration of other elements (including sulfur) that cause highly polluting emissions upon combustion.

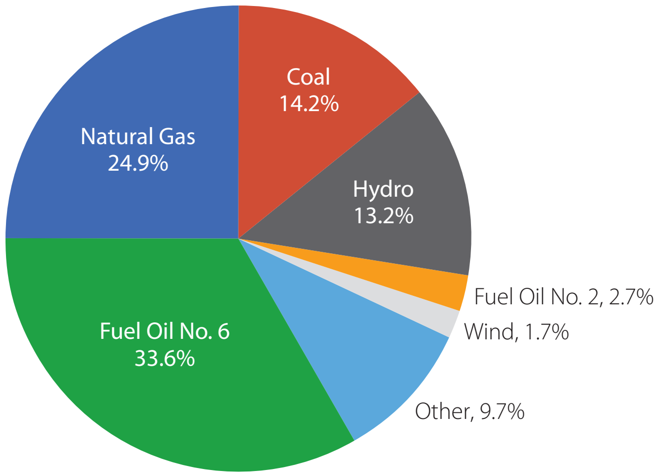


Figure 1.1

Annual Electricity Generation in the Dominican Republic, by Fuel Type, 2013

Source: OC

Natural gas-fired power plants generate 24.9% of the country's electricity, and three coal-fired plants contribute 14.2%.[16] Domestic renewables account for about 15% of generation, dominated by 26 small and large hydropower plants (13.2%).[17] In 2010, construction began on the country's first utility-scale wind farms: Los Cocos, which has an installed capacity of 71 megawatts (MW), and Quilvio Cabrera, which has an installed capacity of 8.25 MW. Together, they provide almost 2% of renewable generation. Biomass contributes well below 1% of generation.[18] Table 1.1 provides a breakdown of the country's power plants by fuel.[19]

Table 1.1 Installed Capacity of Power Plants in the Dominican Republic, by Fuel

Fuel	Installed Capacity
	MW
Fuel Oil No. 6	1,190
Hydro	608
Natural Gas	581
Fuel Oil No. 2	402
Coal	314
Fuel Oil No. 2 and No. 6	185
Natural Gas and Fuel Oil No. 6	160
Wind	79
Solar	1
Total	**3,520**

Source: See Endnote 19 for this chapter.

Most of the oil-fired power plants that provide the majority of the country's electricity generation are old and in need of retirement or replacement. Due to the unreliability of the national grid, many industries and private individuals generate their own electricity using relatively inefficient small-scale fossil fuel-based units. This further perpetuates high consumer electricity prices and a dependence on imported oil.

In 2013, the Dominican Republic spent USD 4.4 billion on fossil fuel imports, equivalent to more than 7.3% of its GDP.[20] Before the recent world economic crisis, fossil fuel imports accounted for an even higher share of GDP.[21] It cost the Dominican government over USD 1.2 billion in 2013 to cover the deficit between electricity costs and subsidized electricity prices.[22] The government is committed to lowering this subsidy by increasing generation capacity substantially and diversifying the energy mix, although the most severe challenge that the sector faces is electricity theft and lack of bill payment by consumers of all sizes.

Because local utility companies (which are ultimately state-owned) do not collect the full amount of money owed them, they are not able to pay the generating companies from which they purchase electricity to sell to their consumers. The utility companies then pass that debt to the overarching state-owned utility company, CDEEE, and the debt becomes the responsibility of the Dominican government. In recent years, this debt has been as high as USD 700 million and has severely affected the country's credit rating and, by extension, its ability to attract investment that can take advantage of indigenous renewable energy resources.

The Dominican Republic's reliance on fossil fuels for electricity generation results not only in massive transfers of wealth to other countries for imports, but also in high generation costs per unit of electricity. High expenditures on fuel imports leave the country especially vulnerable to oil price fluctuations. Because electricity prices are not indexed to fuel prices, but rather are set by the government's price cap, distributors sell electricity for a much lower price than is economical.

Despite relying on expensive oil for over 40% of its power generation, the Dominican Republic has some of the cheapest electricity rates in the region, with industrial and commercial rates at 22 U.S. cents per kilowatt-hour (kWh) and residential rates at just over 20 U.S. cents per kWh.[23] (See Figure 1.2.) Overall, the artificially low price for electricity contributes to the power sector's debt, which diminishes the quality of energy services as well as the overall credit rating of the country.

Plans for new capacity aim at diversifying the electricity generation mix away from petroleum-based fuels and reducing generation costs. It is estimated that by 2016, the Dominican Republic will require an additional 1,451 MW of installed capacity to meet growing demand and to decommission several inefficient diesel generating plants.[24] In 2013, 731 MW was added to the national energy system.[25] An additional 1,380 MW of generating capacity is expected by 2018, the majority of which will be powered by natural gas and coal.[26] There are also plans for two utility-scale renewable energy projects, featuring wind and solar PV.[27] Table 1.2 provides an overview of recent electricity capacity additions and planned expansions in the country.[28]

The Dominican Republic's natural gas import facility is utilized at less than half of capacity, indicating that there is potential to expand natural gas generation in the country while retiring costlier and dirtier coal and petroleum-based generation sources.[29] Although many stakeholders continue to discuss the possibility of expanding natural gas generation capacity, only 25 MW was added in 2013, far from the 600 MW projected by the National Energy Commission (CNE).[30]

There are plans for two coal-fired power plants, with a combined capacity of 675 MW, that are intended to displace HFO generation, rather than to add additional capacity to the grid. The contract was awarded in

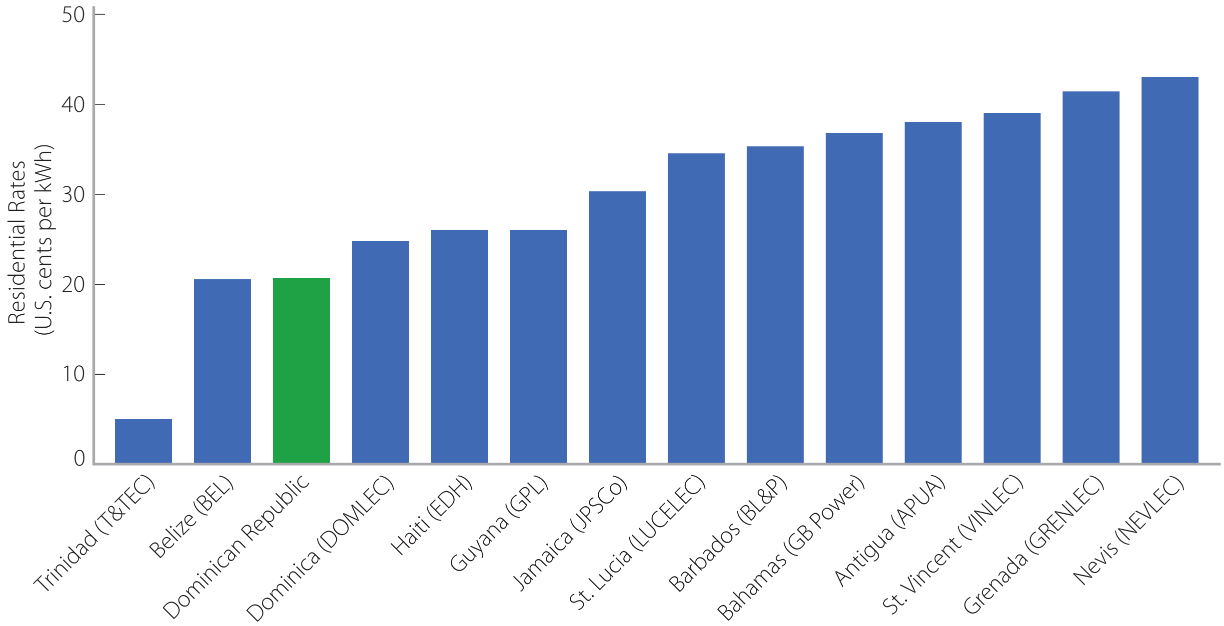


Figure 1.2

Residential Electricity Tariffs in the Caribbean Region, 2014 *Source: CARILEC, SIE, EDH, GPL, SIE, VINLEC, MSTEM, BEL*
© Worldwatch Institute

Table 1.2 Recent Electricity Capacity Added and Planned Electricity Expansion in the Dominican Republic

Year	Name	Type of Fuel	Capacity (MW)
2013	Los Cocos Expansion	Wind	52
	Estrella del Mar 2	Natural Gas, Fuel Oil No. 6	110
	San Lorenzo 1	LNG	34
	Los Origenes	Natural Gas, Fuel Oil No. 6	25
	Palomino	Hydro	80
	Quisqueya 1 & 2	Natural Gas, HFO, Fuel Oil No. 6	430
2014	Los Origines Expansion	Natural Gas, HFO, Fuel Oil No. 6	34.5
2015	North Central Energy	Natural Gas	400
2016	Los Guzmancitos	Wind	100
	Larimar	Wind	49
	Matafongo	Wind	50
	Monte Plata	Solar PV	30
2018	Punta Catalina Power Central 1	Coal	675

Source: See Endnote 28 for this chapter.

2013 to a consortium composed of Norberto Odebrecht, Tecnimont, and Enginiera Estrella.[31] Meanwhile, construction has begun on the two wind power plants and the solar PV plant, which will add 180 MW of renewable energy capacity.[32]

1.3. Dominican Republic Sustainable Energy Roadmap: Methodology and Report Structure

This Roadmap is the result of an intensive, multi-year research project on how to seize opportunities and overcome existing barriers to a sustainable energy transition in the Dominican Republic. Because energy infrastructure decisions are decisive for a country's development and involve difficult trade-offs, it was essential to gather the most recent and high-quality data. To make feasible suggestions for concrete actions, it was important to understand the interests and positions of all parties—governmental and non-governmental—that are critical to making these actions a reality.

The Worldwatch Institute worked closely with Dominican officials and partners to ensure that the scope of work will complement, not duplicate, previous research efforts that have looked at different aspects of the potential for energy efficiency and renewables in the Dominican Republic and the Caribbean region. These studies all served as important references for this project and provided essential information about different parts of the renewable energy picture; however, a comprehensive overview of efficiency and sustainable energy options and strategies at the country level was lacking. This Roadmap report aims to help address this information gap.

The most important input came from a previous Worldwatch pilot project that became the most detailed assessment of wind and solar resources ever undertaken in the Dominican Republic.[33] Worldwatch partnered with 3TIER, Inc., a renewable energy risk-analysis company that develops high-resolution mapping and data, to produce comprehensive wind and solar resource datasets. (See Appendices I–III.) The present report builds on the earlier solar and wind roadmap and presents new analyses of how these resources fit into the overall Dominican power system.

This report provides an overview of all major energy resources in the Dominican Republic. It includes a newly commissioned study of the country's biomass and small hydropower resources. (See Appendix IV.) Worldwatch also partnered with other ongoing assessment efforts to provide the most comprehensive and recent data on sustainable energy potential.

The Worldwatch Sustainable Energy Roadmap methodology takes a holistic approach to assessing the interdependent components that are essential to integrated energy planning. (See Figure 1.3.) Only in their totality do they enable a country to develop an energy development strategy that is in its best social, economic, and environmental interest.

A first step in identifying sustainable energy opportunities is to pinpoint areas for energy savings and efficiency improvements. By targeting high-consuming, energy-intensive sectors and low-cost ways of reducing energy needs, Chapter 2 of this Roadmap identifies key leverage points for improving efficiency in the Dominican Republic.

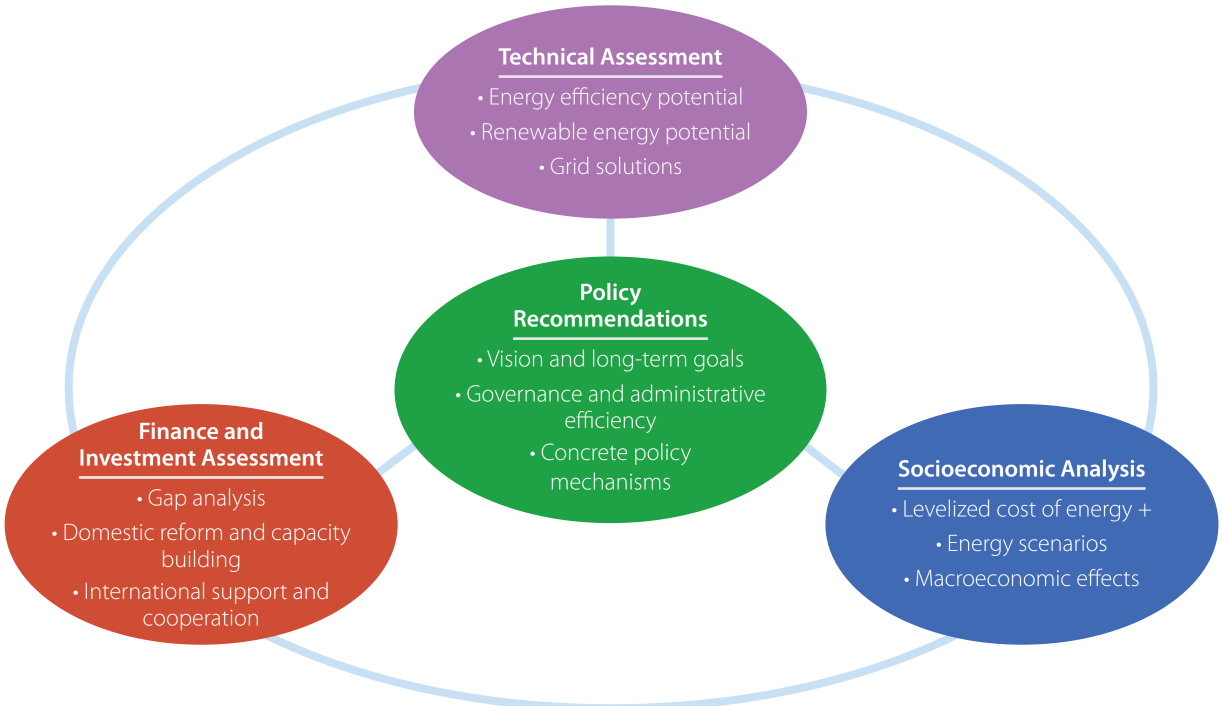


Figure 1.3

Worldwatch Sustainable Energy Roadmap Development Methodology *© Worldwatch Institute*

Chapter 3 provides country-wide maps visualizing the Dominican Republic's diverse renewable energy resources. The chapter also includes an in-depth analysis of the country's solar, wind, biomass and hydropower resources.

This Roadmap focuses on cost-effective ways to build a strong and reliable national power system. The technical analysis provided in Chapter 4 makes it possible to catalogue the grid enhancement and extension needs that can support the increased use of renewables. It also discusses opportunities for distributed renewable generation. The technical assessment is the result of consultations with in-country experts and relates infrastructure needs to the resource assessments undertaken in this study.

An in-depth analysis of the socioeconomic benefits and impacts of transitioning to renewable energy will help decision makers make the case to energy developers and investors that harnessing domestic renewable energy resources is economically beneficial, while showcasing to government officials and the public that it is in the country's best interest. Chapter 5 presents detailed scenario analyses for alternate electricity pathways that the country could take, demonstrating the technical feasibility of meeting expected demand with high renewable energy penetration.

Chapter 6 builds on these technical scenarios to present the costs of electricity generation from various fossil fuel and renewable energy sources based on locally gathered data. It also assesses the cross-sectoral impacts of developing these resources by quantifying the environmental (greenhouse gas emissions), social (pollution-linked health costs), and economic (job creation potential and fuel savings) costs of different energy pathways.

The technical feasibility and socioeconomic advantages of an energy system built on a high degree of efficiency and a high share of renewables provoke the question of why sustainable energy souces have not become mainstream technologies in the country. Chapter 7 identifies domestic and international sources of private and public financing for renewable energy and discusses how to overcome existing market and finance barriers in order to achieve the level of investment needed for a sustainable energy transition.

Chapter 8 surveys existing Dominican energy laws and regulations and, drawing on international lessons learned, discusses opportunities for policy reforms from key principles that should guide successful energy policymaking from an overarching vision to concrete policies and measures. The chapter suggests policy and administrative changes necessary to make the sustainable energy transition that is envisioned in this Roadmap a reality.

Throughout the project, Worldwatch has engaged in local capacity building and knowledge-sharing through workshops, conferences, and hundreds of interviews and conversations. These consultations were essential for compiling this integrated study but also had a purpose in themselves: they brought stakeholders together and bridged knowledge gaps between government, private renewable energy investors, utilities, and the financial sector. Worldwatch has used blogging, op-eds, and other social media efforts to further communicate research findings, both in the Dominican Republic and abroad. This final Roadmap will be presented to local stakeholders in the country as a concrete tool that they can use to plan and implement new renewable energy policies and projects.

2 | Energy Efficiency Potential

Key Findings

- Energy efficiency measures can result in significant cost savings over a short time frame, especially in the Dominican Republic where high energy costs, outdated technologies, and the potential for behavioral changes create many low-hanging fruit options.
- The five least-cost ways to mitigate greenhouse gas emissions in the country are related to energy efficiency. They are: installing efficient lighting controls in new commercial buildings, switching from incandescent light bulbs to LEDs in the residential and commercial sectors, Investing in more-efficient electronics in the commercial and residential sectors, and replacing fuel oil plants with natural gas-fired plants.
- The Dominican Republic's petroleum power plants are highly inefficient; upgrades or replacements at existing plants can play an important role in reducing energy costs in the near to medium term.
- Air conditioning accounts for more than half of electricity consumption in government and residential buildings. More-efficient HVAC systems, better-insulated buildings, and weather-aware positioning of buildings provide significant energy- and cost-saving opportunities for these sectors.
- The hotel and tourism industry has particularly high potential for achieving energy savings due to high electricity bills from air conditioning, lighting, and water heating, and it has the necessary financial resources available to implement improvements.
- High electricity costs pose an enormous burden for Dominican households, despite relatively small per capita power consumption by international standards. More-efficient light bulbs and air conditioning systems, better-insulated buildings, and the implementation of cool roofs could improve residential energy services while lowering electricity bills.
- Financing barriers continue to hinder implementation of cost-saving efficiency measures.

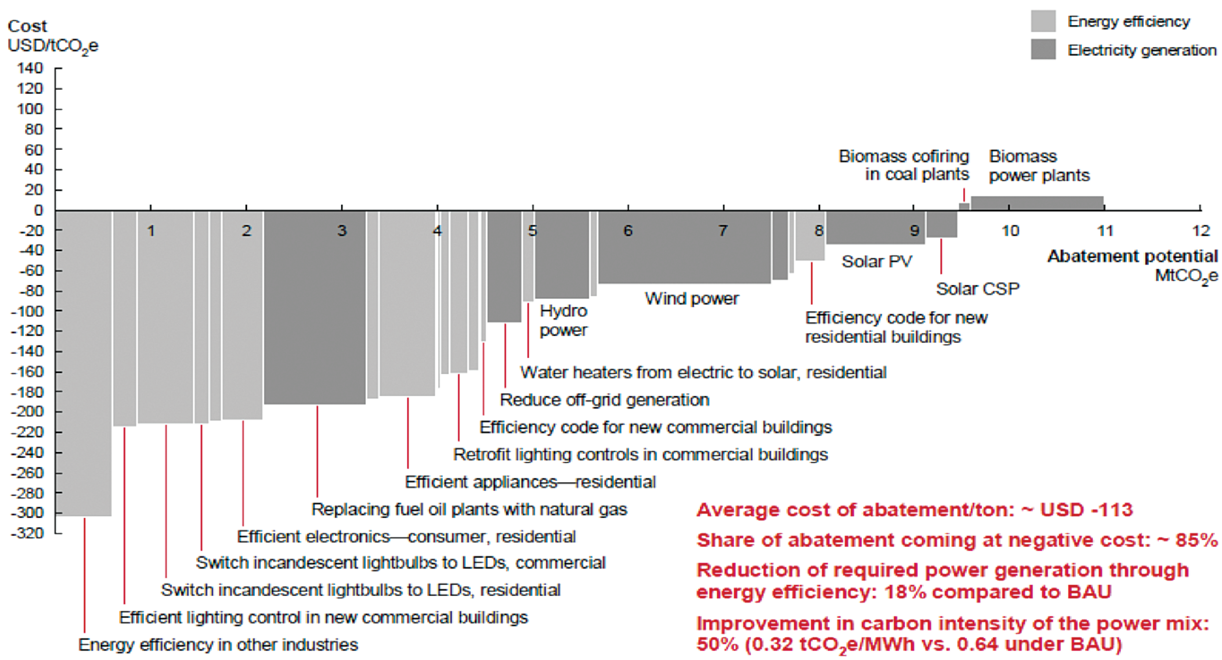
For the last two years, the Dominican Republic has been developing new energy efficiency legislation. The National Energy Commision (CNE) began the process, but now that the new Ministry of Energy and Mines (MEM) has been established and staffed, it remains unclear which organization will be responsible for carrying the work forward. However, work on this Roadmap report allowed the authors to be in constant consultation with actors involved in the formation of this new legislation and to provide advice where possible. Because energy efficiency plays such an important role in a low-carbon economy, and because the Dominican Republic is at such a vital point in its energy policy formation, this Roadmap pays particular attention to energy efficiency technologies and policies that are affordable, reliable, and politically feasible in the country.

2.1 Background

Every country has a unique set of challenges and opportunities for undertaking a sustainable energy transformation. The energy structure and level of energy efficiency are determined by a broad range of factors, including past energy prices and policies, types of economic activity, overall electricity demand, and local knowledge and attitudes about energy conservation. In developing a Sustainable Energy Roadmap for a given entity, identifying opportunities for efficiency improvements in the most energy-intensive sectors is an important initial step.

Energy efficiency measures are used to reduce the energy required to provide the same services for all economic sectors, including residential, commercial, and industrial. For example, employing energy efficiency technologies and practices in buildings can provide the same level of comfort but at a lower level of energy consumption.[1]

In the power sector, 60% of the abatement potential comes from a cleaner generating mix while the rest comes from energy efficiency measures



Analysis by the National Council on Climate Change and Clean Development Mechanism

Figure 2.1

CO_2 Abatement Cost Curve for the Dominican Republic

Energy efficiency measures also offer some of the most cost-effective tools for reducing carbon dioxide (CO_2) emissions, especially in a country like the Dominican Republic that has relatively few efficiency measures in place. To determine how energy efficiency measures can positively affect the country through reduced energy costs and lower CO_2 emissions levels, the National Council for Climate Change and the Clean Development Mechanism (CNCCMDL) completed a Climate-Compatible Development Plan (CCDP). The plan identifies efficiency gains that can be realized in various sectors of the economy, and concludes that the five lowest-cost CO_2-abatement measures are all related to energy efficiency.[2] (See Figure 2.1.)

The Dominican Republic's electricity consumption per capita is roughly on par with other countries in the region that are at a similar level of economic development.[3] (See Figure 2.2.) However, many of the countries with similar GDPs per capita consume much less electricity.[4] Although many factors—including the industry mix, economic structure and history, supply chains, and local climate—all have an impact on a country's energy needs and intensity, energy efficiency can play a pivotal role in mitigating the Dominican Republic's electricity consumption and resulting environmental pollutants.

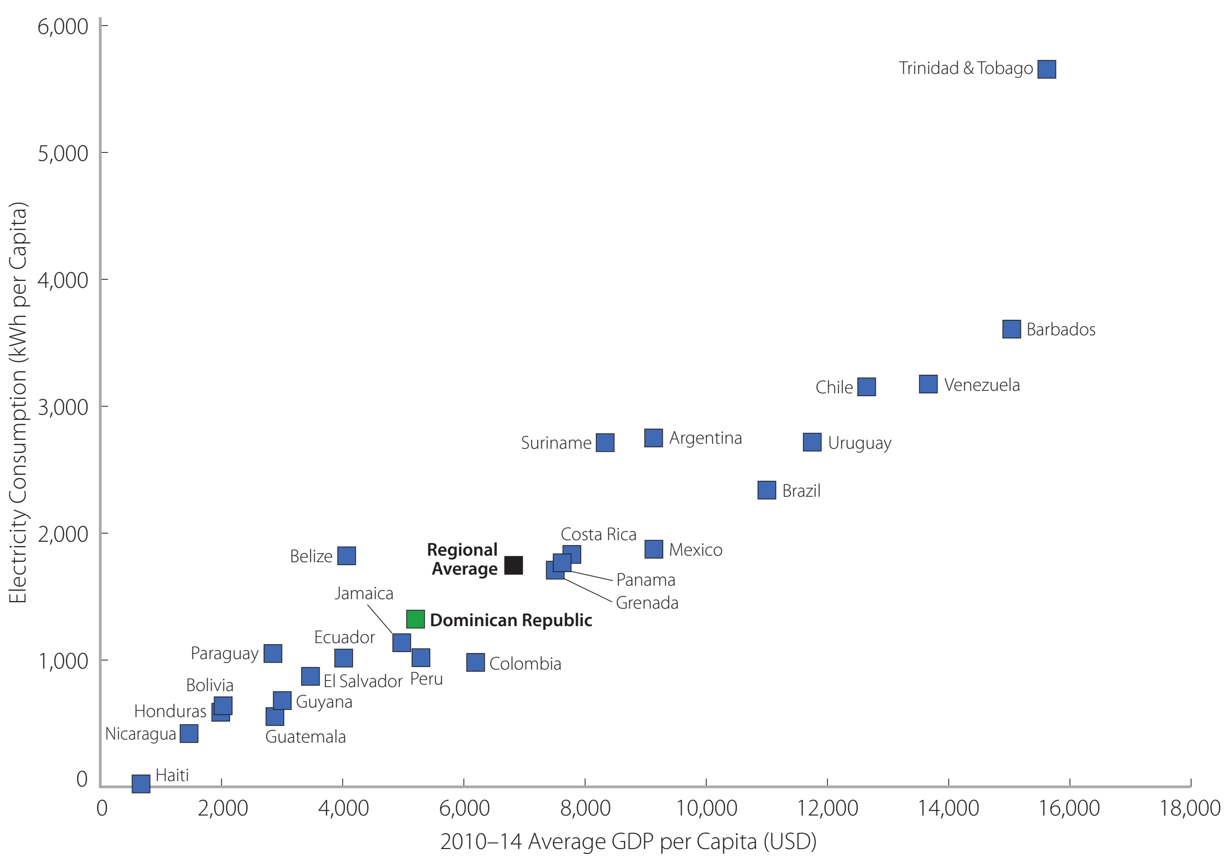


Figure 2.2

Electricity Consumption Compared to Per Capita GDP in Latin America and the Caribbean, 2010–14

Source: EIA, World Bank

2.2 Defining Priority Sectors for Efficiency Measures

Economic sectors that should be targeted for energy efficiency measures are those that: 1) account for a large share of the country's energy consumption and greenhouse gas emissions, 2) are highly energy intensive or inefficient, and/or 3) are central to the national economy and thus have an impact across sectors. Assessments of the Dominican economy indicate that the industry and residential sectors together account for 76% of electricity consumed, with smaller contributions from commercial and public services, agriculture, and forestry.[5] (See Figure 2.3.)

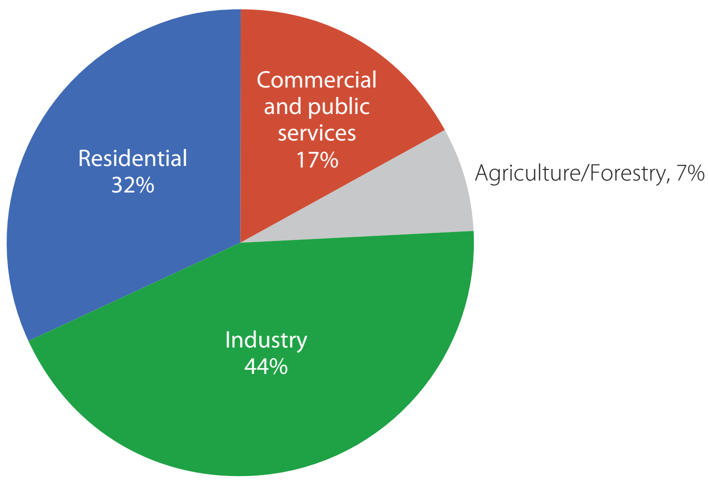


Figure 2.3

Electricity Consumption in the Dominican Republic, by Sector, 2013

Source: CNE
© Worldwatch Institute

Buildings are an important focus of comprehensive energy efficiency improvements in any country, largely because they have significant presence across all sectors (commercial, residential, government, industry, etc.). The Dominican government has asked the authors of this study to specifically examine building management solutions as input for new energy efficiency legislation. Buildings account for most of the electricity consumption in the country's commercial, public, and residential sectors and represented more than half (52%) of electricity consumption in 2012.[6]

Significant efficiency gains can be made in other key sectors and areas of the economy. Electricity generation exhibits low levels of efficiency due to antiquated equipment, as does the transmission and distribution network. These losses are compounded by high electricity theft at the residential and business levels. Both the residential and hotel sectors experience high electricity use due to inefficient lighting and the need for air conditioning and/or HVAC equipment. The public services sector is another large electricity consumer that can improve its efficiency through better energy auditing and targeted measures to reduce energy intensity. Finally, the industrial sector can gain from switching to more-efficient electricity sources such as combined-cycle liquefied natural gas (LNG) plants and a higher share of renewable energy that can be generated on site.

2.3 Electricity Generation

Improvements in energy efficiency are often the cheapest and fastest way to lessen the environmental and economic costs associated with an energy system. Efficiency measures are also an important first step because of their compounding effects: when a user demands one less unit of energy because of efficiency measures, the system typically saves two to three times more than that one unit of energy because of avoided losses during generation, transmission, and distribution. Especially for the Dominican Republic, where total electricity system losses near 38%, end-user efficiency savings can translate into much greater savings in generation. As a result, efficiency improvements can amplify the benefits of renewable energy by increasing the impact of added renewable power capacity.

The Dominican Republic has the highest CO_2 emissions per unit of generated electricity of many Latin American and Caribbean countries.[7] (See Table 2.1.) Not only does the country rely on a large share

Table 2.1 CO_2 Emissions from Electricity Generation in Selected Latin American and Caribbean Countries, 2002, 2007, and 2011

Country	2002	2007	2011
		gigatons of CO_2 per GWh	
Dominican Republic	**0.79**	**0.84**	**0.81**
Barbados	0.67	0.71	0.73
Guyana	0.39	0.76	0.68
Suriname	0.71	0.71	0.67
Trinidad and Tobago	0.68	0.65	0.62
Jamaica	0.78	0.42	0.61
Grenada	0.53	0.54	0.55
Nicaragua	0.58	0.52	0.48
Chile	0.28	0.43	0.42
Cuba	0.46	0.89	0.42
Mexico	0.57	0.41	0.41
Bolivia	0.24	0.31	0.38
Haiti	0.43	0.29	0.38
Panama	0.21	0.30	0.36
Honduras	0.33	0.39	0.35
Guatemala	0.50	0.39	0.31
Argentina	0.22	0.31	0.30
Peru	0.14	0.18	0.26
Venezuela	0.28	0.18	0.23
Uruguay	0	0.09	0.17
Colombia	0.14	0.13	0.16
El Salvador	0.34	0.27	0.16
Costa Rica	0.05	0.11	0.10
Belize	0.22	0.11	0.05
Brazil	0.06	0.05	0.05
Paraguay	0	0	0

Source: See Endnote 7 for this chapter.

of polluting fossil fuels in its power mix, but these fossil fuel plants are also very inefficient, thereby exacerbating the emissions challenge. Increasing the efficiency of the power sector, in terms of generation, transmission, and distribution, needs to be a major priority in the country's transition to a sustainable energy system.

The average efficiencies for fuel oil and coal steam generation in the Dominican Republic are extremely low, at 26.6% and 28.0%, respectively.[8] (See Table 2.2.) Increasing the number of combined-cycle diesel and natural gas installations, which in the country currently operate at efficiency rates of 45.3% and 45.4%, respectively, could cut fuel costs and emissions enormously.[9] According to the CCDP, replacing old electricity generation units with natural gas can be performed at a net-negative cost of USD 200 per ton of CO_2-equivalent.

Table 2.2 Power Plant Efficiencies in the Dominican Republic, by Generation Technology

Generation Technology	Thermal Efficiency
	percent
Combined-cycle natural gas	45.4
Combined-cycle diesel	45.3
Diesel engine – fuel oil	40.9
Combined-cycle fuel oil	32.9
Coal steam turbine	28.0
Gas turbine – natural gas	27.9
Gas turbine – diesel	27.5
Fuel oil steam turbine	26.6

Source: See Endnote 8 for this chapter.

2.4 Electricity Transmission and Distribution

The Dominican electricity grid experiences a very high level of transmission and distribution losses, at 32% in 2014.[10] For comparison, the neighboring island of Jamaica experiences combined losses of around 25%, and the United States averages losses of only about 7% annually.[11] According to the country's electricity regulator, factors responsible for the Dominican Republic's high technical losses include capped electricity prices, which lead to inadequate investment in capacity upgrades, as well as blackouts.[12] Electricity theft is not adequately addressed because of limited regulatory capacity.[13] In some cases, when authorities are sent to disconnect illegal connections, they are met with threats and sometimes physical violence from local residents. Authorities may avoid making these visits altogether out of fear for their personal safety.[14]

Around 12% of the country's electricity losses are due to technical inefficiencies at generation plants, substations, and transmission lines, which contribute roughly USD 100 million to the electricity sector's deficit.[15] The remaining 20% of system losses is attributed mainly to electricity theft, which is considered the largest obstacle that the electricity sector must overcome. All told, electricity theft, often referred to as "non-technical losses," cost the country an estimated USD 1 billion in 2014—about 1.7% of national GDP—through budgetary transfers to the electricity sector.[16]

When customers do not pay their bill or simply steal the electricity they use, distribution companies are left with a debt to the electricity generators. Distributors try to mitigate this loss by purchasing only an amount of electricity equal to what they believe they will collect (based on past experience). Any outstanding debt is then transferred to their parent company, CDEEE, which is then responsible for paying the debt to electricity generators, but often does so after a period of 60 to 90 days.[17] This leads to further poor service, which in turn exacerbates a situation in which the Dominican citizenry, whose average monthly household income is roughly DOP 14,000 (around USD 400) does not want to pay for such continually bad service.[18]

Distribution losses and grid inefficiencies leave considerable room to improve and expand the nation's grid, which also would allow for the integration of a higher share of intermittent renewable energy. Electricity losses are a major contributor to the power sector's significant debt, which affects the credit rating of the entire country and results in elevated costs for consumers. Increasing the efficiency of the transmission and distribution system therefore should be a major priority going forward.

Both grid strengthening to reduce technical losses and anti-theft measures to reduce illegal connections and increase payment collection for electricity services are needed to improve the efficiency of the transmission and distribution system and reduce the electricity sector's unsustainable debt load. These measures, as well as the regulatory and policy framework necessary to implement them, are examined in Chapters 4 and 9 of this Roadmap.

2.5 Buildings

2.5.1 Energy Use and Greenhouse Gas Emissions

Worldwide, buildings account for a significant share of energy consumption. In the Dominican Republic, this is especially true in large cities such as Santo Domingo and Santiago. This section addresses general building efficiency measures, while the following two sections address particular areas where energy efficiency measures can be adopted in the commercial, industrial, and residential sectors.

In an effort to better understand the energy use of government buildings, CNE has been piloting a monitoring program, starting with its own building. In addition to the rooftop solar PV array that the agency installed, which has reduced its energy use by about 15% and therefore its reliance on fossil fuels, it is using a software-based system to try to detect abnormal energy consumption. Air conditioning comprises the bulk of the CNE building's energy use (see Figure 2.4), but more work remains to further assess the energy usage of equipment such as elevators and appliances.[19] Thorough knowledge of all aspects of building-related energy consumption is the first step in a targeted efficiency plan.

The impact of buildings is made more significant by their long life-cycles. Unlike most appliances, buildings are designed to be operated for many decades.[20] Energy-efficient buildings have estimated refurbishment cycles of 60–80 years, compared with cycles of 30–40 years for conventional buildings, which presents an opportunity for substantial efficiency gains through thoughtful design.[21] The development of building

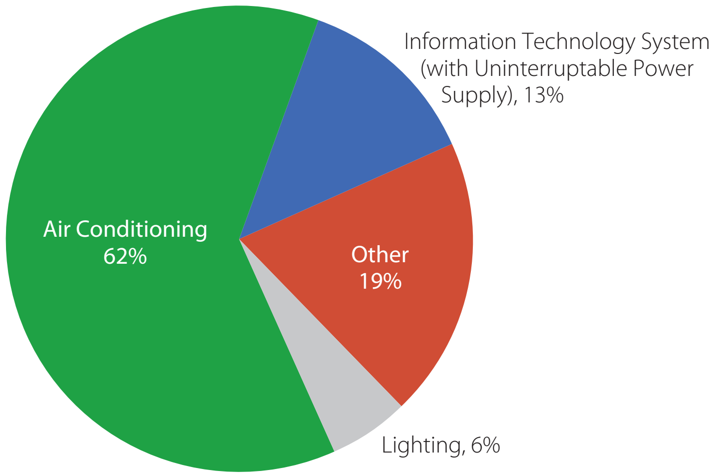


Figure 2.4

Energy Consumption in the CNE Building, by End Use

Source: CNE
© Worldwatch Institute

codes and standards directly influences design decisions, which are important in improving a country's energy efficiency and have the potential for long-term impact.

Buildings constructed today will be in existence for the next 50–100 years; therefore, energy efficiency improvements are cost-effective when combined with ongoing maintenance and refurbishment work.[22] As Figure 2.1 illustrated, emission reductions through increased energy efficiency in buildings can be achieved at an average negative abatement cost of USD 35 per ton of CO_2, reflecting energy cost savings compared to a net negative abatement cost of USD 10 per ton of CO_2 in the transport sector and a positive abatement cost in the power sector of USD 20 per ton of CO_2. Energy efficiency measures are often the most effective way to mitigate greenhouse gas emissions.

When measuring the costs and benefits of energy efficiency in residential or commercial buildings, economists use a Total Cost of Ownership (TCO) approach that considers the differences in upfront investment costs alongside long-term costs and benefits. Even though energy-efficient buildings require a higher upfront investment than inefficient buildings, they are much more cost-effective in the medium and long term because of lower energy bills, reduced greenhouse gas emissions, decreased negative health impacts, and improved worker productivity. In developing countries, a USD 90 billion investment in energy efficiency is estimated to reduce overall energy expenditure by some USD 600 billion.[23] The International Energy Agency (IEA) estimates that USD 2.5 trillion of additional investment in green buildings globally between 2010 and 2030 would yield USD 5 trillion in energy savings over the life of the investment.[24]

In the residential sector, energy efficiency upgrades can help reduce exposure to volatility in energy prices, increase energy services, and decrease food spoilage, among other benefits. The average Dominican household spends a high share of its income on energy, highlighting the need and potential for efficiency improvements. According to many home-performance contractors, the non-financial benefits of efficiency-related upgrades may have greater value to homeowners than purely financial benefits. Increased energy efficiency may contribute to such auxiliary benefits as greater reliability and resilience in the electricity grid. Energy efficiency allows the grid to provide more energy services with the same amount of energy, and since load-shedding is a common practice in the Dominican Republic, energy efficiency could help the currently installed capacity reach more people.

Additionally, efficiency-related upgrades in commercial buildings can increase worker productivity directly and indirectly through reduced sick leave. Higher indoor air quality itself can increase worker productivity by as much as 5%.[25]

2.5.2 Building Codes

The Dominican Republic first approved a building code, *Law no. 142*, in 1931 in response to the devastating San Zenon Hurricane of 1930.[26] In 1944, this law was abolished and replaced with *Law no. 675, About Construction and Public Adornment*, which established minimum requirements related to a building's architectural and structural characteristics. It also dealt with two major issues: the requirements from Councils and the National District, and the technical requirements of building construction, which was the responsibility of the National Secretary of Public Works and Communications. In 1982, *Law no. 687, System of Technical Regulations in Engineering, Architectural and Similar Fields*, was approved, establishing a mechanism of technical regulations but keeping the development and public adornment requirements described in *Law no. 142*.[27]

In 2004, the Dominican Republic approved an overall strategy for energy efficiency, describing objectives in the short term (1 to 18 months), medium term (18 months to 5 years), and long term (5 years onward).[28] With regard to buildings, the strategy document establishes that:

> Buildings in the Dominican Republic should start complying with international regulations for efficiency in countries with similar climates, and an implementation institution must ensure that developers comply with the codes. The National Energy Commission should explore the costs to develop and manage those codes and consider them against its expected savings and other benefits. Those analyses should consider the availability of improved construction materials, measures to improve the envelope, office equipment and appliances, and local experience in design and improved construction of buildings. The ability/education must be provided by architects, engineers and construction companies, as well as the government's departments that are tasked with running and implementing those measures.[29]

In 2006, *Law no. 687* was replaced with the *General Regulations of Buildings* code. The code, which comprises nine areas (see Sidebar 1), establishes the minimum requirements of compliance for any building, temporary or permanent, public or private, built in the country.[30] It spans the whole cycle of a building's creation, from the issuing of the license (including design) through construction, supervision, and inspection of building sites in order to guarantee their quality and the protection of their users. Architectural and construction projects are now regulated by the General Directory of Norms and Systems (DGRS), which is responsible for developing building codes and monitoring their implementation. The DGRS's "Tramitación de Planos" (Plans Processing) is responsible for reviewing plans according to the established regulations, while the "Supervisión de Obras" ensures that actual construction conforms to the plans that DGRS approved.

The R-021 unit of the code (*Requirements to apply the general building code and processing of building plans)*, in article 1.7.1, defines the basic requirements of the building: "buildings must be projected, built, maintained and kept in a way that guarantees the safety of the people, the well-being of the society and the protection of the environment, by compliance with the rules of this code and the minimum requirements regarding functionality…, safety… and habitability…."[31] However, there is no mention of minimum energy efficiency standards.

Sidebar 1. The Dominican Republic's General Regulations of Buildings Code

The building code's nine units are:

1. General requirements
2. Architectural regulations
3. Fire safety systems
4. Geotechnical reports
5. Structure
    a. Minimum loads
    b. Reinforced concrete
    c. Masonry
    d. Wood
    e. Steel
    f. Special structures
    g. Assessment of vulnerability and re-design
6. Electrical systems in buildings
7. Sanitary systems
8. Mechanical systems
    a. Ventilation
    b. Cooling
    c. Liquefied petroleum gas
9. Building specifications

Source: See Endnote 30 for this chapter.

2.5.3 Building Envelope

The building envelope refers to the physical separator between the exterior and the interior environments of a building, including walls, floors, roofs, windows, and doors.[32] It is the main tool to keep heat inside or to prevent it from entering a building.

The tropical climate in the Dominican Republic generates high energy demand for cooling buildings. Improvements in the glazing, insulation, and ventilation system can reduce energy needs for cooling significantly. Solar radiation based on the penetration of sunlight in the building will increase the need for cooling. Heat gains from people and appliances in buildings increase the need for cooling, too.[33]

To ensure a high level of performance throughout the life of a building, one must take into account not only the design but also the operation. As buildings age, so does the effectiveness of their electrical and mechanical systems. Maintenance requirements in standards and codes can play an important role in ensuring that these are designed to be efficient and continue to perform effectively.

Established building codes such as the International Energy Conservation Code (IECC) provide an excellent base for developing regulations and standards, but it is also important to assess conditions that are specific to the region in which they are implemented. Equally important is a regulatory regime that enforces building code application.

The main indicator used to evaluate the effectiveness of the building envelope in maintaining a comfortable indoor environment is the overall heat transfer coefficient, known as the U-value. The U-value indicates the heat conduction capacity of a material or group of materials, and is expressed in W/m^2K or $BTU/hft^{2}{}^{0}F$.* A low U-value means that the building materials conserve energy effectively by limiting the transfer of heat in and out of the building. Building orientation also affects the U-value, by influencing how much the building envelope and interior are heated by the sun.[34]

Low U-values help keep buildings warm in winter and cool in summer, and can reduce cooling demands by up to 75%. Low U-values indicate good building insulation, meaning that less energy consumption is needed to maintain buildings at a comfortable temperature. The impact of low U-values is especially relevant in roofs, reducing heat gains due to the large amount of solar energy that falls on the roof, and in walls with a low thermal mass.[35] (See Sidebar 2 on "cool roofs.")

Reducing air drafts by ensuring insulation continuity and properly sealed window and door joints improves overall building efficiency. Drafts can be identified by using thermal imaging, although this process can be expensive depending on the size of the surveyed building. Accurate thermal imaging also requires large differences between indoor and outdoor temperatures. This is an important process to undergo for buildings that use air conditioning.

Building envelope efficiency improvements have the most potential to save energy in the commercial and public services sector, but there is also significant potential for efficiency gains in the residential and industrial sectors.

2.5.4 Air Conditioning

Although many homes in the Dominican Republic do not have air conditioning, these systems still account for half of the electricity consumption in the country's residential sector. On average, replacing air conditioner systems with more-efficient units can save up to 30% of the energy costs spent on cooling.[36] Ventilation fans also can contribute dramatically toward energy savings, with efficient fans using up to 60% less energy than standard ones.[37]

Air conditioner efficiency will become even more important in the future, as more households will be able to afford air conditioning systems. For larger buildings in the commercial and public sectors, measuring the efficiency of mechanical ventilation systems and implementing higher-efficiency systems could lead to significant energy savings for the Dominican Republic.[38] (See Sidebar 3.)

2.5.5 Lighting

Lighting is one of the largest consumers of electricity in the residential sector of the Dominican Republic and has significant potential for efficiency gains. According to a study by CNE, robust energy efficiency measures for lighting could save the country an estimated 848 megawatt-hours (MWh) of electricity and 540,000 tons of CO_2 emissions per year.[39] There are two main approaches to maximizing lighting efficiency: 1) targeting communities that still use incandescent light bulbs and replacing these with more-efficient compact fluorescent lamps (CFLs) or light-emitting diodes (LEDs) (see Sidebar 4), and 2) minimizing the need for artificial lighting by relying on building and space design to optimize natural light.[40]

---

* Watts per square meter per Kelvin degrees; British Thermal Units per hour per Fahrenheit per square foot.

Sidebar 2. Cool Roofs

Cool roofs are an effective and inexpensive tool through which to increase building efficiency in the Caribbean climate. A cool roof is a roof than reflects light and emits heat more efficiently than traditional roofs. Dark roofs in warm climates can reach above 150°F (66°C), while cool roofs can help to reduce roof temperature by about 50°F (10°C). Cool roofs are most effective and economical in climates that are hot year-round. Therefore, the Caribbean is an ideal location to implement cool roof policies. Dividing a country into climatic zones and matching those zones with ideal roof material and color specifications can help building developers realize the greatest energy savings.

The two measures used to evaluate a cool roof are solar reflectance and thermal emittance. Solar reflectance, or the ability of a roof to reflect sunlight, is measured on a scale of 0 to 1; the more reflective a surface, the higher its score. For example, if a roof reflects 60% of incoming sunlight, its solar reflectance in 0.6. Dark roofs typically have a solar reflectance of 0.05–0.2, whereas lighter roofs are in the range of 0.55–0.9. The more sunlight a roof reflects, the less heat it (and the building) absorbs. Lighter-colored roofs thus help to cool down roofs and building spaces.

Thermal emittance measures how effectively a space emits thermal radiation. It too is measured on a scale of 0 to 1, and if a material can perfectly emit all of its thermal radiation, it has a thermal radiation of 1. Most non-metallic surfaces have thermal emittance of 0.8–0.95. The higher a roof's thermal emittance, the cooler the building space will be, as heat will escape more easily through the roof.

Generally, the Solar Reflectance Index (SRI) is used to measure the coolness of a roof. It is calculated by combining the solar reflectance and thermal emittance of a roof, and its scale is from 0 to 100. The higher a roof's SRI, the cooler it is. Dark roofs typically have an SRI of less than 20. The U.S. Green Building Council defines a cool roof as a low-sloped roof with an SRI of at least 78, and a steep-sloped roof with an SRI of at least 29.

Cool roofs have many direct benefits. They can lower air conditioning demands, therefore reducing energy bills. For buildings that do not have air conditioning, they can make indoor climates cooler and more comfortable. Also, cool roofs can extend a roof's lifetime, as they operate at cooler temperatures.

The indirect benefits of cool roofs include their ability to reduce local temperatures by reflecting more solar radiation directly to the atmosphere; their ability to reduce power demand and lead to load-shaving (as a result of reduced air conditioning needs), and the resulting reductions in greenhouse gas and particulate emissions.

In the United States, cool roof standards have been implemented on a local level. The state of California has made it mandatory to install cool roofs on most new buildings, as well as in cases where roofs are altered or buildings extended. New York City's building code requires 75% of the roof area of all new buildings with flat or low-sloping roofs to be white or to comply with Energy Star requirements. Likewise, improvements made under the city's CoolRoofs program reduce internal building temperatures by up to 30% and displace 1 ton of CO_2 emissions for every 1,000 square feet of roof space covered, although this affects primarily the topmost floor of a building.

Source: See Endnote 35 for this chapter.

Focusing on lighting is critical because it is one of the lowest-cost options for reducing energy use in the Dominican Republic. For rural communities, CFL and LED installations and public lighting retrofits have been shown to be among the most cost-effective solutions.[41] The CCDP concluded that switching from incandescent bulbs to LEDs in the commercial and residential sectors can be achieved at a net negative cost of around USD 200 per ton of CO_2-equivalent.[42] Energy efficiency gains through lighting measures are also critical and feasible in the industrial, commercial, and public service sectors.

Relying on natural daylight, the second way to maximize lighting efficiency, could be a double-edged sword, because increasing natural light may lead to overheating inside the building. Shadowing devices, or "louvers," angled to let in light while keeping out direct sunshine, can mitigate this potential problem.[43]

Sidebar 3. Building Ventilation Systems and the Coefficient of Performance

Building ventilation is required for healthy indoor air quality. There are three main types of ventilation:

- **Natural ventilation** supplies and removes air to and from an indoor space without using mechanical systems. Air flows through the building naturally as a result of pressure or temperature differences between the building interior and exterior.
- **Mechanical ventilation** uses ducts and fans to circulate air through the building. Air flow rates can be changed by adjusting the exhaust fans.
- **Mixed-mode ventilation**, also called hybrid ventilation, uses both mechanical and natural ventilation. Mechanical systems are used when natural ventilation does not provide an adequate air flow rate or when natural ventilation cannot be regulated, due to weather conditions (e.g., high wind speeds).

The Coefficient of Performance (CoP) measures the efficiency of mechanical ventilation systems by taking the ratio between the energy output and the energy input:

CoP = Eu / Ea, with Eu being the useful energy acquired and Ea being the energy applied.

A higher CoP corresponds to a more energy-efficient ventilation system, meaning that it consumes less energy to provide the same level of ventilation. Measuring the CoP for large buildings in the commercial and public sector could help to conserve energy for the Dominican Republic.

Source: See Endnote 38 for this chapter.

Sidebar 4. Lighting Options for the Dominican Republic

There are several types of light bulbs with varying levels of efficiency. These include:

- **Incandescent light bulbs**, which produce light by heating a filament wire to a high temperature to make it glow. Incandescent bulbs are widely used in domestic and commercial buildings, but are increasingly being replaced in favor of more energy-efficient lighting. Incandescent bulbs are relatively inefficient, as about 90% of the energy that they consume is lost through waste heat, and only a small amount is actually harnessed to produce visible light.
- **Compact fluorescent light bulbs (CFLs)**, which have a gas-filled tube that generates light when ionized by an electrical discharge. CFLs use less power than incandescent light bulbs to produce the same amount of light. A compact fluorescent lamp that consumes energy at the rate of 15 watts (W) produces as much light as an incandescent light bulb that consumes at 60 W. The light output of CFL bulbs is proportional to the bulb surface area.
- **Light-emitting diodes (LEDs)**, which work by moving electrons to release energy in the form of photons. LEDs are more efficient than incandescent light bulbs (as a 10 W LED is equivalent to a 60 W incandescent light bulb), and they are being used increasingly for indoor lighting. Unlike CFLs, LED efficiency does not depend on bulb shape or size.

Source: See Endnote 40 for this chapter.

In some modern systems, the angle can be modified mechanically to let more light in, depending on weather conditions and the time of day.

Different spaces have different lighting needs, so it is important to evaluate the varying needs for residential, commercial, and work spaces. The U.S. Occupational Health and Safety Administration (OSHA) has set standards for the minimum lighting requirements for different spaces.[44] (See Table 2.3.)

Table 2.3 OSHA Standards for Lighting Needs for Building Spaces

Space typology	Minimum lighting requirement
School space	45 foot-candles/484.4 lux
Office space	30 foot-candles/322.9 lux
Residential: Dining room	10 foot-candles/107.6 lux
Kitchen	20 foot-candles/215.3 lux

Note: A foot-candle is a unit of illumination equivalent to the illumination produced by one candle at a distance of one foot. A lux is that same level of illumination produced at a distance of one meter.[45]
Source: See Endnote 44 for this chapter.

Photo sensors, also referred to as infrared sensors, are an easily accessible tool that can be used to improve the energy savings of a lighting system by automatically turning off lights when a building space is unoccupied. Photo sensors detect the presence or absence of a building occupant by using a light transmitter and a photoelectric receiver. Photo sensors can be considered excess in most residential buildings, but they can save tremendous amounts of energy in larger and more frequented buildings, such as in the commercial and public sectors.

Although a transition away from incandescent light bulbs and toward CFLs would save energy and costs for the Dominican Republic, it is important to consider the proper waste disposal of CFLs, given their mercury content. Any program advocating the use of CFLs must keep this in mind. There is also no formal process in the country to handle the disposal of electronics, which similarly contribute to environmental degradation, and both electronic and CFL disposal should be a priority for energy efficiency programs and legislation.

For every 3 W of avoided lighting, there is a savings of 1 W for cooling needs. Because lighting reductions can lower cooling energy needs by an additional 30–40%, this needs to be considered as well when evaluating the commercial and industrial sectors.[46]

2.6 Residential Sector

The residential sector accounts for roughly one-third of total energy consumption and 42% of electricity consumption in the Dominican Republic, making it a high-priority sector for efficiency measures.[47] Yet although the residential sector consumes nearly half of the country's power, electricity represents only 21% of the energy use in the sector.[48] (See Figure 2.5.) Better understanding how residences consume energy in the country can help to maximize the impact of energy efficiency efforts in the sector.

Energy consumption in the Dominican Republic's residential sector varies distinctly between rural and urban residences. In 2001, urban residences constituted 46% of the sector, and rural residences represented 53% (with the remaining 1% represented by well-populated coastal towns).[49] LPG, fuel wood, and electricity supplied roughly 94% of the energy in the sector and were used mostly to support cooking and

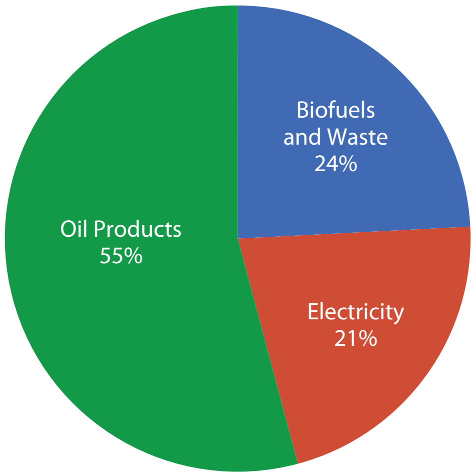


Figure 2.5

Residential Energy Use in the Dominican Republic, by Source, 2011

Source: IEA
© Worldwatch Institute

ventilation in homes (although the balance of use varies depending on location and household income). In urban homes, liquefied petroleum gas and electricity account for nearly 90% of energy supply, whereas in rural homes, fuelwood and charcoal account for around 63% of supply, and electricity represents only a small share.[50]

Another factor in energy consumption is household income, which determines which energy source is used more prominently and for what purpose. The most notable example is the use of electricity: higher income households have higher demands for lighting, refrigeration, and especially cooling—and therefore for electricity. Electricity accounts for 47.3% of energy use in urban homes, more than half of which is used for air conditioning and ventilation.[51] A comparison of electricity use at different income levels in the country shows a direct correlation between the two.[52] (See Table 2.4.)

Table 2.4 Electricity's Share of Energy Consumption in the Dominican Republic, by Income Level

Income Level	Electricity's Share of Energy Consumption
High	70.4%
Medium	50.4%
Low	27.0%

Source: See Endnote 52 for this chapter.

The high amount of energy consumed in food storage/cooking and by HVAC systems suggests an opportunity to realize significant efficiency gains. Performance requirements for household appliances could greatly reduce the energy consumption in cooking and other end uses, such as refrigeration. In the urban subsector, cooling is a significant consumer of energy. Building codes related to the building envelope and mechanical systems of buildings offer a great opportunity to meet cooling needs more efficiently. Figure 2.6 shows the breakdown of electricity consumption in the residential sector.[53]

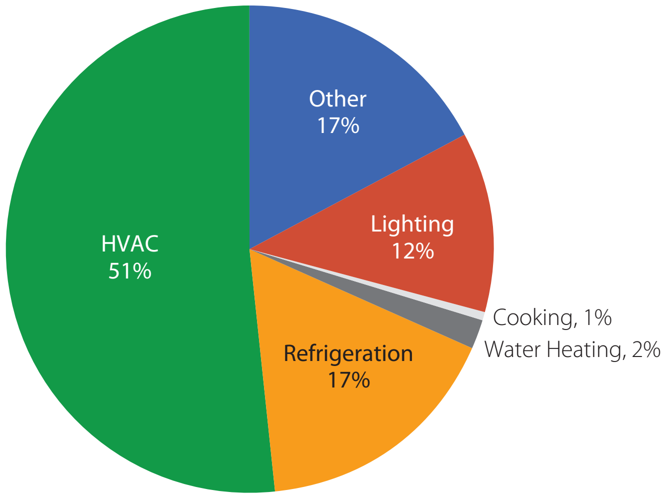


Figure 2.6

Residential Electricity Consumption in the Dominican Republic, by End Use, 2004

Source: IDEE/FB-CNE
© Worldwatch Institute

2.6.1 Appliance Labeling and Standards

Appliances have a major impact on a building's energy consumption, and more-efficient appliances can dramatically reduce this consumption. In the European Union (EU), energy ratings for domestic and commercial appliances range from A to G, with A being the most efficient.[54] High efficiency ratings of A+ and A++ are also available for certain appliances. Although the rating label varies slightly depending on the type of appliance, the main criteria assessed are energy consumption (kWh), volume (liters), and noise level (decibels). Similarly, premium efficiency standards, known as IE3, are widely targeted at motors and pumps and could be effective at reducing the energy consumption of backup generators, air conditioning, and water removal systems. In addition to providing informational labels on efficiency, some countries have programs (such as the U.S. Energy Star program) that provide consumers with financial incentives for purchasing or switching to high-efficiency appliances. Efficiency labeling can be applied across all energy-consuming sectors.

An energy efficiency study by CNE concluded that an effective labeling program in the Dominican Republic could result in annual savings of approximately 350 MWh of electricity and 222,000 tons of CO_2 emissions.[55] And the CCDP shows that moving to more-efficient appliances in the residential sector can be achieved at a net negative cost of around USD 180 per ton of CO_2-equivalent. However, one of the greatest challenges facing an energy labeling program in the country is creating a uniform labeling system. The Dominican Republic has passed its first attempt at such a system, NORDOM 655, but it is too early to gauge its effectiveness.[56] Because consumers have varying levels of education, experts believe that a color-coded system might be more effective in reaching a wide audience than traditional written labeling.[57] Any program should ensure that the label metrics are well-researched and communicated effectively.

2.7 Commercial Sector

The commercial sector, which includes government and public service buildings, accounted for 9.6% of electricity use in the Dominican Republic in 2009.[58] More than 75% of the energy consumed in the commercial sector is for electricity, predominantly for lighting, air conditioning, and appliances.[59] Understanding the balance of energy sources and their end uses is vital in addressing energy efficiency in building codes.

2.7.1 Hotels

Hotels are the most prominent energy consumer in the Dominican commercial sector, accounting for an estimated 43% of energy use.[60] The country's hotel and tourism industry is energy-intensive, due mostly to the requirements for air conditioning, lighting, and water heating.[61] (See Figure 2.7.) Overall, electricity accounts for up to an estimated 40% of expenditures for hotels with fewer than 300 rooms—or the equivalent of 0.2% of the country's GDP.[62] Despite the industry's high energy costs, hotels have been slow to introduce efficiency measures in their long-term plans.

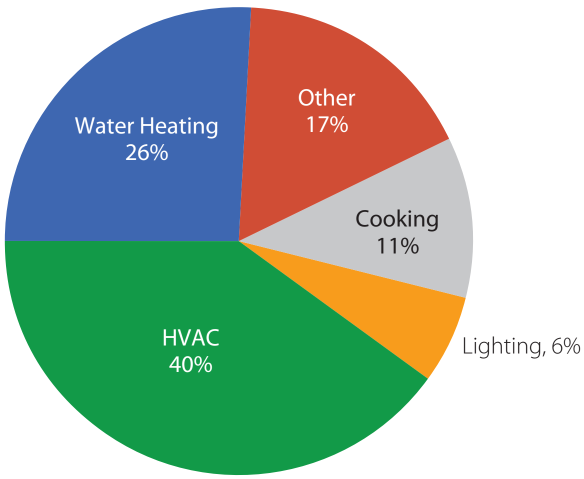


Figure 2.7

Energy Consumption in Dominican Hotels, by End Use, 2004

Source: CNE
© Worldwatch Institute

A 2012 assessment of hotels throughout the Caribbean showed that the adoption of energy efficiency measures in air conditioning, lighting, and other end uses could save 34.4% of electricity costs.[63] In the Dominican Republic, this means that hotels can save up to 13.7% of their total costs by adopting energy efficiency measures.

The Dominican Republic is home to more than a quarter of the Caribbean's hotel rooms and has the most hotels and the largest average hotel size in the region.[64] Consequently, adopting energy efficiency measures in Dominican hotels is important if the region is to mitigate its greenhouse gas emissions significantly. Dominican hotels consume 1,161 GWh of electricity annually, representing two-thirds of their total fuel use (see Figure 2.8), and energy efficiency measures have the potential to save 279 GWh of electricity and 237,600 tons of CO_2 annually.[65]

Reaching these targets would require an estimated USD 44.7 million in investment, which would result in estimated energy-cost savings of USD 27.9 million annually.[66] Table 2.5 shows the energy efficiency potential for hotels for the entire Caribbean region, including with specific technology payback periods.[67] As can be seen, air conditioning, lighting, efficiency controls, and solar water heaters have high savings potential and relatively short payback periods.

2.7.2 Government Buildings

Another subsector of note is government buildings, which rely on electricity for the bulk of their energy needs and alone accounted for 6.5% of the Dominican Republic's total electricity use in 2001.[68]

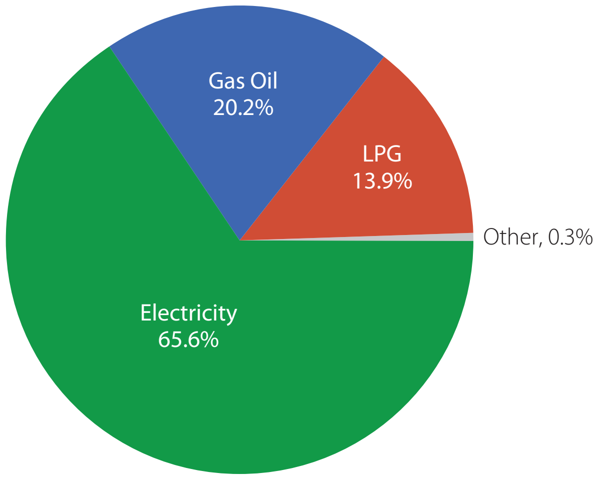


Figure 2.8

Energy Consumption in Dominican Hotels, by Fuel Source, 2004

Source: CNE
© Worldwatch Institute

Table 2.5 Savings from Energy Efficiency Measures in Hotels in the Caribbean

Equipment	Electricity Saving	Cost Saved	Investment	Payback Period
	GWh	Million USD	Million USD	Years
Air conditioning	340	105	185	1.8
Lighting	83	24	18	0.7
Efficiency controls	76	24	41	1.7
Solar water heater	47	8	9	1.1
Solar PV	36	10	39	3.8
Window film	35	9	19	2.0
Pool pump	19	5	3	0.6
Pump	8	2	1	0.5
Exhaust fan	3	1	1	1.5

Source: See Endnote 67 for this chapter.

Moving beyond its own building, CNE began a program performing energy audits on other government buildings. In a 2011 audit of the national health insurance company, SeNaSa, CNE determined that 72% of electricity use was for air conditioning.[69] This is the same share in government buildings overall and indicates a major opportunity for targeted energy efficiency measures.[70] (See Figure 2.9.)

As energy audits continue in government buildings, the government has begun testing a software-based energy monitoring system. This program monitors circuits and electric appliance performance and makes the data trackable through a web interface. By implementing the program in its own building, CNE was able to reduce its energy consumption by 20% between August 2013 and April 2014.[71] (See Figure 2.10.)

Historically, energy efficiency audits in the Dominican Republic have relied on individuals to track and report data, but programs were quickly forgotten and there was no follow through from "the top down,"

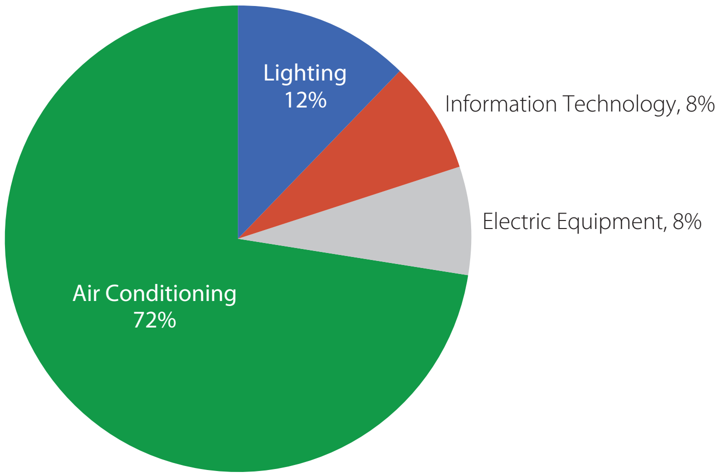


Figure 2.9

Electricity Consumption in Government Buildings, by End Use, 2004

Source: CNE
© Worldwatch Institute

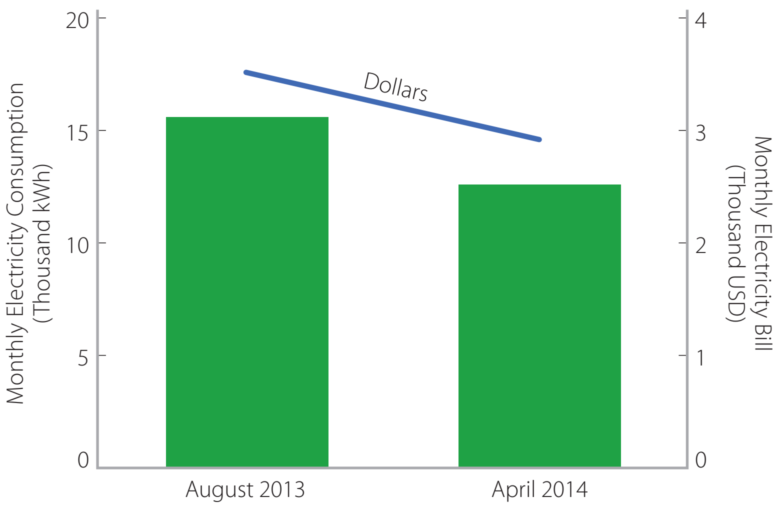


Figure 2.10

Reduction in CNE Electricity Consumption After Installing Monitoring System

Source: CNE
© Worldwatch Institute

resulting in marginal program success. It is hoped that programs like this one will make it easier to collect data and to implement and observe efficiency measures. The program will continue to be used in government buildings, and the plan is to extend its use to small and medium-sized businesses and hotels.[72]

2.7.3 Restaurants

In the Dominican restaurant industry, electricity accounts for 58.7% of energy consumption. Of this, refrigeration accounts for 25%, HVAC for 9%, water heating for 7%, and lighting for only 1% (among other uses).[73] Unlike the residential sector, most restaurants meet their cooking energy needs through the use of electricity and LPG, which together accounted for 98.7% of the energy used in restaurants.[75]

2.7.4 Summary

Although the commercial sector represents a smaller share of overall energy use than the residential sector, the potential gains from efficiency improvements are significant. Building codes can have a major impact in the commercial sector as well, given the dependence of commercial buildings on electricity for end uses such as ventilation and lighting. Unlike in the fragmented residential sector, the prominence of electricity use in the commercial sector means that the impact of energy efficiency regulations will be easier to manage and regulate. It also opens the door for renewable energy to become a more viable contributor.

2.8 Industrial Sector

Industry accounts for 44% of electricity consumption in the Dominican Republic.[75] The country has a network of free trade zones (known locally as Zonas Francas) that are home to various businesses, including clothing and shoe production, medical device assembly, and some energy equipment design and fabrication. Encouragingly, the Dominican economy has become twice as efficient over the past decade.[76] In 2008, the industrial sector consumed 0.21 tons of oil equivalent (toe) per USD 1,000 of economic production, a level of energy intensity that is 40% lower than the global average of 0.35 toe per USD 1,000.[77] In 2012, the Dominican Republic had the second lowest energy intensity of 27 countries assessed in the Latin America region.[78]

The sugar and cement industries accounted for the majority of energy consumption in the early 2000s, at 28.9% and 25.5%, respectively.[79] Although these two energy-intense industries remain prevalent, gold and copper mining operations also have increased in importance. In 2013, the Quisqueya I power plant, a 215 MW combined-cycle plant that can be fueled by heavy fuel oil, diesel, and LNG, was commissioned to provide power solely to the Pueblo Viejo gold mine. Prior to this, the mine relied on more expensive petroleum-based electricity generated at older plants with low efficiency levels. Efficiency opportunities exist in the sugarcane industry through more efficient use of bagasse (see Chapter 3). Additionally, the banana, cocoa, coffee, plantain, and rice industries have un-utilized waste that could be used for energy production (see Chapter 3).

2.9 Summary of the Dominican Republic's Energy Efficiency Potential

The Dominican Republic's significant technical and non-technical electricity losses mean that energy efficiency improvements can result in significant cost savings for the country. Overall, the five least-cost ways to mitigate greenhouse gas emissions in the country are related to energy efficiency.

End-use improvements and standards for key sectors can result in significant energy savings. The country should prioritize further studies assessing the potential energy efficiency gains in the agricultural and hotel industries. In the residential sector, lighting and refrigeration show the most potential for energy savings. In the commercial and public service sectors as well, HVAC systems and building envelope improvements could save significant energy and money.

Despite the economic motivation for energy efficiency improvements, upfront financing costs as well as lack of awareness of the benefits pose barriers to implementation. Chapter 7 of this Roadmap examines existing financing options and capacity building needs, and Chapter 8 recommends additional energy efficiency programs and standards.

3 | Renewable Energy Potential

Key Findings

- The Dominican Republic has excellent renewable energy potential, especially for solar and wind power. The country's entire electricity demand could be met using renewable resources.
- Solar energy potential is extremely strong across the entire island. Solar irradiance is relatively consistent throughout the year and is strong even in winter months. An estimated 86 square kilometers of solar PV panels could meet the country's total power production in 2010.
- Distributed solar PV generation at the household and commercial levels can play an important role in the country's energy mix.
- Several locations in the country have extremely strong wind energy potential. Just 35 medium-sized wind farms (with ten 3 MW turbines each) could supply over half of the current power demand.
- Wind energy potential varies throughout the day and year, but several locations still have very high wind speeds even during relative lows.
- Although additional hydropower capacity is limited in the country, micro-hydro generation has some potential to relieve blackouts and provide increased electricity services to remote and underserved areas. If extensive droughts become more common, however, this capacity might not be reliable year-round.
- Hydrological data are 20 to 30 years old and are not sufficient to inform future hydropower investment decisions. More data need to be collected in areas with untapped resources.
- Sugar cane, rice, and coffee have the highest potential for biomass energy in the country, although waste from banana, cocoa, and plantain production also could be used to generate power. Sugarcane bagasse alone could fuel an additional 535 GWh annually of electricity generation.
- Geothermal energy has limited potential to play a significant role in the Dominican electricity sector and should instead be used for heating and cooling. Wave and tidal energy face technological barriers currently but could become appropriate technologies as prices decline globally. Waste-to-energy is already playing a role in isolated areas and could become more important going forward.

This chapter assesses the Dominican Republic's physical renewable energy resources and explores the renewable technologies that are applicable today in the country. Because Worldwatch released a more detailed assessment of wind and solar resources in the Dominican Republic in July 2012 (with support from the mapping company 3TIER), the present analysis summarizes those resources only briefly while focusing more heavily on biomass and hydropower.[1]

3.1 Building on Existing Assessments

Resource assessments at the national level provide a country with the data, maps, and other information necessary to justify interest in and financing of domestic energy development. Higher-resolution assessments that focus on individual regions and cities, however, can be critical when planning expansions in power generation and transmission, although these assessments can be more expensive and time-consuming to obtain. To avoid duplicating other ongoing resource assessments that are being conducted with the support and interest of the Dominican government, Worldwatch collaborated with CNE and the institutions undertaking these assessments to present their results in this Roadmap and to integrate them into our broader recommendations for the country's electricity sector and policies.

In previous years, Worldwatch consulted closely with stakeholders in the Dominican government to determine priority areas for our solar and wind assessments. CNE carefully selected the solar zones after examining national resource maps, and helped to select the wind zones based on initial results from an evaluation of sites with the strongest wind potential. In addition, Worldwatch commissioned a biomass assessment from the country's Universidad Instituto Superior de Agricultura (ISA), evaluating waste biomass opportunities in the banana, cacao, coffee, plantain, rice, and sugarcane industries. The findings of these assessments are described in greater detail below.

3.2 Solar Energy Potential

3.2.1 Global Status of Solar Energy

Today, a suite of relatively mature technologies is available to convert the sun's energy into electricity. These generally fit into one of two categories: photovoltaic (PV) modules that convert light directly into electricity, and concentrating solar thermal power (CSP) systems that convert sunlight into heat energy that is later used to drive an engine. Solar power can operate at any scale, but whereas CSP systems are considered viable typically only as utility-scale power plants, PV technology is modular and can be scaled for use on a household rooftop, in medium-size settings such as resorts and industrial facilities, or as part of a large network of utility-scale PV farms.

Traditionally, solar power has not been cost-competitive with conventional electricity generation, due in part to the high level of direct and indirect subsidies benefiting fossil fuels.[2] Government support, whether in the form of feed-in tariffs, renewable portfolio standards, tax credits, or other mechanisms, has been necessary to help level the playing field and accelerate the adoption of solar technologies. But costs for solar systems are falling rapidly, and an oversupply of modules may further speed this decline. Solar is already cost-competitive in certain situations: PV installations in the Persian Gulf region, for example, are offsetting oil-generated electricity, bringing positive returns.[3] The 39% increase in new PV installations worldwide in 2013 alone is a result of both strong support policies and rapidly declining technology costs.[4]

In addition to providing electricity, solar energy is used for water and space heating, replacing electric or gas systems. Solar water heating can be active or passive, meaning that the systems either use pumps and controllers to move and regulate the water, or rely only on convection. Active systems are more efficient but also are more expensive and require significantly more maintenance. Passive systems have no moving parts and are valued for their simplicity. Solar hot water systems are broadly cost-competitive globally, with payback periods under two years in many cases. By the end of 2013, global solar water and space heating capacity reached 255 gigawatts-thermal, or enough energy to power more than 22,000 average U.S. homes for one year.[5] More than half of this capacity is in China, and the vast majority is used for water heating.[6]

In small-island states, the attractiveness of solar water heating is clear. Cyprus is the world leader in installations per capita, and Barbados's experience is considered a Caribbean renewable energy success story.[7] Duty-free equipment imports and tax incentives in Barbados have created a thriving market, with more than 40,000 solar hot water systems installed on homes, businesses, and hotels, as well as a market penetration of 33% for residential buildings.[8] The success of this project was cited explicitly by the Inter-American Development Bank (IDB) in announcing a multimillion-dollar loan to the country for continued renewable energy development.[9]

3.2.2 Current Status of Solar Energy in the Dominican Republic

The Dominican Republic has limited but growing solar capacity. A 220 kW commercial solar PV installation in Monte Plata is expected to expand to 30 MW, and large installations are present on commercial and public buildings such as the Dominican Fiesta Hotel (500 kW) and CNE (22 kW).[10] In total, more than 15 MW of renewable energy, most of which is solar PV, has been connected to the Dominican grid through the country's net metering program.[11] Although existing solar assessments indicate a strong solar resource in the country, these studies are more outdated and/or lower resolution than the newer assessments conducted by 3TIER that are provided in this Roadmap.

3.2.3 Solar Energy Potential

The Dominican Republic shows tremendous solar potential. Global horizontal irradiance, or GHI, ranges from 5 to 7 kilowatt-hours per square meter per day (kWh/m^2/day) throughout most of the country, and approaches 8 kWh/m^2/day in some regions.[12] (See Sidebar 5 and Figure 3.1.) By comparison, Germany, which has nearly half of the world's installed solar PV capacity, has few locations with a GHI above 3.5 kWh/m^2/day, and Phoenix, Arizona—a city in the U.S. southwest famed for its solar potential—has an average GHI of 5.7 kWh/m^2/day.[13]

The two study sites of Santo Domingo and Santiago have strong solar potential, which peaks during the summer months and reflects average GHIs of 5.5 and 5.6 kWh/m^2/day, respectively.[14] (See Figure 3.2 and Appendices I and II.) Although other sites nationwide boast higher insolation, the integration efficiencies and economies of scale involved in installing and servicing solar in these cities—the country's two biggest load centers—are notable. At these GHI levels, an estimated 93.5 square kilometers of solar PV panels in Santiago would be sufficient to power the entire country.[15] (See Table 3.1.) In general, development of solar PV, not CSP, is better suited for the Dominican Republic because the country has relatively stronger GHI resources than DNI (DNI, or direct normal irradience, is more representative of CSP potential because it does not include diffuse solar radiation).

Sidebar 5. Key Measurements of Irradiation and Their Application to Solar Resource Analysis

The solar assessment for the Dominican Republic produced by 3TIER for Worldwatch includes three different measurements for solar irradiation: global horizontal irradiance (GHI), direct normal irradiance (DNI), and diffuse horizontal irradiance (DIF).

Measurement	Description	Application
GHI	Total solar radiation per unit area that is intercepted by a flat, horizontal surface	Solar PV installations
DNI	Total direct beam solar radiation per unit area that is intercepted by a flat surface that is at all times pointed in the direction of the sun	CSP installations and installations that track the position of the sun
DIF	Diffuse solar radiation per unit area that is intercepted by a flat, horizontal surface that is not subject to any shade or shadow and does not arrive on a direct path from the sun	Some PV installations that are best suited to diffuse radiation (DIF is included in the GHI calculation)

Based on the specific conditions of the Dominican Republic's solar resource and the suitability of specific solar technologies, this assessment focuses mostly on the country's GHI measurements for solar PV installations and DNI for solar water heating applications.

For additional detail, see Appendices I and II.

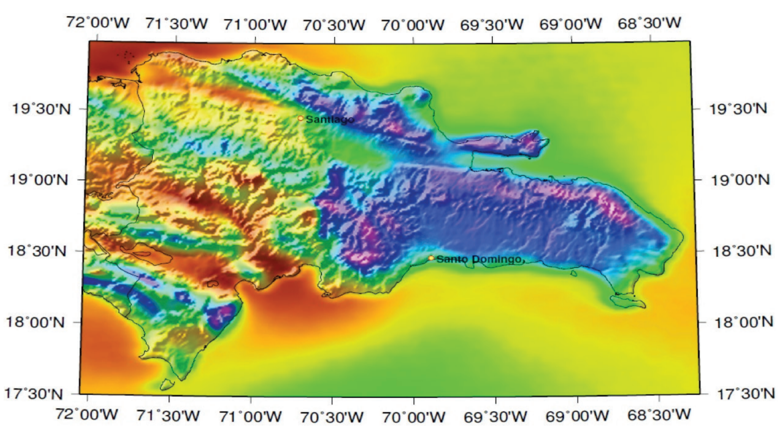


Figure 3.1

Average Direct Normal Irradiance (DNI) in the Dominican Republic

Source: 3TIER

Other avenues for solar development deserve closer scrutiny. Outside the cities, particularly in the sunnier western region, grid-scale PV or CSP may be viable. Opportunities also exist for off-grid solar, both for the small number of households not yet connected to the national grid and in the tourism industry, where many resorts currently rely on off-grid generators. In addition to being more economical than diesel and other fuels in some circumstances, solar installations may help resorts to market themselves as "eco-friendly," in the mold of destinations in Costa Rica and elsewhere in Latin America.

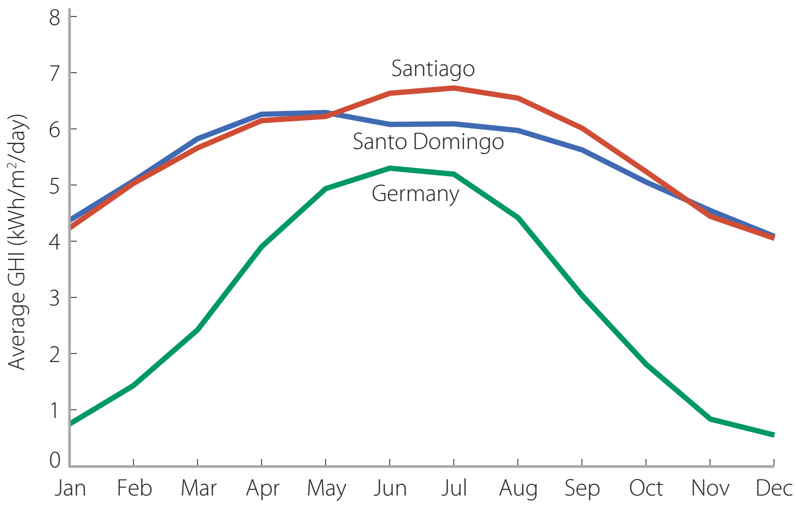


Figure 3.2

Comparison of Monthly Average GHI, Selected Dominican Zones vs. Germany

Source: 3TIER, DWD
© Worldwatch Institute

Table 3.1 Potential Annual Solar Energy Yield in Santiago and Santo Domingo

Site	Annual Generation per 175 W Module*	Annual Generation per Square Kilometer†	Total Area Needed to Meet National Power Generation in 2012	Share of 2012 Generation from One Square Kilometer of PV Modules
	kWh	GWh	km^2	percent
Santiago	393.9	142.9	93.5	1.1
Santo Domingo	383.6	139.2	96.0	1.0

**Includes effects of wind and temperature*
†Assumes that energy production per meter is halved to account for maintenance, the prevention of shading, and construction of other buildings.
Source: See Endnote 15 for this chapter. ©Worldwatch Institute

3.2.4 Summary of Solar Energy Potential

Both Santiago and Santo Domingo have strong solar potential, although other sites in the country boast higher GHI levels, above 7 kWh/m^2/day. A majority of the land area appears to have an average GHI of at least 6 kWh/m^2/day, signaling that solar PV could be an electrification solution for many rural communities. Both of the assessed study sites appear capable of supporting utility-sized PV generation, as well as solar water heating and residential and commercial solar PV installations; however, they may not be ideal for CSP development. Just 93.5 square kilometers of PV modules in locations with a similar resource to Santiago would be able to generate as much electricity as the entire country generated in 2012. Other avenues for solar development that deserve closer scrutiny include opportunities for off-grid solar, especially in rural communities currently not connected to the grid.

3.3 Wind Energy Potential

3.3.1 Global Status of Wind Energy

Outside of hydropower, wind has been by far the most successful renewable electricity source worldwide, with 318 GW of wind capacity installed globally by the end of 2013.[16] In some markets, the costs of wind power are estimated at 4–7 cents per kWh in attractive locations, making it fully competitive with fossil fuels.[17] Although turbines come in many sizes, wind power is used mostly for centralized utility-scale generation, but innovations for smaller-scale generation make decentralized wind energy an increasingly viable option. Small-scale (50–100 kW) wind-diesel hybrid systems are growing in the Caribbean, and a U.S.-funded project in Dominica aims to demonstrate the viability of wind generation facilities of under 250 kW in the region.[18]

Wind turbines can provide on-site electricity generation for large electricity consumers such as a factory or a farm. Unlike traditional on-site thermal generators, however, wind is intermittent and cannot be started up at will. Connecting these turbines to the grid can increase the value of the electricity significantly, as landowners are able to sell excess power.

3.3.2 Current Status of Wind Energy in the Dominican Republic

The Dominican Republic currently has two commercial-scale wind farm in operation. The first is Quilvio Cabrera, an 8.25 MW installation that was built in 2011 and is located in the province of Pedernales in the southwest of the country. On a neighboring piece of land is the Los Cocos Wind Farm, which consists of two phases: Phase 1, completed in 2011, comprises 33.5 MW, and Phase II, completed in 2013, raised the installed capacity to 77 MW. In 2012, Los Cocos had a capacity factor of about 30%, above the level deemed necessary for a commercial project to be economical; however, integration with the grid has not been easy, as grid operators struggle with voltage regulation.[19] A third wind park, Larimar, will be located in the province of Barahona just to the north of Quilvio Cabrera and Los Cocos, and is expected to come online in 2016 with an installed capacity of 49.5 MW. These two provinces are home to the country's strongest wind potential.

For some time, the country has had plans to build two additional wind farms. The 50 MW Parques Eólicos del Caribe (PECASA), in El Guanillo in the province of Monte Cristi, is expected to cost USD 127 million, but the project has been on hold due to financing problems and disagreements with the state-owned transmission company, ETED. Meanwhile, Grupo Eólico Dominicano planned to develop a 30.6 MW wind farm in Matafongo, in the province of Peravia, at an estimated cost of USD 68.9 million. The IDB had been involved in financing both projects, and the European Investment bank had been involved in the former. Given the extended length of the "on hold" status of the projects, both are considered largely failed.[20]

3.3.3 Wind Energy Potential

3TIER's wind resource map for the Dominican Republic indicates that the country has strong wind potential that is suitable for wind power development.[21] (See Figure 3.3 and Appendix III.) 3TIER also conducted more granular analysis for six zones: Pedernales, Baní, Montecristi, Puerto Plata, La Altagracia, and Samaná. (For more detail on the six study sites, see Worldwatch's 2012 solar and wind assessment.) The data, which reflect mean data for several points assessed in each zone, were chosen not to represent actual wind farms, but rather to best characterize the entire wind zone. According to the analysis, 214 of the 494 assessed grid points have capacity factors at or above 20%, and 78 have capacity factors at or above 30%.[22] (See Table 3.2.) It should be noted that the data come from raw model outputs and should be used to guide future on-site studies, ideally conducted for at least one year prior to project construction.

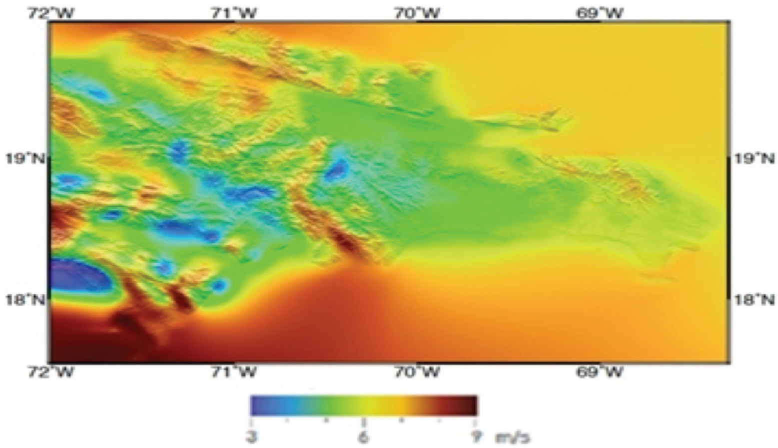


Figure 3.3

Average Wind Speed in the Dominican Republic

Source: 3TIER

Table 3.2 Total Grid Points and Wind Capacity Factor by Region

Region	Total Grid Points	Grid Points with Capacity Factor >= 20%	Grid Points with Capacity Factor >= 25%	Grid Points with Capacity Factor >= 30%
Pedernales	92	70	60	55
Baní	43	41	29	18
Montecristi	91	72	30	5
Puerto Plata	84	30	2	0
La Altagracia	139	0	0	0
Samaná	45	1	0	0
All Regions	494	214	121	78

Source: See Endnote 22 for this chapter. ©Worldwatch Institute

Of the six study sites, Pedernales shows the greatest wind energy potential, with 55% of the assessed grid points indicating capacity factors of at least 30%. At a capacity factor of 30%, some 85 square kilometers of wind turbines would be sufficient to meet the electricity generation needs of the entire country in 2012.[23] (See Table 3.3.)

Table 3.3 Potential Annual Wind Energy Yield in the Dominican Republic

Average Net Capacity Factor	Annual Generation per Turbine	Annual Generation per Square Kilometer*	Total Area Needed to Meet National Power Generation in 2012	Total Area Needed to Meet Projected Net Generation in 2030
	GWh	GWh	km^2	km^2
35	9.20	184.0	72.6	172.4
30	7.88	157.7	84.7	201.1
25	6.57	131.4	101.6	241.3

Source: See Endnote 23 for this chapter. ©Worldwatch Institute

3.3.4 Summary of Wind Energy Potential

The 3TIER mapping shows that the Dominican Republic has many locations with strong wind energy potential, particularly in the southwest—but these must be chosen carefully. Overall, Pedernales shows the most potential of the six study sites. With an average capacity factor of 30% (the observed capacity factor at Quilvio Cabrera and Los Cocos), it would take 85 square kilometers to generate annually the same amount of electricity that the country generated in 2012, and 201 square kilometers to meet projected annual generation needs in 2030. However, as discussed in Chapter 4, the national electricity grid would have to be upgraded dramatically to absorb such a high level of intermittent renewable energy.

3.4 Hydropower Potential

3.4.1 Global Status of Hydropower

Large hydropower comprises the majority of global renewable power generation and accounts for about 16% of the world's electricity production.[24] But despite being a low-carbon, renewable energy source, large hydro often has serious environmental and socioeconomic impacts, including widespread ecosystem disruption and occasional large-scale displacement of populations.[25] China's controversial 20 GW Three Gorges Dam, for example, forced the relocation of 1.3 million local residents and has resulted in significant erosion and landslide dangers.[26] Because of the many potential downsides of large hydro, this report focuses primarily on small-scale hydropower development, which has fewer negative human and ecological impacts.

Small hydropower is used around the world, especially in remote areas, and can be an important renewable resource for powering communities that may not have access to other energy options. Usually classified as hydropower that generates less than 10 MW of electricity, it can operate as "run-of-the-river" systems that divert water to channels leading to a waterwheel or turbine, or, similar to larger hydropower stations, it can operate as dammed systems that have small-scale storage reservoirs.

Among the advantages of small hydro is its ability to provide cheap and clean electricity to communities that may not have access to other energy resources. But small hydro has relatively high upfront costs compared with conventional energy sources and requires certain site characteristics, including adequate stream flow and ensuring that users are close to the harvested hydro resource. Low consumer demand for the electricity due to the lack of economically productive uses for power in many rural areas often makes attracting funding difficult. Issuing grants or setting up preferential financing schemes, as well as cultivating local small hydro manufacturing economies, have proven crucial for initiating and maintaining small hydro projects.

3.4.2 Current Status of Hydropower in the Dominican Republic

Hydropower generation in the Dominican Republic ranges from as low as 65 MW in the dry season to as high as 180 MW in the wet season, with a capacity factor of 15–25%.[27] The country's total installed capacity is 523 MW, but the size of on-grid plants varies widely, from 0.1 MW to 98 MW.[28] Generation tends to peak in the evening, from 6 p.m. to 11 p.m., as two-thirds of the total supply is used to satisfy peak demand (with the remaining one-third used as baseload power). Two hydro plants, located in Angostura and Valdesia, are used exclusively to relieve blackouts.[29]

The National Institute for Hydraulic Resources (INDRHI) is responsible for regulating all hydrologic activities in the country. Ownership of these activities is almost entirely public, although plants may be privately owned if their maximum generation capacity does not exceed 5 MW. Micro-hydropower (between 0.1 and 4 MW in size) plays a growing role nationwide. A successful rural electrification program directed by the United Nations Development Programme has relied heavily on micro-hydro resources (see Sidebar 6), and, since 2012, 18 of the country's 21 "climate change mitigation" projects under the Global Environment Facility's (GEF's) Small Grants Programme have been related to micro-hydro.[30]

Sidebar 6. Micro-Hydropower in the Dominican Republic

Multiple communities throughout the Dominican Republic have benefited from a rural electrification project overseen by the United Nations Development Programme (UNDP) and the Unidad de Electrificacion Rural y Suburbanas (UERS), the country's rural electrification office. Launched in May 2008 under the name PERenovables, the project promotes sustainable development in rural communities by using renewable energy to improve quality of life and reduce dependence on fossil-based liquid fuels. By 2011, 33 energy systems had been built, including 30 micro-hydropower plants with capacities of 5–150 kW, a wind power plant of 50 kW, and a hybrid biomass/solar energy system. Four additional micro-hydro plants were built in 2013, benefiting more than 360 families that had no previous access to electricity.

The project was made possible by funds from the European Union, INDRHI, the Direccion General de Cooperacion Multilateral (DIGECOOM), UERS, and UNDP. INDRHI carries out most of the technical training and supervision, as well as topographical and hydrologic mapping. UNDP, in partnership with field experts, has led various workshops on the design, implementation, and management of micro-hydro plants for local organizations that are responsible for implementing each energy system project. UERS provides the design and installation of the micro-grid and the connections to each household. To incorporate communities into the process and promote system ownership, local residents must perform any non-specialized manual labor and are trained to operate and maintain the new system.

In total, the rural electrification project has affected communities in 13 of the country's 30 provinces. The micro-hydro installations have not only provided residents with continuous access to electricity for the first time, but also spurred economic activity and improved education and health services in remote areas—all in a sustainable manner.

Source: See Endnote 30 for this chapter.

3.4.3 Hydropower Potential

Hydropower is not considered a promising resource for addressing the Dominican Republic's future electricity capacity needs. Because an estimated 90% or more of the country's large hydro potential has already been tapped, any new plants would have only a marginal impact on the system. Despite this reality, the government has devoted a large share of its power sector investment (USD 1.6 billion over the last five years) to hydropower, and evidence suggests that this funding was not spent as efficiently as possible. Hydro plants in the country currently operate for only four to six hours a day because of water dispatchment regulations (electricity is the third legal priority for water use, after drinking and agriculture), suggesting less-than-optimal value for the money. Moreover, national hydrological data are of insufficient quality (most projects are based on estimates from 20–30 years ago), and capital costs are not included in the overall cost evaluation for the sector.[31]

Hydropower is not expected to play a significant role in interacting with other renewable energy sources in the country—such as wind and solar energy—because it is almost fully tapped and is used mainly to satisfy peak demand. Micro-hydro generation does have some potential to relieve blackouts, however, particularly in the north where related projects already exist.[32] A crucial way to improve the hydro sector's finances is to encourage payment for environmental services, as the state-owned hydropower company, EGEHID, is seeking to do. Overall, the most pressing issue for the sector is to ensure that ongoing construction plans are fully implemented: of the 328 MW of hydroelectric concessions awarded up to 2012, some 105 MW may never come online.

3.4.4 Summary of Hydropower Potential

Overall, hydropower has limited potential to expand its role in the Dominican electricity system. Limited remaining potential, in addition to regulations that dispatch water for drinking and irrigation before power services, make any significant future hydro development unlikely. Moreover, data on hydropower potential are outdated, and economic assessments of the costs are not robust. Although hydropower will continue to play a role in meeting peak demand during the late evening, it should not be considered a strong candidate to help ease the transition to integrating more intermittent renewable energy sources such as solar and wind in the future.

3.5 Biomass Energy Potential

3.5.1 Global Status of Biomass Energy Technology

Energy can be generated from a wide variety of biological materials, including agricultural crop residues, forestry wastes (woody biomass), and even municipal solid waste. Electricity generation from biomass sources has the advantage of providing reliable baseload renewable power and can offset some of the intermittency of wind and solar generation in an integrated electricity system.

In most agricultural locations, crop residue follows a regular pattern of production and can be measured proportionally to the amount of land used to grow the crop and the number of times the crop is produced each year. Both crop residue and woody biomass can be used for heat or electricity, or they can be gasified to have the same functionality as oil and natural gas, but with lower net carbon emissions. Many potential sources of biomass feedstock exist in the Caribbean, including agricultural crop residues such as sugarcane bagasse, coffee husk, rice straw, and coconut shells, as well as woody biomass.

A key barrier to developing biomass as an energy source is the logistical challenge of collecting the dispersed biomass residue in an economically efficient way. In addition, the agriculture sector in the Dominican Republic is very informal. Even if a formal biomass market were in place, most producers would currently lack the ability to invoice or collect payment from the projects and companies to which they would sell. Further, the diversion of crop residues for energy purposes has the potential to compromise soil quality for future agricultural production by removing a source of soil nutrients. Proper agricultural waste management is thus important to achieving a net positive societal outcome from using biomass.

Scaling up biomass production also can have serious implications for the local environment, affecting key ecosystem services, biodiversity, and the tourism industry. Large-scale production of energy crops can encourage monoculture agricultural practices that cause a host of local environmental problems including soil degradation, loss of biodiversity, overuse of chemical pesticides and fertilizers, and contamination of waterways. Expanded use of biomass energy also can create competition with food crops for limited agricultural land, a trend that in some places has driven up food prices and placed a particular burden on poorer populations.[33]

Given the sizeable role that biomass energy may play in the future, however, this resource cannot go overlooked. In the short-to-medium term, biomass generation can serve as a reliable, renewable source of baseload power, particularly as solutions are still being developed to address the variability challenges that arise with other renewable energy sources such as wind and solar.

Like biomass energy, bio-based fuels (biofuels) can be used for power generation as well, although they are used most commonly in the transportation sector. In particular, biodiesel derived from oilseed crops, such as the jatropha tree, can be used as a substitute for diesel to fuel thermal power plants. The use of biofuels for electricity generation, however, is not suitable for communities that are less reliant on petroleum-based fuels. It is also important to consider the wider impacts of biofuel production, which can be similar to those of biomass production—such as the effect on local food prices.

One way to assess biomass resources is to model the potential for cultivating crops in particular locations, looking at environmental variables such as annual rainfall, soil nutrient levels, and average temperatures, as well as variables like land availability and economic costs. Although resource potentials vary depending on the location and crop considered, they are relatively easy to assess assuming that the data are readily available. It is more difficult, although equally important, to measure the secondary impacts of biomass development, such as the effects on food production. Assessing the potential of municipal solid waste is generally easy in areas that have waste collection and storage programs and that maintain data on waste levels.

3.5.2 Current Status of Biomass Energy in the Dominican Republic

In the Dominican Republic, biomass energy could be an important option for populations that currently rely on diesel or heavy fuel oil for generation. Most of the interest in biomass, however, has arisen from companies seeking to "green" their operations. Cogeneration, primarily in sugarcane production, has been pursued domestically for some 30 years. One recent CDM project at a textile mill in Bonao uses residues from rice husk, coconut shell, sawdust, and other crops to fuel thermal generation and a 615 kW on-site generator, allowing the mill to reduce electricity consumption from the grid.[34] Another textile mill project in the Dos Rios Free Trade Zone in Bonao relies on rice, wood, bagasse, and other residues to produce steam.[35]

In the 1980s, the Dominican Republic devoted some 260,000 hectares to sugarcane production. Thanks primarily to the Caribbean Basin Initiative, the United States was the country's largest export destination. But as the United States reduced its imports and relied more on homegrown sweeteners such as corn syrup, the price of sugar fell sharply and the Dominican market began to collapse. The number of large sugarcane producers has fallen from 12 to 4, and the area cultivated has shrunk to roughly 100,000 hectares.

The country's four large sugar producers are Ingenio Cristobal Colon, Ingenio Barahona, Ingenio Porvenir, and Ingenio Central Romana.[36] Ingenio Cristobal Colon, located in San Pedro de Macoris, produces some 30,000 tons of sugarcane bagasse annually. The facility's owner, the Vicini group, uses some of this feedstock to turn a 7 MW turbine on-site and to supply all of its own electricity needs, although it never uses the generator to full capacity. Vicini sells much of its bagasse to the Canadian company Gildans, housed in one of the country's free trade zones. In the future, Veccini aims to supply all of its bagasse to a soon-to-be-built 30 MW power plant, which would satisfy the group's own power needs and enable surplus generation to be sold to the grid.[37]

Ingenio Barahona has 6 MW of installed capacity and is able to power itself completely with its own bagasse feedstocks. Likewise, Ingenio Porvenir, also located in San Pedro de Macoris, powers itself with its own bagasse stocks.[38] Ingenio Central Romana, the largest sugar company on the island, is owned by the Fanjul Corp. and produces some 12,000 tons of sugar a day. With an installed capacity of around 54 MW, half of its bagasse goes to generating its own electricity, while the rest is used to make furfural, a liquid aldehyde used for a variety of industrial applications. The company uses fuel oil to supply any supplemental electricity it needs.[39]

3.5.3 Biomass Energy Potential

In 2013, the Agronomy Department of Universidad ISA in Santiago conducted a quantitative survey of six Dominican crops that have the potential to be used for biomass energy production: banana, cacao, coffee, plantain, rice, and sugar cane.[40] (See Table 3.4 and Appendix IV.) The assessment provides estimates for the available waste remaining from each crop annually but does not explore in detail the energy potential of each waste source. To form a more complete picture of the amount of biomass available for energy production in the country, assessments are needed of the alternative markets and competitive uses for these waste resources.[41]

Based on Worldwatch analysis of the Universidad ISA survey and on discussions with stakeholders in the biomass industry, we conclude that sugar cane, rice, and coffee are the biomass crops with the highest potential for electricity generation in the country. To extrapolate the generation potential from sugarcane bagasse, we use current and projected levels of cane production, as well as the potential for growing

Table 3.4 Biomass Potential in the Dominican Republic

Source	Amount of Biomass Available Annually	Energy Density
		megajoules per kilogram
Coffee	496,905 tons (farm level); 576,420 tons (pulping waste)	Not available
Cocoa	1.5 million tons	Not available
Sugar cane	2.3 million tons (farm level, unused); 1.2 million tons (factory level)	8–9
Rice	48,739 tons (bran); 112,142 tons (husk)	15.8 (husk); 15.1 (straw)
Plantain	7.9 million tons fresh or 945,748 tons dry	Not available
Banana	7.9 million tons fresh or 945,748 tons dry	18.9 (peel)

Source: See Endnote 40 for this chapter.

and processing additional feedstock based on the cultivation area and factory capacities. Currently, the Dominican Republic produces some 1.5 million tons of sugarcane bagasse per year.[42] Only 30% of existing bagasse is used to generate electricity, although the major sugar mills use bagasse for cogeneration.[43] Overall, sugarcane bagasse is the highest-potential biomass feedstock in the country.

If bagasse generation is connected to the grid to enable the sale of excess electricity, efficient high-pressure boilers can generate 370–510 kWh or more per ton of bagasse. If all Dominican sugar factories utilized efficient sugar processing and generation technologies, bagasse could feed up to 535 GWh of additional electricity into the grid each 185-day harvest season (December through April).[44] (See Table 3.5.) The seasonality of bagasse production is a possible concern, but bagasse fuel can be pelleted and stored to dispatch the energy potential year-round.[45] Analysis suggests that sugarcane bagasse, if used to its full potential with high-efficiency technology, could fuel up to 4% of the country's electricity generation.[46]

Table 3.5 Sugarcane Bagasse Potential in the Dominican Republic

Unused Bagasse	Cogeneration Efficiency	Potential Annual Generation	Estimated Installation Capacity	Share of National Electricity Production in 2012
tons	kWh per ton	GWh	MW	percent
1.05 million	370	388.5	88.7	2.9
1.05 million	510	535.5	122.3	4.0

Source: See Endnote 44 for this chapter. ©Worldwatch Institute

Each year, the Dominican Republic produces some 112,000 tons of rice straw (stalk), most of which is left on the ground to fight erosion and replenish soil.[47] Surplus straw is simply burned because there is no domestic market for it.[48] The country also produces some 48,000 tons of rice husk (the outermost layer of the grain that is separated during milling), a small share of which is now being used by rice farmers to generate heat.[49] Although rice husk has the potential to be used for power generation, competing demands for the material (such as use for hen-house flooring and as a feedstock to dry the rice) limit its availability.[50] Determining the volume of rice husk available for combustion should be a priority going forward.

Rice husk residue also could be fed into gasifiers, at a generation rate of two tons per MWh, as is done in Williams, California, with a 26 MW generator, and in Stuttgart, Arizona, with a 15 MW generator. Overall, rice husk is the second-highest potential biomass feedstock in the Dominican Republic (after sugar cane bagasse), and although no rice mills are currently members of the country's net metering program, experts see tremendous opportunity for them to join.[51]

Coffee pulp is the third-greatest potential biomass feedstock in the Dominican Republic. The country produces some 576,000 tons of coffee pulp annually, from which it is possible to produce biogas. Typically, the pulp will break down and release methane, which can attract pests; capturing this methane instead can provide energy while helping to prevent infestation. Currently, only one large coffee plant produces biogas in the country. Coffee pulp is attractive for electricity generation because very little of it is recycled for other uses, such as fertilizer.[52] Assessing the biogas potential of coffee pulp should be prioritized going forward.

Traditionally, feed-in tariffs have been the market drivers for biomass development in the EU and the United States. In Latin America, however, the main driver has been high electricity prices. The Dominican Republic's minimal potential for cheap electricity could help to drive biomass development in the future. Yet several barriers to biomass expansion exist, including the lack of robust assessments of biomass resource potential. As biomass projects sprout, there is genuine worry that the biomass supply will run out if the country does not develop a more holistic picture of its existing resources.[53] The Universidad ISA assessment highlights the importance of funding future studies that assess the energy potential of the most promising biomass resources.

Another barrier is the absence of infrastructure to absorb biomass resources. Most agricultural areas that have significant biomass potential are not located near power lines. Moreover, there is little experience with (and expertise in) mixing different types of biomass to make fuel, which is important if biomass power is to be distributed domestically.[54] Meanwhile, some biomass crops, such as sugar cane, have seen production declines recently. This also presents an opportunity, however, because taking advantage of biomass for energy production could serve as a catalyst for many struggling industries. Another major obstacle is that sources of biomass are seasonal: for example, sugarcane is normally produced for only half the year, meaning that substitute fuels are needed if power plants relying on bagasse are to run year-round.

Finally, a pricing mechanism needs to be in place for biomass feedstock. Although many sources of biomass have the benefit of not being usable for other purposes, this does not mean that their collection and distribution will be free. More focus needs to be placed on how to properly price biomass feedstocks so that farmers or private biomass waste collectors have an incentive to capitalize on this low-hanging energy opportunity.[55]

3.5.4 Biomass Energy Summary

Sugar cane, rice, and coffee are the biomass resources with the highest potential in the Dominican Republic. Sugarcane bagasse alone could fuel an additional 535 GWh per year of electricity generation. However, the lack of infrastructure, detailed resource assessments, and pricing mechanisms for biomass feedstocks are all barriers to greater use of biomass. Going forward, Worldwatch recommends that the Dominican Republic prioritize two new studies: first, a study that assesses the biogas potential of banana, cocoa, coffee, and plantain (with a special focus on coffee pulp, which may have significant potential because few farms in the country utilize it); and second, a more detailed assessment of the volume of rice husk available for combustion after competing uses are met.[56]

3.6 Other Renewable Energy Technologies

In addition to the mainstream renewable energy technologies discussed above—for which the Dominican Republic has considerable available resources—three additional options are worth exploring: wave and tidal energy, geothermal energy, and waste-to-energy. In theory, wave and tidal energy have significant potential in island countries like the Dominican Republic, yet technology costs remain too high for commercial-scale development. Geothermal, meanwhile, is a mature technology that can provide a significant share of generation in countries with strong resources. While it appears unlikely that the Dominican Republic has sufficient potential to develop geothermal power, the country could implement geothermal heating and cooling systems, which do not have the same site-specific resource requirements. Waste-to-energy potential is likewise limited, although the use of municipal solid waste or waste from farms could power large parts of the country.

3.6.1 Marine Energy Technology

Wave energy is a third-hand form of solar energy and a second-hand form of wind energy. Sunlight warms pockets of air, producing temperature gradients that induce atmospheric circulation in the form of wind, which then drives water to produce waves. The peaks and troughs that store the wave's potential energy are proportional to how fast and consistent the wind blows over an open area of water.

Tidal energy, in contrast, is created by imbalances between the gravitational forces of the Earth, Moon, and Sun in orbit and the forces required to keep the orbits in place. The regular cycles of the orbits create a regular cycle of inflows and outflows in certain tidal estuaries and channels. Many tidal power systems use a design similar to wind turbines, except the units are located underwater at the base of tidal estuaries and channels. Because water is roughly 1,000 times denser than air, the systems are capable of producing roughly 1,000 times more energy than wind using water moving with the same flow speed as the air. Tidal energy resource assessments are based on grid-based oceanographic data including maximum current velocities, seabed depth, maximum probable wave height, seabed slope, significant wave height, and distance from land.[57]

Unlike most of the renewable energy technologies examined in this chapter, marine energy technologies are far from commercially viable and still have prohibitively high costs. The costs of building and installing these systems, including the generation equipment and the underwater cables, is extremely high, and existing global capacity is almost exclusively in the form of pilot and demonstration projects. Despite this, the newly formed Ministry of Energy and Mines, with the assistance of the Development Bank of Latin America (CAF) is conducting a study for sea water air cooling (SWAC) and ocean thermal energy conversion (OTEC) potential in Dominican waters to supply air conditioning and electricity generation.

Among the factors to be considered when developing marine energy projects are the corrosion of equipment in seawater, coexistence with other human uses of coastal waters such as fishing and recreation, grid connection obstacles, and potentially significant ecosystem disturbances. Despite the current barriers, marine power could become cost-competitive as technologies mature, and may play an important role in small-island states that have extensive coastal territories.[58] The Dominican Republic currently has no marine technology facilities.

3.6.2 Geothermal Energy

Geothermal energy, or thermal energy stored in the Earth, can be used to generate electricity or to provide heating and cooling services. Good geothermal resources can contribute significantly to a region's electricity portfolio: for example, geothermal accounts for 27% of generation in the Philippines and 4.5% in California.[59] A major advantage of geothermal power compared to many other renewables is that it can be used as a baseload source of energy. Yet it currently plays a limited role in global electricity production, with only 12 GW installed in 24 countries.[60] The main limitation is the need for reservoirs with very high temperatures near the Earth's surface. The Geysers in California, the world's largest geothermal power plant, benefits from 300°C steam less than two kilometers below the surface.[61] Such resources are rare, however, and most deep geothermal reservoirs are technologically or economically unfeasible to exploit.

The Dominican Republic currently has no installed geothermal capacity. Regional assessments show low potential for the island of Hispaniola overall, only enough to meet roughly 10% of the country's demand.[62] The greatest geothermal potential in the Caribbean is found on the islands of the Lesser Antilles, and, so far, only Guadeloupe has installed geothermal capacity (4.5 MW).[63]

Because the Dominican Republic does not have high geothermal power potential, the more attractive option is geothermal heating and cooling. Because these systems rely on reservoirs with much lower temperatures, they are not as site-specific and can be built in many locations either for direct heating or to power heat pumps. Globally, at least 78 countries use geothermal energy directly for heating.[64] In the Dominican Republic, geothermal systems could provide cooling in the very warm tropical climate, as well as provide humidity control. Pipes would need to be placed only a few meters below the ground, making it an applicable technology for government and commercial buildings and hotels.

3.6.3 Waste-to-Energy

Municipal solid waste (MSW) contains significant organic material, and, when burned, it can drive a turbine to generate electricity, similar to any other thermal power plant. In addition, the gas produced in landfills (primarily methane) can be captured and used to power a thermal power plant. MSW is advantageous because it can be used as a baseload source of power. Because the waste would otherwise be discarded, it is also a cheap fuel source that requires little resource extraction or change in land use.

In the Dominican Republic, a pig manure biogas project near Santiago produces 21 kW of electricity, or enough to meet the farm's own needs. Four small biodigester projects also operate in the central region of the country. In addition, a landfill-gas collection system has been in operation on the La Duquesa landfill near Santo Domingo since 2010. The project originally planned to capture methane gas and use it for power generation, but the gas is currently flared instead. Captured levels of methane were lower than expected, and assessments of potential energy generation have been delayed.[65] Lastly, the Punta Resort & Club has instituted a zero-waste program but currently uses biomass residue and waste only to generate the electricity needed for its laundry services.

3.7 Summary of Renewable Energy Potential

The Dominican Republic has very strong renewable energy potential spread across the country and can meet nearly all of its current power demand with the resources assessed in this chapter. Wind farms and solar PV are especially viable and should be central in the country's energy mix. Preliminary estimates based on the resource assessments in this chapter show that installing some 24 square kilometers of solar PV capacity and 21 square kilometers of wind farms could supply the equivalent of more than half of the country's electricity generation in 2012. Small hydro and biomass also can play a limited but important role in powering the country. Taking advantage of currently unused sugarcane bagasse can provide almost 4% of current power production. Small hydro capacity additions can be especially useful for expanding energy access in remote and underserved locations.

4 | Grid Improvement and Energy Storage

Key Findings

- The Dominican Republic's electricity grid will require upgrades and expansion to accommodate growing energy demand, regardless of whether these needs are met with fossil fuels or renewable resources.
- Load shedding is a major problem in the country and leads to increased electricity theft across all economic classes, which is the largest obstacle that the sector faces. Installed capacity is currently sufficient to meet demand; this is a distribution management and payment problem.
- Distributed generation, especially from rooftop solar PV systems at the household and commercial scales, can reduce power system inefficiency by avoiding grid losses.
- The cost of grid connection for solar, wind, and small hydro installations will likely be minimal and should not pose a barrier to renewable energy development.
- Challenges associated with renewable energy variability can be minimized by upgrading the grid system infrastructure with higher-voltage transmission lines and by improving operations and forecasting.
- The country's existing diesel, fuel oil, and natural gas power plants can be fired up and down quickly in response to fluctuations in solar and wind generation; the current system is well-suited to renewable energy integration.
- Integrating multiple renewable energy sources across a broad geographic area can further reduce intermittency issues; in particular, combining solar and wind capacity on the grid can smooth out seasonal variability.
- Electricity storage options, especially batteries and pumped-hydro systems, can be paired with renewable energy capacity to store power generated during periods of high production and low demand, to be fed into the grid at peak hours.
- If the necessary grid-strengthening measures are implemented, renewable energy can reliably meet over 85% of the country's electricity demand while lowering energy costs.
- The role of hydropower is limited in addressing the intermittencies of solar and wind.

The Dominican Republic has very strong renewable energy resources that have the potential to generate enough electricity to meet the country's growing power demand. Successfully integrating new renewable power into the national electricity system, however, requires a strong and functioning grid. The management challenges related to electricity transmission and distribution on the grid are different for centralized versus decentralized generation. This chapter provides an overview of the Dominican Republic's current electricity grid and explores proven solutions for strengthening the system to handle new renewable energy capacity.

4.1 Overview of the Dominican Republic's Existing Grid

The Dominican national electricity grid is divided among three regional operators and comprises some 1,657 kilometers of 69 kilovolt (kV) lines and some 1,337 kilometers of 138 kV lines, most of which are located in the country's more populated and tourist-oriented areas.[1] (See Figure 4.1.) The grid also includes a new 345 kV transmission line that spans 160 kilometers between the two largest cities, Santo Domingo and Santiago. In addition to the national grid, there are nine large off-grid systems ranging from 4 to 120 MW in size.[2]

The new 345 kV high-voltage line, the first of its kind in the country, is supported by two substations and is overseen by the country's electricity transmission company, ETED. The new line cost just over USD 170 million and is currently being used at only half of its capacity.[3] Officials hope that the line will help to

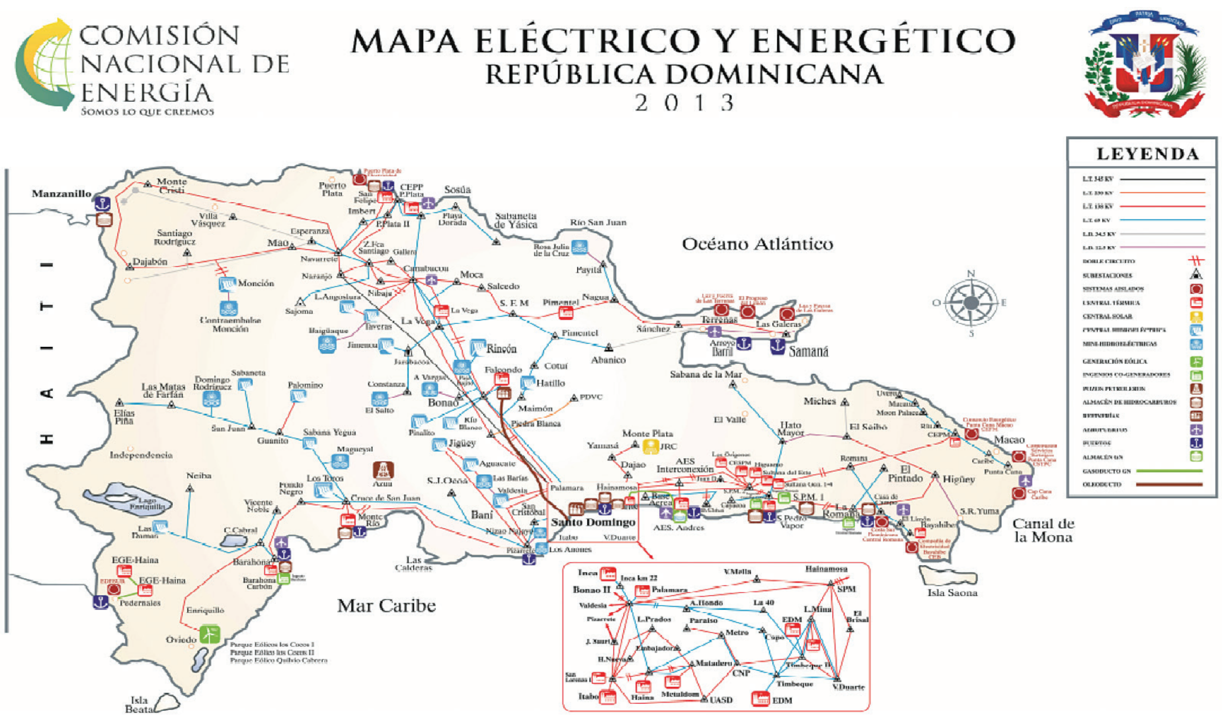


Figure 4.1

Map of Dominican National Integrated Electrical Grid *Source: CNE* alleviate unreliable electricity in the Cibao Valley region. It also helps prepare the country to handle new generation capacity that is expected to come online soon, including both wind and solar projects.

Electricity losses are a major problem in the country, and both an aging grid and electricity theft contribute greatly to grid inefficiencies. Unfortunately, because transmission and distribution companies are not always paid, they do not have sufficient capital to improve their services. A good technical solution for countries that are prone to high levels of electricity theft is "smart meters," which allow for two-way communication between points of consumption and production at short (hourly or more) intervals. Smart meters enable utilities to track customer power usage and irregularities more easily than traditional meter systems. Although smart meters are expensive, well-planned programs that target the greatest culprits of electricity theft can lead to significant energy savings and financial gain.

The state-owned utility company, CDEEE, initiated a smart meter program in 2008, but it was largely unsuccessful because utility employees did not act on the data that were collected.[4] Utility employees often benefit from electricity theft by receiving payments for turning a blind eye, so simply collecting the data is not always enough. Since the inception of the smart meter program, a change in management at CDEEE has corresponded with greater success in combating theft. In the eastern part of the country, the private utility company, CEPM, has invested almost USD 6 million in smart meters and totalizers to ensure quality service and severely cut down on potential electricity theft.[5] Because smart meters can be expensive, programs should prioritize installing the meters at high-demand locations. Although electricity theft is common throughout the residential sector, the larger commercial, government, and industrial consumers comprise the bulk of electricity consumption in the country, and may be an easier target.

Load shedding, or deliberately suspending electricity service for a period of time, is a major issue in the Dominican Republic. Not only does it lead to poor service, but it exacerbates the electricity theft that has left the country's power sector in debt by lowering the quality and value of electricity services in the country and making consumers more willing to steal electricity. Load shedding in the Dominican Republic is more a factor of customer non-payment and electricity theft across all income levels—and therefore a distribution management and payment problem—than shortage of supply.[6] Distributors may purposefully ask for less generation than they know the grid demands, asking for only what they know they will recover in terms of expenses.[7] Distribution companies then transfer any outstanding debt owed to the generators to CDEEE, which may go months without paying it. As a result, generators have been known to impose what is locally known as "financial blackouts"—refusing to provide electricity until outstanding debts have been at least partially paid.[8]

4.2 Decentralized/Distributed Generation

Distributed generation typically refers to electricity generation produced at the site of consumption, and it can range in scale from a few kW in residential installations to tens of MW for large industrial generation. Integrating large amounts of distributed capacity onto the grid requires that both grid operators and regulators have a strong understanding of the technical issues (and solutions) associated with distributed generation, from power flow reversal to unintentional islanding.[9] (See Sidebar 7.)

It is difficult to determine the exact level of distributed generation penetration that will require strengthening of the Dominican Republic's distribution network. It is critical, however, that installers and grid operators devote serious attention to these issues. Utility engineers also should plan for future penetration of distributed generation when completing standard grid maintenance, to reduce any future burdens on the grid or their customers.

Given the relatively high technical and non-technical losses in the Dominican grids (estimated at 32%), distributed generation systems can bring significant positive economic benefits. Because these systems generate electricity at the point of use that does not need to pass through the grid, a kilowatt-hour that comes from a rooftop solar panel is more valuable than a kilowatt-hour from a coal or diesel plant (equivalent to 1.6 kWh from a power plant if losses are 38%). Integrating a distributed generation system with the grid under a net metering or feed-in tariff regime, however, would mean that some of the output of the system would be subject to the grid's losses.

The country's grid losses are reflected in relatively high electricity prices, which make distributed systems more financially attractive than they would be in countries where grid power prices are lower. Moreover, installing distributed systems would reduce the overall number of kilowatt-hours that have to be generated, improving the efficiency of the electricity system. Consequently, the promotion of distributed generation is a worthy national priority.

4.2.1 Minigrids for Rural Electrification

Minigrids, a form of distributed generation, provide a technologically and economically feasible solution to rural electrification. A minigrid is described as "a discrete energy system consisting of distributed energy sources (e.g., renewables, conventional, storage) and loads capable of operating in parallel with, or independently from, the main grid."[10] In the case of rural electrification, minigrids are isolated from the main grid, with the option of interconnecting with the larger grid system if grid extension becomes a possibility.

Minigrid designs vary based on locally available resources and technologies. Many early minigrid projects were powered by diesel generators, which are commonly used to produce electricity in remote areas. Diesel generators have low upfront and capital costs and are dispatchable (able to generate electricity when needed), with the fuel able to be stored until needed. Diesel, however, is susceptible to very high price volatility, especially in remote areas. Supply disruptions in isolated areas (as in the case of a rural minigrid) can decrease the dispatchability of diesel generators, eliminating one of the few advantages that diesel generators have over renewable-powered minigrids.[11] In addition to supply constraints, diesel combustion has environmental and health impacts, affecting local air quality and contributing to respiratory and other health problems.[12]

To generate enough electricity for storage, renewable energy systems must oversize their capacity, potentially leading to an increase in the total cost of energy.[13] Despite their higher upfront costs, renewable systems are often well suited to taking advantage of local energy resources (e.g., solar, hydropower, biomass), and, if properly designed and managed, they have a distinct long-term cost advantage over diesel generators in remote areas. Technologies that utilize solar, wind, and hydro avoid fuel costs and the possibility of supply shortages, but they must deal with the issue of variability and use energy storage

Sidebar 7. Technical Challenges and Solutions Associated with Distributed Generation

- **Power flow reversal.** In instances where high distributed power generation exceeds the local electricity demand, this increases the voltage in the local network and may exceed the voltage that the grid supplies, reversing power flow. Reversed power flow may overload and damage electrical equipment if the grid is already experiencing power flow near its maximum capacity. To design a system that effectively addresses power flow reversal and maximum power flow parameters, engineers must first identify the unique infrastructure of the grid and distributed generation for each new large installation—as well as on a localized aggregate basis if there is a high density of small distributed generation installations.
- **Voltage regulation.** Voltage regulation allows grid operators to ensure a high quality of electricity by maintaining distribution line voltage to within 5–10% of the designed operating voltage. Distributed generation systems fluctuate in voltage output during operation, or when turned on and off, and can potentially harm sensitive loads (such as manufacturing equipment) to which they supply power. Static VAR compensators (a specialized electrical device for high-voltage systems) and load tap changers (mechanisms contained within power transformers) can regulate voltage levels by incrementally adjusting power on the distribution line.
- **Harmonic distortion.** When the fundamental frequency of the electric current is distorted by other interfering frequencies, this can cause the total effective current to exceed the capacity of the transmission system, leading to overheating and voltage regulation problems. Any distributed generation unit connected to the grid must comply with limits for maximum harmonic distortion, as outlined by the Institute of Electrical and Electronics Engineers (IEEE) Standard 519. Modern inverters are able to reduce the distortion effect of distributed generation to the point of negligibility. Passive and active power filters are electronic devices that can also suppress harmonics.
- **Protection scheme disturbance.** This may occur when an existing network has several measures in place to protect against bidirectional power flow or an exceeding of the maximum transmission line capacity. When a new distributed generation system begins feeding power back into the grid, a fuse (for example) may melt if the power flow exceeds a certain threshold to prevent damage to the grid downstream. Fuses, circuit breakers, relays, reclosers, and sectionalizers may all need to be redesigned.
- **Unintentional islanding.** This is the most significant problem that may occur with distributed generation systems, although it has been largely solved by advances in inverter standards. In the event of a grid outage, breakers automatically isolate the section of the grid in which a power interruption occurs. A generator that is still providing power within this "island" during a grid interruption can interfere with the breaker isolation procedure, leading to longer-than-necessary outages. More seriously, a technician attempting to fix a line that is thought to be disconnected but is actually still being powered can create a lethal hazard. Furthermore, if a generator is operating within an island, the alternating current (AC) on the island may begin to alternate out of phase with the AC on the grid, and out-of-phase reconnection can severely damage equipment.

Both passive and active solutions exist for preventing islanding by disconnecting the distributed generation within a standard time frame. Passive methods measure the grid power at the distributed generation unit's point of connection and disconnect the unit if the grid power ceases, but they are designed to be insensitive in order to prevent unnecessary disconnection. Active methods solve the islanding issue by periodically injecting small bursts of power into the grid and observing the response, but they are criticized for reducing power quality.

Source: See Endnote 9 for this chapter.

solutions. Biomass-based systems, in contrast, are dispatchable, similar to diesel generators, but require procuring a stable, sufficient feedstock. With a sufficient fuel supply, they can provide high capacity factors and appropriate sizing to meet minigrid loads.[14] With proper financing to pay for the renewable energy generation and energy storage technologies, renewable energy minigrid systems are an effective and economically viable option for rural electrification.

Another effective design option is the hybrid minigrid. Hybrid minigrid systems combine renewable energy, energy storage, and diesel generator backups to minimize the downsides of each system. Hybrid systems are often the least-cost long-term option, as the large share of renewable energy can reduce fuel costs and lower total energy costs, while the use of diesel backups can minimize the need for expensive energy storage technologies and guarantee a more reliable supply of electricity.[15] Moreover, many remote communities already have access to diesel generators that can be appropriated or used as backup generators for a community-wide minigrid. These hybrid systems can generate as much as 75–99% of the total power supply from renewable energy, removing many of the health and environmental impacts of running diesel generators but still supplying reliable electricity.[16]

4.2.2 Minigrids and Electricity Tariff Collection Rates

Although electricity transmission and distribution in the Dominican Republic is plagued by massive non-technical losses, there are some signs of improvement. Non-payment appears to be less of an issue in off-grid areas of the country that get their power from "micro-grids": groups of consumers, generators, and energy storage entities that are connected together and operate as a small grid that either is connected to the main grid or serves as a self-sufficient island.[17] Although electricity prices from micro-grids typically are much higher than from mainstream grids, payment rates in some places are close to 100%. In the northeastern city of Samaná, about 94% of customers pay their electricity bills, despite a price of 42 U.S. cents per kWh (compared to 22 U.S. cents per kWh in the capital, Santo Domingo). In the eastern city of Bávaro, the payment rate exceeds 95%, despite prices of around 30 U.S. cents per kWh. And in the southern city of Pedernales, near the Haitian border, payment approaches 99%, despite a price of 28 U.S. cents per kWh.

Micro-grids have strong potential for "mushrooming"—that is, the isolated generation systems first develop on their own but eventually reach a critical size and can be connected to the main grid as well as to one another. Other advantages of micro-grids include greater possibilities for automation, isolation from grid disturbances and outages, and higher potential for community involvement.[18] For a country with sufficient renewable energy potential, micro-grids can be a convenient and cheaper alternative to classic grid extension, with additional advantages related to higher payment rates.

4.3 Grid Connection and Integration for Centralized Generation

At the utility scale, connecting to and integrating with the transmission grid poses challenges for variable generation. Generation from utility-scale wind and solar facilities is far more location-dependent than generation from fossil fuel-based plants, which consume portable (though often costly to transport) feedstocks. Finding a viable site for renewable generation requires balancing the resource available at the location with its proximity to existing infrastructure. In the Dominican Republic, even in areas with strong renewable resources, the costs of grid extension may make development prohibitively expensive in some of the zones surveyed in this Roadmap.

Preliminary Worldwatch calculations using the World Bank Model for Electricity Technology Assessment (META) demonstrate that, overall, grid connection does not present a significant additional cost for renewable energy development in the country. Based on modeling results, even building a 50-kilometer transmission line would contribute less than 1 U.S. cent per kWh to the cost of electricity from a new wind farm.[19] (See Figure 4.2.)

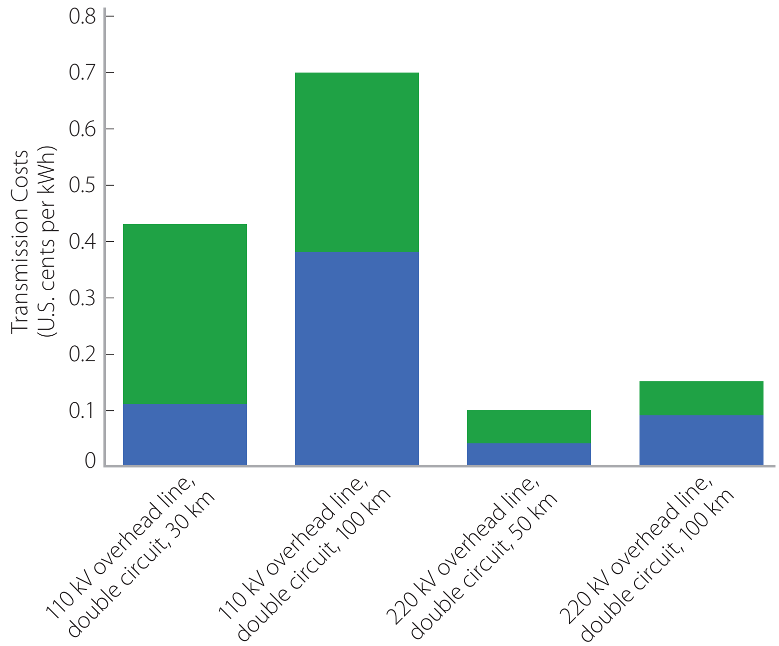


Figure 4.2

Cost Estimates of Grid Connection in the Dominican Republic

Source: World Bank

Grid flexibility—how quickly an electricity system can adjust the electricity supply and load up and down—is a function of both the grid's physical characteristics and its operational and market design.[20] All grids require a certain amount of flexibility to balance fluctuations in demand throughout the hour and day, as well as to balance unexpected changes in supply in situations such as malfunctions or severe weather events. The integration of variable generation adds another element of variability to the system and generally requires greater grid flexibility. Consequently, changes that can increase the grid's overall flexibility or reduce the need for flexibility to respond to demand fluctuations increase the potential for accommodating higher levels of variable generation.

Some of the physical characteristics that determine flexibility are beyond the control of grid operators. For example, larger grids or balancing areas, whether measured by the number of generating facilities or the geographic area covered, are more flexible because variability in supply and demand can be smoothed by aggregation in balancing areas with more diverse types of power plants. The ability of the generation fleet to supply variability to respond to changes in variable generation increases linearly as the balancing area grows, but the variability of the generation increases less than linearly.[21] For example, two wind farms in different locations will generate a combined output that is less variable than that of either single farm. A study in New York State, an area twice the size of the Dominican Republic, found that combining the 11 zones of the state's power system reduced hourly wind variability by 33% and five-minute wind variability by 53%.[22]

For similar reasons, the number and capacity (in MW) of interconnections with neighboring grids is also positively correlated with grid flexibility. If neighboring grids are equipped to supply each other with needed variability in order to deal with excess or missing production, they can recreate the advantage of a larger balancing area within a single grid. In the case of the Dominican Republic, interconnection with Haiti could boost the renewable energy potential of both countries. Since Lac Azeui—the area of Haiti with the most substantial wind resource—is located near both Port-au-Prince and the Dominican border, it could potentially serve as a significant load source through which to connect the two nations' grids.

The correlations between renewable generation and demand also help determine the amount of variable generation that can be integrated comfortably. If the peaks and valleys of wind or solar generation match up well with the peaks and valleys of demand, it is easier to fit them in with the rest of the generation fleet. On these counts, the Dominican Republic does not appear to be an ideal location for heavy centralized variable generation. Small islands tend to have small and geographically isolated grids (if any), and although underwater transmission lines can be built, the cost rises sharply with the distance and depths they must cross.[23] The Dominican Republic's current grid is smaller than regional grids in the United States and national grids in many areas that have existing high penetrations of variable generation. Studies indicate, however, that some island regions, such as Oahu in the U.S. state of Hawaii, may be able to integrate variable generation with the grid without sacrificing reliability.[24]

Grid planners do have control over other physical factors that affect grid flexibility. Grid strength—the ability to transport electricity from its point of generation to its point of demand—is positively correlated with grid flexibility; however, it can be limited by old, inefficient, or bottlenecked transmission and distribution networks, as exist in some parts of the Dominican Republic. The number, location, and types of power plants also contribute to determining grid flexibility. Accounting for variable generation does not require increasing the installed capacity of a generation fleet, but it can require changing its makeup. Quick changes in variable generation output must be counterbalanced by quick increases or decreases in output from other generators that are explicitly designated as being responsible, at the direction of the grid operator, for responding to such changes.

Some power plant technologies are better suited to this task than others. Steam turbines, for example, take a long time to ramp up and down, and lose efficiency when they are not operating at their design load. Cycling places mechanical stress on these plants, potentially leading to higher maintenance needs and shorter lifetimes. Other plant technologies, such as oil or gas turbines or reciprocating engines, ramp up and down very quickly, and lose less efficiency when they are operating at partial loads. By these metrics, the Dominican Republic looks more attractive. The country's reliance on fuel oil, diesel, and natural gas means that a very large share of its generation fleet is of the more-flexible variety.

Hydropower generation in the country, however, depends heavily on the level of rainfall, and even then, there is a pecking order for using that rainfall: personal consumption, irrigation, and then electricity generation. Any water that accumulates in reservoirs is quickly used to generate electricity. As a result, these facilities (as currently operated) are not as useful for dealing with variability, in contrast with systems such as the Bonneville Power Administration in the U.S. Pacific Northwest that routinely have used hydroelectric plants to balance increasing amounts of wind generation. The situation in the Dominican Republic could change, however, if overall generation capacity is increased significantly, such as with the addition of new renewable sources.

In the absence of continued improvements to infrastructure and market design, the ability of the Dominican grid system to absorb variable generation may slow the growth of renewable electricity production in the country. Although much of what dictates the ability of a grid to accept variable generation is predetermined, there are many steps that the country can take to ease the process. In one promising move, there are plans to "close" the Dominican grid, which currently is not interconnected between the northern and southwestern provinces of the country. A planned extension through Manzanillo and then to the south will help to integrate intermittent renewable energy sources, as power will then be able to flow both ways in case there are issues along the grid.

4.4 Integrating Complementary Renewable Energy Resources

Some of the largest challenges associated with the variable nature of renewable electricity generation can be addressed by identifying complementary resources—that is, renewable potential from different sources or geographic areas that are strongest at different times of the day or year. If resources are complementary, the weak period for one coincides with strong generation from another on the same grid, creating a relatively steady level of total generation. Solar and wind are both variable energy sources, and, in the Dominican Republic, small hydropower is part firm capacity and part variable, as it fluctuates with the seasons. Likewise, biomass potential varies with the seasonality of crops.

Wind power provides a useful example of the benefits of integrating complementary resources, as intermittency is one of wind energy's largest challenges. The wind does not blow continuously but varies greatly throughout the year and the day. How pronounced this variation is, and how well wind resources with different variability patterns across a country can be integrated to reduce overall intermittency, go a long way to determining the viability of adding wind power to the electricity grid. Seasonal variation is useful for power system planning and scheduling of long-term maintenance, whereas daily variation is especially important for examining if and when peak wind generation coincides with daily peak electricity demand. In the Dominican Republic, demand tends to peak from 7 p.m. to 10 p.m. and stays relatively high and consistent from 9 a.m. until 11 p.m. It is lowest from about midnight until 8 a.m.[25] (See Figure 4.3.)

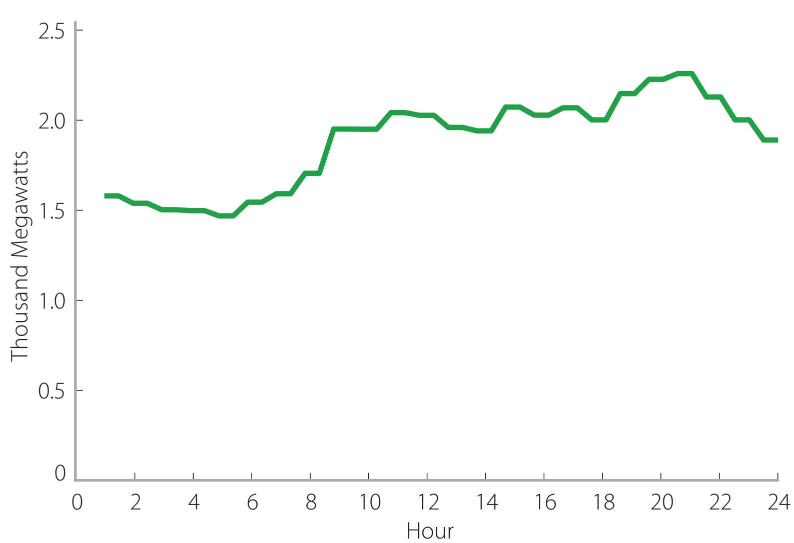


Figure 4.3

Daily Load Demand Curve for the Dominican Republic

Source: OC

© Worldwatch Institute

Results from the six zones studied in our resource assessment indicate that wind resources in diverse locations of the country appear to have varying but complementary daily generation patterns.[26] (See Figure 4.4.) Although the average generation of all six sites is fairly constant throughout the day, with generation dipping around midday (see black line), there are some variations. Pedernales and Baní both see generation peak overnight (11 p.m. to 2 a.m.) and then slowly decline throughout the day, reaching a minimum at around 6 p.m. In Montecristi and Puerto Plata, however, generation peaks at around 5 p.m., stays high until around 9 p.m., and stays low overnight and through most of the day. Thus, Baní and Pedernales would be effective at meeting peak demand from late morning to early evening, with Montecristi and Puerto Plata able to meet the end of peak demand during the late evening.

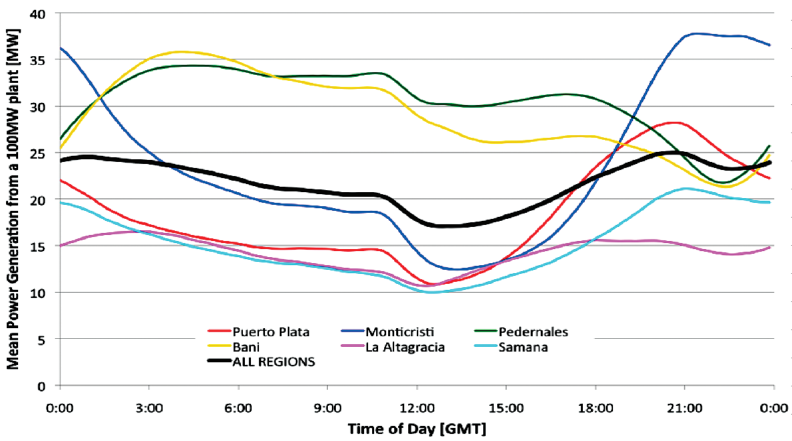


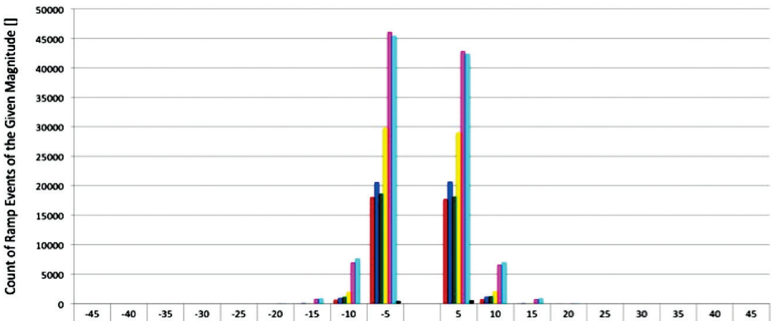
Figure 4.4

Diurnal Variability of Wind in the Dominican Republic

Source: 3TIER

The frequency with which potential wind energy sites experience "ramp events"—changes in generation of more than 5% of installed capacity over a short period of time—also plays a role in determining their attractiveness. Our assessments examine wind variation over 10-minute and hourly intervals at representative sites.[27] (See Figures 4.5 and 4.6.) In both time frames, geographical diversification reduces both the number and the size of ramp events, but the effect is much greater over 10-minute intervals, as there is less time for multiple sites to be affected by the same weather pattern. One way to significantly reduce the variability of wind generation is to place wind farms in multiple locations that show a diversity of seasonal and daily variation, in order to level out daily and yearly generation. Of the four provinces with the best wind resource, representative sites in Puerto Plata, Montecristi, and Pedernales show less variation in 10-minute intervals, whereas Puerto Plata and Baní are the least variable from hour to hour.

The concentration of wind turbines has a meaningful effect on ramp events as well, again most notably when examining such events over 10-minute periods. A lower concentration of turbines, with fewer units per grid point, would mean that an installation of a given capacity would cover more area. The wind speed seen by each turbine would be less strongly correlated with the wind speed seen by the other turbines in the installation, making ramp events less severe and less frequent. In general, the relationship between the area covered and the number of ramp events over 10-minute periods is roughly exponential, whereas it is roughly linear when looking at hourly variation. Simply expanding the size of installations is not a

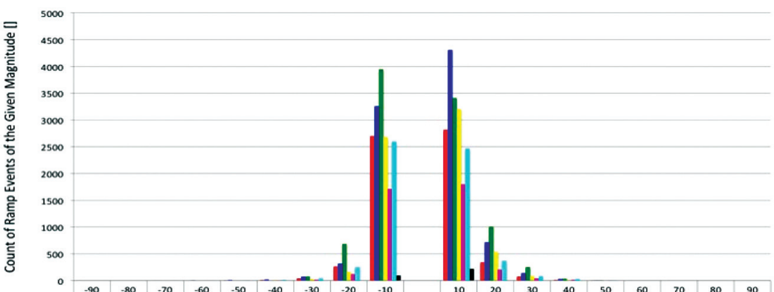


	-45	-40	-35	-30	-25	-20	-15	-10	-5		5	10	15	20	25	30	35	40	45
PuertoPlata	0	0	0	0	1	4	37	636	18033		17704	709	57	6	0	1	0	0	0
Monticristi	0	0	1	1	6	15	107	958	20561		20651	1156	101	30	7	4	0	0	0
Pedernales	0	0	0	0	1	10	55	1152	18630		18148	1249	52	5	0	0	0	0	0
Bani	0	0	0	0	2	10	80	1982	29829		29032	2057	116	6	3	1	0	0	0
LaAltagracia	0	0	0	0	2	66	793	6956	46083		42825	6604	726	77	10	0	0	0	0
Samana	0	0	0	2	7	83	894	7638	45406		42379	6994	881	93	21	3	1	1	0
ALL SITES	0	0	0	0	0	0	0	0	446		566	0	0	0	0	0	0	0	0

Figure 4.5

Histogram of 10-Minute Ramp Events for Representative Sites in Six Dominican Provinces

Source: 3TIER



	-90	-80	-70	-60	-50	-40	-30	-20	-10		10	20	30	40	50	60	70	80	90
PuertoPlata	0	0	0	1	6	13	41	263	2704		2821	342	77	13	6	1	0	0	0
Monticristi	0	0	1	6	13	21	75	319	3260		4309	719	144	33	7	1	1	0	0
Pedernales	0	0	0	0	1	3	76	685	3948		3411	1007	254	36	8	0	0	0	0
Bani	0	0	0	0	4	8	28	161	2685		3202	535	81	13	1	3	0	0	0
LaAltagracia	0	0	0	1	1	6	17	122	1712		1800	209	43	15	4	0	0	0	0
Samana	0	0	2	1	5	13	43	253	2601		2466	369	83	31	7	1	0	0	0
ALL SITES	0	0	0	0	0	0	0	1	95		221	1	0	0	0	0	0	0	0

Figure 4.6

Histogram of 60-minute Ramp Events for Representative Sites in Six Dominican Provinces

Source: 3TIER

solution, however, since a small ramp at a large project can be larger in megawatts than a large ramp at a small project.

From a seasonal perspective, the similarity in generation among the six zones is more pronounced.[28] (See Figure 4.7.) Like most tropical countries, the Dominican Republic experiences significant seasonal variation, including heavy seasonal rainfall, and weather events tend to be heavily influenced by long-lasting high and low pressure zones, which occur relatively consistently. The country's wind potential tends to be highest during the summer months from May to August, but the two highest-potential sites (Baní and Pedernales) also experience a winter peak from December through February.

Seasonal wind patterns are relatively consistent year-to-year as well. The summer winds have almost always peaked from June to August; however, the winter winds have been somewhat more variable over the past 10 years, with the December–January peak sometimes pushed back as late as March. This variability can lead to challenges in power system planning and the scheduling of long-term maintenance. Overall, looking at seasonal and diurnal variation among different provinces, it is clear that having wind

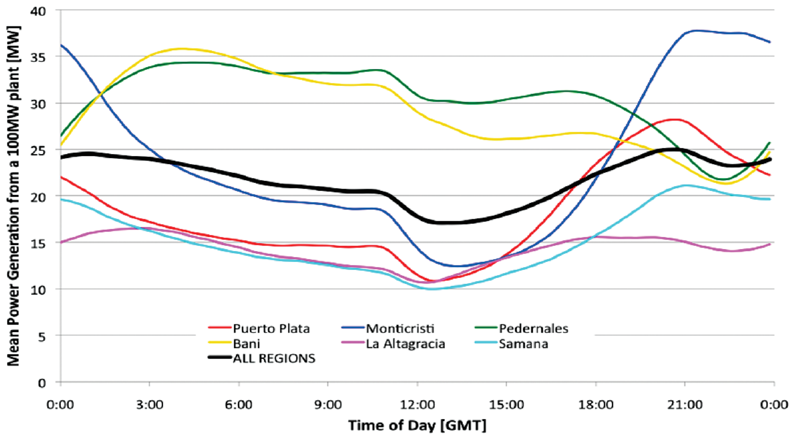


Figure 4.7

Seasonal Variability of Wind in the Dominican Republic

Source: 3TIER

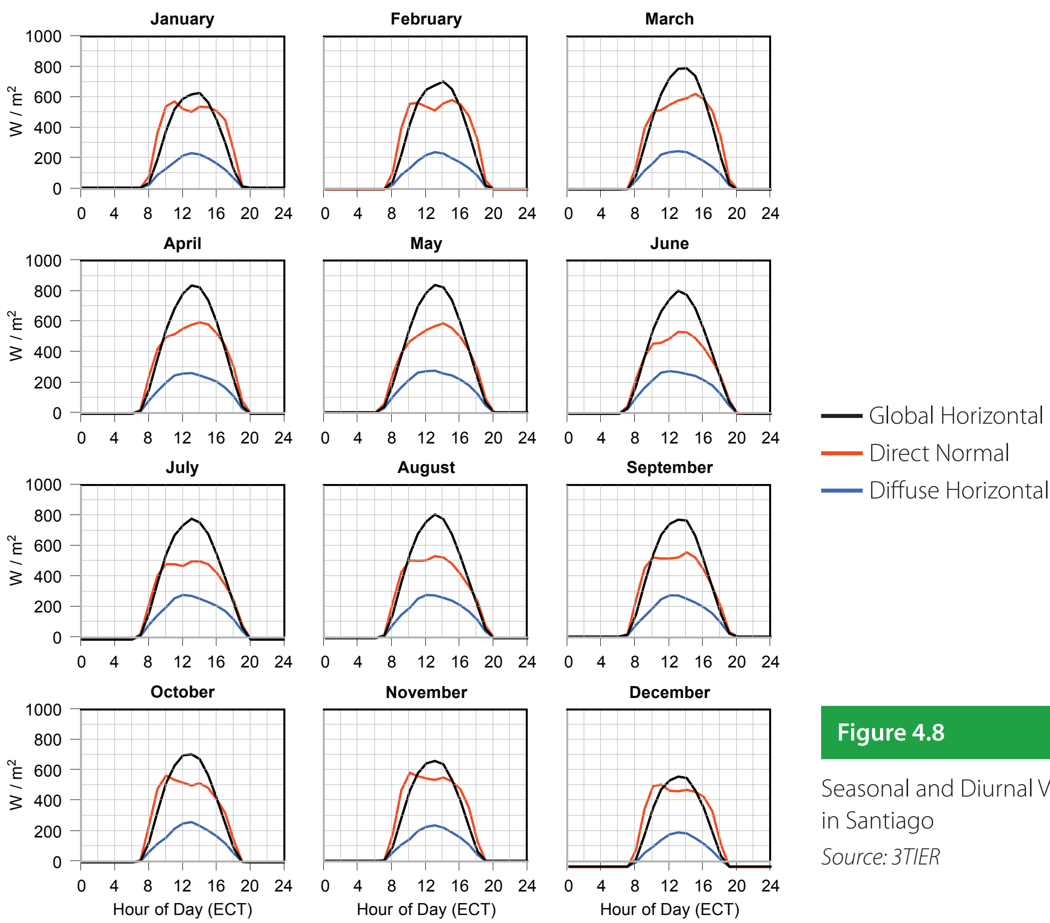


Figure 4.8

Seasonal and Diurnal Variation of Solar in Santiago

Source: 3TIER

farms in both the northern (Montecristi and Puerto Plata) and southern (Baní and Pedernales) zones, if properly placed, could lead to more consistent output than farms in any one location. (See Figure 4.7.)

With regard to solar energy, studies of Santiago and Santo Domingo indicate that solar potential peaks around midday, between 10 a.m. and 2 p.m.[29] (See Figure 4.8.) Because solar power relies on sunlight, there is little complementarity to be found among different sites in the same region because they are producing energy at the same time. Likewise, seasonal variation of solar resources appears to be fairly uniform across the Dominican Republic.

Complementary generation from different renewable resources, such as wind and solar, can also be integrated on the same grid to smooth out daily and seasonal variability. In the Dominican Republic, solar and wind resources peak at different hours, meaning that they could potentially complement each other on a daily basis. Wind resources are often strongest during the evening and early morning and weakest during midday, meaning that solar installations can generate electricity when wind is not producing.

The *seasonal* complementarity between solar and wind, however, is not as clear. Both resources tend to peak in the summer from June to August, which is beneficial considering that this is the time of year when electricity generation and demand are highest.[30] (See Figure 4.9.) Solar then dips and reaches its low from November to February, while many of the wind zones also dip outside of the summer months. Two wind sites in particular, however—Baní and Pedernales—show another generation peak from November until February, meaning that these sites could help to complement solar generation.

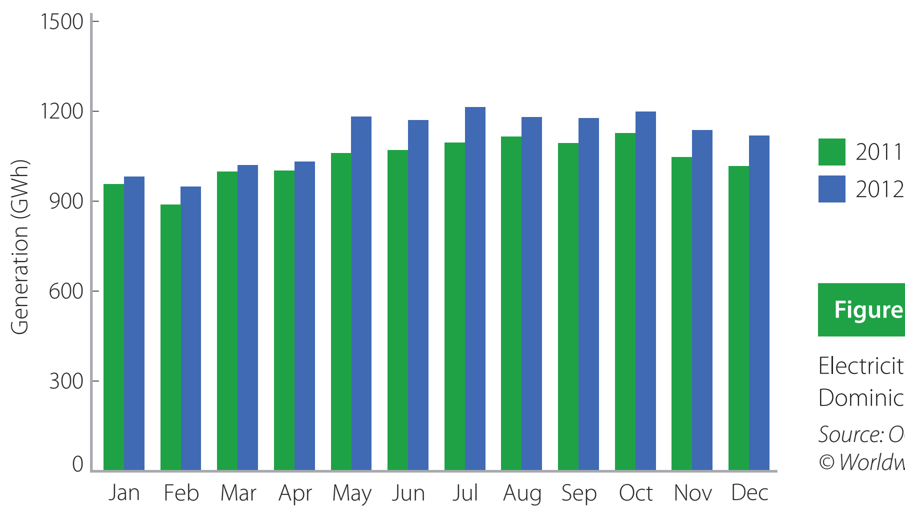


Figure 4.9

Electricity Generation by Month in the Dominican Republic, 2011 and 2012

Source: OC
© Worldwatch Institute

The role of hydropower in addressing the intermittencies of solar and wind power in the Dominican Republic is limited. The country's hydro resource is already largely tapped—used in large part for meeting peak demand—and the flexibility of distribution is limited by competing water needs for irrigation and human consumption. Moreover, hydropower potential is greatest from June to August, the same months that solar and wind are plentiful.[31] (See Figure 4.10.) Hydro potential is lowest from January to May, meaning that it has little ability to make up for lower production from solar and wind during those months.

With regard to biomass, the non-harvest season for sugar cane in the country is from May to November. Because hydro, solar, and wind resources tend to peak during the summer, some seasonal complementarity may exist between bagasse cogeneration and these other renewable energy sources. If biomass resources are stored and made available year-round, they can complement intermittent resources such as solar and wind well. Biomass plants can be fired up quickly to make up for variability in other resources.[32] Some developers in the country have expressed interest in building biomass and solar power plants together so that they can generate baseload power collectively.[33]

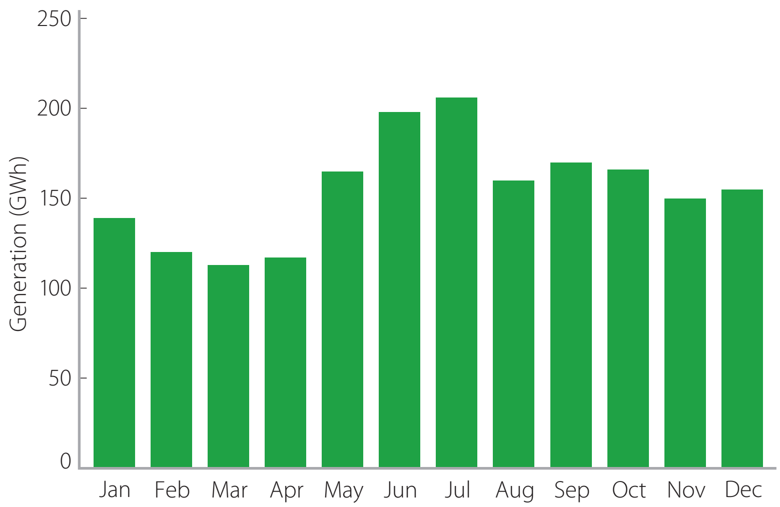


Figure 4.10

Hydropower Generation by Month in the Dominican Republic, 2013

Source: EGEHID
© Worldwatch Institute

4.5 Operations, Markets, and Forecasting

Operational matters influence a grid's overall flexibility as well, not least because there are many situations where existing flexible generation cannot be accessed because of the grid's institutional framework or scheduling rules. Each grid is governed by grid codes that define how and whether wind or solar devices respond to certain grid conditions, including voltage sags and over-generation. If grid codes are not designed to accommodate wind and solar PV, grid operators may, for example, curtail more renewable energy than necessary.

The rate at which electricity markets operate also affects grid flexibility, with close-to-real-time market clearing allowing for better response to unanticipated variability than hourly markets.[34] Within a single energy market, a range of time frames may exist: some generators provide constant, stable power and sign contracts far in advance because their maneuvering cost is too high to respond to price signals; others enter into new contracts (for a certain level of generation at a certain price) at the beginning of each market period; and still others respond to changes in load or supply within the market period as the grid operator requires. This last segment of the market, the ancillary services market, is typically the most expensive from the grid operator's perspective, because it requires generators to ramp production up or down quickly. These generators therefore sacrifice efficiency for flexibility, and require a high price to make such an arrangement worthwhile.

Historically, most energy markets have operated with an hour-long market period, so that those in that second category (intermediate and peaking generators) enter into new contracts with the operator each hour. This means that changes in load or supply within that hour must be balanced using regulation services. If this market period, providing economic dispatch, can be shortened to 5 or 15 minutes, as it has been in many parts of the United States and elsewhere, the market provides greater incentive for generation flexibility and there is less need to pay for regulation services.[35]

The reason for this is that the market clearing price will change more frequently, and the intermediate and peaking plants that can produce economically will then be more precisely fitted to the amount of energy needed to meet load over the market period. A study on the New York Independent System Operator (NYISO) found that providing intra-hour response in this way—relying on the economic incentives of a sub-hourly market—has been shown to come at no added cost. Freeing up generators that sell into the regulation market from having to respond as much to load changes provides more flexibility that can be used to smooth out variable generation ramps.[36]

The quality of wind and solar forecasting affects the ease of grid integration as well. The more accurately that variable generation producers and the grid operator are able to predict wind and solar production, the less they will have to rely on the regulation market to account for unexpected changes. Improving forecasting can be as simple as improving the methodology or technology used, but there are also operational elements. Multiple studies of wind forecasting have shown that forecast error is reduced significantly when aggregated over a large geographic area, suggesting that it is better to forecast production from a variable generation system as a whole rather than from each facility independently.[37] Forecasting error also decreases as it approaches real-time. Markets that operate with quicker economic dispatch are therefore better able to predict the amount of variable generation that they will have on hand during each market period.

The Dominican Republic has definite room for improvement on these measures. The grid currently operates hourly, so converting to faster dispatch, especially with a generation fleet dominated by generating technologies that are well suited to functioning as intermediate or peaking plants, would have considerable benefits for the integration of variable generation.

The discussion of grid flexibility is based on the assumption that the grid operator must deliver the amount of power needed to meet the load at all times. The need to quickly adjust the energy delivered both up and down to respond to changes in load or variable generation is grounded in this requirement. In the Dominican Republic, however, load shedding—temporarily suspending energy delivery to some customers—is commonly used to deal with generation shortages. If the country continues to rely on load shedding, this in essence makes the integration of variable generation easier, because it provides a solution to a situation where unexpected drops of generation cannot quickly be counterbalanced.

If the country is committed to ending its reliance on load shedding, however, high penetrations of variable generation could make the task more difficult. Both the effect of load shedding on integration of variable generation and the effect of this integration on any attempts to end dependence on load shedding deserve further discussion. Integration of variable generation should be handled carefully to avoid any increases in the need for load shedding. Planned demand management for select customer classes, particularly large consumers, could help demand respond to the supply of variable generation in an orderly and pre-agreed way.

4.6 The Role of Oil and Gas Generation in Offsetting Variability

The nature of non-variable power generation on the national grid can affect the electricity system's ability to respond to fluctuations in solar and wind generation. Quick changes in output from variable generators must be counterbalanced by quick increases or decreases in output from other generators that are explicitly designated as being responsible (at the direction of the grid operator) for responding to such changes.

Some power plant technologies are better suited to this task than others. Steam turbines powered by coal, for example, take a long time to ramp up and down, and they lose efficiency when they are not operating at their design load. Cycling places mechanical stress on these plants, potentially leading to increased maintenance needs and shorter lifetimes. Other plant technologies, such as oil or natural gas turbines or reciprocating engines, ramp up and down very quickly, and lose less efficiency when they are operating at partial loads.

By these metrics, the Dominican Republic looks more attractive. The country's reliance on fuel oil, diesel, and natural gas means that a very large share of its generation fleet is of the more flexible variety. Diesel, fuel oil, and natural gas generators can provide backup power to the grid during times of low renewable generation. Using generation for this purpose could allow for up to 85% renewable electricity. (See Chapter 5.)

Because it can be dispatched quickly in response to demand fluctuations, liquefied natural gas (LNG) can be used to address the variability of renewable energy in the near to medium term. The Dominican Republic already utilizes LNG, and this fuel will continue to play an important role over the next couple of decades. Smart integration of LNG can help offset periods of low or intermittent renewable generation. Such integration is most effective with smaller-scale natural gas plants that can respond flexibly to supply and demand needs, rather than large centralized facilities. Natural gas development in the Dominican Republic has not necessarily followed this path, with just three plants providing 555 MW of capacity.

There is potential for more, smaller gas plants in the country. Although the existing LNG terminal has a capacity to receive 160,000 cubic meters of natural gas, it receives only some 120,000 cubic meters every 28 days and is not being used to its full capacity. And while there is demand for more LNG and natural gas generation, this demand is not for additional capacity, but rather to replace existing, expensive generation from heavy fuel oil. For example, the province of San Pedro de Macrois has around 900 MW of installed capacity, running mostly on heavy fuel oil, which can be converted to natural gas. Sultana del Este (150 MW), Cogentrix (300 MW), Quisqueya I & II (215 MW each), and Los Origenes (60MW) currently run on heavy fuel oil because no infrastructure exists to carry LNG to these sites.

Another major challenge to widespread LNG conversion is that the country's natural gas industry is uncompetitive. If new natural gas plants were operated by a different (and competing) company, this competition would lead to lower electricity prices and prevent the current company, AES, from simply selling power at the spot market price even though it produces power for less.

Diesel generators can be used in a similar way to provide backup power to the grid during times of low renewable generation. Because of their flexibility, they can be ramped up or scaled down depending on the needs of the moment. Using diesel generation for this purpose could require just 5–10% of the Dominican Republic's current overall generation capacity.

4.7 Electricity Storage

Energy storage systems—including batteries, pumped hydropower, compressed air energy storage, molten salt thermal storage, and hydrogen—can address the intermittency challenge associated with variable renewable energy sources such as solar and wind.[38] (See Table 4.1.) These systems store surplus renewable energy generated during periods where production exceeds demand, and then dispatch this energy at times of low renewable generation. Because battery systems are the most mature and widely implemented energy storage technology, they are the most likely option to be implemented in the Dominican Republic in the near term.

There also has been interest in the country in pumped-storage hydro systems, which use excess electricity from power plants during periods of low power demand to pump water uphill to be stored in reservoirs, and then later released as hydropower during periods of high demand. Pumped-storage hydro systems could be paired with solar or wind farms sited near viable waterways. Assessments are needed to determine if there are sites that have potential for pumped-hydro systems and that would minimize the ecological impacts associated with large hydropower development. (See Chapter 3.)

4.8 Curtailment

When electricity supply exceeds demand for short periods of time, grid operators may choose to "curtail," or reduce, the output from intermittent renewable energy sources such as wind or solar in order to stabilize the electricity system. Curtailment requirements vary from day to day, but high amounts of curtailment often occur even when conventional plants are operating at their minimum and fast-start units such as diesel generators are turned off.

Curtailment should be minimized if at all possible. When wind (or less frequently, solar) generators are asked to reduce their output, this can result in significant loss of revenue. Systems with large curtailment needs can decrease investment security and investor interest in the market. Support policies for renewables can counteract this fear and may include compensating renewably produced electricity even if it is curtailed. Curtailment is also economically disadvantageous because once wind parks have been constructed or solar panels installed, the marginal costs of this renewable generation are near zero; thus, consuming renewable power in place of electricity from coal, oil, or natural gas would result in significant savings in fuel expenditures.

Curtailment needs should not prevent the Dominican Republic from accelerating its renewable energy use. The country's goal should be to build a system that is as flexible as possible to minimize curtailment but still reap the benefits of a sustainable energy system. An important way to limit curtailment and increase system flexibility is to invest in only those fossil fuel-generation options that can react quickly to changes in supply by intermittent resources. This becomes increasingly important as the share of renewables increases. Petroleum and natural gas plants are more suitable for this task than coal power plants. Coal use forms a barrier to a more accelerated renewable energy expansion and requires substantially greater amounts of curtailment than systems that use flexible natural gas or petroleum-based plants. Another option for limiting curtailment is the use of energy storage.

Table 4.1 Energy Storage Technology Options

Option	Description	Current Status of Technology	Scale of Technology	Cost per Discharge Power	Levelized Cost of Storage	Annual Operating Costs	Suitability for Dom. Rep.
Lead-acid batteries	Used widely with off-grid technologies. Most commonly used to store electrical energy from PV systems, including at the household level.	Mature technology	10 MW or less	USD 300–800 per kW	USD 0.25–0.35 per kWh_{life}	USD 30 per kW per year	Suitable for off-grid applications. Environmental and health concerns arise from lack of maintenance and disposal of old batteries.
Nickel-cadmium (NiCd) batteries	Have higher energy density and cycle life than lead-acid batteries, but are more expensive.	Mature technology. As with lead-acid, used for standalone power systems but not considered suitable for bulk storage due to cost.	A few kW to tens of MW	USD 3,000–6,000 per kW (in bulk storage)	Data not available	Data not available	Same as above
Lithium ion batteries	Rechargeable batteries used widely in mobile applications due to high energy density. Various types exist and offer different pros and cons.	Emerging technology. Need further development for power generation energy storage, but offer promise.	10 MW or less	USD 400–1,000 per kW	USD 0.30–0.45 per kWh_{life}	USD 25 per kW per year	Needs more R&D
Liquid-metal (NaS) batteries	Other types of batteries are being developed for utility-scale storage applications. NaS batteries utilize the sodium-sulfur reaction and require high operating temperatures.	Emerging, pre-commercial technology	100 MW or greater	USD 1,000–2,000 per kW	USD 0.05–0.15 per kWh_{life}	USD 15 per kW per year	Expensive and not yet developed enough to be worthwhile. Potential to pair either with wind power could be useful, once the technology is more developed.
Vanadium redox and zinc-bromine flow batteries (VRB and ZBB)	Flow batteries utilize electrochemical energy storage, just like lead-acid batteries, but require little maintenance. Large capacity potentials make VRBs suitable for wind energy storage, while ZBBs are more appropriate for smaller-scale systems.	Emerging, pre-commercial technology	25 kW–10 MW	USD 1,200–2,000 per kW	USD 0.15–0.25 per kWh_{life}	USD 30 per kW per year	Expensive and not yet developed enough to be worthwhile. Potential to pair either option with wind power could be useful, once the technology is more developed.
Pumped-hydro storage	Most commonly used for large-scale energy storage, and to complement solar and wind. At times of low power demand, excess electricity is used to pump water uphill into a sealed-off reservoir. During periods of peak demand (or low energy production), the stored water is released through a hydropower plant, pushing a turbine that rotates a generator to produce electricity. Requires hydro resources and mountainous landscapes.	Mature technology	Typically 200 MW or greater	USD 1,000–4,000 per kW	USD 0.05–0.15 per kWh_{life}	USD 5 per kW per year	Very suitable. Assessments needed to identify viable sites.

Table 4.1 continued

Option	Description	Current Status of Technology	Scale of Technology	Cost per Discharge Power	Levelized Cost of Storage	Annual Operating Costs	Suitability for Dom. Rep.
Compressed Air Energy Storage (CAES)	Functions similarly to pumped-storage hydro and fits well into a micro-grid system. During times of low energy demand, cheap electricity is used to power a motor, which runs a compressor that forces air into tight underground reservoirs. During periods of peak demand, the compressed air is released and heated with natural gas, causing the air to expand and push a turbine that drives a generator to produce electricity.	Mature technology. Expansion limited due to availability of natural storage sites.	500 MW or greater	USD 800–1,000 per kW	USD 0.10–0.20 per kWh_{life}	USD 5 per kW per year	Depends on availability of natural storage sites.
Thermal storage	Often used in conjunction with CSP systems. Relies on heat-absorbing materials, such as molten salt, to absorb and store heat. In such systems, several hours, and in some cases up to a couple of days, of thermal energy can be stored in molten salt. This stored heat can later be released to help generate electricity at night or on a cloudy day.	Demonstration projects under way.	MW-sized	USD 50 per kWh USD 375 per kW (@ 50 MW for 7.5 hours)	Data not available	Data not available	Depends on suitability of CSP generation for Dominican Republic
Flywheel energy storage	Uses electricity to accelerate a rotor to very high speeds and stores the energy as rotational energy.	Emerging technology. Used mostly for uninterruptible power supply/ bridging power.	100 kW to 200 MW	USD 2,000–4,000 per kW	Data not available	USD 15 per kW per year	For bridging power applications at critical institutions (e.g., hospitals), potentially.
Superconducting Magnetic Energy Storage (SMES)	Stores energy in the magnetic field resulting from the flow of direct current through a superconducting coil that has been cooled below its superconducting critical temperature. SMES is highly efficient, losing less of its stored energy than any other energy storage system. Can be dispatched very quickly.	Emerging technology. Used for short-duration energy storage and power-quality improvement. Numerous technical challenges still to be overcome.	1 MWh units in use for power quality control and grid stability; 20 MWh unit is a test model; currently viable for short-term power (seconds) in the 1–10 MW range.	Estimated capital costs of USD 200,000–500,000 for systems with energy storage capacity between 200 kWh and 1 MWh. Costs often vary based on current.	Data not available	Data not available	Not suitable due to expense and limited application.
Electrochemical capacitors	Stores energy in the electrical double layer at an electrode/electrolyte interface	Still under development for use with renewable power systems.	Commercially viable for hundreds of kW scale for short power needs (seconds); utility-scale, longer-term (hours) storage not currently feasible.	USD 1,500–2,500 per kW (projected)	Data not available	Data not available	Not suitable

Table 4.1 continued

Option	Description	Current Status of Technology	Scale of Technology	Cost per Discharge Power	Levelized Cost of Storage	Annual Operating Costs	Suitability for Dom. Rep.
Hydrogen storage	Hydrogen is produced through the electrolysis of water or the reforming of natural gas with steam. The hydrogen is then compressed or liquefied and stored for later conversion to electrical energy.	Future technology. Barriers still exist with regard to hydrogen storage and safety.	MW-sized	N/A	Data not available	Data not available	Not suitable

4.9 Summary of Grid Improvements for a Renewable Energy System

Enormous opportunities exist for renewable development in the Dominican Republic. Distributed generation is particularly attractive because of the high losses in the existing transmission and distribution system and because many light-commercial customers already have inverters and batteries for backup power.

Although the Dominican Republic, as a relatively small and isolated country, faces a particular challenge in integrating variable generation into its grid, its flexible generation fleet and superior wind and solar resources make it an attractive location for renewable energy development. The many positive externalities associated with renewables—including reduced fossil fuel dependency, improved air quality, and job creation—make development even more beneficial.

The technical challenges associated with both distributed and centralized wind and solar power will need to be addressed for any initial projects to lead to significantly higher penetration of renewables. Handling distributed generation should be considered when conducting maintenance and performing upgrades to distribution networks, and improving the reach and capacity of the transmission grid should be a top priority to allow for the acceptance of greater amounts of variable generation.

Variable generation also can be addressed through complementary on-site resources. Pairing solar PV with biomass generation can create a solar-biomass hybrid system that acts as a source of baseload power. Because biomass generators are flexible, they can be ramped up or down depending on the solar PV output. Plans for this already exist at the Monte Plata solar farm, and future projects should also consider these complementary systems

The effect of variable generation on the need for load shedding should be considered carefully. With improvements to grid infrastructure, however, the amount of flexible generation available from the country's conventional generation fleet suggests that a substantial amount of variable generation can be integrated successfully into the national grid.

5 | Technological Pathways for Meeting the Dominican Republic's Future Electricity Demand

Key Findings

- A sustainable Dominican electricity sector based on a share of more than 85% renewable energy by 2030 is technically feasible.
- Although rising energy demand will require adding new generating capacity in the future, the country does not face an immediate capacity problem.
- Renewables are able to fill this gap in demand security. A share of 50% renewable energy by 2030 would cover some 90% of projected new demand. A share of 85% renewable energy by 2030 would allow for a rapid reduction in oil use in the electricity sector.
- The country does not need to build new coal-fired power plants. Natural gas plants are more flexible solutions that have fast ramp times and lower minimum operating levels, allowing a smoother integration of larger renewable energy shares.
- Investments in new coal plants will ultimately limit the amount of renewable energy that the system can integrate.
- Simultaneous investments in new coal power, natural gas, and renewables will limit the amount of renewable energy that the system can integrate and/or raise concerns about the profitability of natural gas plants.

The Dominican Republic faces a critical decision. As the demand for electricity grows, the country will need to find ways to reduce its reliance on imported fossil fuels. This chapter assesses different technological pathways for the Dominican electricity sector, which is larger and more diverse than that of most other Caribbean countries. The sector relies on a greater mix of generation sources, including fuel oil (33.6% in 2013), natural gas (24.9%), a combination of fuel oil and natural gas (9.7%), coal (14%), and renewable energy (15%), most of which is hydropower. This chapter outlines different options for meeting rising demand with increasing shares of renewable energy, while also replacing older power plants.

Although the Dominican grid is in need of upgrades and extension, this chapter focuses exclusively on changes to the power generation mix. It assumes that a functioning transmission infrastructure exists that is able to connect and integrate all required new capacity. This assumption seems reasonable given that the country's grid will require renovation regardless of whether future electricity demand is met by new investments in fossil fuels or renewable energy. The costs of expanding the existing grid infrastructure to accommodate renewable energy are relatively manageable, particularly when compared to overall renovation and investment needs. (See Chapter 4.)

The chapter begins by presenting demand projections that build the foundation for evaluating the future Dominican electricity generation mix. It then discusses the different scenario types and details their results. The chapter concludes that an electricity system based largely on renewable energy is technically feasible, and that substantial new generating capacity is needed if demand grows as projected. Investments in new conventional power beyond what is already planned are not necessary, and even the country's two planned new coal-fired plants are put into question. Existing natural gas plants are well suited to integrate growing shares of intermittent resources and can best function as a bridge to a system based largely on renewable energy.

5.1 Demand Projections

In our scenario analysis, we evaluate different technological options for meeting future electricity demand in the Dominican Republic. Electricity demand developments depend on many factors, including changes in economic growth (GDP), demographics, electricity pricing, and the energy intensity of the economy. Where possible, our analysis of the Dominican electricity system relies on existing data, including from the Coordinator of the National Interconnected Electrical System (OC-SENI), which is responsible for coordinating electricity dispatch), the Dominican Corporation of State Electricity Companies (CDEEE), which brings together all government-owned generation, transmission, and distribution companies), the National Energy Commission (CNE), and the management and consulting company Nexant.

For historical trends and projections for 2013–16, SENI distinguishes between annual demand and net generation. It predicts that both demand and generation will increase in the coming years, but that the gap between them—due to persistent electricity theft at all levels—will remain. Following this approach, Worldwatch applied projected generation growth rates from CDEEE (4% and 5% annually) and Nexant (3.3%) to both electricity production and demand for 2017–2030. We adopted CDEEE's first scenario of 4% annual growth because it best fits historical trends while also allowing for a growing Dominican economy.

The analysis shows that the country will require an estimated 31,712 GWh of electricity to meet demand in 2030, up from only 12,031 GWh in 2003. (See Figure 5.1.) Based on this annual demand, peak demand is estimated to exceed 4.7 GW by 2030 (see Figure 5.2), indicating that the country will need to add significant new capacity in order to secure demand at peak times of the day over the next 20 years.

Electricity demand has the potential to be substantially lower than these projections, however. As discussed in Chapter 2, available energy efficiency solutions could place the Dominican economy on a path of much lower energy demand, which would make the transition to an electricity system based largely on renewable energy much easier. We have adopted the growth scenarios here to show that a transition to a more sustainable energy system can be achieved even under conservative assumptions.

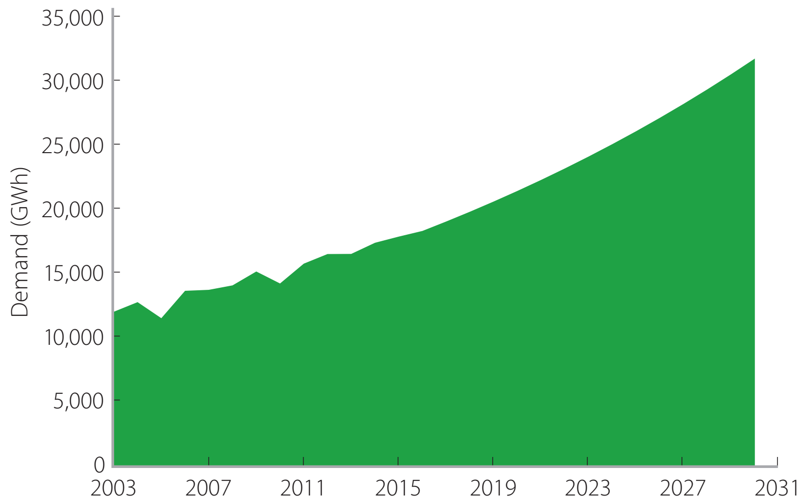


Figure 5.1

Annual Demand Projection to 2030

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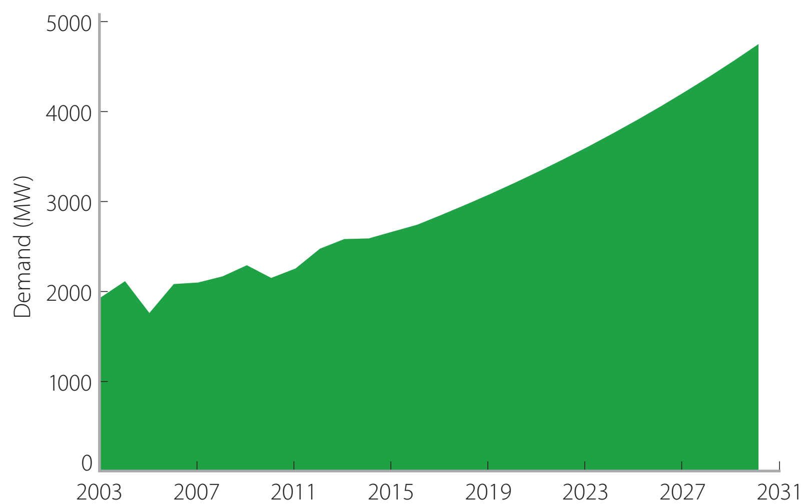

Figure 5.2

Peak Electricity Demand Projection to 2030

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In other words, if renewables can be relied on to meet this higher demand, then the transition should be even easier in cases of lower demand.

In the scenarios that follow, we assume that electricity generation will increase over time to equal demand. The goal of the Dominican government is to ensure secure, reliable, and constant access to electricity for all customers. This chapter demonstrates different pathways for how this could be done. Chapter 6 then compares the costs of the various options.

5.2 Scenario Types

Based on our demand projections, Worldwatch has developed three transition scenarios to assess how growing shares of renewable energy can be used to meet the Dominican Republic's future energy needs. (See Table 5.1.) These are compared to a business-as-usual (BAU) scenario that assumes that, despite rising demand, the country's current electricity mix remains unchanged to 2030.

Table 5.1 Worldwatch Scenarios for a Renewable Energy Transition in the Dominican Republic by 2030

Scenario	Renewable Share of Electricity Generation	Assumptions for Capacity Additions Beyond Renewable Energy
BAU	12.76%	All generation sources expand according to their current share of production
1	30%	All planned projects plus additional coal
2	50%	All planned projects plus additional coal
3a	85%	All planned projects
3b	85%	Only planned natural gas projects

The scenarios are differentiated by the level of penetration of renewable energy in 2030, ranging from a 12.7% share under BAU to an ambitious scenario that has renewables meeting 85% of Dominican electricity demand that year. In the scenarios, solar and wind power comprise the majority of renewable capacity additions, and their potentials are calculated based on the resource assessment presented in Chapter 3. Hydropower and biomass-based generation are assumed to expand in order to make use of additional untapped resource potential. Installed hydro capacity grows from 513 MW in 2010 to 1,331 MW by 2030, and biomass-based generation increases to 151 MW to utilize existing and unused bagasse potential, in line with Universidad ISA's assessment for available sugarcane waste in the country.

The scenarios also vary in the conventional fuel used in the transitioning phase. In all scenarios, electricity generation not covered by renewables is produced by a mix of natural gas, coal, and petroleum plants. All plants currently planned or under construction are modeled to come online within the next seven years, with the exception of Scenario 3b. Older plants are assumed to retire according to their age and average lifespans (approximately 35 years for coal plants and 30 years for natural gas and petroleum plants). Worldwatch assumes that no new investments in oil plants will be undertaken. In all three transition scenarios, the role of petroleum generation is set to diminish over time, as envisioned by the government and reflecting the high costs of oil-based generation in comparison to alternatives. (See Chapter 6.)

Given the government's current interest in investing in more coal power, we assume that coal power will be the preferred fuel in scenarios where further capacity additions are needed beyond the targeted renewable energy capacity and currently planned conventional projects.[1] This assumption should be viewed as conservative, however, in light the varying socioeconomic costs and benefits of the different technological pathways, as discussed in Chapter 6. If it can be shown that a replacement of coal—believed to be the cheapest of the conventional generation sources—by renewable energy pays off over time, then the same also goes for oil and natural gas.

As the analysis that follows illustrates, all three transition scenarios are technically feasible, including a share of 85% renewables by 2030. Our scenarios demonstrate that the Dominican Republic's current electricity mix is a good starting point for an ambitious transformation to a system based largely on renewable energy.

5.3 Scenario Results

In our analysis, we assess how the country's annual electricity demand to 2030 can be met under the different scenarios. In the BAU scenario, all existing generation sources retain their current shares of the electricity mix (dominated by petroleum, followed by natural gas, coal, and renewables), but overall production expands as demand grows. (See Figure 5.3.) Scenarios 1–3, on the other hand, depict varying pathways for an increasing role of renewable energy, reflecting different levels of ambition and mixes of fossil fuels. (See Figure 5.4.)

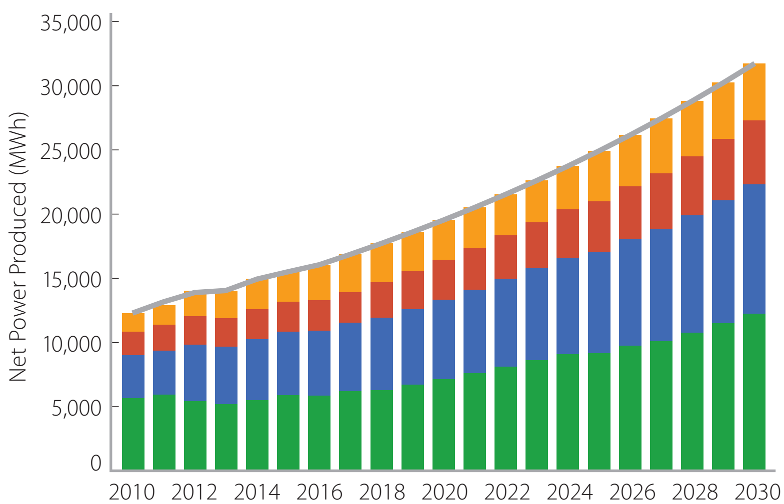

Figure 5.3

Electricity Demand and Generation Under BAU, 2010–30

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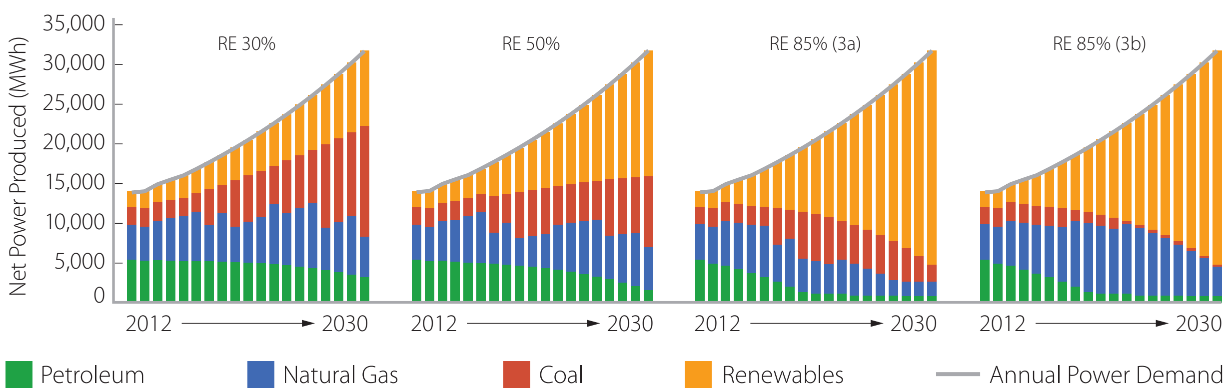

Figure 5.4

Electricity Demand and Generation Under Scenarios 1 to 3, 2012–30

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Scenario 1 illustrates a rather modest change, with moderate growth in renewables, a decline in the share of oil-based power, and new investments in natural gas and coal. This scenario resembles somewhat a projection of the sector under a continuation of current government plans and activities. Scenario 2 presents a slightly more ambitious transition to renewables—reaching 50% of generation by 2030—as well as the construction of three new fossil-based plants beyond those that have been recently added to the mix. (See Table 5.2.) Despite the growing importance of renewables in Scenario 2, a 50% renewable share by 2030 would cover only around 90% of projected new demand.

Scenario 3 is the only pathway that would displace conventional power capacities beyond current levels. It highlights the technical feasibility of transitioning to a sustainable electricity sector based on a share of more than 85% renewables by 2030. Scenario 3a assumes that the country will build all plants that are currently planned (both coal and natural gas). Scenario 3b, however, assumes that the recently proclaimed tender of over 600 MW of coal power will not proceed, and that only the announced natural gas projects will be built. Worldwatch included this scenario to address some stakeholder concerns about the need for additional coal plants.

Table 5.2 Recently Added and Planned Conventional Power Plants in the Dominican Republic

Year	Name	Capacity	Fuel
		MW	
2012	Seabord (Estrella del Mar 2)	110	Natural gas (two modes of the plant currently run on fuel oil, but our scenarios assume it will be repowered by natural gas)
2012	San Lorenzo 1	34	Fuel oil originally, but our scenarios assume it will be repowered by natural gas
2012	Los Origenes	25	Natural gas, HFO, diesel
2013	Los Origines Expansion	34.5	Natural gas, HFO, diesel
2014	Quisqueya 1 & 2	440	Natural gas, HFO, diesel
2016	North Central Energy	300	Natural gas
2018	Coal Tender 1	300	Coal
2020	Coal Tender 2	300	Coal

As renewables are expanded in Scenarios 1–3, the share of electricity generation from petroleum-based technologies falls below the current 46%. By 2030, petroleum accounts for 10% of generation in Scenario 1, 5% in Scenario 2, and only 2.5% in Scenario 3 (enabling a near phase-out of oil-based generation). From 2020 onward, petroleum plants that have not been shut down due to their old age are used at minimum capacity rates for ancillary services only.

Moreover, greater investments in renewable energy render new conventional power plants unnecessary. For example, a jump from a renewable energy target of 30% (Scenario 1) to one of 50% (Scenario 2) would allow foregoing the construction of one 300 MW coal plant. Scenario 3 illustrates that no new conventional plants are required beyond those that are already planned. Scenario 3b even puts into question the need for the proposed coal plant tender, reflecting the fact that natural gas plants run at slightly higher capacity factors to make up the lost electricity generation from coal power.

In all three transition scenarios, existing and planned natural gas plants serve a crucial role by providing the system with the flexibility required for a smooth integration of intermittent renewable resources, enabling adjustments in power output to match supply with demand at all times. Because of its ability to react to annual, seasonal, daily, and hourly variability in renewable energy output, natural gas is an ally of renewables in powering low-carbon economies.[2] The Dominican Republic has the advantage of already having natural gas infrastructure in place, and the country should optimize this rather than encouraging investments in coal and other technologies that risk closing the door to renewable energy and putting the country on an unsustainable growth path.

Despite natural gas's technical flexibility, it is important for economic reasons that plants are utilized at levels that ensure that they are profitable. Closer analysis of the scenario results reveals that simultaneous investment in coal, gas, and renewables threatens to either limit the use of renewable energy or results in an underutilization of natural gas plants that would challenge their economic profitability. For example, simultaneous investment in fossil fuel technologies leads to lower capacity factors for many natural gas plants and to higher levels of load shedding for renewable energy plants, both of which hurt the economics of individual plants.

The Dominican Republic is in a good starting position to make such a transition a reality. The country does not face an immediate capacity problem: installed generation capacity (3,343 MW in 2012) exceeds peak demand (2,476 MW) and can supply enough electricity to meet annual demand. Moreover, although growing demand requires the construction of some additional plants, most conventional plants were built in the 1990s and 2000s and therefore will still be in operation for another 10–25 years. (See Table 5.3.)

Table 5.3 Number and Installed Capacity of Conventional Power Plants in the Dominican Republic, by Decade

	1960s/70s	1980s	1990s	2000s	2010s
Number of plants	4	3	9	13	5
Installed capacity (MW)	220.5	299	677.2	1,253.7	185.6

The country's existing investment plans for conventional energy would add more than 50% of currently installed capacity. Although new plants can further strengthen security of supply, particularly when older plants will need to be replaced, all scenarios have shown that it is sufficient for these additions to come online gradually. For a smooth integration, Worldwatch assumes that current projects will be built progressively until 2020. While recognizing the need for capacity additions, emphasis should now be on building a smart mix that reflects the government's long-term goals, including those outlined in the CCDP.[3] Renewables will be able to take on increasing system responsibilities, not only generating enough electricity to capture growing demand but also helping to replace older petroleum plants.

Under Scenarios 3a and 3b, a comparison of installed capacity with peak demand for the different generation technologies illustrates a high security of supply. (See Figures 5.5 and 5.6.) Installed capacity increases successively with growing shares of variable renewable energy because intermittent resources such as wind and solar do not produce constantly. The model estimates that an installed renewable capacity of 10,404 MW is required to meet annual demand in 2030. About 40% of petroleum plants are set to retire due to their age by then; however, as generation estimates in Figure 5.3 show, petroleum plants become redundant and therefore can be used as a backup reserve, offering important ancillary services and minimizing overall oil use.

By comparison, Scenarios 1 and 2 require new investments in conventional power. Given the age structure of existing plants, however, new conventional facilities would not be needed until the mid-late 2020s. By then, most renewable energy technologies are projected to be cheaper than coal, raising concerns about the economic attractiveness of Scenarios 1 and 2. (See Chapter 6.)

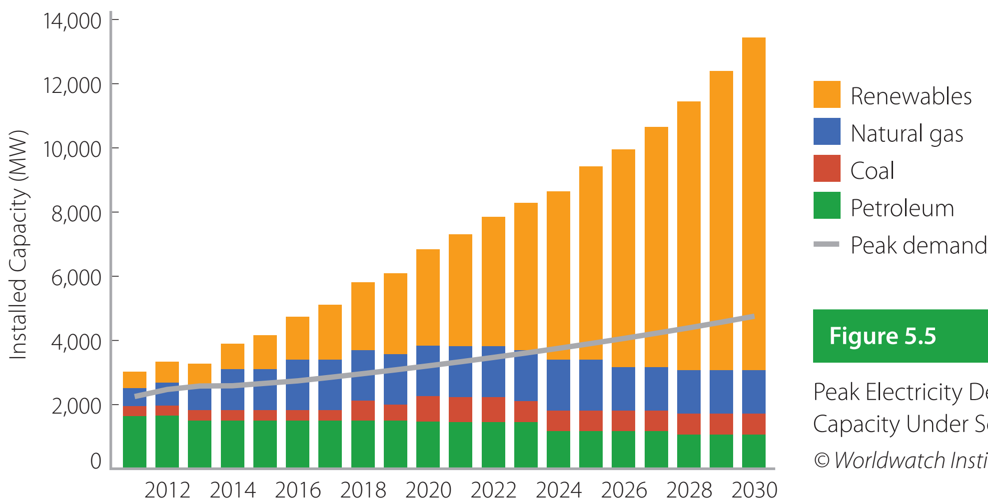

Figure 5.5

Peak Electricity Demand and Installed Capacity Under Scenario 3a

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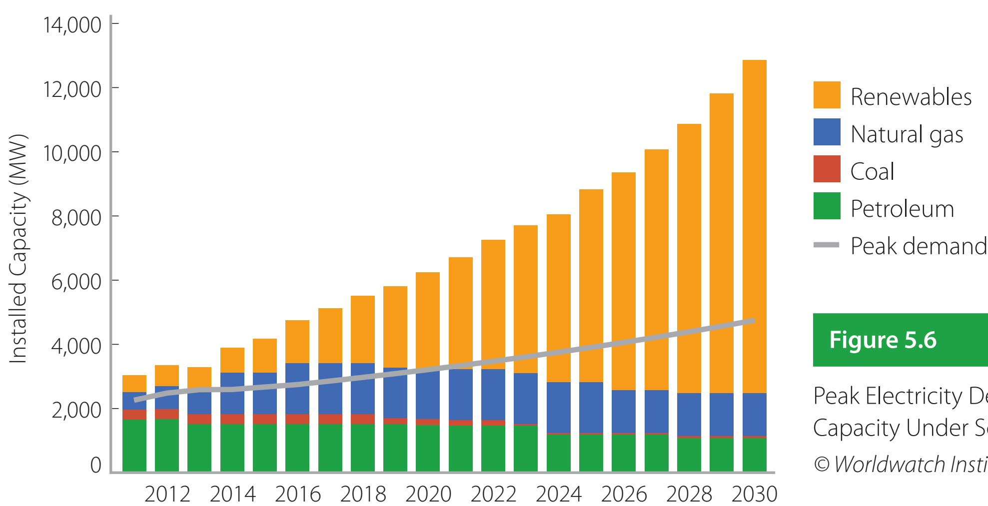

Figure 5.6

Peak Electricity Demand and Installed Capacity Under Scenario 3b

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Scenario 3 presents the manageable growth path for renewable energy in the Dominican Republic. (See Figure 5.7.) Projected installed capacities of solar (4,708 MW) and wind (4,205 MW) in 2030 are roughly similar and together amount to over 85% of total renewable capacity that year. Hydropower comprises most of the remaining renewable share, with the country needing to add just under 10,000 MW to its existing hydro capacity to achieve an 85% renewable share by 2030. The role of biomass-based generation is marginal.

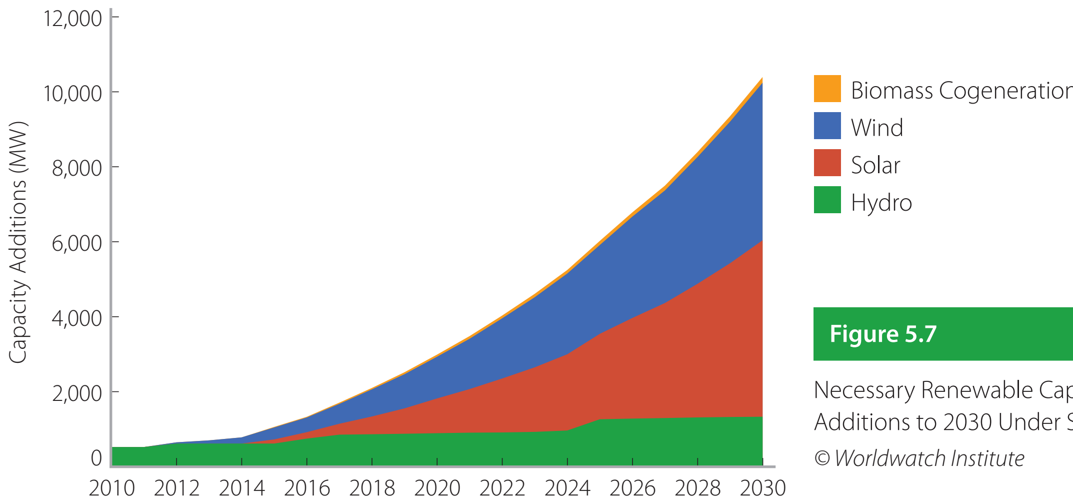

Figure 5.7

Necessary Renewable Capacity Additions to 2030 Under Scenario 3

5.4 Conclusion

This chapter has shown that a transition to a sustainable electricity sector based on an expanded use of renewables—up to 85%—is technically feasible in the Dominican Republic. Future demand can be met throughout the year using existing and planned natural gas plants in addition to renewables. Although rising energy demand will require further capacity additions, the country does not face an immediate capacity problem. Current plans for new conventional power amount to more than half of today's overall installed capacity, and Worldwatch recommends integrating these projects into the system over several years.

Natural gas-based generation technologies are best suited to accommodate expanding renewable energy use. Existing and planned natural gas plants give the Dominican electricity system the flexibility it needs to smoothly integrate intermittent renewable resources. Electricity produced by smaller natural gas plants can be dispatched very quickly in response to demand fluctuations throughout the day. The country already has natural gas infrastructure and can maximize its use.

Our scenario analysis challenges the need for tendering additional coal power. The construction of new coal power plants is redundant and will lock in a technology for the next 35 years that puts the Dominican economy on an unsustainable growth path. New coal power also will reduce the capacity of the electricity sector to integrate larger shares of renewable energy, and/or it will prevent an economically profitable use of natural gas plants.

Overall, Worldwatch believes that Scenario 3b is the Dominican Republic's preferable technological pathway to allow for a successful transition to an electricity system based on renewable energy. The government, however, is currently closest to pursuing Scenario 1.

6 | Assessing the Socioeconomic Impacts of Alternative Electricity Pathways

Key Findings

- The Dominican Republic's energy future lies in developing local resources to increase energy security, reduce fossil fuel import costs, decrease government debt from running the state-owned utility, lower electricity prices, reduce emissions, and create new jobs.
- Wind, solar, and biomass are local renewable resources that can be readily integrated into the Dominican electricity system and can decrease energy prices. These renewables have strong resource potential, making them cost-competitive generation options already today.
- Wind, biomass, and hydropower are the country's cheapest options for electricity generation. The costs of solar PV are below those of petroleum technologies, currently the country's biggest generation source.
- By 2030, the cost of renewable energy is expected to decrease further, to below 7 U.S. cents per kWh on average. The costs of new oil, natural gas, and coal-fired power plants are expected to be 27, 18, and 11 U.S. cents per kWh, respectively.
- Business as usual (BAU) is not a feasible energy expansion option for the country. Rising energy demand will increase the reliance on fossil fuels and make the economy increasingly susceptible to price shocks; meanwhile, already-high fossil fuel imports will place an even larger burden on economic progress. An expansion of renewables and diversification of the energy mix, in contrast, will have many positive socioeconomic impacts.
- Transitioning to an electricity system based largely on renewable energy can decrease the average cost of electricity in the country by almost 50%, from 14 U.S. cents per kWh in 2012 to 7.5 U.S. cents per kWh in 2030.
- Higher shares of renewables require higher investments but reduce the total cost of electricity generation. Our analysis shows that the country can save over USD 25 billion by investing in renewables, whereas continuing the status quo will cost some USD 70 billion to 2030, of which USD 52 billion is fuel costs alone.
- In addition to the significant economic benefits, a transition to renewables creates social benefits from job creation and reduced greenhouse gas emissions. With higher renewable shares, the country can create more than 12,000 new jobs, or 10,000 more than under BAU.
- The country can reduce annual emissions in the electricity sector by half by 2030 in comparison to today, saving an estimated 100 million tons of CO_2-equivalent versus BAU.

Although the Dominican Republic's natural resource endowment is very favorable to an expanded use of renewable energy (see Chapter 3), the country is failing to utilize this enormous potential and plans to invest further in coal and natural gas power. Petroleum-based power plants remain the largest generation source, fired by costly imported fuel. This high reliance on fossil fuel imports makes the country vulnerable to international oil price shocks, posing an economic burden for homes and businesses. With electricity demand projected to grow at an average of 4% annually through 2030, these economic costs will likely only worsen in the future.

The Dominican government is tasked with guiding the transition to a truly sustainable electricity system in order to ensure simultaneous security of supply, affordability, and environmental integrity. Given the country's projected demand growth and plans to add substantial additional capacity, it must make decisions now that will shape the energy sector for the coming decades. To aid the government in this planning process, this chapter explores the economic aspects of transitioning to a sustainable electricity sector. The chapter first presents comparative cost assessments of different electricity generation technologies, then expands this analysis by integrating the negative impacts of several externalities to offer a better picture of the full costs of these generation sources. After projecting future costs, Worldwatch evaluates macroeconomic impacts of the different technological pathways described in Chapter 5.

The chapter concludes that an accelerated expansion of renewable energy will bring important benefits to the Dominican economy. The country would save more than USD 30 billion in imported fuel costs, create 12,500 new jobs, save up to 137 million tons of greenhouse gas emissions, and reduce negative health effects from local pollution.

6.1 Analysis of the Levelized Costs of Electricity Generation

6.1.1 Methodology

Ideally, comparative cost assessments of different electricity generation options should go beyond the initial investment needs of constructing different technologies, and also include important variables such as operations and maintenance expenses as well as fuel costs. A useful tool for such assessment is "levelized cost of electricity" (LCOE) analysis, which calculates the price (per unit of electricity) required for the investment in an electricity project to break even over its useful life.[1] Helpful for energy sector planning, LCOE allows policymakers to compare—using one common measure—the costs of generation technologies that have different lifetimes, utilization rates, fuel costs, and operations and maintenance (O&M) needs.[2]

To estimate the LCOE for the Dominican power system, Worldwatch extended the Model for Electricity Technology Development (META) developed by the World Bank's Energy Sector Management Assistance Program (ESMAP). META is populated with common default values that are necessary inputs for estimating LCOE, but it also allows users to customize input data to calculate country-specific costs. Worldwatch modified the model to reflect the Dominican Republic's project- and country-specific performance characteristics and cost parameters and extended the time frame to 2030 to reflect a more appropriate planning horizon. We gathered extensive in-country data and drew on local conditions, including the resource assessments discussed in Chapter 3; local cost data for equipment, fuel, and labor;

as well as local performance data for plant efficiencies, capacity factors, and fuel quality. Worldwatch collaborated with local partners to ensure validity of the results.

META can be a useful tool for governments. In addition to comparing the economic attractiveness of different investment projects, its results can inform policymaking by showcasing the long-term effects of different fuel-cost developments, as well as likely cost reductions due to technological improvements and learning effects sparked by initial support instruments. META is also helpful for energy sector planning. Although it does not take an integrated energy system approach and is not an optimization model, it gives planners an accurate cost overview of different supply options that should be used along with other planning models to help policymakers and regulators make informed choices. (See Worldwatch's technical pathway assessment in Chapter 5.)

LCOE analyses are not financial assessments, however, and they exclude taxes and subsidies. Moreover, the model uses the social discount rate instead of the financial interest rate that is more relevant in investment decisions for loan-financed projects. Project-specific investment analyses therefore would require also including the costs of subsidies and incentives, as well as the costs of loans that can vary substantially depending on the project's technology and size as well as the type of investor. (See Chapter 7 for important aspects of financing renewable energy projects.)

6.1.2 LCOE Results

The LCOE for the various electricity generation options for the Dominican Republic shows that when the costs of capital, O&M, and fuel are factored in, renewable energy technologies already are competitive solutions for the country. (See Figure 6.1.) Although most conventional technologies tend to have lower overnight capital costs than renewables, their ongoing fuel costs make them a much more expensive option over their lifetime. This is particularly true when renewable energy sources are compared to petroleum-based technologies, which currently comprise 46% of the Dominican generation system yet are the most expensive supply option. Transitioning away from petroleum power plants should therefore be a priority for the government.

Biomass cogeneration, wind, and hydropower are the cheapest generation technologies available for new projects in the country, at less than one-third the cost of electricity from diesel generators and one-fourth that from oil combined-cycle. Wind power is widely feasible in many good locations and is a competitive alternative to coal or natural gas. Although solar PV is currently the most expensive renewable energy source, costs have fallen substantially in recent years. This trend is set to continue if the Dominican Republic can take advantage of economies of scale and learning curves as it expands its PV use. Moreover, expanding solar PV use could reduce overall system costs because during midday, PV would compete with petroleum-based generation, the country's most expensive generation technology. Using solar PV to replace electricity from diesel generators or oil combined-cycle would save the country at least 5 U.S. cents per kWh, depending on the size of the PV installation.

Electricity generation from bagasse offers another competitive renewable energy solution and should be utilized, although expansion is limited because the resource is available only during the harvest season.[3] An expansion of hydropower is also very cost-effective, and the country should tap into unused potential that does not compete with other uses of water.

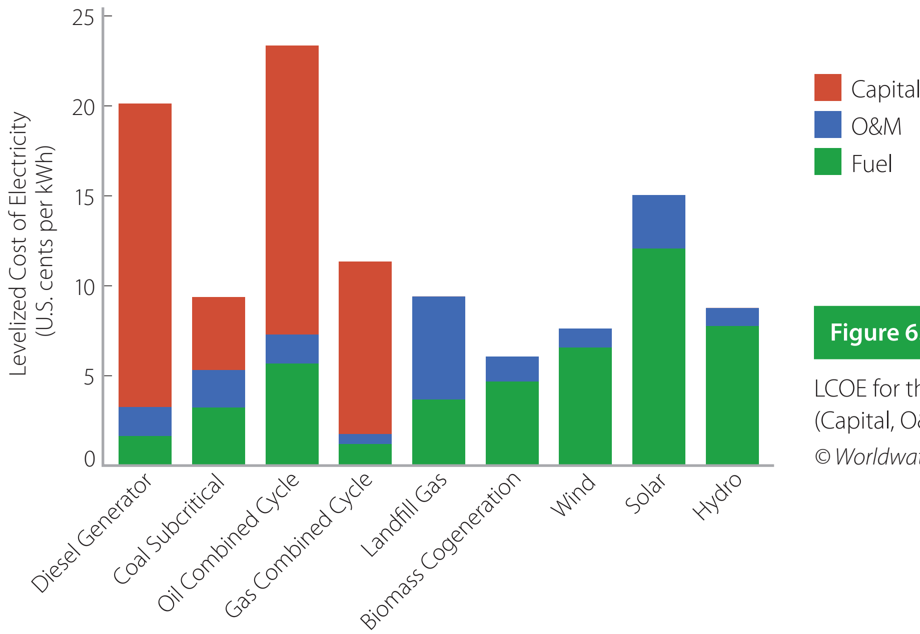

Figure 6.1

LCOE for the Dominican Republic (Capital, O&M, and Fuel Costs)

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Given the country's great renewable energy potential, new investments in oil-based generation are not advisable from an economic perspective. The comparatively small upfront construction costs of these plants are deceiving of the high lifetime costs. Fuel expenditures drive up costs considerably, making oil-based plants uncompetitive solutions that place a burden on national finances. Figure 6.1 distinguishes between base costs (overnight capital costs and fixed O&M costs) and fuel costs to highlight the importance of the latter.

Coal is the least expensive resource for fossil fuel-based generation, with comparatively low fuel costs and high utilization rates. But unlike natural gas and oil, coal can be used only for baseload generation and must be accompanied by additional flexible generation options. As shown in the technological pathways (see Chapter 5), an expansion of coal power would impede the energy system's ability to respond to intermittency and would likely limit the long-term overall share of renewables in the Dominican electricity sector. Natural gas is a much more suitable ally to renewables, and although it is more expensive than coal by 2 U.S. cents per kWh, it can decrease overall system costs by avoiding unnecessary curtailment of renewable energy and offering flexibility to react to short-term fluctuations in demand. Natural gas plants have the lowest initial investment costs aside from diesel generators; however, the ongoing fuel costs are what largely determine the cost of gas-based power.

Given the Dominican Republic's remoteness as an island nation, natural gas must be imported in its liquefied form (LNG), which requires storage and regasification facilities. In comparison to most neighboring islands, because the country has one of the largest economies in the region and an intact gas import infrastructure, it serves as an export market for gas-rich Trinidad and Tobago. The United States, which is exploring the possibility of increased LNG exports, also could potentially export gas to the Dominican Republic in the future. If such market entry were to happen, LNG prices would likely decrease or remain the same in the Caribbean region. In its LCOE analysis, Worldwatch assumes an LNG import price of USD 12.74 per million Btu.

When deciding on the most cost-effective option for expanding generation, the Dominican government should take into account additional infrastructure costs. Although new transmission lines and substations likely will be needed for large-scale renewable energy projects, the costs are relatively low compared to infrastructure costs on the generation side. Moreover, the country's aging electricity grid requires repair, renovation, and upgrading anyway. Small-scale renewable generation technologies, used for distributed generation, do not need additional transmission lines, making them an attractive option for household use or for communities located farther from existing grid infrastructure.

Even under optimistic fossil fuel price assumptions, renewable energy sources—particularly wind power—already offer a competitive alternative to conventional generation that could shield the Dominican Republic from uncertain import prices and serve as a price hedge from international market price volatility.

6.2 LCOE+: Assessing the Full Costs of Alternative Electricity Sources

6.2.1 Methodology

The standard LCOE analysis, discussed above, offers policymakers a useful tool for energy sector planning as well as important information about what policy priorities can be developed. Energy sector decisions should not focus on generation costs alone, however, but rather should reflect a more holistic assessment that includes additional costs to society—so-called externalities—such as negative health effects caused by local emissions of pollutants like particulate matter (PM), sulfur oxide (SO_x), and nitrogen oxide (NO_x).[4] This is particularly relevant for emerging or developing countries like the Dominican Republic, where health care is often a luxury good and where generation technologies often lack the latest environmental control equipment.

In this analysis, Worldwatch has attempted to assess the true costs of electricity generation in the country using an "LCOE+" approach to quantify some of these additional negative effects on society. To offer a more transparent measure of the costs of different generation technologies, we have added damage values in U.S. cents per kWh for the most important negative impacts, on top of the standard LCOE values calculated in Section 6.1. This allows for a renewed look at the competitiveness of different technologies from a wider societal point of view.

ESMAP's META model is again helpful because it allows for the integration of costs caused by local pollution and climate change. Users can assign input values for the costs of carbon in USD per ton of CO_2-equivalent and for the damages caused by emissions of SO_x, NO_x, and PM, measured in USD per ton. Based on the type and quality of fuel as well as plant efficiency, the model then attaches additional costs to LCOE estimates. Worldwatch has built on this feature to offer the Dominican Republic a more holistic assessment of the real costs of different generation technologies, highlighting societal costs that usually are not integrated in market prices. In doing so, we conducted extensive literature reviews to assign values for climate as well as pollution costs.

6.2.2 Costs of Local Pollutants

Local air pollutants that are emitted during combustion processes—such as SO_x, NO_x, and PM—can have adverse effects on human health, agricultural productivity, materials, and visibility. Depending on the age and efficiency of power plants, electricity production can contribute substantially to harmful emission concentrations near these plants. Expanding fossil fuel-based generation will only increase local air pollution, further deteriorating the environment and posing an economic burden to major economic sectors such as agriculture and tourism.

Pollution levels are at dangerous levels in certain parts of the Dominican Republic. The highest levels of atmospheric contaminants are in Haina, where nearby power plants produce some 40% of national electricity, including from coal and fuel oil.[5] Haina is also the country's most important industrial port as well as the site of an oil refinery and a battery recycling industry; overall, some 109 industries emit atmospheric contaminants in the city. Haina reached international fame when the Blacksmith Institute voted it one of the "world's worst polluted places" in 2007.[6]

Worldwatch's goal through LCOE+ analysis is to better illustrate environmental externalities of electricity generation that currently are not being reflected in market prices. The most precise approach would be to conduct site-specific assessments that evaluate in detail factors such as the expected dispersion of pollutants from a particular plant, the increase in pollutant concentrations, and the stress on the local environment given specific ecoystem characteristics; however, these analyses tend to be extremely cost, time, and data intensive. Yet it is possible to draw general conclusions about pollution costs from electricity generation based on key inputs such as the technology and fuel used, the age of the plant, the existence of pollution control equipment, and a country's income and population density.

Efforts to quantify and internalize the negative impacts of electricity generation reach back more than 30 years.[7] Putting a monetary value on damages has proven challenging at times. The causal links between pollutant concentrations and health impacts are still being studied, creating uncertainties; and, although human life depends on the services that ecosystems provide, the benefits of specific conservation efforts are only partially measurable. Moreover, attaching a certain value to human life can significantly alter the results and has tremendous ethical repercussions. Despite these difficulties, progress has been made on the research front.[8] For its estimates, Worldwatch employed a second World Bank model developed specifically to evaluate pollution damage in developing nations.[9] We adapted the model for the Dominican Republic, with adjustments for income and population, and incorporated it into the LCOE to evaluate the damage costs of local pollutants per unit of energy generated.

6.2.3 Costs of Global Climate Change

In addition to releasing local pollutants, fossil fuel-based power generation is one of the greatest emitters of greenhouse gases, contributing to human-induced climate change. Global impacts of climate change include increasing temperatures, more-frequent heat waves, higher sea levels, more drought-affected areas, and increased storm intensity.[10] The severity of these impacts varies by region, but Caribbean islands are believed to be among the most vulnerable.[11] The most significant consequences for small-island states are likely to be related to changes in sea level, given the coastal locations of most of the economic activity, infrastructure, and population. The Dominican Republic, like most island nations, is likely to also suffer from changes in rainfall, soil moisture, and prevailing wind patterns.[12]

Carbon dioxide and the other greenhouse gases are global pollutants whose impact is independent of the point of emission. A specific point source in the Dominican Republic, such as a power plant, contributes to global warming, but it cannot be made solely responsible for negative regional impacts. Thus, a ton of CO_2 emitted in the Dominican Republic has the same negative effect on the country as a ton emitted in the United States, China, or Saudi Arabia. To integrate the costs of climate change into its LCOE+ analysis, Worldwatch assumed a global carbon cost of USD 100 per ton of CO_2-equivalent. Although at the upper-mid range of existing estimates, this value is in line with prominent economic research, and also arguably better represents new findings about the severity of climate change's negative impacts.[13]

Despite the global nature of climate change and the historic responsibility of industrialized countries to reduce their emissions, the Dominican Republic's potential for emission reduction is significant from a regional perspective. In 2009, the country had the second highest CO_2 emissions of 15 Caribbean nations.[14] (See Table 6.1.) While this is largely a result of the size of the economy, a transition to renewables can shift the country to a climate-compatible growth path that allows and enables further economic expansion while reducing the economy's impact on the global climate.

The inclusion of climate change costs in the Dominican Republic's LCOE is not intended to imply that its population should cover these costs. The goal is rather to change policymakers' perception of the completeness of conventional cost assessments, to illustrate the potential economic burden that climate change poses to the Dominican economy, and to heighten awareness of the opportunities that alternative energy sources bring for putting the country on a climate-compatible development path.

Table 6.1 Emissions Intensities of 15 Caribbean Countries, 2009

Country	CO_2 Emissions
	kilotons
Trinidad and Tobago	52,069
Dominican Republic	**20,640**
Jamaica	9,557
The Bahamas	4,734
Suriname	2,335
Haiti	2,103
Guyana	1,672
Barbados	1,442
Antigua and Barbuda	732
Belize	536
St. Lucia	425
St. Kitts and Nevis	303
Grenada	269
St. Vincent and the Grenadines	199
Dominica	142

Source: See Endnote 14 for this chapter.

6.2.4 Results

A more holistic LCOE+ assessment of the costs of different generation technologies—which includes the environmental costs from both local air pollution (PM, SO_x, NO_x) and climate change (CO_2, nitrogen dioxide, methane)—highlights some of the benefits of renewable resources that normally are not captured in market prices. Since societies must bear the costs of local pollution and a changing climate, the data provide a pressing argument in favor of a transition toward clean energy alternatives. (See Figure 6.2.)

Given the Dominican Republic's population density, local pollution threatens to damage the health of populations living in the vicinity of power plants. The model estimates particularly high costs for PM emissions. The analysis indicates that petroleum-based power has significant impacts, raising the cost of generation by about 10 U.S. cents per kWh for diesel generators and oil combined-cycle plants, due in part to the high sulfur and particulate content of heavy fuel oil.

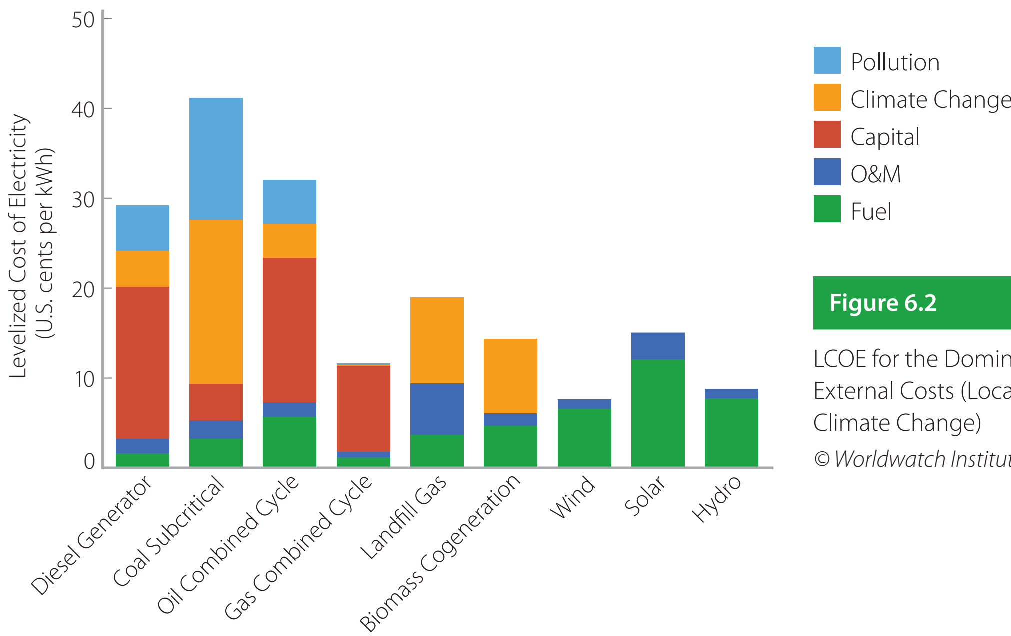

Figure 6.2

LCOE for the Dominican Republic with External Costs (Local Air Pollution and Climate Change)

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From a global climate perspective, coal use is particularly carbon intensive and therefore has the greatest effect on global warming. Natural gas has low pollutant concentrations and is also less carbon-intensive than any of the other conventional technologies. Combined-cycle technology is the most efficient form of thermal power generation.

Overall, the LCOE+ analysis offers a new view on the competitiveness of different electricity generation sources. Coal power becomes more than 30 U.S. cents per kWh more expensive than its conventional estimates and now costs more than 40 U.S. cents per kWh. The generation cost of diesel generators nears 30 U.S. cents per kWh, and that of oil combined-cycle generation nears about 31 U.S. cents per kWh. Natural gas is the only conventional fuel that retains some level of competitiveness, with its costs increasing only marginally.

The cheapest generation sources are wind and hydro. Generating 1 kWh of wind power is less than one-seventh the generation cost of coal plants and around one-sixth that of diesel generators and oil combined-cycle plants. Solar PV is substantially less expensive than all conventional power apart from natural gas. It is about half the price of oil combined-cycle generation and more than 25 U.S. cents below coal generation. Bagasse-based generation is less competitive compared to other renewable energy sources because it can cause significant local pollution.

The conclusions from this analysis change very little if only the costs of local pollution are added. Health-related pollution costs, particularly those caused by coal and petroleum-based generation, make these technologies highly undesirable from a societal point of view. Moreover, it should be emphasized that these findings are conservative. The World Bank model that is utilized to determine pollution costs in developing countries ignores key impacts, evaluating only the effects on human health, visibility, and soiling of buildings. More-comprehensive studies of developed countries have evaluated the effects of local pollution on variables such as agriculture, forests, fisheries, recreation, tourism, habitat, and biodiversity.[15] Further research on pollution costs in developing countries is therefore recommended to extend the LCOE+ work.

6.3 LCOE Projection: The Future Costs of Electricity Generation

6.3.1 Methodology

Chapter 5 of this report assesses the technical feasibility of transitioning to a Dominican electricity sector based almost entirely on renewable energy by 2030. Analyzing the socioeconomic impacts of such a transformation demands looking beyond current generation costs (see Sections 6.1 and 6.2) and assessing likely cost trends in the future. These can then be used to further analyze macroeconomic impacts such as clean energy investment needs and/or changes in fossil fuel import costs (see Section 6.4).

Although it is impossible to predict future energy prices accurately, analysts can make projections based on current available information and qualified assumptions. In this report, Worldwatch uses its LCOE estimates as a basis from which to extrapolate cost developments for different generation technologies. We assume that future base costs for thermal and hydropower generation will remain very similar to today's levels, in line with the U.S. Department of Energy's cost database.[16] We also assume that the costs of wind and solar PV will decline further, as indicated by the International Renewable Energy Agency's (IRENA) cost analysis series.[17] And we assume that fuel prices overall will increase in real terms from 2010 to 2030, as projected in the U.S. Energy Information Administration's *Annual Energy Outlook*—with the largest increases seen in the price of oil.[18]

6.3.2 Results

Based on these assumptions, Figure 6.3 projects the LCOE for various electricity generation technologies in the Dominican Republic to 2030. By 2020, all renewable energy technologies are projected to be cheaper than fossil fuel-based power. Solar PV experiences the sharpest cost reductions and becomes cost-competitive with coal and natural gas in 2015, overtaking biomass, wind, and hydro as the least-expensive form of electricity generation by 2025. The cost of generation using bagasse cogeneration is projected to stay the same, as the technology is believed to have reached maturity. If other biomass resources such as rice husk or coffee pulp are used in the future, the costs of biomass cogeneration could be altered by rising costs for biomass feedstock. Among fossil fuels, coal is projected to be the cheapest generation option in 2030 because of abundant global reserves; however, its costs are still higher than those of renewables.

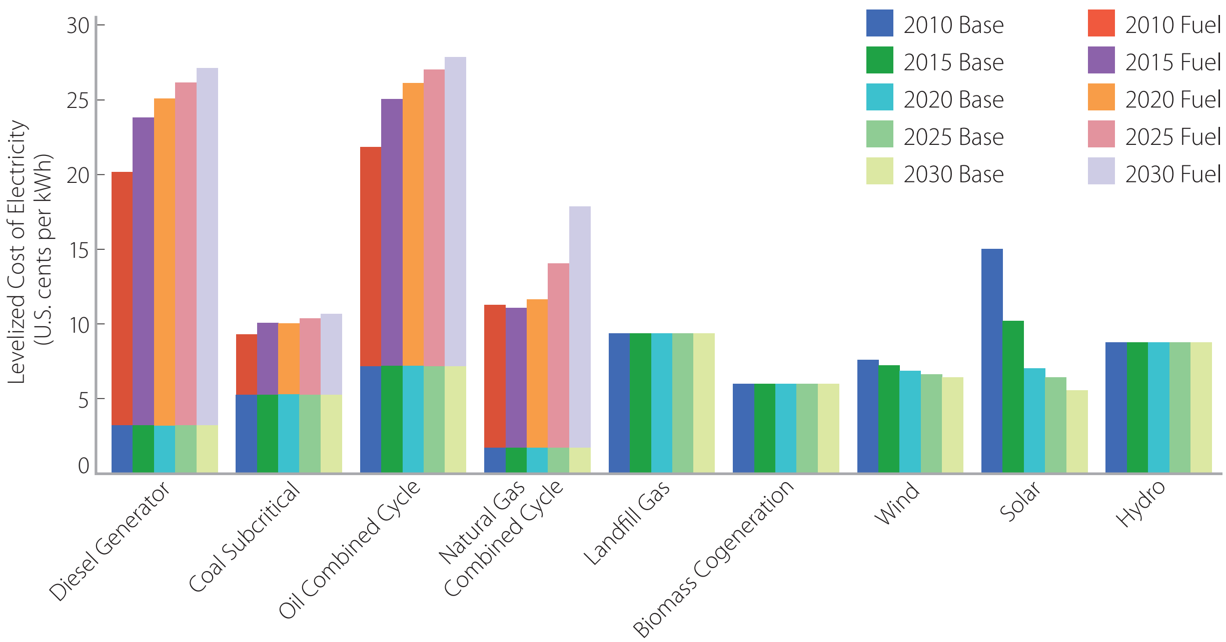

Figure 6.3

Dominican Republic LCOE Projection to 2030, by Technology © *Worldwatch Institute*

Figure 6.3 also shows that a continued reliance on oil-based power generation threatens to challenge the Dominican Republic's economic success by burdening industry and households with electricity price increases to cover rising generation costs. Oil-based generation is not currently cost-competitive with any other form of electricity generation in the country, nor will it be in the future. These LCOE results are sensitive to new developments, including the emergence of new technologies and the discovery of new natural resources. Given currently available information, however, an expansion of renewable energy is a good price hedge against volatile and rising fossil fuel prices, and over time it becomes the most economical electricity option.

6.4 Macroeconomic Impacts: Benefits of a Transition to Renewable-Based Electricity Systems

Rebuilding an energy system based on renewable energy will have economic impacts. The following sections apply the findings from the LCOE results to the different technological pathways outlined in Chapter 5 in order to assess their potential economic impacts. Although opponents often argue that an expansion of renewables poses an economic burden, the quantitative analysis in this chapter shows the exact opposite for the Dominican Republic: that a system based largely on renewable energy can reduce average and total electricity costs, save the country much-needed public funds on avoided import fuel costs, and create new jobs in the energy sector.

6.4.1 Falling Costs of Electricity Generation

The Dominican government currently subsidizes electricity prices to protect consumers from the high costs of electricity generation that result primarily from importing oil. Yet this support measure puts pressure on public funds and is no longer sustainable. Unless electricity generation costs can be lowered, the country will face significant economic pressure and two equally unsatisfactory and unviable solutions: either the government will have to further accumulate debt to finance electricity consumption, or it will have to charge consumers significantly higher rates, which would be very unpopular with ratepayers.

A look at generation costs to 2030 is therefore a good proxy for possible developments of future industry and household electricity prices or accumulating government debt. Figure 6.4 shows the average LCOE in 2030 for the different Worldwatch scenarios presented in Chapter 5. The average cost of electricity is calculated using projections of LCOE estimates (see Section 6.3) as well as annual generation and utilization rates (see Chapter 5) from each generation source.

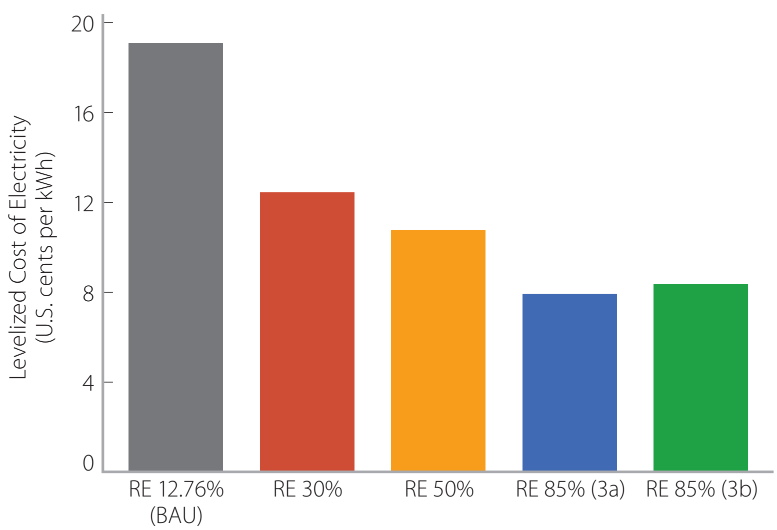

Figure 6.4

Average LCOE in 2030 Under All Scenarios

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Figure 6.4 shows a clear trend: that continuation of the status quo is more expensive than any of the outlined transition scenarios. This is largely a result of projected rising oil prices. Moreover, as the costs of renewables decline and fall below those of conventional power, the average cost of electricity will decrease with growing renewable energy penetration. The average LCOE is therefore lowest in Scenario 3, at around 8 U.S. cents per kWh. Costs are slightly lower in Scenario 3a than in Scenario 3b due to a greater share of coal versus natural gas power (the assessment here does not take into account the costs of operating natural gas plants below optimal levels in 3a).

Overall, an expansion of coal and/or natural gas power can have a price-dampening effect in comparison to a continuation of the status quo. As the costs of all renewables fall below that of coal power, however, generation costs are much lower in scenarios with a greater reliance on renewable power than in those with greater shares of coal or gas. (See Figure 6.5.)

These results are susceptible to changes in fuel costs, which may lead the price differentials among the scenarios to increase or decrease. Overall, however, the graphs show that an accelerated transition to renewable energy pays off. Greater shares of renewables have the potential to nearly halve the current cost of today's electricity system, and therefore leave room for substantial tariff reductions for the Dominican economy and population.

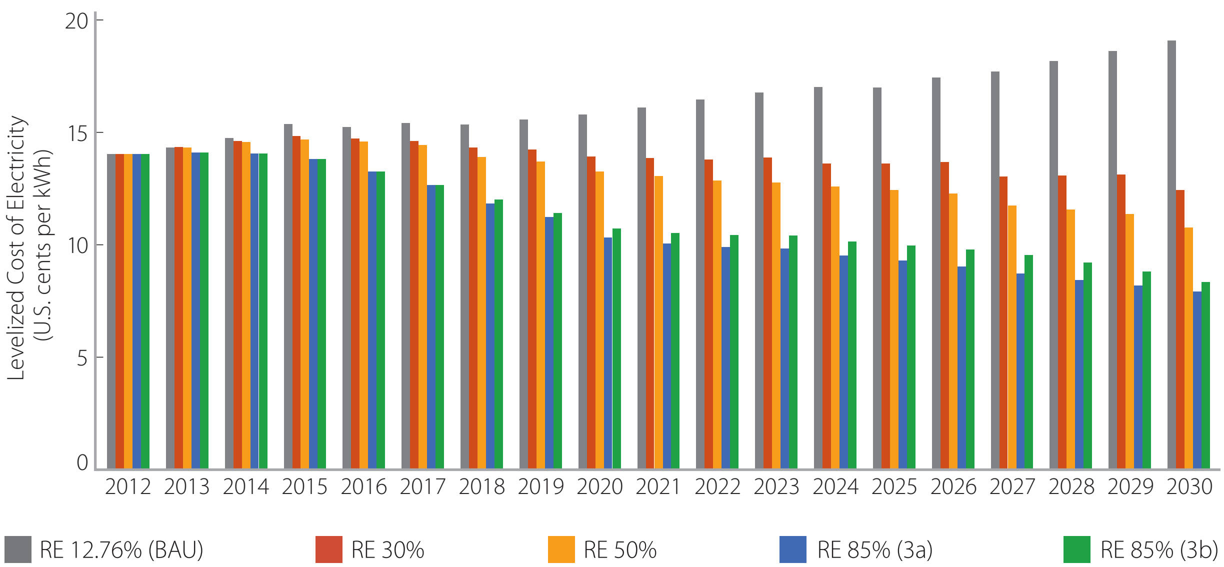

Figure 6.5

Annual Average LCOE to 2030 Under All Scenarios © *Worldwatch Institute*

6.4.2 Saving Billions on Reduced Fossil Fuel Imports

Transitioning away from a fossil fuel-based power system can save the Dominican Republic significant financial resources that can instead be invested in renewable energy and other aspiring economic sectors, as well as help to balance the budget. The country spent USD 4.4 billion on fossil fuel imports in 2013, or more than 7.3% of GDP.[19] By subsidizing electricity rates, the government benefits consumers but increases public debt. Without reform, fossil fuel import reliance is set to increase due to rising fuel needs in the electricity sector, further burdening the country's finances and industry and decreasing energy security. Growing energy demand and rising fossil fuel prices threaten to become an economic and security disaster.

In the BAU scenario, annual import costs in the electricity sector are set to increase from USD 1.5 billion in 2012 to USD 4.8 billion in 2030. A switch to renewable energy can substantially reduce this import reliance, to as low as USD 600 million annually by 2030. Figure 6.6 shows the cumulative costs for fossil fuel imports under Worldwatch's transition scenarios. The graph also shows fuel costs savings of the different scenarios versus BAU. Fuel imports under BAU add up to nearly USD 52 billion by 2030; a switch to renewable energy can save the country over USD 30 billion in foregone fossil fuel imports within the same time period. This savings is set to grow even further beyond the 2030 time frame assessed in this study.

Overall, the analysis illustrates the enormous savings that the Dominican Republic can reap through an ambitious switch to renewables. The results could change, however, with new information about fossil fuel price trends. A continued shale gas revolution could reduce gas prices globally, although this will not likely significantly alter the attractiveness of an ambitious shift to domestic renewables. Given the Dominican Republic's enormous and cheaply available renewable resources, lower-priced natural gas is unlikely to outcompete renewables but is likely to become an even more attractive alternative to coal.

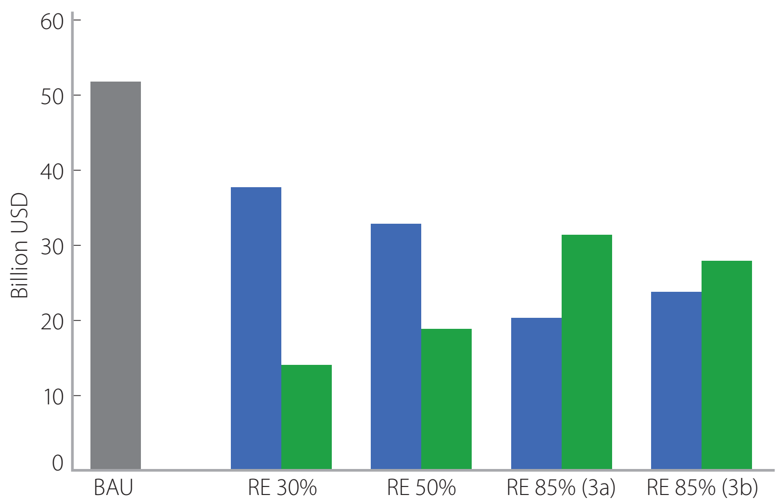

Figure 6.6

Cumulative Fuel Costs and Savings to 2030 Under All Scenarios

6.4.3 Investment versus Total Cost of Electricity: Upfront Costs But Long-term Savings

When analyzing the economics of the different technological pathways (see Chapter 5), it is also useful to compare total investment needs and the total cost of electricity generation. Investment needs are a measure of the initial capital requirements to transform or modernize an energy system. Analyses of the total cost of electricity generation look beyond the investment needs and also take into account O&M costs, including total fuel costs. Unlike the average LCOE for specified years, total cost of electricity estimates are an aggregate of electricity costs over a defined period.

Figure 6.7 shows that, by 2030, the total annual cost of electricity generation would increase sharply under BAU. The Dominican Republic also would face a near doubling of costs under Scenario 1. Greater shares of renewables, meanwhile, can keep the costs of electricity generation stable relative to today's levels through 2030, as in Scenario 3.

Figure 6.8 shows the total cumulative investment required for building up necessary capacities in all scenarios. It also shows the total cost and savings versus the BAU scenario of electricity generation until 2030. The estimate assumes that investment includes only the overnight capital cost required to meet demand, and ignores both interest during construction and project contingencies. The cost of electricity

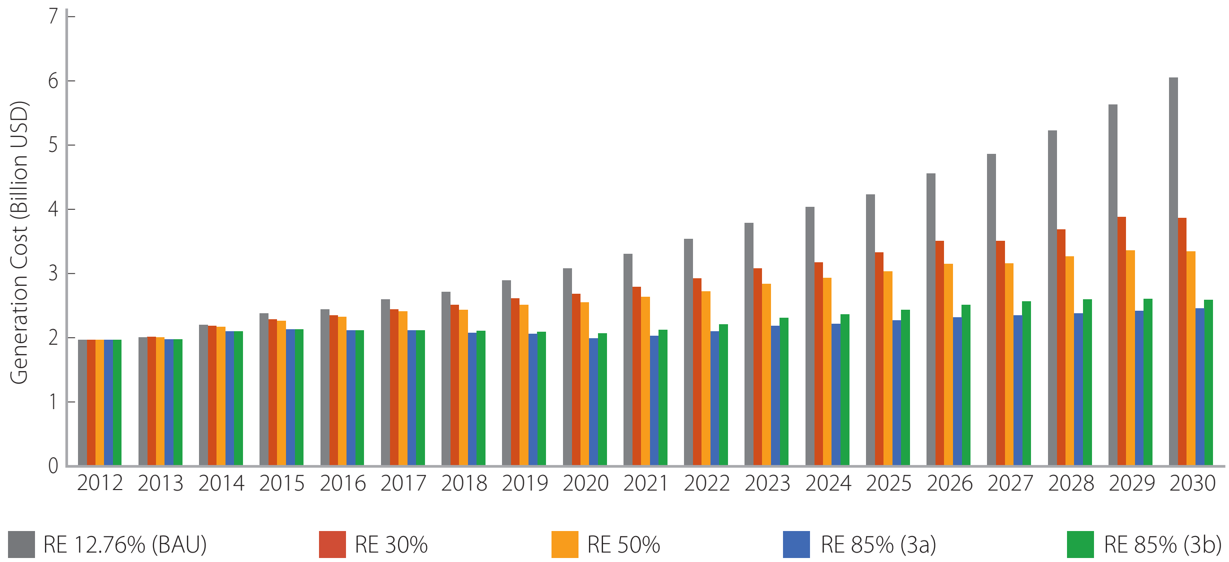

Figure 6.7

Total Annual Cost of Electricity Generation to 2030 Under All Scenarios

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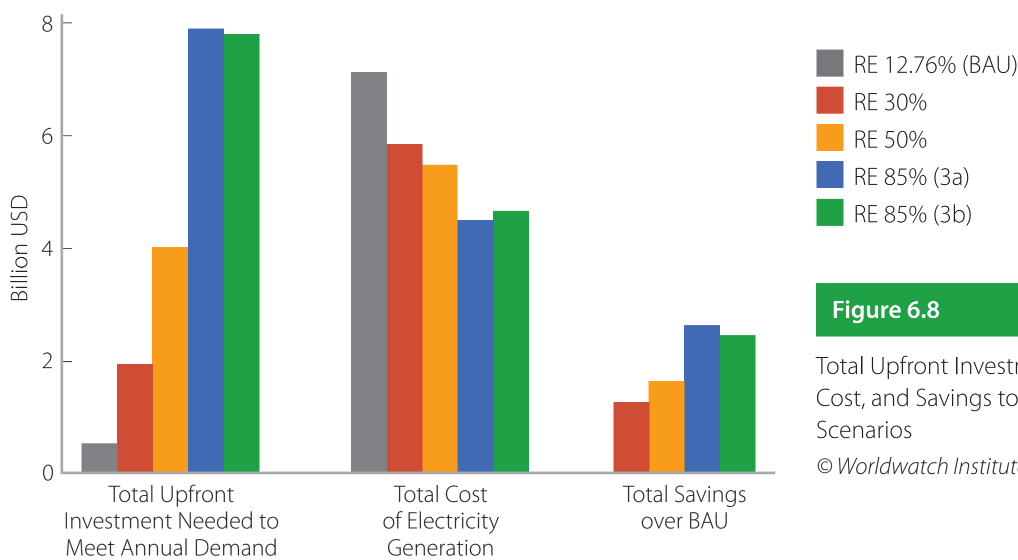

Figure 6.8

Total Upfront Investment, Generation Cost, and Savings to 2030 Under All Scenarios

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generation comprises the total levelized cost of electricity production and therefore has the same assumptions as the LCOE analysis.

Figure 6.8 shows that the BAU scenario requires the lowest investment but is the most expensive form of electricity generation due to rising oil prices. All scenarios share the result that increasing renewable energy penetration requires more investment but also yields greater savings over BAU. Building up enough renewable energy capacity to power 85% of Dominican electricity would require investments of around USD 78 billion; investment needs are about USD 1 billion lower in Scenario 3b than in Scenario 3a, as Scenario 3b assumes that the country foregoes building two big coal plants.

While such investments seem challenging, implementing a largely renewable-based energy system could in the long term save the country more than USD 25 billion versus BAU by 2030. Moreover, a share of 85% renewable energy by 2030 compares favorably to scenarios with lower penetration of renewables. Scenario 3 would save the country at least USD 12 billion by 2030 compared to Scenario 1, and around USD 8.5 billion compared to Scenario 2.

As the solar and wind industries mature, progressively more markets are being served. A growing number of developing countries, such as Kenya, Morocco, and South Africa, are attracting renewable energy finance in rapidly increasing amounts.[20] The development of a similar investment climate could put the Dominican Republic on a path to a clean electricity sector. Investors are increasingly seeking opportunities in developing countries with good natural resources and stable policy environments. It is in the power of local policymakers to help attract the necessary financial resources for a successful transformation of the Dominican electricity sector. Chapters 7 and 8 explore how the country can access more finance and what policy frameworks are helpful in attracting domestic and international investors.

6.4.4 Greenhouse Gas Emissions Savings

Meeting rising electricity demand with a continued reliance on conventional power sources will increase the Dominican Republic's greenhouse gas emissions. Only an ambitious growth of renewable energy can prevent an increase in emissions over today's levels. Of the various transition scenarios, Scenario 3b results in the greatest savings, with annual CO_2-equivalent emissions from electricity generation dropping to about a third of current levels. (See Figure 6.9.)

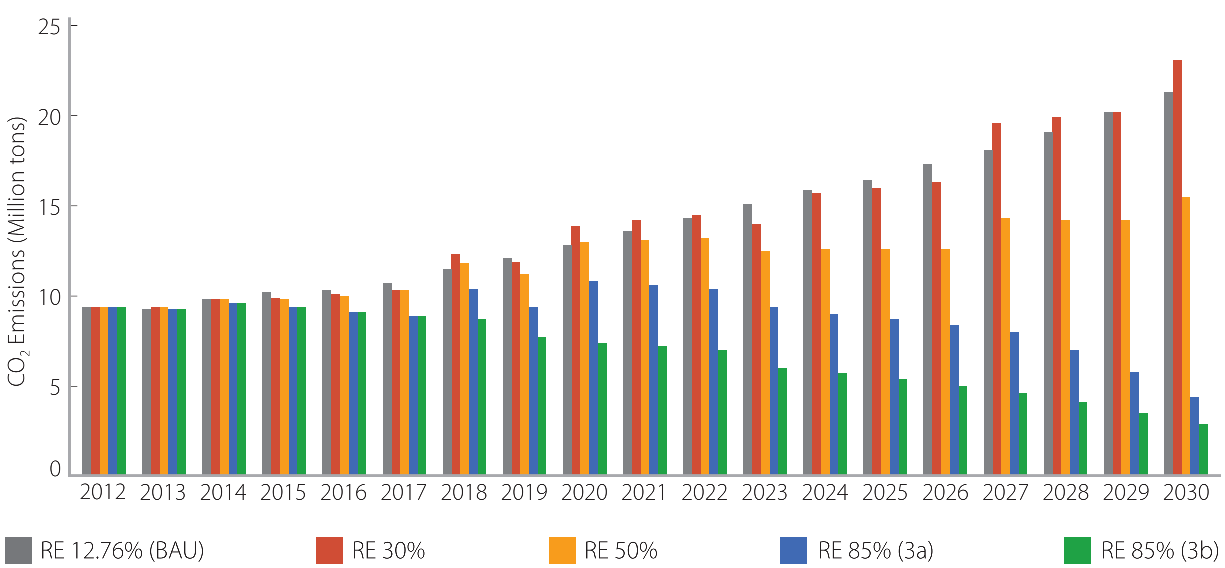

Figure 6.9

Annual Greenhouse Gas Emissions to 2030 Under All Scenarios *© Worldwatch Institute*

Figure 6.10 shows the projected cumulative electricity sector-related greenhouse gas emissions (CO_2, nitrous oxide, and methane) for the different scenarios. Scenario 3b has the greatest total emission savings versus BAU, at around 137 million tons of CO_2-equivalent by 2030. By comparison, the Dominican electricity sector is projected to release some 9 million tons of CO_2-equivalent emissions in 2013. Emission savings versus BAU therefore would amount to more than 15 years of current electricity sector annual emissions. Scenario 3a saves around 100 million tons of CO_2-equivalent compared to BAU, or more than 11 years of current annual emissions.

These results illustrate the role of coal in driving emission increases. For example, emission projections for Scenario 1 marginally exceed BAU estimates, and results for Scenario 2 indicate that a 50% renewable energy share cannot lead to substantial emission reduction savings if combined with new coal power investments. Investing in new coal plants therefore would put into question the Dominican Republic's commitment to mitigating climate change.

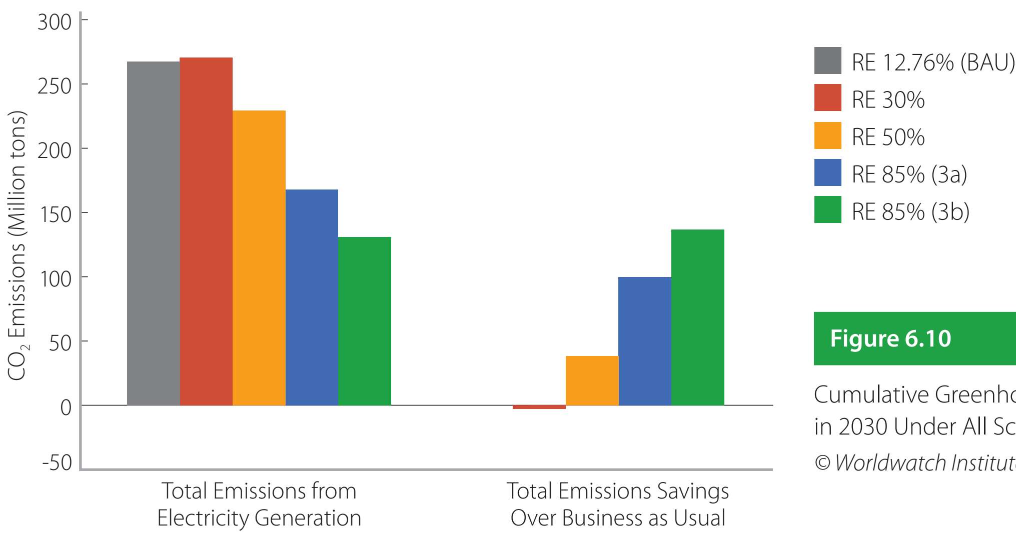

Figure 6.10

Cumulative Greenhouse Gas Emissions in 2030 Under All Scenarios

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6.4.5 Job Creation

A tangible economic benefit from investment in renewable energy is new job creation. New jobs can include direct jobs in the energy sector's core activities, indirect jobs in sectors that supply the energy industry, and induced jobs that are created when wealth generated by the energy industry is spent in other sectors of the economy.[21]

Direct jobs in electricity generation projects are generally divided into two categories: construction, installation, and manufacturing (CIM); and operation and maintenance (O&M).[22] (See Figure 6.11.) CIM jobs typically are concentrated in the first few years of setting up an energy facility, whereas most O&M jobs exist for the lifespan of the installation. To estimate long-term job creation, CIM jobs can be averaged out over the expected lifetime of new projects. In general, renewable power plants are more labor intensive than conventional power plants.[23] (See Figure 6.12.)

Indirect and induced employment opportunities are more difficult to quantify and therefore are excluded from the analysis that follows. Nonetheless, they can be significant. Indirect jobs are positions created

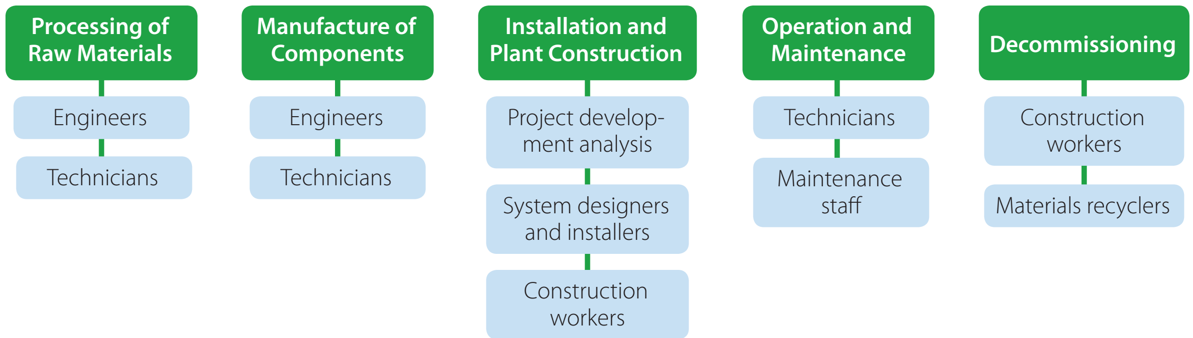

Figure 6.11

Direct Jobs in the Power Plant Lifecycle Value Chain

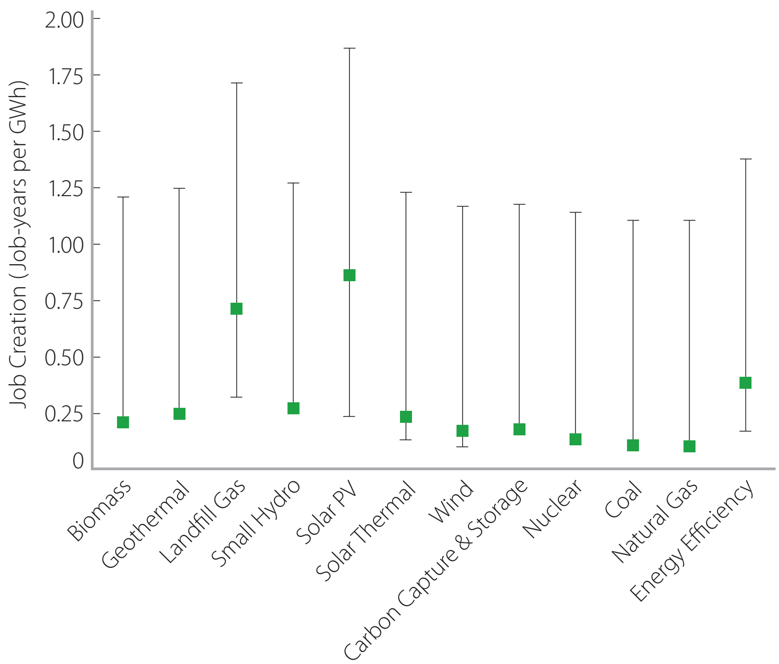

Figure 6.12

Global Job Creation Estimates for Various Power Generation Sources

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throughout the supply chain based on the increased demand for materials and components required for energy equipment. Induced jobs are the jobs created as the salaries earned in the direct and indirect jobs in the renewable value chains are then spent on a range of goods and services in the wider economy. The increased spending from the renewables jobs creates and supports induced jobs. In addition, reliable and affordable access to energy allows for investments in new local businesses, which bring additional revenue, incomes, and jobs.

Job Creation Estimates and LCOE

Figure 6.13 compares the job creation estimates of different power generation technologies with the LCOE for each technology examined. Wind and hydro are not only less expensive than coal and natural

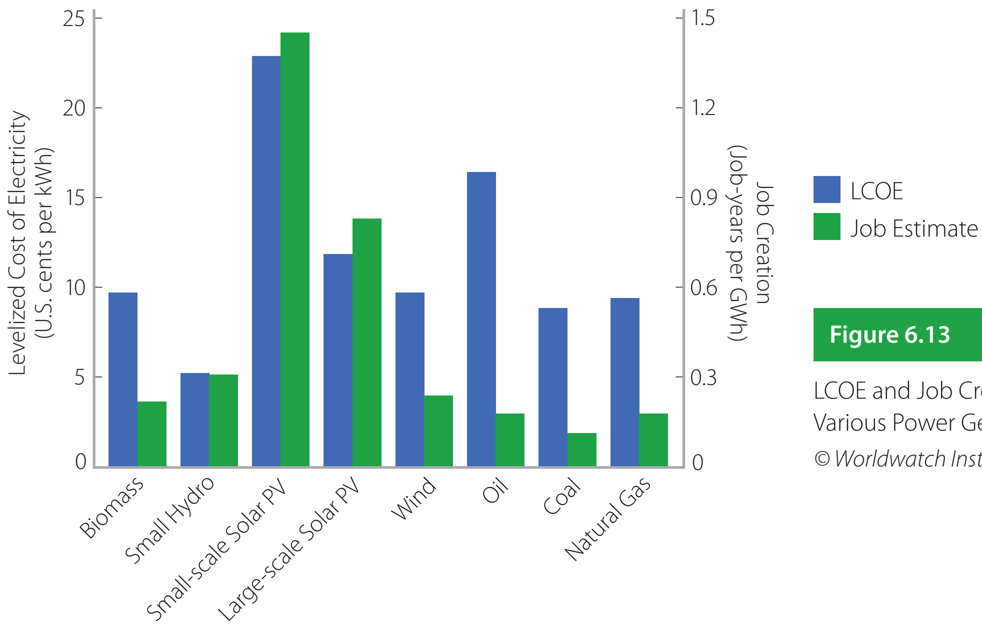

Figure 6.13

LCOE and Job Creation Estimates for Various Power Generation Sources

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gas, but also create more employment per GWh of generation. Solar PV is slightly more expensive than other renewable technologies but has the potential to create the highest number of jobs. Biomass also has the potential to create more jobs than either coal or natural gas.

Model Methodology

To assess the employment impacts of the different scenarios, we used a simple but thorough methodology developed by Wei, Patadia, and Kammen (WPK) to estimate the number of jobs created in the Dominican Republic according to electricity demand and the composition of the generation mix.[24] The model is derived from a meta-analysis of 15 job creation studies, which report employment within a specific energy sector using a top-down or bottom-up approach. From this meta-analysis, the model produces direct job multipliers per unit of energy that can be applied to an electricity scenario with a specified generation mix.

It is important to note that assumptions in the WPK model can lead to uncertainties in job creation estimates. Because the model assumes that transmission and distribution are unconstrained, job impacts from developing transmission lines and pipelines are not captured. Import leakage can lead to decreased local employment but is not considered in the model. In addition, technology or product improvements can lead to lower job requirements but are not accounted for in the model.

We applied the WPK model to the three electricity scenarios elaborated in Chapter 5 to determine the cumulative number of local jobs (employment that occurs within the Dominican Republic) created by 2030 in each scenario. (See Figure 6.14.) The BAU scenario creates the lowest level of employment because the current electricity system is not labor-intensive. As the share of renewables in the electricity system increases, however, the level of employment rises with the increasing use of labor-intensive technologies. Under Scenario 3, with 85% renewable energy penetration, the Dominican Republic has the opportunity to create more than 12,500 new jobs in the electricity sector. (See Figure 6.15.)

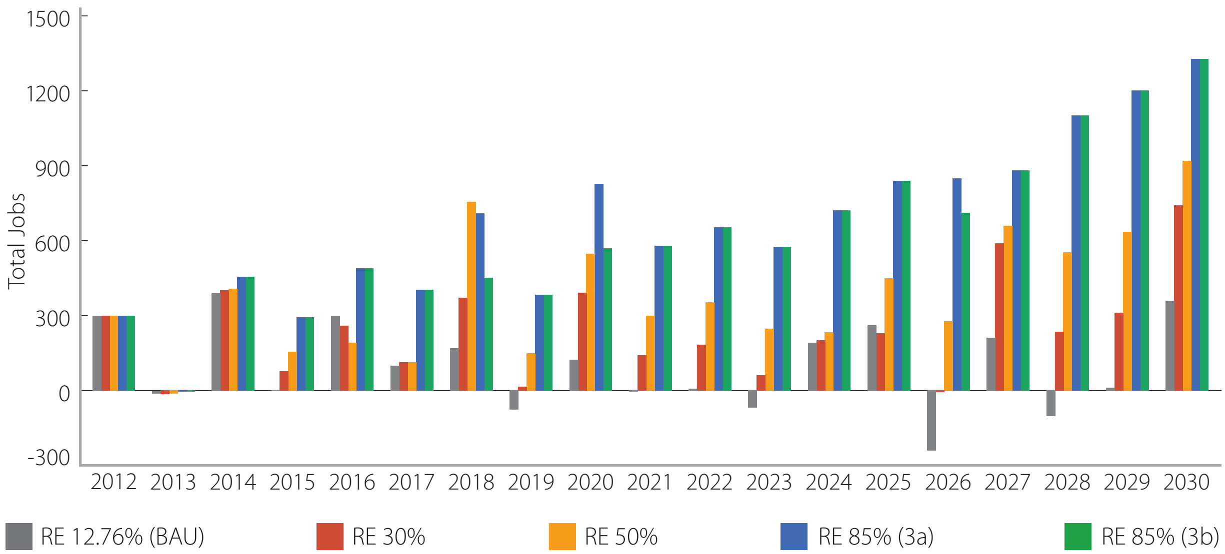

Figure 6.14

Total Jobs Created Annually to 2030 Under All Scenarios

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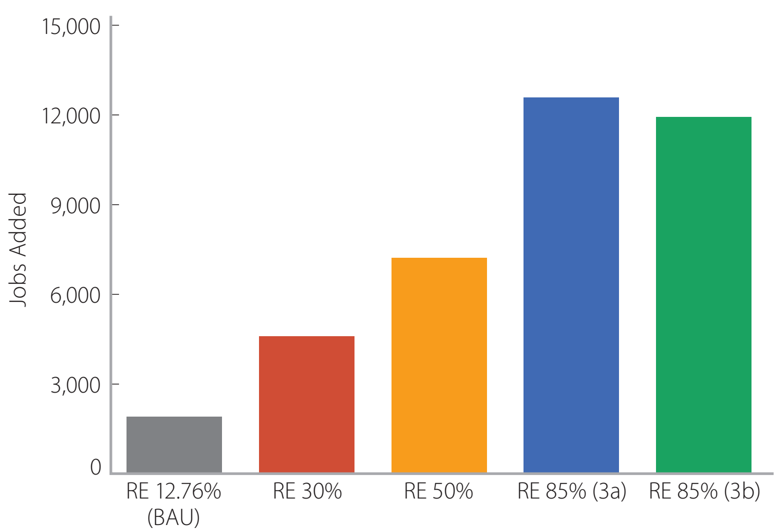

Figure 6.15

Total Jobs Created by 2030 Under Each Scenario

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Considering the current unemployment rate of 14.7%, these are valuable job additions that come at no additional cost.[25]

Renewable energy development clearly offers the Dominican Republic promising employment opportunities and an alternative to transferring its wealth out of the country to pay for fossil fuel imports. It is important to note, however, that most of the initial local jobs from renewables will occur in installation and O&M, since these positions are located in-country. To capture additional employment opportunities from renewable energy, the country would need to invest in capacity building, including expanding its domestic manufacturing base to allow for production of renewable energy equipment and training a skilled labor force to install, operate, and maintain new facilities. The success of Barbados in manufacturing solar water heaters for domestic consumption and export throughout the Caribbean is a success story that the Dominican Republic could emulate for this and other technologies.

6.4.6 Impact on Economic Sectors

Further research is needed to understand the economic risks that local pollution and a changing climate pose to the Dominican Republic's different economic sectors. Such assessment is beyond the scope of this study but would be very insightful given the country's vulnerability to environmental disasters and its reliance on tourism as a leading industry. In general, the impacts of pollution and climate change in the country will likely be higher than is discussed in this chapter. This is primarily because the Dominican Republic is an environmentally at-risk island nation: according to the Environmental Vulnerability Index, it is "highly vulnerable" because of its susceptibility to hazards that include meteorological events, geological events, human-caused events, climate change, and sea-level rise.[26]

6.5 Conclusions

The economic case in favor of a transition to an electricity system that is based largely on renewable energy is strong in the Dominican Republic. It offers the country a chance to reduce power sector debt, charge electricity prices that cover generation costs, save scarce resources on fossil fuel imports, decrease the trade deficit, increase energy security, and reduce greenhouse gas emissions and local pollution at negative costs. On average, renewables in the country already cost less than conventional power, underlining the economic benefits of better use of domestic renewable resources. Wind, hydro, and biomass are competitive generation solutions currently, and solar energy will, over time, become the cheapest source of electricity if the country can make use of learning curves and economies of scale.

Assesments of the rising environmental costs associated with electricity generation make it possible to think in new paradigms that make the societal costs of generation more transparent. Our scenarios demonstrate that coal plants in the Dominican Republic are the most injurious to human health and the environment. The costs of local pollution alone increase the costs of coal power by around 170%, and when these externalities are added to the traditional LCOE, coal becomes the most expensive generation technology for the country. Accounting for both local pollution and climate change costs, generating 1 kWh of wind power is less than one-seventh the cost of coal generation and around one-sixth that of diesel generators and oil combined-cycle plants. Solar PV is substantially less expensive than all conventional power apart from natural gas; it is about half the price of oil combined-cycle generation and more than 25 U.S. cents cheaper than coal generation.

Given these powerful arguments in favor of a transition to renewables, a continued reliance on fossil fuels would be economically ill-advised. The government of the Dominican Republic therefore should be encouraged to develop a more ambitious plan to rebuild the country's electricity sector based on renewable energy.

An assessment of the comparative macroeconomic benefits of Worldwatch's different scenarios to a more sustainable electricity sector further underlines this importance. Transitioning to an electricity system powered by 85% renewables can decrease average generation costs per kWh by around 40% by 2030 in comparison to today's levels. Such a transition also can create an estimated 12,000 new additional jobs and decrease greenhouse gas emissions in the electricity sector to a mere 3 million tons of CO_2-equivalent annually. Although an accelerated expansion of renewables requires higher upfront investments, it reduces the total cost of electricity generation and can save the country around USD 25 billion by 2030, freeing up public money to be spent on more pressing social and economic concerns.

7 | Sustainable Energy Finance in the Dominican Republic: Barriers and Innovations

Key Findings

- Barriers to broad sustainable energy development in the Dominican Republic include the risk perception of project investments, underdeveloped domestic financial markets and institutions, structural problems within the electricity sector, and the weak financial condition of the national government.
- Between 2005 and 2014, the long-term Petrocaribe deal with Venezuela added USD 4.1 billion to the Dominican Republic's total debt burden.
- Widespread non-technical losses of electricity constrain the ability of distributors to pay generators and necessitate direct government support of up to USD 1.2 billion to address the revenue gap and sustain operations. The combination of high technical and non-technical losses and artificially low electricity prices challenges the financial viability of distributors.
- Irregularities and imbalances in the electricity sector, along with the government's burgeoning debt, strain the country's overall credit rating, discouraging new investments in the power sector and limiting reforms.
- The lack of favorable long-term loans and a propensity to favor asset-backed guarantees over more traditional project finance make it difficult for local institutions to provide appropriate debt financing for sustainable energy projects. As a result, projects have needed to rely on strong balance sheets or to find creative solutions and use outside funding sources to provide capital.
- Traditionally conservative approaches to financing, such as the seven-year loan tenures provided by domestic commercial banks, render renewable energy projects financially unviable. International banks provide longer-term loans but at higher interest rates. An energy credit line disbursed through Banco BHD, supported by the IFC, provides low-interest medium-term loans for primarily medium-sized sustainable energy projects and is currently the only viable financing source available through a domestic private bank.
- No effective financing options are in place to support small-scale renewable energy projects, presenting a challenge given the low levels of reliable electricity service at the utility scale. This highlights an opportunity for smaller renewable installations to improve electricity services for residents and small enterprises.
- CDEEE's financial instability has led to its inability to act as a credible off-taker in renewable energy power purchase agreements (PPAs), making it difficult for projects to secure necessary project financing.
- Loan guarantees, if implemented, would de-risk sustainable energy investments. In some cases, the government has made sovereign guarantees contingent on transferring ownership of the generating asset once it is built. But without the sovereign guarantee, developers have difficulty accessing financing.

- The ability of domestic financial institutions to provide loans for energy efficiency and renewable energy is limited and should be addressed through capacity building in the financial sector.
- The Dominican sustainable energy fund and Petrocaribe savings could buttress other mechanisms that provide financing to sustainable energy projects.
- The country should harness traditional development assistance from bilateral and multilateral agencies to establish and strengthen existing energy efficiency and renewable energy programs.
- Climate financing should be scaled up and expanded to support the country's sustainable energy transition by providing additional revenue and reducing the risk for investors and developers.

The LCOE and scenario analyses in Chapter 5 provide the backdrop for determining the investment needed to transition the Dominican Republic to a more sustainable energy economy. The modeling results show that reaching 85% renewable electricity generation by 2030 would require an estimated USD 78 billion from 2013 to 2030, at a savings of more than USD 25 billion over BAU by 2030. (See Section 6.4.3.) These investment needs can be compared with current domestic and international financing options available for energy efficiency and renewable energy to determine existing opportunities and financing gaps.

In many cases, interest rates are the make-or-break factor in determining the viability of renewable energy projects. Over a 10-year loan period, increasing the interest rate from 5% to 20% can nearly double financing costs.[1] (See Figure 7.1.)

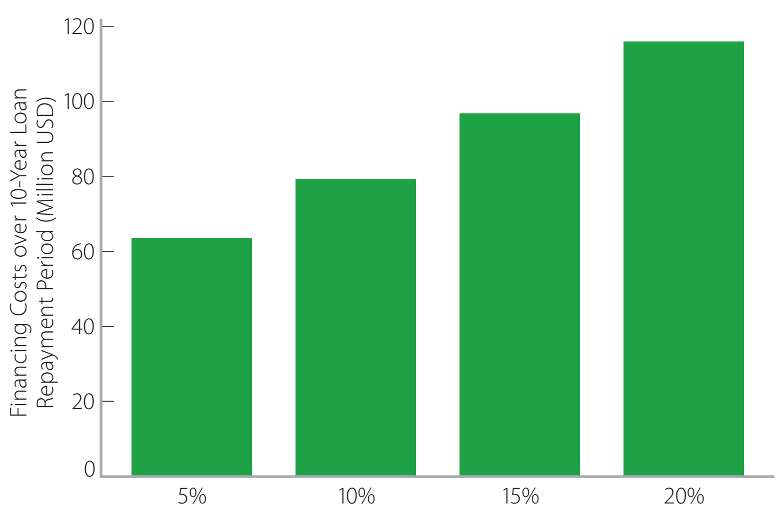

Figure 7.1

Impact of Interest Rates on Financing Costs for a Utility-Scale Wind Farm

Note: Assumes a 10-year, USD 50 million loan
© Worldwatch Institute

High interest rates pose a barrier to accessing finance in the Dominican Republic and can be especially problematic for energy efficiency and renewable energy projects that have high upfront capital costs. Moreover, because sustainable energy financing is a relatively new market in the country, banks are still building their lending capacity and project developers often lack experience in obtaining loans and permits. In economic sectors that do have reliable access to financing, such as the hotel and tourism industry, the lack of sustainable energy investment is more a matter of the need for education about the benefits and of the will to implement energy upgrades.

Numerous challenges as well as opportunities exist with respect to financing renewable energy and energy efficiency development in the country. This chapter discusses various ways to promote sustainable energy through financial institutions. However, many of the barriers to investment can be addressed most effectively through policy and regulatory mechanisms, as examined in Chapter 8.

7.1 Existing Business Environment

Globally, USD 214 billion was invested in renewable power and fuels in 2013.[2] Although the Americas (excluding Brazil and the United States) represents only a small share of global investments, renewable energy investment in the region increased by USD 2.4 billion that year, reaching USD 12 billion.[3] Notably, this increase came during a time of large declines in major markets such as Brazil, Europe, India, and the United States.

Renewable energy investments in the Dominican Republic have been sporadic over the past five years. In total, USD 644 million has been invested in the country's renewables sector, with the majority of this going to solar (53.7%) and wind (40.5%).[4] (See Figure 7.2.) More recently, however, investment has declined, with only some USD 1.2 million in green micro-loans distributed to borrowers in 2013.[5]

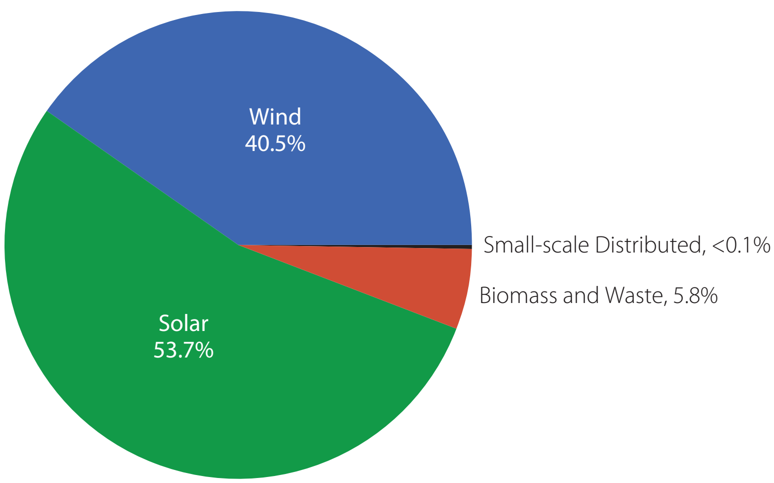

Figure 7.2

Renewable Energy Investment by Technology in the Dominican Republic (Excluding Large-Scale Hydropower)

Source: MIF, BNEF
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Although renewable energy investments continue to diversify worldwide, they tend to reflect the specific investment perceptions and trends within a given country. The overall fiscal climate in the Dominican Republic, as reflected by various financial indicators and international metrics, may pose a challenge in attracting investment to the renewables sector. Traditionally, gross domestic savings (GDS) and foreign direct investment (FDI) are linked. If one is strong, so is the other. However, GDS in the Dominican Republic has consistently fluctuated since the turn of the century, while FDI has remained relatively constant at roughly 4% of GDP.[6] (See Figure 7.3.) This may indicate larger systemic factors that create an investment climate that is not conducive to renewable energy investment.

A country's business climate influences the perceived market attractiveness for renewable energy investors, affecting the cost of capital, goods, and services and influencing investor decisions. Challenges

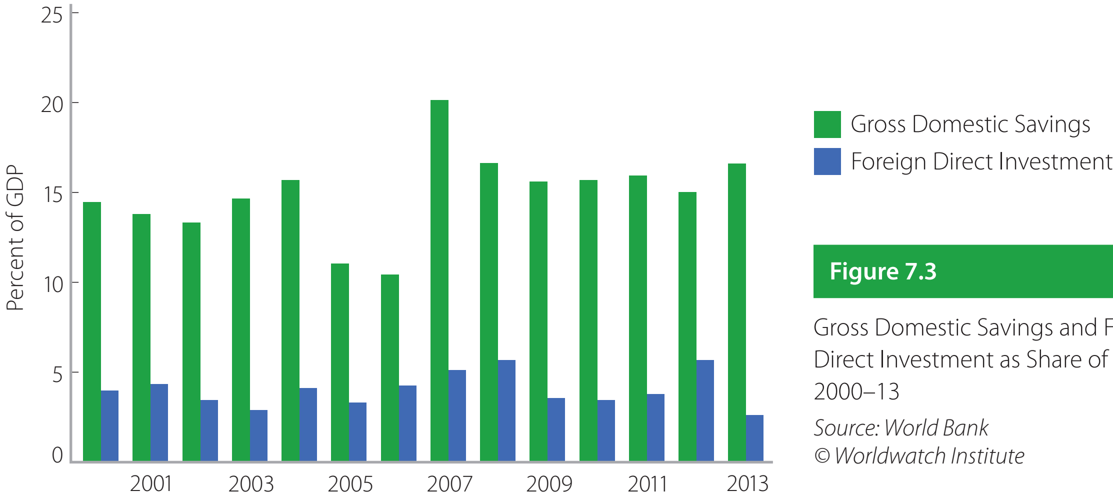

Figure 7.3

Gross Domestic Savings and Foreign Direct Investment as Share of GDP, 2000–13

Source: World Bank
© Worldwatch Institute

in the Dominican Republic's business climate, as measured in the International Finance Corporation's *Doing Business* report, may constrain investment in the renewable energy sector.[7] The country ranks in the bottom third globally with respect to both its macroeconomic environment and the development of its financial market, according to both the IFC analysis and the World Economic Forum's *Global Competitiveness Index*.[8] (See Table 7.1)

Economic and energy challenges are often interlinked. A country's overall investment climate can affect the financial attractiveness of the energy sector; at the same time, conditions within the energy sector can influence the overall economic climate of a country. The international bond credit rating organization Moody's lists the financial instability of the Dominican electricity sector as a primary factor behind the

Table 7.1 Selected Economic and Business Competitiveness Indicators for the Dominican Republic

Indicator	Ranking*
Global Competitiveness Index (GCI) (2014–15)	**101**
• Macroeconomic Environment	94
• Financial Market Development	99
• Quality of Electricity Supply	128
"Doing Business" Rankings (as of 2015)	**84**
• Enforcing Contracts	73
• Protecting Investors	83
• Dealing with Construction Permits	96
• Starting a Business	113
• Getting Electricity	119

** The GCI ranking is out of 148 countries, and the Doing Business ranking is out of 185 countries. In both rankings, a rating of 1 indicates the most favorable conditions.*
Source: See Endnote 8 for this chapter.

country's "B1" credit score, which indicates a speculative and high-credit-risk market.[9] JP Morgan and Fitch also have expressed concern about the financial viability of the electricity sector.[10]

The country's high government support to the electricity sector has a strong impact on finances, contributing to the 48% ratio of gross public debt to GDP.[11] Transfers to the electricity sector comprise an estimated 3.5% of the debt burden.[12] Based on Moody's analysis, reducing these transfers is key to any strategy to improve the national fiscal balance.

Reducing this support is challenging, however, because the electricity sector struggles to maintain a positive fiscal balance without government intervention. Distribution companies suffer from low cash recovery based on low collection rates and high technical losses. They also are constrained by low government-regulated electricity tariffs that are set below what is needed for the companies to operate effectively. In November 2012, the average Cash Recovery Index (CRI) for distributors was 62.3%, based on losses of 31.6% and a collection rate of 91.1%.[13] In its agreement with the International Monetary Fund (IMF), the country set a target of improving the CRI to 70%.[14] But by the end of 2013, the three electricity distributors—EDE Norte, EDE Sur, and EDE Este—still had CRIs of only 54%, 55%, and 60%, respectively.[15]

By the end of 2014, the Dominican government owed USD 963 million in outstanding electricity sector debt.[16] It also owed USD 4.1 billion to the government of Venezuela through the Petrocaribe program, although that debt has since been reduced to just under USD 100 million.[17] The low recovery and tariff gap faced by distributors challenges their ability to pay generators, which rely on government support to make up the gap in revenue. Government transfers to cover these costs often are delayed, placing additional strain on the companies and further weakening their financial standing and ability to attract investment. Payment delays also add to the cost of the government subsidies, as they accrue a 7–10% interest rate.[18] Overall, commercial losses account for an estimated 69% of potential lost revenue, and the tariff deficit accounts for the remaining 31%.[19]

For 2013, the Dominican government budgeted USD 1.05 billion in transfers to the electricity sector, or an estimated 1.7% of that year's GDP. An additional 10% was needed to sustain the electricity sector through the end of that year.[20] The situation was not much improved in 2014, as the sector's outstanding debt exceeded USD 900 million.[21] Because of the high dependence on government support, both the financial stability and investment ratings of companies in the electricity sector are heavily tied to national sovereign ratings, which themselves are challenged by transfers to the electricity sector.[22]

Yet there is cause for optimism. The 2014 *Climatescope* report from Bloomberg New Energy Finance and the IDB ranks the Dominican Republic tenth out of 26 countries in the Latin America and Caribbean region with respect to the "investment climate for climate-related investment."[23] The country ranked second out of the eight Caribbean nations assessed (behind Costa Rica) with respect to this investment climate, and fifth with respect to its "enabling framework" and "clean energy investment & climate financing." This points to opportunities for sustainable energy projects, while also highlighting the need to strengthen the country's financial sector and energy governance so that projects can take advantage of the strong policy environment for renewables.

Unfortunately, several important policy incentives, especially those extending financial support to renewable energy projects, have recently been rolled back. (See Chapter 8.) However, efforts, commitment, and interest remain, as a variety of domestic and international organizations are active in supporting the country's renewable energy sector. These efforts should be scaled up and expanded.

7.2 State of Domestic Financing

Both private and public financing exist for energy efficiency and renewable energy investment in the Dominican Republic. For project developers, identifying attractive loan packages, funds, and other sources of financing is an important step in determining the financial viability of investments.

To date, private financing has proven insufficient in enabling widespread investments in sustainable energy in the country. Public financing is often essential to mobilize additional private finance by demonstrating confidence in and viability of projects, and can help make the risk-return profile more favorable for private investors. The degree of positive adjustment to the risk-return profile can be reduced over time, reflecting the increased risk appetite, maturity, and capacity of the private sector. The effectiveness of public finance at achieving these goals is key to creating a strong investment climate for sustainable energy.

Dominican project developers often lack sufficient capital of their own to invest in renewable energy projects and have little access to financial instruments such as soft loans, credits, or grants. Because access to capital remains a challenge (as indicated in the Global Competitiveness Index; see Table 7.2), typically only self-financing and well-capitalized businesses can take advantage of the country's renewable energy potential.[24] Strengthening financial intermediaries such as banks and investment companies is a good way to leverage private capital; however, this alone may not be sufficient.[25] In addition to enabling commercial financing for projects, countries that have successfully promoted renewable energy at a larger scale have set up effective public finance and regulatory support mechanisms for renewables.

Table 7.2. Selected GCI Financial Market Development Indicators for the Dominican Republic

Indicator	Ranking*
Ease of Access to Loans	57
Venture Capital Availability	86
Financing Through Local Equity Market	106

** Ranking is out of 148 countries, with a rating of 1 indicating the most favorable conditions.*
Source: See Endnote 24 for this chapter.

Other related and recognized barriers to financing sustainable energy projects include the absence of long-term, concessional commercial loans, and a difficulty for local actors to access international funding for projects. Local developers generally lack knowledge and awareness of the financing opportunities and conditions of international climate finance institutions. Some of these barriers could be addressed effectively through better execution of existing laws and regulations, while others will require a concerted effort at capacity building and education, as discussed later in this chapter.

The low credit-worthiness of power off-takers and electricity distributors is a common high risk for investing in renewable energy in the Caribbean.[26] In the Dominican Republic, these factors limit the ability of lending institutions to provide loans for renewable energy projects. Lack of trust in the government to meet its payment obligations to distributors and to independent power producers (see Section 4.1) reduces investor confidence and the willingness of banks to lend. Many international banks therefore require a sovereign guarantee (from the national government) that ensures that loan repayments will be met even if the energy developer defaults, as a pre-condition to lending to sustainable energy initiatives in the country.

Bureaucratic and permitting delays for greenfield renewable energy projects significantly increase project costs and deter banks from lending to renewable energy developers. This situation is exacerbated by the perceived lack of human capital and experience on the part of energy companies developing new projects in the country. As a result, energy efficiency and refurbishment projects are often easier to finance because they rely on the use of local experience to extend the lifetime of an existing asset and avoid many of the bureaucratic costs and hurdles associated with developing new electricity generation projects.[27]

Despite these barriers, the market for smaller-scale residential and commercial systems is expanding. The Dominican Association of Renewable Energy Businesses has counted more than 40 companies that specialize in supplying, developing, or installing renewable energy technologies to the domestic market, highlighting the opportunities provided by inefficiencies and imbalances in the current system.[28]

7.2.1 Domestic Private Financial Institutions

Most private financial institutions in the Dominican Republic have limited or no experience with energy efficiency and renewable energy financing. Because renewable energy projects have high upfront costs, they typically require long-term financing windows that do not align with the time frames that Dominican banks currently offer. Long-term loans generally are capped at 7 years but can be extended to 10 years for projects with 20% equity financing. The needed repayment period for renewable energy projects, however, typically spans from 10 to 20 years. Although these terms are the same for conventional energy projects, the latter are more easily refinanced to extend loan payback because of the size of the companies involved and the banks' familiarity with investing in these projects.

An expert from Banco BHD, one of five major banks in the Dominican Republic, has indicated that banks are hesitant to engage in the renewable energy sector because of 1) the lack of an appropriate public or private guarantee mechanism (allowing banks to share some of the risk with the government or another organization), and 2) the high rate of loan loss provision for banks.[29] The loan loss provision, determined by the Dominican Banks Superintendent, requires banks to set aside a high allowance in case of customer default.[30] In the absence of a developed domestic secondary market for renewable technologies, banks are wary of using the equipment as collateral.

In part as a result of domestic policy measures, loans for renewable energy projects pose a higher risk to banks than loans for conventional energy projects. Banks are constrained by current laws that limit their ability to collateralize no more than 30% of the value of renewable energy equipment that they invest in, leaving a large gap of 70% of lost collateral from the value of the system if the project defaults on its debt.[31] As a result, renewable energy projects such as wind farms have had to rely on other incentives, such as those from the Clean Development Mechanism (CDM), to be successful.[32] (See Sidebar 8.)

Sidebar 8. Financing the Los Cocos Wind Farm

The Los Cocos Wind Farm, together with the neighboring Quilvio Cabrera Wind Farm, is the first utility-scale wind project in operation in the Dominican Republic. Los Cocos Phase I was inaugurated in 2011 and was originally constructed with a total installed capacity of 25.2 MW, comprising 14 Vestas V90 turbines, each with a capacity of 1.8 MW. Initial cost estimates for the project were roughly USD 72 million, including USD 15 million in hardware costs and approximately USD 54 million in construction costs. In January 2013, the project's second phase was completed, increasing the total capacity to 77 MW. The expansion includes 26 Gamesa 2 MW turbines, adding an additional 52 MW to the Los Cocos site. The expansion was inaugurated with an investment of USD 103.4 million. Construction on an additional 30–40 MW under Los Cocos Phase III is tentatively slated for 2015.

The project has overcome financing and regulatory barriers faced by other projects in the country by operating under a previously existing 300 MW power purchase agreement (PPA) between EGE Haina and CDEEE. Due to high spot prices in the Dominican Republic, EGE Haina is able to operate Los Cocos without a PPA specifically designed for the wind farm by selling power directly into the spot market at a price that is competitive with fossil fuel generation. The company sells wind power at 18 U.S. cents per kWh, slightly above the floor price of roughly 14 U.S. cents per kWh.

The challenge of securing debt financing for renewable energy projects in the Dominican Republic was mitigated through EGE Haina's ability to entirely finance both project phases through equity investments. Additionally, Los Cocos has benefited from both domestic and international support. Tax incentives implemented under Law 57-07 have proven beneficial to the development of the wind farm. When the project received its original license in 2004, the project size was 100 MW. However, in order to qualify for the law's tax incentives, the size of the first phase was reduced so as to not exceed the 50 MW capacity cap for wind projects.

Under the terms of the incentives, the project is exempt from import duties, sales tax, and income tax (for a period of 10 years), among other incentives. After the 10-year income tax exemption expires, the project has an income tax liability averaging over USD 2.5 million per year to 2030. Many of these tax incentives have since been rolled back, adding significant additional costs to future project developers that were not faced by the developers of Los Cocos.

One of the challenges in determining the effectiveness of wind power on electricity prices in the Dominican Republic is that the electricity generated from wind is bundled with electricity generated by other plants owned by the same company to satisfy an existing electricity supply contract with an already-negotiated price. Therefore it is difficult to determine which electrons came from which source. This also can affect priority dispatch mechanisms that ensure that renewable energy is fed into the electricity grid prior to electricity generated from fossil sources.

Los Cocos is also a registered Clean Development Mechanism project, with emissions reductions of 54,183 tons of CO_2-equivalent per year. Annual reductions from Los Cocos II have been estimated at 111,127 tons of CO_2-equivalent per year. CDM financing has provided an additional fiscal incentive, allowing the project to be completed successfully. Despite government incentives and the relative ease in accessing capital by EGE Haina, calculations of the projected internal rate of return (IRR) for Los Cocos found that without CDM revenues, the project was still expected to be financially unattractive. The initial phase of the Los Cocos wind farm is expected to generate enough revenue to cover EGE Haina's initial USD 72 million investment by 2017.

Source: See Endnote 32 for this chapter.

Currently, Banco BHD is one of the only commercial banks that provide a credit line for renewable energy, energy efficiency, and clean energy production in the country. (Promerica and Banco Popular also have funds available to support renewable energy and energy efficiency, but funding levels are very low.) Supported by the IFC, the credit line offers low-interest (around 5.5%) medium-term (repayment within five years with a one-year grace period) loans for small-to-medium project developers, with 80% of the project's investment cost available for financing. BHD is responsible for most aspects of the lending process, including marketing, appraisal, and credit approval. The company also has set up a project development assistance facility to provide technical expertise (resource assessment, feasibility studies, etc.) and business assistance to developers throughout the project preparation process.

To date, USD 12.4 million has been disbursed from the IFC credit line, with an additional USD 9.5 million being disbursed from BHD funds.[33] A portion of the disbursed funds has been used to finance two solar PV projects as well as an energy efficiency project at a Dominican university. Much of the support from this credit facility has been used for natural gas development, including LNG regasification plants and natural gas dispensaries for vehicles.[34]

Although the capacity and willingness of BHD to engage in energy efficiency and renewable energy lending has improved over the past few years, the lessons from these efforts should be applied to extend lending capacity in other domestic banks. Overall, the average lending interest rate (a measure generally used for short-and medium-term commercial credit) in the Dominican Republic declined from nearly 26.8% in 2000 to 15.6% in 2011, ranking it the 31st highest out of the 131 countries assessed by the World Bank in 2011.[35] With market interest rates in the country decreasing dramatically, banks have been able to bring down lending rates for traditional energy investments to 4.5–5.5%.[36]

7.2.2 Public Financing Mechanisms

Along with private financial actors, domestic public financing plays a key role in the development and deployment of renewable energy and energy efficiency. In the Dominican Republic, two funds have been pledged to support alternative energy development—under the Petrocaribe agreement and through a “sustainable energy fund—yet neither has been active in providing the envisioned financial support.

Petrocaribe

Through the Petrocaribe agreement with Venezuela, the Dominican Republic is able to buy oil at market value while benefiting from preferential financing terms tied to the price of oil.[37] (See Table 7.3.) Since 2008, the country has imported roughly 10 million barrels per year via the agreement, at just over USD 1 billion annually.[38] (See Table 7.4.) The program has been credited with being an important lifeline for much of the Caribbean at a time of rising oil prices. However, Petrocaribe also has led to the buildup of significant external debt. By the end of 2014, the Dominican Republic had received USD 4.1 billion in financing for oil imports since its participation in the agreement began in 2005.[39]

In early 2015, Venezuela agreed to write down the Dominican Republic’s debt by just over 50%, bringing the outstanding balance down to USD 1.97 billion.[40] The Dominican government then paid off 98% of that balance with funds generated from a USD 2.5 billion debt issuance, leaving the country with an outstanding debt of just under USD 100 million.[41] The maturity of the remaining debt was extended from 14 years to 20 years. However, the Petrocaribe program remains in place, and the Dominican Republic remains authorized to import 50,000 barrels of oil per day from it.

Despite the heavy debt burden from participation in Petrocaribe, the long-term, low-interest financing has offered the opportunity to invest the avoided near-term payments domestically. In 2007, then-President Leonel Fernández indicated that the internal savings generated by participation in Petrocaribe would be used to support alternative energy projects, as has occurred in other countries.[42] So far, however, the

Table 7.3 Petrocaribe Financing Terms for the Dominican Republic

Oil Price	Share Financed Through Loans	Interest Rate	Financing Period*
USD/barrel	percent	percent	years
>15	5	2	15
>20	10	2	15
>22	15	2	15
>24	20	2	15
>30	25	2	15
>40	30	1	23
>50	40	1	23
>100	50	1	23

** An additional two-year grace period is included on top of the given financing period for total repayment periods of 17 and 25 years.*
Source: See Endnote 37 for this chapter.

Table 7.4 Petrocaribe Expenditures in the Dominican Republic

Year	Volume of Oil	Monetary Value	Financing Received
	million barrels	billion USD	million USD
2008	9.9		538.1
2009	10.0		263.6
2010	10.6		407.1
2011	9.6	1.085	637.2
2012	9.7	1.146	714.5
2013	10.2	1.131	704.8
2014	10.3	1.093	681.3

Note: Figures for 2013 and 2014 are estimates.
Source: See Endnote 38 for this chapter.

Dominican Republic has not followed through with this opportunity. Yet doing so may soon prove vital as the downturn in global oil prices tests the long-term viability of the Petrocaribe program. Venezuela has begun demanding more-stringent regional trading agreements to finance domestic spending. Diversification of the Dominican energy mix, with a focus on developing indigenous renewable resources, will likely prove essential for achieving energy security.

Dominican Sustainable Energy Fund

As early as November 2000, the Dominican Republic established the overall principles of a public fund for sustainable energy in its Law 112-00 (the Law on Hydrocarbons). Law 112-00 outlines the creation of "a special fund from the tax differential on fossil fuels in order to finance projects of great national interest for the promotion of alternative, renewable or clean energy and energy savings."[43] The fund is designed to be financed through the allocation of 5% of the income generated through the application of taxes levied under Law 112-00.

The share of the fuel-differentiated tax, set in DOP per gallon and to be dedicated to funding sustainable energy projects, initially was set at 2% and then increased annually to 5%, where it currently stands. If properly harnessed, the fund could be a major driver of renewable energy development in the country. Unfortunately, institutional challenges, inconsistent application of laws, and a lack of accountability for ensuring that the earmarked funds are utilized as mandated have weakened its ability to financially support the renewable energy sector. (See Chapter 8 for more details.)

Utilizing these resources can help to de-risk renewable energy investments by providing government-backed loan guarantees. Similar national funds, such as the U.S. Department of Energy's Loan Programs, have worked well in this regard. Loan guarantees have been identified as being especially critical in financing renewable energy projects in the Dominican Republic, but to date the government has been hesitant to back loans to renewables. The revenue earmarked for the sustainable energy fund could be an opportunity to provide the needed guarantees. Provided that the necessary capacity and expertise is developed to successfully assess the risks associated with individual projects, the fund would leverage a significant share of private capital, with minimal outlays by the government.

In contrast to direct project loans or fiscal support through a feed-in tariff, loan guarantees allow the government to support projects without an initial capital outlay. If properly selected, the vast majority of projects will never need to collect on the commitments from the government, as the private loans that are made accessible and affordable as a result of the guarantee can be repaid in full based on revenue from successful project operation. The U.S. Department of Energy's Loan Program, for example, has a loan default rate of below 2%, despite committing USD 34.4 billion since 2009.[44]

The Development Bank of Jamaica (DBJ) has a partial loan-guarantee program to address the lack of capacity of commercial banks in Jamaica to accept renewable energy equipment as collateral for loans, and it can enable larger-scale project financing.[45] Through the partial loan-guarantee mechanism, DBJ provides a guarantee to the lending bank that it will take responsibility for the debt in the event that the borrower defaults on loan payments. The DBJ's program is administered through the JMD 250 million (approximately USD 3 million) Credit Enhancement Fund and supports up to 80% of the loan amount with a maximum of JMD 10 million (approximately USD 100,000).[46] Examples like this could be applied to the Dominican context.

7.2.3 Bundling Projects to Lower Costs

Two ways to lower the per-unit financial costs of sustainable energy are creating economies of scale and lowering transaction costs. Even though the levelized costs of many renewable energy technologies are lower than those of fossil fuel technologies (see Chapter 6), renewables are still more capital-intensive initially. As a result, it is even more important that utility-sized renewable projects are built to scale, as this can lower financing costs. In relatively small markets like the Dominican Republic, however, it would be difficult and arguably imprudent to build one very large renewable project, such as a 300 MW wind farm. It therefore is important to explore the idea of bundling renewable energy projects in the country.

This could involve bundling many renewable projects across the country as one project, or even bundling one renewable project with other development or infrastructure projects in the areas of education, health, and telecommunications. Including renewable energy developments in bundled projects could help to reduce financing and capital costs for individual projects and could be used to leverage greater private investment in the sector. This strategy also could be used to garner funding from banks and programs that typically do not fund sustainable energy projects.

7.2.4 Reforming Electricity Pricing

It also will be important to reform the method by which the Electricity Superintendent (SIE) sets the electricity tariff in the country. While many factors help determine a final electricity tariff, including capital cost recovery, return on capital, and capital financing costs, one important factor is the cost of the fuel used to generate that electricity. However, instead of applying a formula that includes the actual cost of the fuel used to generate the electricity consumed, SIE applies a formula that is not indexed to the real fuel cost. This results in electricity prices that are well below the level necessary for generators to fully recuperate their operating costs.[47] (See Figure 7.4.) Prices are set for varying levels of consumption and for various blocks (or categories) of consumers.

Because the Dominican Republic operates a state-owned monopoly utility company (CDEEE), this approach has contributed to the current USD 900 million government debt in the electricity sector and is a major barrier to effective operation of the national electricity system, as it makes it extremely difficult for CDEEE to pay generators on time. Reforming electricity price setting to institute an indexed electricity price is an important step to establishing the state-owned utility company's financial viability. If cheaper energy sources—including renewable energy technologies—are used, CDEEE can still lower electricity prices for consumers while recovering its own costs.

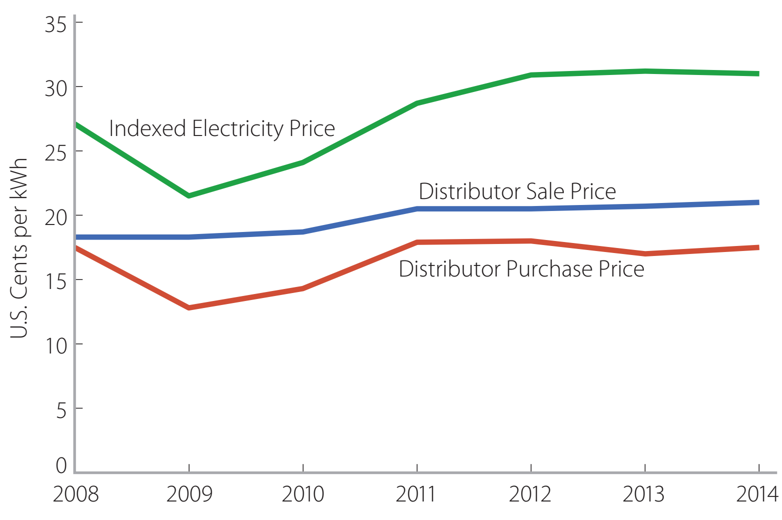

Figure 7.4

Dominican Republic Electricity Distributor Sale and Purchase Prices, 2008–14

Source: CDEEE, ADIE
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7.2.5 Summary

To achieve widespread development and deployment of renewable energy and energy efficiency projects, opportunities to access financing through domestic financial institutions and mechanisms must be expanded and scaled up. Currently, only one domestic bank, Banco BHD, has experience lending to such projects, and even this experience is fairly limited. To enable wide-scale project development, BHD's lending portfolio could be used as a platform from which the local market could be expanded, thereby strengthening the capacity of the domestic financing sector to lend to alternative energy projects.

Furthermore, financing through domestic mechanisms that have been pledged to support alternative energy development is yet to materialize. Neither the Dominican sustainable energy fund created under Law 112-00 nor the internal savings accrued from participation in the Petrocaribe agreement have been directed toward supporting renewable energy or energy efficiency projects in the country. Harnessing these mechanisms as designed could play a significant role in closing the domestic financing gap for alternative energy.

Lastly, the Dominican government must continue to improve its fiscal condition vis-à-vis the energy sector. Artificially low electricity prices (which have not been revised in at least two years), technical losses due to a decrepit and inefficient electricity grid, a pervasive culture of electricity theft and non-payment, and inefficient management of the public utilities have led to an unsustainable debt that the government can no longer shoulder. As long as CDEEE is the off-taker of an energy project, risk premiums become too high and discourage outside investors who otherwise are ready to invest in the country's renewable energy market. As a result, government support for the electricity sector continues to strain national finances and negatively affect the country's credit rating.

7.3 International Financing

International financing has and will continue to play a key role in funding sustainable energy projects in the Dominican Republic. (See Appendix VI for an expanded list of international financing institutions.) Examining past and current internationally financed programs demonstrates the importance of this funding source, as well as potential future opportunities and projects that would be well suited to receiving additional finance. However, the country's high debt burden is only one of the barriers to accessing international financing for public programs and project development. High national debt can create a spillover effect that affects lending operations in the wider private sector. International institutions perceive this debt as a cause for higher risk ratings, leading to longer periods of due diligence and to higher interest rates for project loans (energy and otherwise).

7.3.1 Traditional Development Assistance

Traditional development assistance from multilateral or bilateral agencies can be harnessed to support sustainable energy initiatives in the Dominican Republic. The country has accessed such financing in the past to support specific renewable energy capacity investments and energy efficiency projects, as well as capacity-building programs in the government and finance sectors to promote institutional strengthening and policies in support of sustainable energy.

Several governments, international organizations, and nongovernmental organizations (NGOs) have directed (and currently are directing) monetary and technical assistance to the country to support energy sector development. These include the World Bank, the IMF, the IDB, the European Investment Bank (EIB), the Japan International Cooperation Agency (JICA), the German Development Agency (GIZ),

Table 7.5 Selected Past Internationally Funded Energy Efficiency and Renewable Energy Projects in the Dominican Republic

Funder	Program/ Project	Dates	Key Aspects	Success
IDB	Support to Renewable Energy and Bioenergy Programs	September 2011–March 2012	Technical cooperation to finance the development of necessary studies to facilitate decision making related to production and use of biofuels.	USD 200,000 disbursed to date, out of USD 750,000 approved
World Bank	Power Sector Program – Second Generation Reforms	May 2005–May 2007	Support for improving services in the electricity sector, including reducing blackouts, encouraging the financial stability of private sector companies in the sector, and expanding electricity access to un-electrified populations.	USD 100 million in loans disbursed from 2006 to 2007
IDB	Biodiesel for Jatropha Project	September 2009–February 2013	Technical cooperation to finance feasibility studies on the use of jatropha, including an assessment of how to increase the market for jatropha oil by analyzing and establishing price Incentives, and an assessment of biodiesel refinery construction, carbon offsets, the regional market for biodiesel, and transportation logistics.	USD 134,000 in non-reimbursable technical cooperation funding disbursed
IDB	Energy Efficiency Analysis in Dominican Republic	June 2010–July 2010	Assistance in promoting and developing institutional capacity for increased energy efficiency. Specific project activities are designed to 1) sensitize decision makers on the modalities and benefits of energy efficiency programs, 2) train trainers on key issues of energy efficiency while ensuring the development of local capacity and sustainability initiatives, and 3) educate people and develop a culture of energy saving.	USD 116,000 non-reimbursable technical cooperation funding disbursed
IDB	Power Sector Sustainability and Efficiency Program	November 2011–December 2011	Initiation of the electricity sector reform process through promoting policy measures to form the basis of the institutional, planning, and regulatory changes needed to strengthen and transform the Dominican power sector.	USD 200 million loan disbursed
IDB	Support to Renewable Energy and Bioenergy Programs	September 2011–March 2012	Financing to support studies to allow for planning and decision making concerning the production and use of biofuels.	USD 150,000 non-reimbursable technical cooperation funding disbursed
IDB	Electricity Distribution Network Rehabilitation Project	October 2008–March 2009	Financing to support the rehabilitation of electricity distribution circuits of the EDEs, enabling the companies to add and regularize users, improve the quality of electricity service, as well as establish closer ties to the communities, especially those with low rates of collection and high levels of electricity theft.	USD 34.9 million loan disbursed
U.S. Ex-Im Bank	Hotel V Centenario EE Project		A loan guarantee to enable the Hotel V Centenario to implement an energy efficiency project including the installation of water-cooled chillers, cooling towers, a variable frequency drive, and an energy management system.	USD 680,000 five-year loan guarantee. Loan paid back within the five-year term based on energy savings accrued from the project

Table 7.5 continued

Funder	Program/ Project	Dates	Key Aspects	Success
IDB	EDE Sur EDE Norte Power Project	May 2001–December 2001	Finance of an investment program designed to improve the quality and efficiency of the service and to strengthen environmental protection of the two firms.	USD 188 million in loans disbursed to two private electricity distribution companies
USAID	National Rural Electrification Alliance	May 2003–September 2008	Establishment of rural electrification partnerships, training of institutional energy saving committees, and detailed energy audits of government buildings	44,070 people have greater access to modern energy services; 15 electric partnerships; 2 electric cooperatives achieved legal incorporation; hundreds of seminar attendees and trainees; multiple studies completed, including the tariff and subsidy analysis

UNDP, the U.S. Export-Import Bank, the U.S. Trade and Development Agency (USTDA), the OPEC Fund for International Development (OFID), and the Organization of American States (OAS). (See Tables 7.5. and 7.6.) The country also is engaged with several international initiatives helping to develop renewables, including the Caribbean Renewable Energy Development Program (CREDP), the Energy and Climate Partnership of the Americas (ECPA), and the Latin American Energy Organization (OLADE).

7.3.2 International Climate Finance

The Dominican Republic has capitalized on funding from the Global Environment Facility and the Clean Development Mechanism as part of its strategy to generate capital for low-carbon investment. Trade of certified emission reduction units (CERs) provides flexibility to developing countries to reduce the costs of their transition to sustainable sources of energy through investment.

The CDM has been criticized, however, because of difficulties in establishing "additionality" for projects (i.e., whether they would have happened anyway without its funding), and thus its capacity to curb global greenhouse gas emissions. So far, the CDM has been a largely untapped financial resource in Latin American and the Caribbean, with the region accounting for only 14% of past CDM projects worldwide, compared to 46% in China and 21% in India.[48] The Caribbean represented only 0.003% of total registered CDM projects as of May 2013.[49]

The UNFCCC has identified a mix of technical and non-technical barriers constraining CDM participation in the region, including low per-capita emissions, high transaction costs for project compliance, lack of awareness of the opportunities for CDM, lack of experience and technical expertise in CDM, and insufficient financing for investments and funding for CDM transaction costs.[50] As of mid-2013, CDM prices had plummeted to less than 50 U.S. cents per ton of carbon due to an oversupply of credits, causing a steep drop in new project financing; new carbon credit contracts fell 91% between April 2012 and April 2013.[51] In July 2013, the UNFCCC and St. George University in Grenada launched a joint

Table 7.6 Current Internationally Funded Energy Efficiency and Renewable Energy Projects in the Dominican Republic

Funder	Program/ Project	Dates	Key Aspects	Success/ Expected Results
UNDP	GEF Small Grants Program	First energy project approved in 1994	Small loans of USD 50,000 or less provided to community organizations for sustainable development projects.	To date, 19 community hydropower projects have been installed, powering over 2,100 families. By 2016, this is to be expanded to 50 micro-hydro plants powering 5,500 families.
UNIDO	Stimulating Industrial Competitiveness Through Biomass-based, Grid-connected Electricity Generation	Approved February 2012	USD 1.3 million GEF Trust Fund grant and USD 7.48 million in co-financing to promote the implementation of decentralized, biomass-based energy production in industrial free zones in the Dominican Republic.	Development and strengthening of the facilitating policy and regulatory framework for renewables in manufacturing zones, and deployment of a 2.5 MW biomass power installation at the Santiago IFZ.
IDB	Bani Wind Power Project	Approved July 2011	Private sector project requiring USD 27.6 million from the IDB and USD 41.3 million from a private company.	Development of a 30.6 MW wind farm in the town of Baní.
World Bank	Electricity Distribution Rehabilitation Project	Approved May 2008	Increase the cash recovery index of the three electricity distribution companies and improve the quality of electricity service.	Rehabilitation and upgrading of medium- and low-voltage circuits (USD 37 million), outreach to consumer communities (USD 3 million), and technical assistance (USD 2 million).
IDB	Support to the Design and Execution of the Power Sector Sustainability Program	Approved December 2012	Technical cooperation to support the sustainability and efficiency of the power sector.	Successfully completed in October 2014 as part of larger policy planning program in the energy sector.
IDB	PECASA Wind Power Project	July 2011	Private sector project requiring USD 50.7 million from the IDB and USD 76.1 million from a private company.	Development of a 50 MW wind farm in Guanillo.

initiative to build regional capacity to access CDM financing.[52] Through the establishment of the Regional Collaboration Centre (RCC) for the Caribbean, initially targeting 16 Caribbean nations including the Dominican Republic, the UNFCCC is committed to providing technical support to increase the uptake of CDM projects.[53]

CDM projects in Latin America and the Caribbean to date have focused on hydropower and methane avoidance (nearly 25% each), biomass and landfill gas (around 15% each), and wind energy (5%).[54] Although the Dominican Republic represents a very small share of global CDM projects, it leads the Caribbean countries, with 14 registered projects.[55] (See Table 7.7.) Unlike other Caribbean nations, the country has an office dedicated to participation in the international climate regime, including CDM. The National Council for Climate Change and the Clean Development Mechanism (CNCCMDL) is responsible for formulating and implementing the country's strategies for climate change mitigation and adaptation, and for managing national participation in the CDM.

Table 7.7 Registered CDM Projects in the Dominican Republic

Date	Name	Contributing Parties	Estimated Emission Reductions	Project No.
			tons of CO_2-equivalent per year	
20-Oct-06	El Guanillo wind farm in Dominican Republic	Spain	123,916	175
9-Apr-10	Bionersis project on La Duquesa landfill, Dominican Republic	U.K., France	359,810	2595
28-Nov-11	Matafongo Wind Farm	U.K., France	70,275	5456
29-Mar-12	Quilvio Cabrera Wind Farm Project	—	10,937	5528
1-Jun-12	CEMEX Dominicana: Alternative fuels and biomass project at San Pedro Cement Plant	U.K.	99,797	4542
6-Aug-12	Textile Offshore Site Dominicana Biomass Residues Cogeneration Project (TOS-2RIOS)	France	35,738	6929
27-Aug-12	Los Cocos Wind Farm Project	—	54,183	7093
14-Sep-12	Steam Generation Using Biomass	France	48,050	7287
12-Oct-12	Palomino Hydropower Project in the Province of San Juan de la Maguana in the Dominican Republic	Dominican Republic	119,598	6591
17-Oct-12	Solar PV Project in Dominican Republic	France	35,375	7781
27-Oct-12	Granadillos Wind Farm	U.K.	69,657	7902
3-Dec-12	30 MW Solar PV - Monte Plata	Switzerland, U.K.	29,254	8530
30-Dec-12	La Isabela – Heat & Electricity generation from biomass residues	—	29,968	9435
23-Jan-13	Los Cocos II Wind Farm Project	—	112,489	7100

Source: See Endnote 55 for this chapter.

To receive consideration for CDM financing, most low-carbon energy projects must generate at least 10,000 CERs per year, with each CER representing one ton of reduced CO_2 emissions.[56] Additional opportunities for financing small-scale projects through the CDM exist through the CDM Program of Activities.[57] (See Sidebar 9.)

The GEF serves as a finance stream for renewable energy in the Dominican Republic as well. It is the largest public funder of environmental improvement projects worldwide, disbursing USD 11.5 billion in grants and leveraging USD 57 billion for more than 3,215 projects since 1991.[58] The Latin America and the Caribbean region has received USD 1.7 billion in GEF grants (16.7% of the global total), covering 545 projects (18.7% of the global total).[59] The Caribbean region accounts for 1.1% of all GEF grants (USD 107 million) and 3.7% of projects (107) financed by the fund.[60] Within the region, nearly a fifth of all projects (20) and half of all grant funding (USD 50.1 million) are found in Cuba.[61]

Sidebar 9. Financing Small-scale, Low-Carbon Energy Projects Through International Climate Finance

Although international climate finance is traditionally used to promote medium- to large-scale projects, it also can be harnessed to support community-level low-carbon energy projects. Two specific mechanisms, the CDM Program of Activities and the GEF Small Grants Programme, provide valuable financial and technical assistance for small-scale project development.

CDM Program of Activities

The CDM Program of Activities (PoA) was introduced in 2005 as a way to group several smaller-scale projects that individually would not generate the volume of certified emissions reductions (CERs) necessary for traditional CDM financing. In contrast to project bundling, the PoA requires only the project concept and one concrete activity in order to register as a CDM, thus reducing investment risk for low-carbon energy project developers. Furthermore, even if an individual activity under the PoA is found to be non-compliant, the rest of the activities can continue to operate.

Procedures for PoA projects were adopted in 2007, but the need for clearer guidance held back widespread use of the mechanism. In 2009, the United Nations Environment Programme (UNEP) released a primer on CDM PoA in an effort to provide clarification and guidance for countries and projects seeking to benefit from its flexibility. The PoA procedure increases the ability for small countries like the Dominican Republic to benefit from CDM financing by accommodating activities in several countries under one PoA. New activities also can be added throughout the 28-year time frame that a PoA is valid.

A further benefit of the PoA is that, unlike the traditional CDM process in which developers have to prove that projects provide additional emission reductions, renewable energy projects under 5 MW are automatically considered additional. Not having to prove additionality removes a significant bureaucratic and financial burden from low-carbon energy project developers.

GEF Small Grants Programme

The GEF Small Grants Programme (SGP) provides needed capital to facilitate the development of small-scale projects. Unlike the larger GEF mechanism, the program, executed through a partnership between the GEF and UNDP, provides grants of up to USD 50,000 directly to local communities, financing projects below the size supported through traditional GEF funds.

After a successful Pilot Phase beginning in 1992, the SGP began its official First Operational Phase in 1996 with the aim of providing financial and technical support to small-scale sustainable development projects in several thematic areas. Due to strong demand from small-island developing states (SIDS) and the least-developed countries, the program has been scaled up considerably since its inception and is now in its sixth operational phase. To date, USD 460 million has been invested through the SGP to support 14,500 projects worldwide, including many clean energy projects under the Climate Change Mitigation and Adaption program area.

The Dominican Republic began participation in SGP in 1993 as one of the initial members involved in the program's pilot phase. Although the SGP covers a wide array of sustainable development sectors, many clean energy projects have been financed under the Climate Change Mitigation and Adaption program area. In the energy sector, the program has been successfully utilized for community-scale electrification projects across the in the Dominican Republic. The SGP has supported a total of 411 projects in the country and provided financial support to 126 projects related to climate change mitigation.

Source: See Endnote 57 for this chapter.

The Dominican Republic has nine projects, totaling USD 13.3 million in GEF grants. To date, only one renewable energy project in the country has received financing from the larger GEF funds.[62] (See Table 7.8.) Since the mid-1990s, however, the GEF Small Grants Programme has provided significant financial support to small-scale renewable energy initiatives across the country. (See Sidebar 9.) Within

Table 7.8 Ongoing GEF Small Grants Programme in the Dominican Energy Sector

Start Date	Program Description	Technology	Grant Amount	Households Impacted
			USD	number
Jun-12	Harnessing renewable energy in rural electrification from a micro hydroelectric power plant	Hydro	34,974	154
Jun-12	Water use for community electrification	Hydro	36,269	228
Jun-12	Electrification and environmental protection of La Pelada community	Hydro	45,337	38
Jun-12	Electrification and protection of natural resources of the buffer zone of the National Park Armando Bermudez community of Arroyo Frio, La Cienaga	Hydro	106,960	116
Jun-12	Clean energy for two communities	Hydro	31,088	109
Jun-12	Micro hydro power for integral development of the community and environment in Chinguelo	Hydro	47,927	80
Jun-12	Renewable energy production and natural resource protection for the electrification of the community of Mata Café	Hydro	49,500	78
Jun-12	Proposed renewable energy utilization and conservation of water resources in the community of La Ensenada	Hydro	47,927	50
Jun-12	Proposed renewable energy utilization in the community The Capá	Hydro	28,497	26
Jun-12	El Vallecito-El Montazo hydroelectric project	Hydro	49,000	160
Jun-12	Cabirma community micro-hydroelectric project	Hydro	28,497	56
Jun-12	Bocaina micro-hydroelectric project	Hydro	25,259	45
Jun-12	Naranjito photovoltaic system	Solar	23,316	40
Jun-10	Los Mangos community micro-hydroelectric project	Hydro	45,405	32
Jun-10	Vallecito community microhydro project – the Montazo	Hydro	46,361	140
Jun-09	Harnessing micro-hydroelectric production in Paradise Township communities (Hydroelectric Villa Nizao)	Hydro	42,857	50

Source: See Endnote 62 for this chapter.

the Dominican Republic, the Small Grants Programme has allocated USD 7.9 million in grants to 369 projects, including supporting the extension of electrification services through nearly USD 2 million in grants to community hydropower, solar PV, and bioenergy installations.[63]

Although traditional climate finance mechanisms should continue to play a role in financing renewable energy projects, future climate finance for upper-middle income countries such as the Dominican Republic is likely to shift away from the CDM to Nationally Appropriate Mitigation Actions (NAMAs). In the UNFCCC negotiations, developed countries have pledged funds through the Green Climate Fund

(GCF), rising to USD 100 billion per year by 2020.[64] Much of this funding is expected to be channeled to developing countries to support NAMAs, low-emission development, or other programs, projects, and initiatives focused on mitigation, adaptation, or strengthening resilience in the productive sector.

NAMA guidelines remain loosely defined, and as yet no funding has been dispersed through the process beyond that used for program design. However, there is strong interest on the part of multilateral and bilateral climate finance sources for recipient countries to design NAMAs that will be ready to receive funding once the necessary guidelines are finalized. NAMAs can include a broad range of activities, including support for specific renewable energy capacity additions, funding to support renewable incentive mechanisms such as feed-in tariffs and energy efficiency programs, and capacity building and institutional strengthening for sustainable energy governance. In addition to climate mitigation, NAMAs are required to demonstrate co-benefits, such as health impacts from reduced local air pollution.

The Dominican Republic is one of 34 countries to have officially engaged in the NAMA process and is one of only two Caribbean nations, along with Dominica, to have submitted NAMA proposals to the UNFCCC NAMA Registry.[65] One proposed project, promoting alternative energy and waste management in the tourism sector, was submitted with the goal of project implementation beginning in 2013. As of the end of 2014, however, it was still seeking financial support. The project aims to promote capacity building and provide financial support to facilitate renewable energy deployment in the tourism industry, lowering energy costs and reducing the sector's environmental impact.[66] The project is designed to initially target 45% of the hotel rooms in the country, with subsequent plans to expand the program nationwide, at a cost of USD 370 million for full implementation.[67] The Dominican Republic also has filed NAMAs to support using waste material for co-processing in cement plants, energy efficiency in the public sector, and reducing the greenhouse gas emissions of pig farms.[68]

The Dominican Republic has active initiatives to support sustainable energy through concrete projects, policies, and country-wide planning, providing the opportunity to secure climate financing to support these efforts. To make itself more attractive to sources of international financing, the Dominican Republic should actively pursue an aggressive Intended Nationally Determined Contribution (INDC) as part of the UNFCCC's effort to derive a globally binding agreement to address global greenhouse gas emissions and the increasing impacts of global climate change. Resources including this Roadmap report and the CCDP can play a strong role in developing ambitious goals that international institutions are eager to support.

Leveraging international assistance or climate finance to support loan guarantees also can help strengthen the country's energy market. Many companies will not invest in the country by themselves, and receiving support from an organization like the IFC can provide the security they need to make these investments in an affordable manner.[69]

7.3.3 Remittances

Remittances (money sent home by expatriates) play a significant economic role throughout the Caribbean and Latin America, and are increasingly recognized as an important opportunity to promote sustainable energy development. Remittances are transferred into the Dominican Republic through a combination of banks, transfer agencies, and informal mailmen, who make deliveries to friends and family.[70] In 2012, USD 3.16 billion in remittances was transferred to the country, an amount that is more than USD 1 billion greater than that received by any other Caribbean nation.[71]

The Dominican Republic was the only Caribbean nation to witness significant growth in remittances in 2012, at 4.8%.[72] However, the country is less dependent on remittances than some of its Caribbean neighbors, such as Jamaica and Haiti, with remittances accounting for 5.4% of GDP in 2012.[73] Although the overall cost of sending remittances to Central America and the Dominican Republic decreased by 12.4% in 2012, the country still has among the highest costs associated with transferring funds.

The majority of the funds remitted are used to cover basic household living expenses, with an estimated 25% of all remittances to Haiti and the Dominican Republic being used to cover energy and electricity costs.[74] Analysis from the IDB has concluded that remitters have a significant interest in controlling how their money is being spent, as well as in linking remittances to the energy sector.[75] With respect to investing in the energy sector, remitters were more likely to favor funding smaller equipment, such as solar lanterns or phone chargers, over larger systems, such as solar home kits or solar water heaters.[76]

Remittances could be pooled and leveraged to help finance larger sustainable energy projects, providing the necessary financial guarantee to convince investors to invest in the country. Pooled remittances also could be used to finance community-wide sustainable energy projects or to finance solar panel leasing programs. Although most renewable energy technologies have a lower levelized cost than fossil fuel technologies, they often are not purchased in lower-income communities because of the high upfront costs, especially for solar. If customers could avoid the upfront costs and simply pay the levelized cost of generation, they would be more willing to pay for renewables. Remittances could be pooled to pay for the initial capital costs of renewable energy technologies, leaving customers responsible only for paying for generation.

7.4 Summary of Financial Recommendations

The financial stability of the Dominican electricity sector is threatened by three major factors. First, high technical and non-technical losses continue to account for significant lost revenue, leading to an average 60% cash recovery rate for state-owned distribution companies.[77] Second, electricity rates set by the government remain below what is needed for generators to recover their costs, creating the need for government support to cover the revenue gap between distributors and generators and preventing funds from being reinvested in new infrastructure. Third, the reliance on expensive imported fuels has led to a high cost of generation and to a significant increase in foreign debt.

Through the end of 2014, loans received through participation in the Petrocaribe agreement accounted for roughly 25% of all non-financial public sector external debt.[78] With the continuation of the preferential loan terms from Petrocaribe now under threat, there is a strong potential that oil imports may put an even greater strain on the country's finances in the near future. To increase the financial stability of the national electricity sector, efforts should be made to address these three critical areas.

Financing renewable energy and energy efficiency projects in the country will require the participation of both public and private actors, utilizing domestic as well as international resources. To encourage the flow of private capital into the sector and to reform existing financial and political environments, two guiding principles should be considered:

1) Strengthen the general investment climate through policy and finance initiatives that ensure a differentiated rate of return for alternative energy investments, so as to increase financing in this sector over more traditional energy investments, and

2) Reduce the risk associated with investing in alternative energy projects.[79] Risk reduction mechanisms are increasingly becoming mainstream elements of climate finance initiatives, funds, and programs and can be incorporated into this policy-level effort. For projects to be developed, specific barriers that currently constrain access to financing in the sector must be addressed.

High interest rates pose a barrier to accessing finance in the Dominican Republic. They can be a particular challenge for energy efficiency and renewable energy projects, where banks are still building their lending capacity. The lack of access to private loans continues to impede project development as well. Initial progress has been made in making domestic private financing available in the alternative energy sector. Lessons learned from Banco BHD's experience in lending to fuel switching projects should be utilized to scale up and expand the bank's lending portfolio and to encourage additional private banks to offer similar loan products. It is critical that additional private lending capacity for renewable energy and energy efficiency projects be developed in Dominican banks.

However, certain economic sectors do have reliable access to financing. In the hotel and tourism industry, in particular, access to financing should not pose a barrier to energy efficiency and renewable energy investment. Here, the lack of sustainable energy investment is more a matter of the need for education, outreach, and capacity building regarding the benefits and opportunities of climate finance, as well as the will to implement energy upgrades.[80]

Furthermore, certain public financing mechanisms, such as the Dominican sustainable energy fund and Petrocaribe, have not been leveraged to support renewable energy and energy efficiency as designed. These funds could play a significant role in mobilizing the domestic financing needed for project deployment.

International financing also must be used to scale up renewable energy development. A number of mechanisms are available to de-risk investments in renewable energy projects, and can be supported through the disbursement of public funds. If well designed, they are capable of leveraging far more in total investments than the cost associated with the mechanism itself. Because project risk continues to be a strong barrier for financing renewable energy projects, de-risking mechanisms should be analyzed and implemented where deemed appropriate.[81] (See Table 7.9.)

The Dominican Republic is a leading Caribbean nation in accessing international climate finance. Support from mechanisms like the GEF (both for large and small-scale projects) and the CDM should continue to play a role in providing financing to renewable energy projects. Domestic capacity should continue to be developed to allow the country to benefit from new mechanisms such as NAMAs, where it has emerged as an early participant, as additional international funding becomes available.

Table 7.9 Sample De-risking Mechanisms for Renewable Energy Projects

Mechanism	Type	Description	Estimated Leverage Ratio
Loan guarantees	Debt-based	Guarantee of loan payback if the borrower is unable to meet the loan terms	6–10x
Policy insurance	Debt-based	Provides a guarantee that support from a policy, such as a FIT, will be provided even if the policy is not enforced as designed	10x
Foreign exchange liquidity facility	Debt-based	Guards against currency risk associated with revenues and debt in different currencies	N/A
Pledge fund	Equity-based	Provides funding to projects without sufficient access to equity and too small to attract equity investors	10x
Subordinated equity fund	Equity-based	Reduces risk to equity investors	2–5x

Source: See Endnote 81 for this chapter.

The renewable energy sector remains a policy-driven market. As such, many barriers to financing projects can be overcome through the development and implementation of well-designed policy mechanisms. Despite certain opportunities for reforms in the financial sector, a thorough scaling up of renewable energy financing will depend on policymakers creating the enabling framework to allow investments to take place. Financial actors and policymakers must communicate to ensure that these specific needs are addressed during the policymaking process. (See Chapter 8.)

8 | Policies to Harness Sustainable Energy Opportunities in the Dominican Republic

Key Findings

- The Dominican Republic's National Energy Plan, National Development Strategy 2030 (Law 1-12), and Climate Compatible Development Plan set important targets for renewable energy (25% share in the overall energy mix by 2025) and greenhouse gas emissions (25% reduction by 2030). Implementing necessary reforms is an important first step to realizing these targets and transitioning to a sustainable energy system.
- Although these targets are ambitious when compared with other developing countries, the shares could be increased to bring even greater economic, environmental, and social benefit.
- Remaining barriers to achieving a sustainable energy transition can be overcome through the right policy mix.
- Despite ambitious targets for renewable energy and greenhouse gas emission reduction, the country's long-term energy vision still appears to support a largely fossil fuel-based system.
- To improve effectiveness, the National Energy Plan needs to be more specific in key areas and to include benchmarks and verifiable and enforceable sub-sectoral goals.
- The new Ministry of Energy and Mines currently has six vice-ministries, with one focused on energy efficiency and none focused solely on renewable energy. We suggest reducing this to three vice-ministries: 1) Administration, 2) Energy, and 3) Mining. This would help to establish a foundation for prioritizing sustainable energy solutions and to streamline important steps, including:
  - Collecting and centralizing all of the reports and data available on the energy sector in the country. This information currently is dispersed across several agencies.
  - Creating a one-stop shop to streamline lengthy and bureaucratic permitting procedures that increase renewable energy investment risk. The office in charge needs to be strengthened with more employees and extra training.
  - Revising the Hydrocarbon Law broadly across all fossil fuels to incentivize sustainable energy generation and consumption. Currently, few fossil fuels, including those used for electricity generation, are taxed.
  - Providing clear roles for subsumed agencies and guidance for other ministries.
  - Ensuring an independent third-party regulator that is free of outside influence.
- The Dominican Republic should incentivize energy audits, establish robust energy efficiency standards in its building code, and encourage cool roofs.

- Annual reviews and fuel-indexing should form the basis of tariff formation. Electricity tariffs are currently set below market price, resulting in a large government debt owed to generation companies. Solar developers cannot compete with existing tariff rates that are kept artificially low.
- Smart metering systems, public awareness campaigns, resisting electoral gift-giving, and government leadership could be solutions to lowering electricity theft.

Chapters 1–7 demonstrate the resource potential, technical feasibility, and socioeconomic benefits of a sustainable energy pathway in the Dominican Republic. Given the country's available renewable energy resources and potential for using energy more efficiently, the high cost of fossil fuel-based electricity generation, and the electricity sector's significant debt and high transmission and distribution losses, Worldwatch identifies five key priorities for the sector's development:

- Reduce technical and non-technical losses, primarily through improved bill and payment collection of both residential and large-scale consumers, technical upgrades to existing infrastructure, and technology upgrades in smart metering.
- Index the cost of electricity to the price of fuel to create a more level and competitive playing field for resources that can capitalize on the country's abundant renewable resources.
- Promote the development of small-, medium-, and large-scale renewable energy projects, utilizing technologies that take advantage of the Dominican Republic's myriad resources.
- Implement a robust energy efficiency program.
- Strengthen the specificity and enforcement of energy planning in the upcoming National Energy Plan.

Achieving these goals will require building an effective policy framework with three important elements: 1) an effective and ambitious vision for sustainable energy development that includes concrete goals and a cohesive strategic agenda, 2) a governance structure with strong institutional capacity and effective administrative processes, and 3) a mix of targeted support policies and mechanisms designed to improve energy efficiency, encourage investment in renewables, and accelerate their deployment. Based on analysis of the Dominican Republic's existing policy framework and relevant international best practices, this chapter makes concrete recommendations for designing these components.

8.1 Establishing a Long-term Sustainable Energy Vision

A critical step toward creating a comprehensive energy policy is developing a vision for sustainable energy that is "loud, long, and legal."[1] The energy sector vision should be "loud" by outlining clear overall goals and targets in writing, to be easily accessible for any interested party. A "long" vision will guide political action well into the future, beyond any changes in leadership. And finally, a "legal" vision serves as a framework and reference point and is designed to commit all government branches as well as key non-governmental stakeholders to a joint agenda of change, thus providing the impetus for the development and implementation of the concrete, consistent policies needed to promote investment within the sector.

The Dominican Republic has recognized the importance of a clean energy supply in its Constitution. Article 67 of the *Constitution of the Dominican Republic* elevates clean energy development to a high-profile national goal, stating that, "The State shall promote, in the public and the private sector, the use of clean alternative technologies to preserve the environment."[2]

The Dominican Republic also has made international commitments to low-carbon development, including by being a signatory to the Kyoto Protocol of the UNFCCC. In its Second National Communication to the UNFCCC, the country details a climate mitigation strategy that includes renewable energy generation and energy efficiency measures.[3] At the UNFCCC COP in Cancún, Mexico, in December 2010, then-Vice President Rafael Alburquerque de Castro highlighted Dominican environmental policies and mitigation efforts while underscoring the need for strong international support for continuing and accelerating such policies.[4]

During the 2012 COP meetings in Doha, Qatar, Omar Ramirez, Executive Vice President of the National Council for Climate Change and Clean Development Mechanism, said about the Dominican Republic's goal to cut greenhouse gas emissions 25% by 2030: "This is a very ambitious goal for a developing economy. We see this not in economic terms, but in moral terms."[5] A recent version of the Dominican national development plan aims at reaching this goal while at the same time doubling the country's GDP.

In 2011, the country's carbon dioxide emissions from energy consumption totaled 20.6 million tons, up from 15.8 million tons in 2000 (see Table 8.1), making the energy sector a core area for implementing mitigation strategies.[6] The electricity sector, at 9.8 million tons, accounted for more than 46% of the country's energy-related emissions in 2009.[7]

Table 8.1 CO_2 Emissions from the Energy Sector in the Dominican Republic

Emissions Source	2000	2005	2011
		million tons of CO_2	
Energy sector	15.8	17.4	20.6

Source: See Endnote 6 for this section.

The Dominican government announced in 2011 that it is committed to reducing its absolute greenhouse gas emissions 50% from 2010 levels by 2030—a share that stands out in the developing world, where many countries perceive continued economic growth and increased emissions as being inextricably linked.[8] The Dominican Republic can begin a paradigm shift in which environmental protection and climate mitigation are not at odds with sustained economic development.

The country also is a signatory to the 2012 Barbados Declaration on Achieving Sustainable Energy for All in Small Island Developing States, a voluntary agreement that commits countries to promote biofuels, plan new generation and transmission and distribution infrastructure, enforce environmental regulations in the electricity sector, and promote energy efficiency measures.[9]

The country's targets for renewable energy development are no less ambitious. Law 57-07, on *Renewable Sources of Energy Incentives and Its Special Regimes*, sets a target for a 25% share of renewables in the country's final energy consumption by 2025.[10] This is comparable to the European Union's "20 by 2020" objective, which calls for a 20% share of renewables in final energy consumption by 2020.

These targets are in the process of being reaffirmed in the Dominican Republic's *National Energy Plan*, which is now being updated. The plan aims to provide the right conditions to ensure a sufficient and secure energy supply at low cost and with minimal environmental impact. It is structured around four main energy policy tasks: 1) the consolidation of governmental functions in designing energy policy and regulating the energy system, 2) the development of domestic energy resources, 3) the supply of safe, low-cost, and high-quality energy, and 4) greater freedom of choice for energy consumers.[11]

CNE is leading the revision process, which will be subject to review by various stakeholders, including the new Ministry of Energy and Mines and CDEEE. The final plan will be integrated into the *National Development Strategy 2030*, a 20-year national public policy roadmap. The Strategy was developed by the Ministry of Economics, Planning, and Development, following Article 241 of the Constitution of 2010, and was passed into law as Law 1-12.*

8.1.1 Recommendations to Strengthen the Dominican Republic's Long-term Energy Vision

In May 2011, the National Council for Climate Change and the Clean Development Mechanism (CNCCMDL) and the private consulting firm, McKinsey & Co., released a *Climate-Compatible Development Plan* (CCDP) for the Dominican Republic, which details a short- to medium-term plan in support of the country's greenhouse gas emission reduction target, including through energy sector measures.[12] Among the plan's key recommendations are fuel switching from petroleum to natural gas in power plants, expanding renewable energy generation, and taking advantage of cost-saving energy efficiency opportunities. (See Sidebar 10.)

In addition to momentum from CNE, the CCDP, and other agencies and plans, there is increasing pressure within the Dominican Parliament for an effective energy policy framework. In a January 2013 presentation to the Institute of the Americas, then-Congressman Mr. Pelegrin Castillo Semán stressed the importance of reducing the country's reliance on fossil fuel imports and moving toward energy independence through improved energy efficiency, development of renewable energy resources, and grid improvements.

In October 2014, the Dominican Republic launched Pacto Eléctrico, a wide-ranging inititative to address the country's persistent electricity challenges. Drawing specifically from the *National Development Strategy 2030*, Pacto Eléctrico intends to provide a reliable, efficient, and environmentally sustainable electricity system.[13] When it was launched, it proposed four stages for arriving at a final agreed-upon plan. Its first stage, completed in the first quarter of 2015, gathered proposals and input from all social and

* The National Development Strategy is a 20-year national public policy roadmap, and the Commission will convene a seminar at the National Congress "with deputies, senators and technicians who can explain the importance of this project and the details, and review the proposal point by point to yield a report" to be submitted to both houses. Public hearings on the Strategy began in El Caribe on July 21, 2011.

Sidebar 10. The Climate-Compatible Development Plan and Worldwatch's Sustainable Energy Roadmap: Complementary Strategies for Emission Reductions

The CCDP provides an essential overarching strategy and recommendations for achieving the Dominican Republic's greenhouse gas emission targets in several sectors. Worldwatch's Sustainable Energy Roadmap for the Dominican Republic complements the CCDP strategy by providing the comprehensive technical, financial, and policy analysis needed to implement the CCDP's overarching framework of development goals and emission reduction targets in the energy sector.

The CCDP recommends expansion of renewable generation through biomass, small hydro, and wind generation. Worldwatch's Sustainable Energy Roadmap, as well as the preliminary solar and wind roadmap, provide thorough resource potential assessments for each of these technologies and identify the most promising sites and technologies for developing this potential. Furthermore, Worldwatch's energy efficiency recommendations, including for appliance standards, building efficiency, and electricity losses as well as feedback on the Energy Efficiency Law, will guide the government in realizing the country's full energy-saving potential in some of the priority areas identified by the CCDP.

Chapter 7 of this Roadmap—the assessment of financing options for energy efficiency and renewable energy in the Dominican Republic—supplements suggestions for international funding sources provided in the CCDP. In particular, Worldwatch provides capacity building advice for sustainable energy lending to private developers within domestic banks. Because, as the CCDP points out, future availability of climate finance through the Clean Development Mechanism will likely be replaced by Nationally Appropriate Mitigation Actions (NAMAs) and other mechanisms, Worldwatch and other organizations are actively identifying emerging opportunities for climate finance in the Dominican Republic.

economic sectors of the country including various government agencies, civil society, private businesses, and local energy experts. The second phase, under way in the second quarter of 2015, is composed of a series of roundtable discussions and working groups staffed by industry professionals that will evaluate all proposals and submitted ideas. An initial draft was expected by July with a final plan signed and in place in August.[14]

The *National Energy Plan*, CCDP, proposals from government officials such as Mr. Castillo Semán, and Pacto Eléctrico all provide a strong overarching vision for moving the Dominican Republic to energy independence while at the same time reducing greenhouse emissions. These strategies acknowledge the importance of implementing energy efficiency measures and harnessing the country's vast renewable energy potential. The integration of energy goals in the Constitution and the *National Development Strategy* also suggests that sustainable energy development is increasingly integrated as a national priority across government agencies.

Nevertheless, all of these energy visions continue to view fossil fuel consumption as important to the country, often citing the perceived high cost of renewable energy technologies as a barrier to transitioning away from fossil fuels more quickly. For example, the CCDP energy plan recommends replacing existing fuel oil generation capacity and moving away from self-generation using expensive, polluting diesel generators, but it sees an expanded role for natural gas in the energy mix. Natural gas can provide a relatively low-cost bridge fuel by complementing renewable intermittency with lower emissions than other fossil fuels, as demonstrated by Worldwatch's electricity generation scenarios (see Chapter 6); however, the government should ensure that gas generation will remain an economical choice even if natural gas prices rise in the future. In addition, energy policies should ensure that expansion of cheaper natural gas generation does not crowd out larger shares of renewable generation and, by extension, exchange oil reliance for over-reliance on natural gas.

Despite wide-ranging support of sustainable energy solutions, some energy-sector government officials also suggest that renewable energy resources could be insufficient to meet the country's energy needs and recommend expanded exploration for domestic on- and offshore oil and gas resources. However, Worldwatch's renewable energy potential and socioeconomic assessments demonstrate that not only does the country have ample renewable resources to meet its energy needs, but, if implemented properly, a renewable energy system could actually save the country money compared to fossil fuel-based alternatives.

Finally, complementing CCDP recommendations, Worldwatch recommends that the Dominican Republic examine key opportunities for solar energy development. While the CCDP judged solar power as too expensive to be a viable near-term energy source, Worldwatch assessments found that self-generation on rooftops can be cost-competitive with current electricity prices; moreover, solar, in addition to micro-hydro, is often the most logical resource for expansion of clean energy services to remote areas that lack electricity access. Significant cost reductions in the international solar market have taken place since the CCDP report was released, further strengthening the economic rationale for deploying solar technologies.

Overall, the Dominican Republic has a strong sustainable energy vision and targets in place that are recognized throughout the government and that provide a long-term foundation for institutional support and concrete implementing policies. The central role of energy efficiency and renewable energy should be prioritized even more in the country's energy vision to ensure that transition strategies, such as natural gas, are designed to work with renewable energy development in ways that establish stronger building blocks and contribute to the realization of the country's ambitious emission reduction goals.

8.2 Administrative Structure and Governance

As policymakers, regulators, citizens, businesses, and international donors grapple with the challenge of providing access to reliable, clean, and affordable electricity, the importance of "good governance," or how multiple actors are included and participate collaboratively in the decision-making process, has been increasingly recognized. Two decades of electricity sector reform have shown how transparency, participation, accountability, and strong capacity of the various actors in the sector can work toward improving electricity governance.

Electricity governance, including the processes, institutions, and actors involved in decision making, has a significant impact on sector performance. Effective governance is considered a necessary and critical condition to attracting private investment in electricity and creating and strengthening a stable marketplace.* Yet energy governance in the Dominican Republic is not as effective as it should be. Despite the creation of a new Ministry of Energy and Mines, it took over a year for a minister to be appointed. Further, the new ministry inherited a long-term legacy of at least five agencies with no central coordination among them, despite laws in place that define the working relationship between these agencies.

* A description of regulatory institutions can be found in Appendix VII.

8.2.1 Ensuring a Sustainable Energy Focus in the New Ministry of Energy and Mines

The Dominican energy sector has developed with resources and initiatives spread across a multitude of government agencies with overlapping, and sometimes opposing, mandates and priorities. This conflict affects various aspects of energy planning and regulation. For example, the Organismo Coordinador (OC-SENI) is responsible for developing a strategy for adding electricity capacity to the grid, which CDEEE is supposed to implement. However, CDEEE often fails to implement these plans accordingly, which often leads to higher-marginal-cost power being sold on the grid earlier than necessary.[15] Frequent personnel changes add to the lack of institutional memory, which poses a challenge to stable support for sustainable energy projects. Changes in ministers, for example, are usually accompanied by comprehensive turnover of an entire bureau's staff.

In an attempt to streamline energy sector governance, President Danilo Medina, during his campaign, promised to create a new Ministry of Energy and Mines (MEM) to develop and implement all energy sector strategies and programs. The Administrative Ministry of the Presidency subsequently organized a Commission for the Constitution of the Ministry of Energy and Mines, leading to the Ministry's official enactment on July 30, 2013 with the signing of Law 100-13.

The establishment of this new ministry is an important development for energy governance in the country because it elevates the energy sector and its issues to the Cabinet level and could streamline energy-related activities that currently are spread among multiple agencies. Ensuring that sustainable energy goals are embraced across all agencies should result in greater clarity and long-term persistence of these programs. Greater ministerial cohesion also would help sustainable energy policies gain traction in the Parliament.

The new MEM is tasked with "the formulation, adoption, monitoring, evaluation and control of policies, strategies, master plans, programs, projects and services related to the energy sector and its subsectors of electricity, renewable energy, nuclear energy, natural gas and mining."[16] Under this mandate, it will oversee and coordinate all energy-related activities currently undertaken by CNE, the National Geological Survey, and any other autonomous bodies engaged in subsectors covered by the law.

Such a change will help resolve challenges such as the fact that CNE always has been governed by an inter-ministerial council chaired by the Ministry of Industry and Commerce. Now it will be chaired by the Minister of Energy and Mines, which will have decision-making authority over developments in the energy sector, something that CNE previously lacked and that severely restricted its influence. Under the new Ministry, this inter-ministerial body should be strengthened and expanded to provide the needed platform for policy mainstreaming and coordination by including representatives from the Ministry of Finance, CDEEE, and other relevant government agencies.

During the reorganization process, the state-owned electricity utility, CDEEE, was left outside the organizing umbrella of the new MEM for fear that its current initiatives would be interrupted. There is some merit to this concern. However, for some time, in the absence of an official Minister of Energy, the Executive Vice President of CDEEE has been seen as the closest alternative. As the official ministry continues to establish itself, it will be important to prioritize consolidation of CDEEE under the larger umbrella of MEM, along with all of the other agencies that are successfully making the transition.

The Minister of Energy and Mining oversees six Vice Ministries: Energy, Nuclear Energy, Mines, Hydrocarbons, Energy Security and Infrastructure, and Energy Saving. This structure, while comprehensive, might not be the most effective in terms of alignment with the country's stated long-term energy goals. It sends a mixed message that relegates the stated priority to increase levels of renewable energy to an office under the Vice Ministry of Energy, while elevating nuclear energy and hydrocarbons, for example. Refocusing MEM's energy diversification efforts on the Dominican Republic's vast and economical alternative and renewable energy resources would be a more sound and effective use of resources.

By law, a Ministry is allowed to have no more than six Vice Ministries. To better address the various components that comprise the country's energy sector, and to avoid apparent conflicts in priorities, it might be simpler to establish three Vice Ministries: Energy, Mines, and Administration. This would allow all sub-topics to be equally established at the sub-office level and would avoid weakening the influence of renewable energy within MEM, which currently has less authority expressly provided under the law. Overall, it remains unclear how MEM will be fully structured, beyond its broader mandate, to successfully undertake specific tasks. Establishment of sub-offices and the like has not been well publicized and has lacked transparency. Any knowledge that Worldwatch has gained on this subject has come through personal interviews; the overall lack of transparency makes it difficult for the general public to voice its opinion as well.

The new MEM will administer any resources and assets specifically allocated for energy-related initiatives, including the fund established by Law 112-00 to support energy conservation and clean energy programs. (See Section 7.2.) However, greater clarity is needed regarding some of the specific roles and authorities of MEM. In particular, the role of existing agencies such as CNE and CDEEE should be more clearly defined, as should the reason why CDEEE will exist outside of MEM until 2018.[17] The responsibility of MEM for new electricity capacity procurement and grid infrastructure development also needs to be elaborated.

The legislation includes detailed discussion about the role of MEM in coordinating and granting permits for fossil fuel exploration and extraction. This is an important role and should be organized in an efficient, streamlined process to simplify compliance and reduce costs for project developers. (See Section 8.2.3.) Beyond the tasks expressly enumerated in the legislation, MEM can play an important role in leading and coordinating numerous other necessary activities. This Roadmap has highlighted the importance of detailed resource and feasibility assessments to spur renewable energy investment, so MEM should facilitate this process. Ideally, a Deputy Minister for Renewable Energy would oversee permitting, on-site assessments, resource assessments, and other issues relating to renewable energy development.

8.2.2 Enforcing Electricity Regulator Independence

An important aspect of a well-functioning electricity sector is an effective and independent regulator. The Dominican Republic's electricity sector is regulated by the Electricity Superintendent (SIE), which oversees and monitors compliance with laws, regulations, and technical standards in relation to generation, transmission, distribution, and marketing of electricity, including oversight of CDEEE, the state-owned monopoly utility company. SIE's independence has been called into question, and in several notable cases it has failed to issue sanctions for violations that fall under its jurisdiction. These violations include CEPM's illegal private transmission line, power sales from La Sultana de Este to CEPM on the national grid, and the failure of Cogentrix to switch from diesel fuel to LNG as mandated.[18] These examples highlight how, even when laws exist in the books in the Dominican Republic, they are not necessarily enforced by the regulator.

To function effectively, the regulator must remain an autonomous entity that receives its mandate from, and is held accountable for its execution by, the Dominican government. Uncertainty regarding SIE's independence as a regulator was reinforced following the establishment of the new MEM in 2013. To maintain an effective regulatory system, the government must reaffirm SIE's autonomy. Furthermore, the regulator must be granted the authority to hold all actors in the energy sector accountable to their legal requirements.

For example, the difficulty in getting the state-owned transmission company, ETED, to buy and operate transmission lines (especially from renewable energy projects, as required by law) has been a challenge constraining renewable energy developers. ETED has been reluctant to take on and operate new transmission lines even in cases where project developers are willing to forgo the sale of the equipment. Without enforcement mechanisms to ensure that ETED complies with its mandate, developers will continue to struggle to develop the infrastructure necessary to connect to the national grid, further limiting the deployment of renewables. For example, ETED refused to operate a transmission line connecting the proposed PECASA wind farm, eventually contributing to the project not going through.[19] Since ETED is responsible for operating a transmission line as long as that project is viable, it should be mandated to do so by the electricity regulator.

8.2.3 Streamlining Renewable Capacity Permitting: A Single Administrative Window

Effective permitting is essential to ensure that the negative environmental and social impacts of energy projects are limited. However, long and bureaucratic permitting processes can result in significant risk and expense, discouraging developers and investors from undertaking renewable projects. (See Figure 8.1.) For example, while the Ministry of Environment is supposed to respond to permit applications within one month, the developers of the 30 MW Monte Plata solar project had to wait more than six months. (See Sidebar 11.) This particularly disadvantages small IPPs, as larger entities with greater influence tend to receive faster responses.[20]

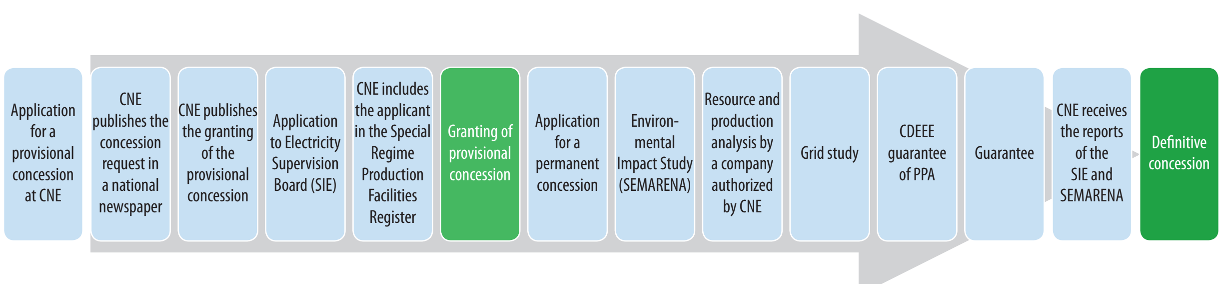

Figure 8.1

Administrative Procedure to Obtain a Renewable Energy Concession

Sidebar 11. Impact of Governance and Administration on the Monte Plata Solar Farm

Bureaucratic hurdles have had a significant impact on the development of renewable energy projects in the Dominican Republic. Since its public announcement in 2010, the Monte Plata solar farm has faced numerous challenges in attempting to become the country's first solar installation operating under a PPA. These complications have significantly delayed the implementation of the project. Originally scheduled for completion in October 2012, by early 2013 the planned 30 MW project had successfully installed only 200 kW of capacity.

Monte Plata has faced delays in coordinating with various government agencies to comply with the country's regulatory procedures for project licensing. Initial project phases were delayed as a result of slow response from the Ministry of Environment on environmental permitting. Despite the Ministry's mandate to respond within a month, developers often must wait many months before their projects are deemed in compliance with environmental regulations. Additionally, government non-responsiveness in granting interconnection permits led to significant project delay and the eventual need to renegotiate the PPA. High staff turnover and a lack of institutional memory within the ministries further complicated already onerous procedures for the project's developers.

Negotiations with CDEEE over the PPA provided an additional challenge to bringing Monte Plata online. An agreement was reached in October 2011 for the project to generate at an initial rate of just under USD 0.20/kWh. Under the agreement, by 2013, power from the plant would be sold at roughly USD 0.22/kWh. Due to project delays, however, developers have been forced to renegotiate the initial agreement with CDEEE. In the renegotiated PPA, power from Monte Plata was to be sold at a rate of USD 0.18/kWh, roughly 5 cents below the original agreement and far below the benchmark rates for solar PV given under Law 57-07.

Despite these setbacks, the country's impressive solar resources have encouraged project developers to continue plans to construct the facility. After changes in project ownership, the new developers were expecting to connect 32 MW to the national grid by year-end 2013, with full operation of a 64 MW plant expected by October 2014. However, financial challenges related to capital investment, financing, and the final PPA price continue to plague the project and it is not yet operational.

Grid connection is often the longest, most uncertain, and costliest part of the permitting process. Worldwatch recommends guaranteed grid access for renewable energy installations, which should eliminate most of the uncertainty and delay associated with this step.

One way that the government can reduce land acquisition conflicts and delays associated with renewable energy projects is to open up public lands for renewable energy development. In particular, the government can establish a bidding process for companies to submit applications to develop specific sites on public land known to have strong renewable resource potential. For example, in the southwest corner of the country, currently home to the largest wind park in the Caribbean, the country is planning to develop an area that is now a protected national park with a relatively untouched coastline. The long-term objective is to increase tourism. The area also boasts incredibly strong solar and wind resources. To minimize the environmental impact of this development, the government should insist that a particular share of the energy needed to facilitate this tourism be met with electricity generated by renewable technology close to the point of consumption.

Accountability measures for the various government agencies involved in renewable energy permitting should be implemented to ensure timely and efficient procedures. All relevant actors should be required to respond to permit applications within set time frames.

International best practice demonstrates the use of a single administrative window where developers can obtain the necessary permits, concessions, and eligible incentives in order to greatly simplify renewable energy development. As examined in Chapter 7, the lack of economically sound contractual PPAs also hinders investments in viable renewable potential. The new Ministry of Energy and Mining, SIE, and CDEEE should work together to develop a standard contract and PPA for different categories of renewable installations to increase investor confidence in the stability of sustainable energy investments.

8.2.4 Strengthening the National Climate Change Council

In 2008, the Dominican Republic established a National Climate Change Council (CNCCMDL) responsible for planning investments for international climate financing under the CDM and other mechanisms. In support of this mission, CNCCMDL coordinated the development of the country's Climate Compatible Development Plan. However, CNCCMDL lacks direct decision-making authority; for example, the Council recommended against expanding coal generation, but it was overruled and two new coal plants have since been commissioned. In general, the Ministry of Planning has been able to bypass recommendations concerning energy planning made by both the CNCCMDL and CNE, even though these organizations are supposed to contribute to energy planning. This underscores a general problem with the energy sector, where agencies that are supposed to focus on energy planning often are outweighed by larger agencies when it comes to actually making planning decisions.

8.2.5 Promoting Energy Education and Outreach

Building awareness among the general public is another key component of improving governance. Increasing the public's understanding of electricity issues and programs on both a national and local level will improve consumer behavior as well as the government's ability to govern effectively. Stakeholder education and outreach includes finding ways to promote broader participation in electricity policy and governance. The Ministry of Energy and Mines, with support from the OAS, is developing an "Education and Awareness for Renewable Energy and Energy Efficiency" program, the content and strategy for which are still being developed.[21]

When it comes to a technical subject like electricity, policymakers may be reluctant to open the discussion to non-experts. However, a review of environmental decision making in the United States reveals that in many cases, decisions were substantively improved through public participation.[22] Similarly, a study on civil society participation in electricity-sector governance in India, the Philippines, Indonesia, and Thailand concludes that, "improved governance can open the door to more creative solutions..., better systems of implementation, and stronger mechanisms of accountability."[23] Successful social and environmental outcomes are more likely if policies and regulations in the power sector are open to public debate and scrutiny. Public participation and insight into crucial and often contentious subjects like electricity theft can improve both policymaking and public compliance with regulations.

8.3 Concrete Policies and Measures

Direct support mechanisms for renewable energy and energy efficiency are needed to facilitate the development and deployment of various technologies and to meet overarching sustainable energy targets.

Because sustainable energy markets are largely policy-driven, government policies—including those targeted at research, development, demonstration, and deployment—play a crucial role in mitigating the technical and non-technical barriers obstructing their deployment and the implementation of other sustainable energy solutions. Maximizing effectiveness requires that policies share three general characteristics:

- **Policies must be implemented as part of an appropriate policy mix:** Although certain policies have proven effective in rapidly increasing renewable energy deployment in certain contexts, policy design is not one-size-fits-all. Policymakers must identify a combination of policy measures that most effectively address existing circumstances, including technological maturity, affordable capital, ease of integration into the existing system, and the available local and national renewable energy resource base.

- **Policies must be sustained:** In order to provide energy investors and developers with the stability and reassurance they need to commit to sustainable energy projects, policies must be sustained over an appropriate period of time. Without the assurance that the policy landscape will remain fairly stable, would-be investors will view commitment as too risky. This is particularly crucial in the Dominican Republic, where policy stability has long been one of the biggest underlying challenges in the energy sector.

- **Policies must be flexible:** Given the dynamism of renewable energy markets and technology developments, policies must be flexible enough to evolve in changing conditions.

The Dominican Republic's legal and policy framework for the energy sector has several provisions to promote energy efficiency and renewable energy in the electricity sector. The breadth and effectiveness of these policies are examined below.

8.3.1 Encouraging and Improving Energy Efficiency

The government of the Dominican Republic has identified the importance of promoting energy efficiency and has included it as one of the key priorities of the new Ministry of Energy and Mines. Likewise, it has several energy efficiency policies and programs in place. CNE established an overarching National Plan for Energy Efficiency in order to promote a broad vision for energy efficiency across all sectors, including housing, industry, the commercial sector, and buildings. The Plan established a National Energy Efficiency Committee (SENCO) with representatives of the various sectors of country, and created a national Energy Efficiency Unit (EEU) in all provinces, in order to provide assistance and guidance to the various sectors of the country with tools to increase their energy efficiency in daily operations. As a first step, government buildings are undergoing energy audits and testing of energy demand monitoring systems.

In October 2012, the Chamber of Deputies (the lower house of the national congress) proposed an energy efficiency bill aimed at implementing goals within the National Plan for Energy Efficiency by establishing energy efficiency standards and incentives and facilitating integration of renewable energy technologies. Specific measures in the law include: appliance efficiency labeling and standards; tax exemptions for energy-efficient equipment; frameworks for improving efficiency in the transportation, building, commercial, and industrial sectors; incentives for electricity generation from waste material; and penalties for non-compliance with standards. When it was first submitted to the Congress for debate, the legislation contained metrics for energy efficiency that were in line with many internationally accepted standards, but these were subsequently weakened as various interests exerted influence on them.[24] It is our view that this legislation should be passed and that implementation should be overseen by the Vice Ministry for Energy Efficiency within the new Ministry of Energy and Mines.

Incentivizing Energy Audits

Tax incentives should be implemented to encourage energy audits, which help consumers identify the simplest and most effective ways to reduce their energy consumption and costs. Several Caribbean countries have implemented such measures. In Trinidad and Tobago, Finance Act No. 13 provides a 150% tax allowance for companies that carry out energy audits and install energy-saving equipment. The same law guarantees 75% accelerated depreciation on all machinery needed to conduct energy audits for companies that perform them. In the Dominican Republic, such measures could have a particularly large impact in the tourism sector, where hotels require significant power for air conditioning and could potentially save a great deal of money by reducing their consumption.

Including and Enforcing Energy Efficiency Standards Through Building Codes

In the Dominican Republic, 33% of the country's final electricity consumption is in the residential sector, which suggests that including energy efficiency standards in building codes would be a highly effective policy for improving economy-wide energy efficiency and conservation. Currently, the country does not have policies to mandate energy efficiency in buildings. The 2006 *General Regulations of Buildings* should be updated to include energy conservation and efficiency as part of the building code.

The most effective way to develop rigorous energy efficiency building codes is to adhere to international performance standards, with additional region-specific regulations to ensure local relevance. Caribbean small-island states deal with conditions specific to their location, such as extreme temperatures, elevated humidity levels, and corrosion from salt air environments. All of these can negatively affect investment in materials and equipment meant to increase energy efficiency. The International Energy Conservation Code (IECC) and the European Energy Performance in Buildings Directive (EPBD) are two international building efficiency codes that could be modified for the Dominican Republic.

Heating and cooling, lighting, and facility of renewable energy technology integration should be central components of an effective building efficiency code for the Dominican Republic. These subsectors are examined below. (See Appendix V for detailed, quantitative recommendations.)

To be effective, energy efficiency building codes must be properly enforced. Buildings require a particularly rigorous enforcement process of compliance, monitoring, and inspection. Enforcement of energy efficiency standards should be integrated into existing building code regulations. Before any physical work is done, construction documents must be reviewed to ensure that the building design complies with code requirements. Once the documents are approved, construction may begin. Monitoring by building code officials during construction is important to ensure that proper procedure is being followed. When construction is completed, code officials should inspect the various building systems to confirm that they conform to the building code regulations. Once the inspections are passed, the building can be occupied.

Once energy efficiency and building performance requirements are adopted, the workforce must be trained to properly implement them, and officials need to be trained to ensure that the codes are being followed. The organizational structure of the DGRS provides an excellent framework within which to accommodate both the adoption of new codes and the training of regulation officials. Within the DGRS, three departments address the major code enforcement components and the capabilities of the workforce: the Department of Coordination and Supervision for the Application of Regulations, the Department of Technical Regulations, and the Department of Orientation, Disclosure, and Continuing Education.

Ideally, efficiency measures will be mandated through the Dominican building code, which will allow implementation and enforcement through the existing framework. If, however, efficiency measures are established through separate standards, these would not necessarily be legally binding and would require a separate enforcement system.[25]

Several specific measures can be adopted to decrease energy use:

- Encourage Cool Roofs: Efficiency standards should focus on technologies that are inexpensive and easy to deploy, particularly passive cooling methods, since air conditioning accounts for upward of 70% of electricity use in large buildings in the Dominican Republic.[26] Cool roofs can be installed at extremely low cost by simply painting roofs white. This would make spaces more comfortable; lower current cooling costs for individuals, businesses, or public buildings with air conditionung units; and reduce future energy expenditures as more Dominican households adopt air conditioning.

- Revise Regulations for Public and Commercial Buildings: The *Reglamento para especificaciones generales para la construccion de edificaciones* (under the lighting installations subsection) and the *Reglamento para instalaciones electricas en la edificacion* (parts 1 and 2) should include measures to guarantee lighting system efficiency.[27] These include using efficient light bulbs, installing timers to automatically turn off lighting systems, and maximizing use of natural light. Public and commercial buildings should be assigned zones to determine limits for lighting energy usage. If measures are taken to expand the use of CFL light bulbs, safeguards need to be in place to guarantee the proper disposal and management of CFLs due to their mercury content.

- Incorporate Renewable Energy Technologies Through Building Codes: Building energy codes should facilitate current or future installation of renewable energy technologies to avoid unnecessary future retrofitting costs. As stated in the *National Energy Plan 2004–2015*, and as demonstrated in Worldwatch's previous assessment of wind and solar in the country, the Dominican Republic has tremendous potential for installing solar thermal and PV technology.[28]

  - The *Reglamento para el diseño y la construccion de instalaciones sanitarias* (Regulation for the design and construction of sanitary installations), in place since 2010, could be updated to encourage or mandate the integration of renewable energy technologies such as solar water heaters in sanitary installations in buildings.[29] Buildings could be required to meet a minimum share of their overall hot water demand from solar water heaters or any other technology that provides the same benefits, according to water usage. Additional requirements for specific sectors, such as water heating for swimming pools in the hotel and tourism industry, should be developed.

- The *Reglamento para especificaciones generales para la construccion de edificaciones* (Regulation for general specifications for building construction), under the lighting installations heading, and the *Reglamento para instalaciones electricas en la edificacion* (Regulation for electrical systems in buildings) should be revised to encourage the integration of PV panels in buildings with large power demands.

To achieve viable payback periods for solar PV systems, buildings with large rooftop areas and relatively high energy consumption should be targeted for facilitating solar PV installation in building codes. Viability of individual PV installations will depend on solar irradiation at the specific site. The building code also should include the minimum requirements for periodic maintenance and inspection of solar water heating and PV installations.

Implementing Appliance Standards and Labeling

Baseline efficiency standards and high-efficiency performance incentives for additional energy-consuming appliances and equipment would reduce residential energy use. Efficiency standards for large commercial and industrial operations could also significantly reduce economy-wide energy consumption.

CNE has included labeling as part of the proposed energy efficiency bill; however, the bill only lays out a framework and does not include metrics for standards and compliance. Once the energy efficiency law is established (which is on hold until the new Ministry of Mines and Energy is up and running), lighting is planned to be the first appliance with official standards, followed by refrigeration and then a more widespread rollout for other appliances. For this part of the plan, CNE will partner with the Dominican Institute for Quality (INDOCAL). The appliances and performance metrics discussed in Chapter 2 should be consulted when developing appliance standards and labels to ensure that priority appliances are covered and that standards are set at appropriate levels.

8.3.2 Reducing Electricity Theft

As discussed earlier, the Dominican Republic experiences high grid losses of 32% due largely to electricity theft. The three distribution companies—EDE Norte, EDE Sur and EDE Este—are still dealing with a Cash Recovery Index (CRI) of around 60%, while the estimated breakeven level is 75%, and many neighboring countries (as well as privately owned distribution companies, particularly in resort areas) have achieved close to 90% figures.[30]

High electricity tariffs—between 20 and 25 U.S. cents per kWh—are a major driver of electricity theft and contribute to a widespread culture of non-payment, or "*cultura de no pago,*" as many households cannot afford to pay for electricity.[31] This issue is not confined to the residential sector. A considerable amount of electricity theft is committed by larger business for whom high electricity prices are financially challenging and who arrange illegal connections to avoid payment.[32]

As awareness of the negative impacts of electricity theft grows, possible solutions and policies have begun to emerge. In light of the Dominican Republic's history, current situation, and examples abroad, the following recommendations could help the country tackle its electricity theft issue:

- **Install smart meters:** An increasingly popular solution worldwide has been the use of smart and remote metering, which has the advantage of being more difficult to tamper with and provides a technical, less politically sensitive solution to the issue. The solution, which essentially removes the human factor from the equation, is gaining clout in Latin America. Brazil, which faces electricity theft rates close to 20%, has encouraged widespread use of these meters (available for USD 140–400 per unit) to remotely monitor usage in real time.[33] Industry estimates predict that by 2020, Brazil could install more than 60 million smart meters, Mexico 22.4 million, Argentina 4.9 million, and Chile 3.2 million.[34] The cost, however, can be detrimental to full-scale implementation: due to low volumes (and thus little economy of scale) and rewiring obligations, the real cost of a meter can reach as high as USD 1,500 in developing countries.

  In the Dominican Republic, CDEEE has been deploying smart and remote metering solutions in recent years with a certain degree of success. The state-owned utility company should continue to build on this momentum. Financial hurdles, particularly upfront costs, can be important, but most meters end up paying for themselves after some months of successful use. Evidence suggests that it is the lack of good will from utilities and government (especially local) to act on the collected data and observed infractions that threatens the relevance of smart meters. A way to address both these issues simultaneously would be to request a meter-specific grant from an independent, third-party institution, which would come with a third-party verification of the proper use of collected data.

- **Improve reliability of electricity services:** An obvious recommendation is to improve the supply-side situation by producing a cheaper, more reliable volume of available electricity, although this is easier said than done. While electricity prices are important, they are not the sole determinant of customer satisfaction. Indeed, many regions serve as success stories in collecting electricity tariffs. For example, an off-grid system in Pedernales is able to collect 97% of bills despite having a tariff of USD 0.28 per kWh, and Bávaro in the east and Samana in the north each have collection rates of around 95% despite having tariffs of 32 and 42 cents per kWh, respectively. Meanwhile, Santo Domingo, which sells electricity at about 22 cents per kWh, faces electricity theft rates more similar to those experienced by the country as a whole.

  This demonstrates that there is not necessarily a correlation between electricity prices and electricity theft. What is important is that people value their electricity services. And getting people to value these services depends largely on how reliable the services are. Reducing the level of suppressed demand—which currently is determined by forcing blackouts in service regions as a function of their level of electricity theft—and providing customers with more reliable electricity services could reduce frustrations as well as grid losses.

- **Improve regulation and enforcement:** The Electricity Theft Law (Law 186-07) criminalizes electricity theft and also establishes CNE and the SIE as responsible for monitoring and ensuring strict compliance with the law. Yet current responses have been inadequate. Inspections to detect theft must be frequent, and the focus should be shifted away from poor neighborhoods. While low-income communities typically have some of the lowest payment collection rates, they do not account for the largest volume of electricity loss due to the relatively low power consumption in these households.[35]

  Adequate pay for utility employees, such as inspectors and meter-checkers, could reduce the willingness of employees to accept bribes to overlook incidences of electricity theft. When these employees do commit fraud, prosecution should be automatic, even for top-level positions. In addition, the Dominican Republic could establish legal repercussions for electricity theft, as has been implemented in other countries. In Malaysia, newspaper ads warning consumers of the illegality of electricity theft have been successful, while in India harsher fines of between INR 5,000 and 50,000 in addition to the threat of disconnection from the grid have helped to deter further theft.[36]

- **Reform utility sector management:** Laws can only go so far in changing a non-payment culture. Due to high upfront capital costs, transmission and distribution utility companies tend to act as natural monopolies, sometimes making it difficult to incentivize good management, especially without an effective regulator.[37] Andhra Pradesh, India's largest state, established a successful anti-theft campaign in 2000 that sought to promote good governance by promoting the anti-corruption executive to a full member of the utility board and making integrity procedures simpler and more transparent. Under the new system, utility employees were monitored based on their collection rate, and customers were profiled according to their payment history, allowing for a better prioritization of enforcement activities.[38] Moreover, there is a lack of incentive for distributors to invest in reducing losses, since the government covers this lost revenue regardless.

- **Ensure that the government leads by example:** Until fairly recently, the government was among the main culprits of electricity tariff non-payment, with unpaid bills in 2006 amounting to 10% of the electricity sector's monthly losses.[39] With tough political choices ahead, government bodies should lead the way in promoting a payment culture, even in cases when non-payment was previously socially or legally accepted. Likewise, the Anti-Fraud Program (PAEF) should continue prosecuting large violators for theft and fraud, to deflect charges of favoritism. In the past, donors have noted that the national and local governments "appeared unwilling to address misfeasance by entrenched interests."[40]

- **Resist electoral gift-giving:** With "short and staggered"[41] political cycles—a major election every two years on average—the window of opportunity for the Dominican government to implement unpopular but necessary measures is small. A correlation has been found between election cycles and more relaxed electricity collection; thus, short of changing the political system altogether, special attention should be cast on electoral periods, through reinforced inspection, stringent collection standards, and tougher corruption prosecution.[42] Independent agencies should take it upon themselves to implement these measures, as politicians' support for them is unlikely to be strong.

- **Educate the public:** In 2007, the World Bank lamented in an implementation report that the government had failed to underpin structural measures in the electricity sector through a "strong communication strategy."[43] Given that electricity theft and fraud stem largely from a non-payment culture and a misunderstanding of risks (personal security, grid reliability, long-term costs), a large-scale public awareness campaign could go a long way in improving the situation. A source of inspiration could be South Africa's Operation Khanyisa, a campaign to mobilize citizens to use power legally.[44] The campaign used exhibitions and advertisements to raise awareness—with such patriotic messages as "keep our country powerful" and "unity is power"—and provided online information sheets and energy-saving tips to translate awareness into action.

After a long period of neglect, the Dominican Republic has begun to implement several programs to tackle electricity theft. The PAEF was launched in 2002 as a partnership between the government and EDEs. So far, it has been relatively successful in prosecuting large-scale violators, including major companies and some businesses owned by politicians.[45] The World Bank also reports that the number of inspections has augmented, remote meter-reading technologies have become more widespread, and electricity theft has been recognized as a special legal issue with adequate sentencing through a 2007 amendment to the General Law of Electricity.[46] CDEEE has continued its census efforts to maintain reliable data on electricity consumption and theft, and has begun instituting a smart metering program to improve electricity demand tracking and reduce meter tampering. CDEEE is also testing electricity pre-payment systems to reduce subsidies, increase consumer awareness of energy management, and reduce non-payment rates.

Results so far have been fairly encouraging. As of early 2011, 521,492 previously unmetered users had been brought back into the market under anti-theft and fraud initiatives; this was 87% of the IMF's stand-by arrangement (SBA) target, which led to an upgrading of the electricity sector's debt rating by Fitch.[47] However, the SBA was terminated in February 2012 because of a higher-than-expected deficit (due to a spike in the price of oil imports) and the Dominican government's reluctance to raise electricity tariffs.[48] President Medina has sought to apply for a new IMF grant, but it likely would come with some strings attached—a raise in electricity tariffs to account for the true costs of production, and a phasing down of subsidies.[49] Both of these measures are necessary to provide an accurate picture of the country's costly fossil fuel reliance and to create a more level playing field where renewable energy has an opportunity to prosper; however, they could easily lead to popular discontent and encourage desperate measures of electricity theft and fraud, if these are not strongly discouraged.

8.3.3 Incentivizing Renewable Energy Development

Existing Incentives

The Dominican Republic has an evolving framework of incentives for renewable energy. These existing initiatives have been enacted under a variety of national laws and implemented to varying degrees of success. Troublingly, recent legislation has weakened or eliminated certain incentives for renewable energies that previously have proven important to project development.

General Electricity Act (Law 125-01)

The key legal document of the electricity sector is the General Electricity Act (created by Law 125-01 of 2001) and its modification with Decree 749-02 of September 2002, which established a regulatory and legal framework for the production, transmission, distribution, and commercialization of electricity. Law 125-01 created CNE as well. (See Appendix VII for a description of its duties.)

Law 125-01 includes provisions to incentivize renewable energy generation, including a five-year local and national tax exemption for renewable energy generators. Renewable energy generators also have priority access for power sales and distribution to the grid, as long as prices and other conditions are equal with other generation options. The law also requires that utility companies pay 10% of fines collected for electricity theft into an incentive fund for renewable energy development.

The General Electricity Act also promotes competition for electricity generation. Under the law, distribution companies—EDE Norte, EDE Este, and EDE Sur—cannot own power capacity greater than 15% of the peak load on the national grid. Renewable power capacity is exempt from this limitation, however, providing an additional incentive for the distribution company to invest in renewables. Power generators are also authorized to connect generation capacity to the national grid or directly to customers under Law 125-01, allowing for competition in power distribution. The legislation also requires that at least 20% of all electricity trading occur on the spot market.

While Law 125-01 has helped to spur renewable development, it is important to ensure that its rules and regulations continue to be followed going forward. For example, Law 125-01 states that CNE is responsible for creating plans and advising the executive branch on all issues related to the energy sector. Given the new Ministry of Energy and Mines, this provision is changing, but prior to this institutional change, CNE had not always been included in energy planning and advising activities. Tax exemptions laid out for renewable energy generators under this law should be guaranteed and made more public. As the Dominican Republic continues tackling the issue of electricity theft more seriously—especially as the Ministry of Energy and Mines is established—it should be guaranteed that 10% of fines do in fact go into an incentive fund for renewable energy development.

Incentives Law for Renewable Energy Sources and Special Regimes (Law 57-07)

Law 57-07—on *Renewable Sources of Energy Incentives and Its Special Regimes*—with its appending regulations, adopted in 2007, sets a solid legal foundation for renewable energy development and "opens the door" to sustained commercial financing for the sector through financial incentives such as a feed-in tariff, tax exemptions, and a renewable energy fund. Law 57-07 also sets a target for a 25% share of renewable energy in the country's final energy consumption by 2025. This target is comparable with similar targets in the region, such as Jamaica's goal of having 20% of its energy come from renewable sources by 2030. Equally comparable is the EU's call for a 20% share of renewables in final energy consumption by 2020.

Broadly speaking, the Law attempts to lay out a comprehensive national framework for stimulating and regulating development and investment in renewable energy projects. The Law is progressive in nature and tries to align its objectives with the *National Energy Plan*. The primary goal is to stimulate private and community investments in renewable energy projects by creating a set of incentives. Through project implementation, the Law purports to create a sustainable and energy-secured future for the country by slowly phasing out dependence on fossil fuels. A secondary goal of the Law is to contribute to the decentralization of electrical supply and to biofuel production in the country.

The Law's main feature is its package of financial incentives for developers and investors in renewable energy projects. These include import tax exemptions (Article 9), income tax exemptions (Article 10), tax reductions on external financing (Article 11), tax incentives for self-producers (Article 12), and various financial incentives for community projects (Article 13). With the passage of Law 253-12 in November 2012, however, many of these financial incentives were rolled back or eliminated altogether. (See Table 8.2.)

Under Law 57-07, all social interest institutions (community organizations, producers associations, and registered and incorporated cooperatives) that develop small-scale renewable energy projects (up to 500 kW) for community use are eligible for funding at the lowest market interest rate for up to 75% of the building and installation costs.

Table 8.2 Incentives to Support Renewable Energy in the Dominican Republic, Enacted and Revised

Type of Incentive	Details under Law 57-07	Revisions under Law 253-12
Import tax	100% tax exemption on the import of equipment and machinery necessary for the production of renewable energy, as well as transformation equipment, transmission, and interconnection of electricity to the grid.	No change
Tax on the Transfer of Industrialized Goods and Services (ITBIS)	100% exemption on the ITBIS for projects based on renewable energy, a value-added tax applicable to the transfer and importation of most goods, and to most services (the usual rate is 16%).	No change
Income tax	Generators are exempted from the tax derived from income from the generation and sale of electricity from renewable sources. Installers are exempted from the tax on income derived from installation of equipment with a minimum of 35% of the value to be produced in the Dominican Republic. The exemption applies for 10 years, up to 2020.	Tax exemption removed
Low interest rate on external financing	Payment of interest rate for external financing for renewable energy projects is limited to 5%.	No change
Tax credit for self-generators	An exemption on the income of the owner of renewable energy technology equipment for up to 75% of the equipment's costs.	Tax credit reduced to 40%
Low interest loans for community projects	Grants and very concessional loans to finance up to 75% of the cost of the equipment for small-scale installations (<500 kW) developed by communities or social organizations.	Incentives for social and cultural institutions removed
Feed-in tariff	Mandates a price to be paid for power produced from renewable energy resources. The Dominican feed-in tariff adds a premium payment to the wholesale electricity price for a period of 10 years, up to 2018.	No change
Net metering (not included in 57-07, August 2011)	Wind and solar small residential self-producers with a capacity of no more than 25 kW, and commercial self-producers with a capacity of no more than 1 MW, can deduct their energy outflows from metered energy inflows.	No change

Increases in both applications submitted and exemptions already granted shows that the domestic renewable energy market has reacted positively to the incentives laid out in Law 57-07. Data for the past five-and-a-half years indicate strong growth in the number and monetary value of project applications.[50] (See Table 8.3.) Applications related to wind power concessions and for tax exemptions for self-generators have both grown substantially.

Nevertheless, some of the companies that have gone through the import-tax exemption process for wind technologies have expressed concern that the procedure still lacks predictability and that the process itself can be lengthy. The process could be improved further by better communicating the criteria by which exemptions are considered. Both predictability and transparency are critical for facilitating the market entry of more companies. Moreover, as discussed earlier, the creation of a one-stop-shop for filing and administering exemption-related paperwork could help facilitate the process.

Tax Reform Law (Law 253-12)

In December 2012, the tax reform law, Law 253-12, was passed to help resolve the Dominican Republic's fiscal imbalances. As part of the broader tax reform package—adopted in November 2012 and subsequently

Table 8.3. Applications for Tax Exemptions to CNE Under Law 57-07

	2008		2009		2010		2011		2012		2013 (Jan-Jun)	
	# Apps	Amount	# Apps	Amount	# Apps	Amount	# Apps	Amount	# Apps	Amount	# Apps	Amount
		million DOP		million DOP		million DOP		million DOP		million DOP		million DOP
Import tax exemption	49	5.05	37	11.08	82	2.98	139	88.18	161	398.22	71	26.26
for self generators					67	14.29	86	24.44	116	56.30	71	26.26
concessions for wind projects					15	283.73	53	63.74	43	337.97		
concessions for solar projects									2	3.95		
VAT (ITBIS) tax exemption	0	0	0	0	26	23.89	51	65.87	131	148.53	36	30.77
Revenue tax credit	3	4.85	6	1.88	41	78.56	49	90.00	88	232.28	21	176.30
Total	**52**	**9.90**	**43**	**12.96**	**149**	**400.46**	**239**	**332.23**	**380**	**779.03**	**128**	**233.33**

Source: See Endnote 50 for this section. ©Worldwatch Institute

revised in January 2013—a number of incentives for renewable energy development adopted under previous legislation were rolled back. The legislation severely impacted a number of the tax provisions enacted under Law 57-07 (see Table 8.2), revised the tax on fossil fuels enacted under Law 112-00, and changed additional incentives under separate sections of the tax code.

Many of the incentives enacted under Law 57-07 have been instrumental in the development of renewable energy projects. When the law came into force, the developers of the Los Cocos wind park revised the project's original design to ensure that the project would be eligible for the new incentives (See Sidebar 8.) Law 253-12 removed several of these important provisions, including the 10-year income tax exemption for generators of renewable electricity and financing incentives for community-owned projects. It also scaled back tax credit eligibility for self-generators from 75% to 40% of investment costs made by the owners.[51]

Law 253-12 also made a number of changes to taxes on fossil fuels. Article 1 of Law 112-00, establishing a tax on fossil fuels, was amended to include a flat fee charged on top of an existing tax that is based on a quarterly review of the central bank's published inflation rate. The revision included changes to the taxes levied on fossil fuels and currently exempts LPG and natural gas (liquefied, compressed, or any other transportable form).[52] This is in addition to exempting electricity generators, free trade zones, and a few of the larger mining and construction companies from sales tax from January-October 2012.[53] Furthermore, the new regulations increased the ad-valorem tax on the internal consumption of fossil fuels and petroleum derivatives from 13% to 16% while decreasing the excise tax on AVTUR to 6.5%.[54]

Generation-Based Incentives: FIT and Net Metering

Feed in Tariff

Law 57-07 establishes a 10-year feed in tariff (FIT) for grid-connected renewable energy installations, which adds a premium payment to the wholesale electricity price for both utilities and self-generators.[55] (See Table 8.4.) However, the FIT has not been officially enacted. Under the Law's regulatory decree, the payment is to increase by 4% in 2009 and 2010 and then will be adjusted based on the U.S. Consumer Price Index (CPI) through 2018. From 2018 to 2027, the rate will adjust according to the U.S. CPI minus one percentage point.

Table 8.4 Renewable Energy Feed-In Tariff Rates Under Law 57-07, Proposed But Not Enacted

Energy Source	Feed-in Tariff Rate
	U.S. cents per kWh
Wind (connected to SENI)	12.5
Wind (self-generation for sales to SENI)	4.9
Biomass (connected to SENI)	11.6
Biomass (self-generation for sales to SENI)	4.8
Municipal Solid Waste (for sales to SENI)	8.5
Solar PV (self-generation greater than 25 kW, for sale to SENI)	10.0
Solar PV (greater than 25 kW, connected to grid)	53.5
Solar PV (less than or equal to 25 kW, connected to grid)	60.0
Small hydro (connected to SENI)	10.0
Small hydro (self-generation for sales to SENI)	4.8

Source: See Endnote 55 for this section. ©Worldwatch Institute

In addition to tax exemptions, the FIT is another key reason why applications for wind energy concessions boomed following the publication of Law 57-07. The Dominican Republic's solar PV FIT rates, however, are very high when compared to international benchmarks.[56] (See Table 8.5.) So while the FIT rates initially drew attention internationally, the rates were considered too high by CDEEE (and by extension, the government) to sustain. As a result, despite setting an attractive FIT rate of between 53.5 and 60.0 U.S. cents per kWh for project developers, no solar PV projects have been funded through the FIT policy. Indeed, to date no renewable energy projects have been developed that rely on the FIT policy, and it is generally accepted that the FIT is not operational in practice. Given the recent success of competitive bidding and open tendering in the Latin America and Caribbean region for renewable energy projects, the Dominican government may want to consider removing the FIT from Law 57-07 given its lack of use.

Going forward, if the Dominican Republic decides to implement a FIT, lawmakers and regulators should work to ensure that FIT levels are realistic enough to promote renewable energy development, but also adequately reflect falling renewable energy technology costs. As a reference point, the off-take price for electricity produced by the 30 MW Monte Plata solar plant was renegotiated at 17.5 U.S. cents per kWh,

Table 8.5 Select International Examples of Large-Scale Solar PV Feed-In Tariff Rates

Country	Feed-in Tariff Rate
	U.S. cents per kWh
Dominican Republic	**0.54**
Japan	0.53
Switzerland	0.47
Czech Republic	0.40
Israel	0.39
Malaysia	0.38
Slovenia	0.38
Uganda	0.36
Ontario, Canada	0.33
Malaysia	0.26
United Kingdom	0.24
Hawaii, USA	0.22
Germany	0.18
France	0.14

Source: See Endnote 56 for this section.

down from the originally agreed 19.96 U.S. cents. This renegotiated PPA is equal to 32% of the FIT rate for a similarly sized solar PV project under the FIT policy, demonstrating that it is feasible to lower the FIT rate while still making projects profitable for developers. Moreover, as the LCOE analysis demonstrates in Chapter 6, a solar PV FIT rate of 20–30 U.S. cents per kWh should be enough to incentivize solar PV development over the next decade.

If FIT rates are adjusted to ensure buy-in from both project developers and the government, it is then essential that all incentives are delivered in a timely manner, and that all contracts are honored. Despite the initial excitement about the Dominican Republic's FIT policy, investor confidence was lost due to CDEEE's unwillingness to support projects funded under that policy.

Net Metering Program

In July 2011, CNE launched a net metering program in the wake of other initiatives to promote renewable energy, in particular the fiscal incentives contained in Law 57-07. A net metering scheme allows consumers to reduce their monthly utility bill by supplanting electricity consumption from the grid with power generated from their own renewable sources such as solar PV. Any surplus electricity that the user generates can be sold back to grid operators at a set price.[57]

In the Dominican Republic, the program was originally designed for solar PV generation.[58] By the end of 2014, solar PV remained the dominant source of generation under the net metering program. Most net metering clients remain fairly small electricity producers. Almost two-thirds, or 333 of the 519 net metering customers, have systems smaller than 10 kW.[59] (See Table 8.6.) Additionally, 68% of the clients (352) are residential, while the remaining 167 clients are commercial.[60]

Table 8.6 Number of Net Metering Customers in the Dominican Republic, by Installation Size

Size of Installation	Number of Customers
<5 kW	152
>5 to <10 kW	181
>10 to <15 kW	71
>15 to <20 kW	21
>20 to <25 kW	18
>25 kW	76
Average Size of Installation	23.67

Source: See Endnote 59 for this section.

However, while the average generating capacity of a net metering system was 10.2 kW in July 2012, that figure had more than doubled to 23.7 kW by the end of 2014. Only 3 clients had a capacity of over 25 kW in July 2012, but that figure jumped to 76 clients by the end of 2014. The net metering program's growth has been remarkable since mid-2011. The program's average monthly growth is 225%, and the total generating capacity is now about 12.3 MW.[61] (See Table 8.7.) Nevertheless, there remains significant potential for expanding the program to additional electricity customers.

Table 8.7 Potential Self-Generator Candidates for Net Metering Program Through 2014

Distribution Company	No. of Customers	kW	Share of Participants
EDE Norte	219	5,734	42%
EDE Sur	172	4,875	33%
EDE Este	44	640	8.5%
Luz y Fuerza de Las Terrenas	44	202	8.5%
CEPM	25	674	4.8%
Proyecto El Progreso del Limón	8	26	1.5%
Proyectos Corporacion Turistica de Servicios de Punta Cana	4	67	0.77%
Proyectos Cap Cana Caribe	2	33	0.38%
Puerto Plata de Electricidad, PPE	1	50	0.19%
Costasur D.	1	7.9	0.19%
CEB	1	4.9	0.19%
All Distributors	**521**	**12,313**	**100%**

Source: See Endnote 61 for this section.

Future issues might hamper the net metering program's development. In particular, extension of the scheme has been limited by the relatively low level of public awareness.[62] Even more worrisome, some Dominicans show distrust in the program. A large-scaled and well-publicized demonstration project could help foster public trust and awareness. The 22 kW installation at CNE's headquarters, inaugurated in March 2012 in the presence of media and officials, is a step in the right direction; however, overcoming public skepticism may be achieved more effectively in a non-governmental building.[63]

The Hotel Dominican Fiesta in Santo Domingo installed over 1,000 solar panels to become one of the most high-profile installations in the country. In addition, the Cibao International Airport, just outside the second largest city, installed a 1.5 MW rooftop solar project that now provides 40% of the airport's energy needs.[64] These types of projects can help assuage public skepticism of a nascent net metering program. To build public trust, it is also crucial that energy distributors dutifully remunerate net metering participants if they still have an accumulated credit in December of every year. So an emphasis must be placed on adequately and promptly paying clients, as this will build public trust and credibility.

Technical concerns also have arisen in the first years of the initiative. Firstly, the absence of a cap for potential capacity allowed under the program could prove problematic.[65] Due to the limited technical and financial capacity of the country's power system, a large influx of net metered power into the grid could put CDEEE, and the distribution companies it oversees, under pressure. It is recommended that CNE and other government agencies develop a maximum net metering installed capacity that allows for significant growth but ensures stability for the grid.

Although the program has grown substantially since 2011, the total level of net metering generation remains manageable. But the rapid increase in clientele, if sustained, could raise management and financing costs. Other sources of funding to finance the program could include the hydrocarbon fund developed under Law 112 or the leveraging of international finance opportunities.

Despite these potential difficulties, the net metering initiative has been successful overall in encouraging the regulation of off-grid power generation billing, as well as in creating a standard for off-grid equipment and providing a financial incentive for renewable self-generation. In the future, more wind energy and possibly biomass (coming, for instance, from the waste produced by rice or sugar mills) could play a larger role in the program. However, as of today the program remains too underdeveloped for significant biomass-based generation, which often is situated far from the grid. Due to its early stage of development, net metering in the Dominican Republic is likely to stay dominantly solar PV-based, and commercial/residential-based, for the foreseeable future.

Recommendations

Implement or Restore Tax Exemptions: Taxes and import duties on energy efficiency and renewable energy technology imports can disincentivize investments by increasing technology costs by up to 20% or even more. Because high capital costs already are one of the largest barriers to renewable energy development, this additional cost could make otherwise viable projects unprofitable. A number of incentives had been offered under the Dominican tax code to promote renewable energy development. While the incentives established in Law 57-07 provide a robust framework for promoting renewables, few of them have been fully implemented. In 2012, Law 253-12 was passed to revise many of the provisions, including a major rollback to tax incentives. Tax incentives should be restored to their earlier levels to ensure a stable investment environment for renewable energy.

Reduce Risks of Private Financing for Renewable Energy: Private local and international banks remain reluctant to offer loans to renewable energy projects due in large part to the perceived risks of these investments. The Dominican Republic's poor credit rating and lack of established sustainable energy markets create a high-risk lending environment. As explored in Chapter 7, measures to reduce sector risk include a sovereign guarantee from the government, which assure creditors that all loan payment obligations will be met even if the project developer defaults. Such de-risking mechanisms are an important tool in opening markets to renewable energy, by making loans available where they previously were not offered and helping to reduce interest rates for projects to more manageable levels.

Although the Dominican Republic's strained financial situation, especially in the electricity sector, makes it difficult for the government to support investments, providing sovereign guarantees and other types of backing is one area where limited domestic finances can be used to great effect to leverage significantly higher levels of private financing. (See Section 7.2.3.) Funds raised from the allocation of taxes levied under Law 112-00, which already are supposed to support the *Sustainable Energy Fund*, could be used to this effect.

8.3.4 Improving Management of Fossil Fuels

Natural Gas

There is a need to review the existing laws that regulate natural gas. The contract between AES and grid operators clearly establishes that electricity must be purchased from the LNG facility, as long as it is less costly than bunker fuel. Because AES's operation is vertically integrated, and the import of natural gas is managed within the group, there is a lack of transparency in the mechanism that could lead to a scenario that ensures that the bunker price cap parameter is never, or seldom, breached, ensuring that the power purchase is guaranteed.

A review of the managing authority or legislation regarding natural gas could ensure that current and future investments in natural gas are more transparent and could prohibit collusion across the natural gas supply chain. Additionally, having an independent regulator with the authority and tools to evaluate, review, and reconsider the use of different technologies and fuels could ensure an optimal or near-optimal energy mix that evaluates the costs of different energy technologies.

Hydrocarbons (Law 112-00)

As discussed in Chapter 7, Law 112-00 outlines the creation of "a special fund from the tax differential on fossil fuels in order to finance projects of great national interest for the promotion of alternative, renewable or clean energy and energy savings." However, a survey of the existing literature, as well as interviews with government officials, revealed that actual implementation of the fund has not yet taken place. Were it to be implemented as originally designed, the Fund would be managed through the new Ministry of Energy and Mines and would pay for a FIT premium and support renewable energy development in low-income areas through a capital subsidy covering up to 75% of the cost of work and installation of small-scale renewable energy projects, as stipulated in Law 57-07.

The Ministry of Industry and Commerce had initial responsibility for the funds, and when CNE was created the following year under the General Electricity Law, Law 125-01, the funds were to be transferred to CNE and implemented as originally intended. The money was never transferred, and in 2004, then-president Lionel Fernandez issued a decree that gave control of the funds to the Ministry of Finance, where the funds have stayed ever since.[66] The legislation creating the new Ministry of Energy and Mines stipulates that the fund (and all other sources of revenue that are earmarked for energy-related work) is to become the responsibility of the new ministry, but it remains unclear if this transaction has taken place. The revisions made under Law 253-12 have an impact on the ability of this fund to perform as originally designed. That foregone revenue shortchanges potential development in renewable energy and reinforces the country's dependence on fossil fuel imports.

Other countries have successfully developed national funding institutions to foster renewable energy development. The design of these funds varies among countries by their financial sources, their governance, and the types of financial vehicles that they have to offer. Renewable energy funds in developing countries often draw on a mix of domestic and international finance: for example, India's IREDA was created with a seminal grant from the GEF and continues to receive funding from the World Bank today.

In the case of the Dominican Republic, the government could consider diversifying the source of revenues for its domestic fund. Technical assistance from international donors could support government establishment of the fund, and, once set up, it could become a major domestic instrument to access international climate finance for renewable energy and mitigation technologies. Additionally, international pools of funding, such as the recently conceived NAMA program, could be used to support a renewable fund.

8.3.5 Promoting Environmental Protection

General Environment and Natural Resources Law (Law 64-00)

Law 64-00 created the Department of Environment and Natural Resources and establishes the importance of policies for the protection of the environment and natural resources.[67] The Law integrates formerly autonomous and semi-autonomous agencies involved in natural resources and environmental protection (i.e., the National Parks, the Forestry Department, the Dominican Institute of Water Resources) under the auspices of the newly created Department of Environment and Natural Resources. The Law tasks the Department with establishing environmental protection standards and regulating the use of natural resources.

References to the energy sector are minimal. Article 35 includes "sustainable use of energy" under the environmental services intended to be guaranteed by the establishment of protected areas. Article 159 states that commercial forest plantations will be encouraged for many purposes, including energy. The most direct reference to the energy sector is Article 84, which states that the import of equipment, systems, or materials that "use atomic energy or any radioactive material shall be regulated by the Department of Environment and Natural Resources in coordination with the competent authority." With the vice ministry for nuclear energy now being part of the new Ministry of Energy and Mines, however, it is unclear whether or not this will remain the responsibility of the Department of the Environment and Natural Resources.

Going forward, the negative externalities associated with the Dominican Republic's reliance on fossil fuels should be made more explicit in environmental laws. The connection between the current energy system and its environmental and atmospheric degradation should be stressed and prioritized in future environmental and sustainable energy initiatives.

Water Management Policy

Water use laws can have an important bearing on the ability to develop hydropower at a given site. In the Dominican Republic, hydropower generation is the third priority for water use, behind supplying drinking water and agricultural irrigation.[68] In locations where these priorities compete for water resources, hydropower development might not be possible. Although hydropower remains an important technology for servicing currently un-electrified communities, it is important that the government maintain the importance of fresh water for human and agricultural consumption. While hydropower could provide a less-polluting source of energy, its greater exploitation should not come at the expense of clean drinking water and the agricultural industry.

8.4 Summary of Policy Recommendations

The Dominican Republic has established many of the elements required to support a transition to a sustainable energy system, including the establishment of a Ministry of Energy and Mines and the passage of numerous tax and other financial incentives aimed at promoting renewable energy generation. The country's commitment to greenhouse gas emissions reduction embodied in its Climate-Compatible Development Plan serves as an example not only for the Caribbean region, but for countries around the world. Nevertheless, existing policies need to be strengthened and new measures established to ensure that these ambitious goals are met. In particular, energy efficiency and renewable energy should be granted higher priority within the newly established MEM, and resources devoted to fossil fuel development should be limited.

The Dominican Republic has expressed significant interest in developing a national energy efficiency building code, and these provisions should be incorporated into the country's existing building code as a cost-effective way to reduce energy consumption. Similar efforts should be deployed to reduce technical electricity losses during transmission and distribution, as well as non-technical losses resulting from non-payment by commercial, government, and residential users.

A renewed government commitment is needed to signal to investors that the Dominican government is seriously undertaking a comprehensive review of its renewable energy marketplace and implementing a plan to strengthen its potential. Although the government has already taken important steps to approve several promising renewable energy measures—including tax exemptions and feed-in tariffs—these have been slow to materialize, and many have since been eliminated. The government should work to establish effective, achievable incentives in order to create a stable investment environment for renewables.

9 | Dominican Republic's Energy Outlook: Transitioning to a Sustainable Energy System

As demonstrated throughout this Roadmap, the Dominican Republic has tremendous potential for transitioning to an efficient electricity system powered by renewable energy resources. Moreover, this pathway appears to be the most affordable and reliable option in the medium to long term. To realize the economic, social, and environmental benefits of sustainable energy, the country will need to implement several policy measures and administrative reforms that help to create a stable investment environment for energy efficiency and renewable energy projects.

This Roadmap has addressed many existing research and information gaps—and outlined some that remain. It has identified remaining capacity-building needs and made concrete suggestions for regulatory reform. Both should be addressed as soon as politically feasible and financially viable in order to support a smooth and well-informed transition to a sustainable energy system. The government can begin to address most present challenges immediately and should be able to overcome some relatively quickly. For others, persistence will be required to achieve the full impact.

Table 9.1 demonstrates the areas in which better energy-relevant data should be collected, processed, and fed into the decision-making process. Continued socioeconomic analysis also is needed in order to support smart policy design. This is particularly true to better understand the role that distributed generation can play in rural areas, including its potential limitations.

The table also shows recommended financial sector reforms. A combination of capacity building and structural changes are suggested to reduce the diverse risks perceived by domestic and international investors. The most important suggestions targeting the creation of a strong policy framework are listed as well. A streamlined implementation of the suggested financial and political measures will create an investment environment prone to enabling a fast, efficient, and enduring transition to a sustainable energy system.

In addition to the indispensable initiatives that the Dominican Republic's government, private sector, academic institutions, and non-governmental organizations should undertake domestically, dedicated and self-confident participation in bilateral, regional, and international sustainable energy and climate change initiatives can enhance the country's resources and reinforce its ambition for reducing energy intensity, increasing renewable energy capacity, and constraining greenhouse gas emissions. The government, private industry, and civil society have acknowledged the important role of energy efficiency and renewable energy in reducing energy costs, bolstering the national economy, addressing key social goals, and protecting the environment. The country is now at a crucial point where it must implement further targeted measures and reforms in order to turn its aspiration into—and make this Roadmap—a reality.

Table 9.1 Key Measures Enabling the Dominican Republic's Sustainable Energy Transition

	Short Term	Long Term
Improve Technical Insight		
Assess energy- and cost-savings potential of commercial and public services sectors	●	
Conduct tourism-sector sustainable energy roadmap and implementation plan	●	
Thoroughly analyze energy end use in key economic sectors and use results to create an up-to-date building code regime that prioritizes energy efficiency through standards appropriate to each sector	●	
Determine energy efficiency standards program for high-energy-consumption appliances and determine readiness for program implementation	●	
Expand energy audit program to all public sector buildings and use information and results to promote wider adoption of energy audits in industrial, commercial, and residential sectors	●	
Conduct further feasibility assessments for utility-scale solar PV and wind farms	●	
Conduct crop-specific energy resource and feasibility assessments, particularly for wood and sugarcane bagasse.	●	
Conduct up-to-date small hydro resource and feasibility assessments	●	
Conduct thorough resource and environmental assessment of biogas vs. direct waste-to-energy combustion	●	
Conduct efficiency upgrade and replacement studies for existing electricity generation plants	●	
Assess feasibility of interconnection with Haiti	●	●
Conduct on-site assessments for pumped hydro storage	●	
Increase knowledge sharing and collaboration among state-owned and private utilities to share best practices regarding electricity theft reduction and improved bill collection, both of which are at the heart of the electricity sector's chronic outages and poor performance	●	●
Strengthen Socioeconomic Analysis		
Conduct in-depth sustainable energy and cross-sectoral job creation and loss study	●	
Develop and run local socioeconomic models, particularly for distributed generation solutions in rural communities, prioritizing communities in the border region that do not yet have energy access	●	
Explore—and design strategy to address—gender inequities with regard to access to sustainable energy wealth and job creation opportunities	●	
Require that additional costs of infrastructure, environmental cleanup, and health care be considered when evaluating new electricity generation options to ensure that the true cost of electricity generation is determined	●	
Reform Financial Sector		
Expand education campaigns to communicate sustainable energy investment opportunities	●	●
Revise current banking rules that restrict financing to a 10-year window in order to provide realistic financing options for utility-scale renewable energy projects	●	
Advance national strategy for accessing climate finance to include support for Nationally Appropriate Mitigation Actions (NAMAs) and Intended Nationally Determined Contributions (INDCs)	●	

Table 9.1 continued

	Short Term	Long Term
Implement Strong Policy Framework		
Put renewable energy unambiguously at the center of the energy vision, and exclude coal as an option for future baseload generation	●	
Elevate renewable energy so that it receives equal importance to energy efficiency, hydrocarbon exploration, and treatment of nuclear material	●	
Specify renewable energy and energy efficiency targets for individual sectors based on any existing feasibility studies	●	
Strengthen the Electricity Superintendent's (SIE's) ability to enforce regulations aimed at electricity theft and other forms of corruption	●	●
Index electricity prices to the real cost of the fuel used in electricity generation and abolish indirect and direct government subsidies	●	
Empower the Organismo Coordinador (OC-SENI) and SIE to ensure that dispatch priority mechanisms that support renewable energy are observed, and penalize offenders	●	
Streamline, simplify, and reduce costs of permitting procedures for renewable energy projects	●	
Create a "one-stop" window to guide renewable energy projects of all sizes through the country's permitting and regulatory processes	●	
Implement proposed energy efficiency standards for buildings and appliances, particularly in those economic sectors where energy efficiency feasibility studies have already been completed	●	
Expand electricity theft audits and automated meter installations	●	●
Increase promotion of consumer-level incentive programs, such as net metering, to bolster participation	●	
Establish a consistent and transparent process to solicit proposals for new renewable energy capacity development that can be processed in a timely, efficient manner	●	
Expand support policies for renewable energy investment including increased exemptions of import duties and sales tax, and accelerated depreciation of equipment	●	
Establish and promote a system of competitive bidding and open tendering for renewable energy project development	●	

Endnotes

Chapter 1. A Sustainable Energy Roadmap for the Dominican Republic: An Integrated Approach

1. United Nations Framework Convention on Climate Change (UNFCCC), "Copenhagen Accord of 18 December 2009," Conference of the Parties, Fifteenth Session (Copenhagen, Denmark: 2009).
2. UNFCCC, "Bali Action Plan of December 2007," Conference of the Parties, Thirteenth Session (Bali, Indonesia: 2007).
3. United Nations Sustainable Energy for All, "About Us," www.sustainableenergyforall.org/about-us, viewed 17 June 2013.
4. Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis*, Working Group I Contribution to the Fourth Assessment Report of the IPCC (Cambridge, U.K. and New York, NY: Cambridge University Press, 2007).
5. J.A. Church et al., "Sea Level Change," in IPCC, *Climate Change 2013: The Physical Science Basis*, Working Group I Contribution to the Fifth Assessment Report of the IPCC (Cambridge, U.K. and New York, NY: Cambridge University Press, 2013).
6. Christopher Flavin, *Low-Carbon Energy: A Roadmap*, Worldwatch Report 178 (Washington, DC: Worldwatch Institute, 2008), p. 5.
7. Alexander Ochs, "Mapping the Future: Why Bidding Farewell to Fossil Fuels Is in Our Interests – And How It Can Be Done," *Climate Action*, released at the UNFCCC Conference of the Parties, Sixteenth Session in Cancun, Mexico (London and Nairobi: United Nations Environment Programme and Sustainable Development International, 2010).
8. International Energy Agency (IEA), *World Energy Outlook 2010* (Paris: OECD/IEA, 2010).
9. Inter-American Development Bank (IDB), *Loan Proposal: Support for the Distribution Network Improvement and Electricity Losses Reduction Program* (Washington, DC: 2014).
10. Dominican Corporation of State Electricity Companies (CDEEE), *Strategic Plan 2013-2016* (Santo Domingo: 2012).
11. IEA, "Dominican Republic: Electricity and Heat for 2011," Statistics: Report, http://www.iea.org/statistics/statistics search/report/?&country=DOMINICANR&year=2011&product=ElectricityandHeat, viewed 22 August 2014.
12. Organismo Coordinador (OC), "Informe de Operación Real del Año 2013," OC-GO-IMORA1402-140214-V0 (Santo Domingo: February 2014).
13. McKinsey & Company, "Climate-Compatible Development Plan (CCDP) for the Dominican Republic," Presentation at the 3rd Steering Committee Meeting, Santo Domingo, 3 May 2011.
14. Figure 1.1 from OC, op. cit. note 12.
15. Ibid.
16. Ibid.
17. Ibid.
18. U.S. Energy Information Administration (EIA), "Electricity Net Generation by Type: Dominican Republic," International Energy Statistics, www.eia.gov/cfapps/ipdbproject/IeDIndex3.cfm?tid=2&eyid=2012&syid=2012&rev erseAxes=0&cid=&cid=DR&pid=alltypes&aid=12&unit=BKWH&updateB=UPDATE, viewed 17 May 2013.
19. Table 1.1 from OC, op. cit. note 12.
20. Central Bank of the Dominican Republic, *Report on the Dominican Economy: January-December 2013* (Santo Domingo: April 2014), p. 28.
21. Ibid.

22. "La tarifa eléctrica no subirá en diciembre," *La Republica* (Santo Domingo), 30 November 2013.
23. Figure 1.2 from Empresa Distribuidora de Electricidad del Este (EDE Este), "Tarifa Vigente," www.edeeste.com.do/index.php/servicios/tarifa-vigente/, viewed 22 August 2014.
24. CDEEE, op. cit. note 10.
25. OC, op. cit. note 12; National Energy Commission (CNE), *Informe Anual: Actuaciones del Sector Energetico* (Santo Domingo: January 2014).
26. Ibid.
27. Ibid.
28. Table 1.2 from OC, op. cit. note 12, and from CNE, op. cit. note 25.
29. CNE, *Estudio de Mercado y Definición Estratégica Para La Penetración Del Gas Natural Residencial en Republica Dominicana* (Santo Domingo: December 2010).
30. CNE, op. cit. note 25, p. 8.
31. "Dominican Republic OKs US$2.04B for 675MW Coal-fired Plants," *Dominican Today*, 24 June 2014.
32. CNE, op. cit. note 25, p. 13.
33. A. Ochs et al., *Roadmap to a Sustainable Energy System: Harnessing the Dominican Republic's Wind and Solar Resources* (Washington, DC: Worldwatch Institute, 2011).

Chapter 2. Energy Efficiency Potential

1. Center for Sustainable Energy California, "How Does One Define Electricity?" http://energycenter.org/index.php/technical-assistance/energy-efficiency/energy-efficiency-definition, viewed 17 February 2012.
2. Figure 2.1 from National Council on Climate Change and the Clean Development Mechanism (CCCDM), *A Journey to Sustainable Growth: The Draft Climate-Compatible Development Plan of the Dominican Republic* (Santo Domingo: September 2011).
3. Figure 2.2 from World Bank, "Electric Power Consumption, Kilowatt-hour Per Capita," http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC/countries?display=default.
4. Ibid.
5. Figure 2.3 data supplied by National Energy Commission (CNE), Santo Domingo, July 2012.
6. International Energy Agency (IEA), "Dominican Republic: Balances for 2012," www.iea.org/statistics/statistics search/report/?country=DOMINICANR&product=balances&year=2012.
7. Table 2.1 from Latin American Energy Organization (OLADE), *Energy Statistics Report 2012* (Quito, Ecuador: 2012).
8. Table 2.2 from CNE, *Balances de Energía 1970-2010* (Santo Domingo: April 2012).
9. Ibid.
10. Asociación Dominicana de la Industria Eléctrica (ADIE), "Informe de Situacion del Sistema Electrico Dominicano Para el 2014" (Santo Domingo: June 2015).
11. Jamaica Public Service Company Limited (JPS), *2013 Annual Report* (Kingston, Jamaica: 2013); U.S. Energy Information Administration (EIA), "How Much Electricity Is Lost in Transmission and Distribution in the United States?" www.eia.gov/tools/faqa/faq.cfm?id=105&t=3, updated 7 May 2014.
12. Electricity Superintendent (SIE), Santo Domingo, personal communication with Worldwatch, 8 November 2013.
13. Ibid.
14. Ibid.
15. ADIE, personal communication with Worldwatch, October 2012.
16. JP Morgan, *Investigación de Mercados Emergentes de América Latina, República Dominicana* (New York: August 2013).
17. ADIE representative, Santo Domingo, personal communication with Worldwatch, 16 July 2012.
18. Ibid.
19. Figure 2.4 from CNE, *National Energy Plan 2004-2015* (Santo Domingo: July 2004).
20. Jens Lausten, *Energy Efficiency Requirements in Building Codes, Energy Policies for New Buildings* (Paris: IEA, 2008).
21. European Commission, *Financial Support for Energy Efficiency in Buildings* (Brussels: February 2012).

22. Ibid.
23. McKinsey & Company, *Energy Efficiency: A Compelling Global Resource* (New York: March 2010).
24. IEA, *World Energy Outlook 2009* (Paris: OECD/IEA, 2009).
25. Hui Zhang et al., *Comfort, Perceived Air Quality, and Work Performance in a Low-Power Task-Ambient Conditioning System* (Berkeley, CA: Center for the Built Environment, University of California at Berkeley, April 2008).
26. Héctor O'Reilly, *Seminario Internacional Desastres Naturales y Manejo de Emergencias* (Santiago, Chile: 7 December 2002).
27. Direccion General de Reglamentos y Sistemas (DGRS), *Ley No. 687, Sistema de Reglamentacion de la Ingenieria, Arquitectura y Ramas Afines* (Santo Domingo: 1984).
28. U.S. Agency for International Development (USAID), *Estrategia de Eficiencia Energetica para la Republica Dominicana* (Washington, DC: November 2004).
29. Ibid.
30. Sidebar 1 from DGRS, "Reglamento General de Edificaciones," www.mopc.gob.do/dgrs/paginas/reglamento_general_de_edificaciones.html, viewed 26 January 2012.
31. DGRS, *Requirimientos de Aplicacin del Reglamento General de Edificaciones y Tramitacion de Planos, R-021, Decreto No. 576-06* (Santo Domingo: 2006).
32. Center for Climate and Energy Solutions, "Building Envelope," www.c2es.org/technology/factsheet/Building Envelope.
33. IEA, *Energy Efficiency in Building Codes, Energy Efficiency Policies for New Building* (Paris: OECD/IEA, 2008), p. 31.
34. D.J. Bonnet et al., "Ultra Low U-value Walls for Low-Carbon-Dioxide Homes," *Proceedings of the ICE - Energy*, vol. 161, no. 4 (2008), pp. 175–85.
35. European Insulation Manufacturers Association, "U-Values: For Better Energy Performance of Buildings" (Brussels: November 2007). Sidebar 2 from the following sources: U.S. Department of Energy, "Guidelines for Selecting Cool Roofs" (Washington, DC: July 2010); California Energy Commission, "Cool Roofs and Title 24," www.energy.ca.gov/title24/coolroofs; "Local Laws of the City of New York for the Year 2011. No. 21" (New York: 2011); NYC CoolRoofs, "About NYC Cool Roofs," www.nyc.gov/html/coolroofs/html/about/about.shtml.
36. Energy Star, "Energy Star Products: Air Conditioning," www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CA, viewed 8 March 2012.
37. Energy Star, "Energy Star Products: Fans," www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=VF, viewed 8 March 2012.
38. Sidebar 3 from Christian E. Casillas and Daniel E. Kammen, "The Energy-Poverty-Climate Nexus," *Science*, 26 November 2010, pp. 1181–82.
39. CNE representatives, personal communication with Worldwatch, 3 July 2014.
40. Sidebar 4 from Casillas and Kammen, op. cit. note 38.
41. Ibid.
42. National Council for Climate Change and the Clean Development Mechanism (CNCCMDL), *A Journey to Sustainable Growth: The Climate-Compatible Development Plan of the Dominican Republic* (Santo Domingo: September 2011).
43. Architectural Louvers website, www.archlouvers.com, viewed 5 March 2012.
44. Table 2.3 from U.S. Occupational Health and Safety Administration website, www.osha.gov, viewed 2 March 2012.
45. Foot candles and lux for architectural lighting website, www.mts.net/~william5/library/illum.htm, viewed 2 March 2012.
46. Institute for Building Efficiency, *Technology Action Plan: Buildings Sector Energy Efficiency* (Washington, DC: December 2009).
47. IEA, op. cit. note 6.
48. Figure 2.5 from Ibid.
49. CNE, op. cit. note 19.
50. Ibid.
51. Ibid.

52. Table 2.4 from Ibid.
53. Figure 2.6 from CNE and Instituto de Economía Energética en Fundación Bariloche, "Informe Sobre Balances" (Santo Domingo: May 2003).
54. European Energy Labels website, www.energylabels.co.uk/eulabel.html, viewed 30 January 2012.
55. CNE representatives, op. cit. note 39.
56. Ibid.
57. CNE energy efficiency representative, personal communication with Worldwatch, 20 August 2013.
58. IEA, "2009 Energy Balance for Dominican Republic" (Paris: OECD/IEA, 2013).
59. Ibid.
60. CNCCMDL, op. cit. note 42.
61. Figure 2.7 from CNE, op. cit. note 19.
62. Commission of the Constitution of the Ministry of Energy and Mining, personal communication with Worldwatch, 2013; Tetra Tech – Caribbean Hotel Energy Efficiency Action Programme (CHENACT), *Energy Efficiency and Micro-Generation in Caribbean Hotels Consultancy* (Arlington, VA: July 2012).
63. Ibid.
64. Ibid.
65. Figure 2.8 from CNE, op. cit. note 19; CO_2 savings from CNCCMDL, op. cit. note 42.
66. Tetra Tech – CHENACT, op. cit. note 62.
67. Table 2.5 from Ibid.
68. CNE, *Estrategia de Eficencia Energetica para la Republica Dominicana* (Santo Domingo: November 2004).
69. CNE, *Informe de auditoría energética de SENASA* (Santo Domingo: June 2011).
70. Figure 2.9 from CNE, op. cit. note 19.
71. Figure 2.10 from CNE representatives, personal communication with Worldwatch, July 2014.
72. CNE energy efficiency representative, op. cit. note 57.
73. CNE, op. cit. note 19.
74. Ibid.
75. IEA, op. cit. note 6.
76. OLADE, op. cit. note 7.
77. United Nations Industrial Development Organization (UNIDO), *Industrial Development Report 2011* (Vienna: 2011).
78. OLADE, op. cit. note 7.
79. CNCCMDL, op. cit. note 42.

Chapter 3. Renewable Energy Potential

1. Worldwatch Institute, *Roadmap to a Sustainable Energy System: Harnessing the Dominican Republic's Wind and Solar Resources* (Washington, DC: 2012).
2. Alexander Ochs and Annette Knödler, "Value of Fossil Fuel Subsidies Decline; National Bans Emerging," Vital Signs Online (Washington, DC: Worldwatch Institute, 11 May 2011).
3. Bloomberg New Energy Finance, "Sun Sets on Oil for Gulf Power Generation," press release (London and New York: 19 January 2011).
4. REN21, *Renewables 2014 Global Status Report* (Paris: 2014).
5. Ibid.; B. Perlack and W. Hinds, *Evaluation of the Barbados Solar Water Heating Experience* (Oak Ridge, TN: Oak Ridge National Laboratory, 2003); estimate of 15,000 homes based on U.S. Energy Information Administration data for 2010 average electricity consumption for a U.S. residential utility customer, available at http://205.254.135.7/tools/faqs/faq.cfm?id=97&t=3.
6. REN21, op. cit. note 4.
7. International Energy Agency, *Renewable Energy Essentials: Solar Heating and Cooling* (Paris: 2009).

8. United Nations Environment Programme, "Success Stories: Solar Energy in Barbados," www.unep.org/greeneconomy/SuccessStories/SolarEnergyinBarbados/tabid/29891/Default.aspx, viewed 14 December 2011.
9. Inter-American Development Bank, "Barbados to Diversify Energy Matrix, Promote Sustainable Energy Sources with IDB Assistance," press release (Washington, DC: 10 November 2011).
10. Samantha Bresler, "Solar Panels Installed at the National Energy Commission Headquarters in the Dominican Republic," ReVolt (Worldwatch Institute blog), 14 March 2012.
11. Comision Nacional de Energia (CNE), Santo Domingo, personal communication with Worldwatch Institute, 18 September 2013.
12. Sidebar 5 and Figure 3.1 from 3TIER, *Full View Solar Assessment: Dominican Republic*, prepared for the Worldwatch Institute, 26 July 2010.
13. U.S. National Renewable Energy Laboratory (NREL), "30-Year Average of Monthly Solar Radiation, 1961–1990," http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/redbook/sum2/state.html, viewed 19 June 2013.
14. Figure 3.2 from 3TIER, op. cit. note 12.
15. Table 3.1 from Ibid.
16. REN21, op. cit. note 4.
17. Mark Delucchi and Mark Z. Jacobson, "Providing All Global Energy with Wind, Water, and Solar Power, Part II: Reliability, System and Transmission Costs, and Policies," *Energy Policy*, vol. 39 (2011), pp. 1170–90.
18. American Wind Energy Association, *Small Wind Turbine Global Market Study* (Washington, DC: 2010); "Wind Farm Selected in First Selection of Clean Energy Projects," RenewableEnergyFocus.com, 11 January 2010.
19. CNE, Santo Domingo, personal communication with Worldwatch Institute, August 2013.
20. CNE employee, Santo Domingo, personal communication with Worldwatch, 15 August 2013.
21. Figure 3.3 from 3TIER, *Full View Wind Assessment: Dominican Republic*, prepared for the Worldwatch Institute, 16 July 2010.
22. Table 3.2 from Ibid.
23. Table 3.3 from Ibid.
24. REN21, op. cit. note 4, p. 17.
25. World Commission on Dams, *Dams and Development: A New Framework for Decision-Making* (London: Earthscan, November 2000).
26. Changjiang Water Resources Commission, *Research on the Resettlement of the Three Gorges Project* (Hubei, China: Hubei Science and Technology Press, 1997); Shai Oster, "China Recognizes Dangers Caused by Three Gorges Dam," *Wall Street Journal*, 27 September 2007.
27. EGEHID employees, Santo Domingo, personal communication with Worldwatch, July 2012.
28. CNE, *Status and Outlook of the Renewable Energies in the Dominican Republic (*Santo Domingo: December 2012).
29. EGEHID employees, op. cit. note 27.
30. Sidebar 6 from United Nations Development Programme, "Programa de electrificación rural basado en fuentes de energía renovable en República Dominicana," www.pnud.org.do/proyectos/energiaymedioambiente/1201, viewed 23 August 2013; Global Environment Facility, Small Grants Programme, https://sgp.undp.org/index.php?option=com_sgpprojects&view=projects&Itemid=154, viewed 3 September 2013.
31. EGEHID employees, op. cit. note 27.
32. Ibid.
33. Jane Earley and Alice McKeown, *Red, White, and Green: Transforming U.S. Biofuels*, Worldwatch Report 180 (Washington, DC: Worldwatch Institute, July 2009).
34. United Nations Framework Convention on Climate Change, Clean Development Mechanism (CDM), "Textile Offshore Site Dominicana Biomass Residues Cogeneration Project," Project Design Document Form (Bonn: 26 June 2012).
35. CDM, "Steam Generation Using Biomass," Project Design Document Form (Bonn: 24 August 2012).
36. CNE employee, Santo Domingo, personal communication with Worldwatch, 31 July 2013.
37. Ibid.
38. Ibid.

39. Ibid.
40. Table 3.4 from M. Adames et al., Universidad Instituto Superior de Agricultura (ISA), *Levantamiento Cuantitativo de Cultivos Agricolas Selectos en la Republica Dominicana con Potencial como Biomasa Energetica*, prepared for the Worldwatch Institute, April 2013.
41. CNE, review of Universidad ISA study (Santo Domingo: 15 August 2013).
42. CDM, "Steam Generation Using Biomass," Project Design Document Form (Bonn: December 2009).
43. CNE employee, op. cit. note 36.
44. Table 3.5 from CDM, op. cit. note 42, and from D. Loy and Manlio F. Coviello, "Renewable Energies Potential in Jamaica" (Santiago, Chile: United Nations Economic Commission for Latin America and the Caribbean, 2005).
45. Loy and Coviello, op. cit. note 44, p. 13.
46. Ibid. Loy and Coviello assume that the harvest period in Jamaica is 185 days. We therefore assume that the Dominican harvest period is one-half year, and that the cogeneration plant can therefore run on the bagasse for only this period. To calculate the maximum generation capacity that can be built for the unused bagasse, we divide the potential annual generation by 4,380 hours (number of hours in a half year). This assumes a capacity factor of 1 and is therefore a conservative estimate.
47. Adames et al., op. cit. note 40.
48. CDM, op. cit. note 42.
49. Ibid.
50. CNE employee, op. cit. note 36.
51. CNE employee, personal communication with Worldwatch, July 2012.
52. CNE, op. cit. note 41.
53. CNE employee, op. cit. note 20.
54. CDM, op. cit. note 42.
55. Interview with private biomass company representative, Santo Domingo, July 2012.
56. CNE, op. cit. note 41.
57. S.E. Ben Elghali, M.E.H. Benbouzid, and J.F. Charpentier, "Marine Tidal Current Electric Power Generation Technology: State of the Art and Current Status," Electric Machines & Drives Conference, May 2007, IEEE International, pp. 1407–12, at http://hal.archives-ouvertes.fr/docs/00/53/12/55/PDF/IEEE_IEMDC_2007_BENELGHALI.pdf.
58. California Energy Commission, "Ocean Energy," www.energy.ca.gov/oceanenergy/index.html, viewed 9 February 2011.
59. Utrecht Faculty of Education, The Philippines, "Geothermal Energy on Leyte," www.philippines.hvu.nl/leyte2.htm, viewed 22 February 2012; California Energy Commission, "Geothermal Energy in California," www.energy.ca.gov/geothermal, updated 29 March 2010.
60. REN21, op. cit. note 4.
61. Ted J. Clutter, "Absolute Commitment: Geothermal Operations at The Geysers," RenewableEnergyWorld.com, 27 April 2010.
62. Katie Auth and Evan Musolino, *Caribbean Sustainable Energy Roadmap (C-SERMS), Phase 1: Baseline Report and Assessment* (Washington, DC: Worldwatch Institute, 2013); Karl Gawell, Marshall Reed, and P. Michael Wright, *Preliminary Report: Geothermal Energy, The Potential for Clean Power from the Earth* (Washington, DC: Geothermal Energy Association, 2009).
63. Auth and Musolino, op. cit. note 62.
64. REN21, op. cit. note 4.
65. CDM, *Verification/Certification Report, Bionersis project on La Duquesa landfill*, *Dominican Republic*, 2nd Periodic - Verification / Certification Report (Bonn: 16 December 2011).

Chapter 4. Grid Improvement and Energy Storage

1. Figure 4.1 from National Energy Commission (CNE), *Status and Outlook of the Renewable Energies in the Dominican Republic* (Santo Domingo: December 2012).
2. Ibid.

3. CNE employees, Santo Domingo, personal communications with Worldwatch, 2013.
4. Jeff Smith, "Smart Meters Take Bite Out of Electricity Theft," *National Geographic*, 12 September 2011.
5. Consorcio Energetico Punta Cana-Macao (CEPM) employee, Washington, DC, personal communication, 12 May 2015.
6. Asociación Dominicana de la Industria Eléctrica (ADIE) representative, Santo Domingo, personal communication with Worldwatch, 16 July 2012.
7. Ibid.
8. Ibid.
9. M. Golkar, "Distributed Generation and Competition in Electric Distribution Market," *IEEE Eurocon*, 2009. Sidebar 7 from the following sources: reversed power flow damage from S.G.M. Therien, "Distributed Generation: Issues Concerning a Changing Power Grid Paradigm," A Thesis Presented to the Faculty of California Polytechnic State University, San Luis Obispo, CA; within 5–10% from C. Lawrence, M. Salama, and R. Elshatshat, "Analysis of the Impact of Distributed Generation on Voltage Regulation," 2004 IEEE PES Power Systems Conference and Exposition; incrementally adjusting power from Therien, op. cit. this note; overheating and voltage regulation problems from Taufik, *Introduction to Power Electronics*, 6th Rev., 2008; reduce the distortion effect and fuses, circuit breakers, etc. from Taufik, *Advanced Power Electronics*, 3rd Rev., 2009; lethal hazard from islanding from G.M. Masters, *Renewable and Efficient Electric Power Systems* (Hoboken, NJ: John Wiley & Sons, 2004); damage from out-of-phase reconnection from P. Barker and R. De Mello, "Determining the Impact of Distributed Generation on Power Systems: Part 1 - Radial Distribution Systems," *Proceedings of the IEEE Power Engineering Society Transmission and Distribution Conference*, vol. 3 (2000), pp. 1645–56.
10. Robert Dohn, "The Business Case for Minigrids" (Munich: Siemens, 2011).
11. Simon Rolland and Carlos Guerroro, *Hybrid Mini-Grids for Rural Electrification: Lessons Learned* (Brussels: Alliance for Rural Electrification, 2011), p. 12.
12. Ibid.
13. Rolland and Guerroro, op. cit. note 11, p. 13.
14. GVEP International, *Policy Briefing: The History of Minigrid Development in Developing Countries* (London: 2011), p. 3.
15. Rolland and Guerroro, op. cit. note 11, p. 12.
16. Ibid., p. 12.
17. Leonardo Energy, "Distributed Generation Microgrids," *Altenergy Mag*, April 2009.
18. johnzactruba, "Microgrids Poised to Soar in Popularity," Bright Hub Engineering, 19 May 2011, at www.brighthub.com/engineering/electrical/articles/90436.aspx.
19. Figure 4.2 from World Bank Energy Sector Management Assistance Program (ESMAP), *META User Manual*, www.esmap.org/node/3051.
20. International Energy Agency (IEA), *Harnessing Variable Renewables: A Guide to the Balancing Challenge – 2011* (Paris: OECD/IEA, May 2011).
21. M. Milligan and B. Kirby, *Market Characteristics for Efficient Integration of Variable Generation in the Western Interconnection* (Golden, CO: U.S. National Renewable Energy Laboratory (NREL), August 2010).
22. GE Energy, *The Effects of Integrating Wind Power on Transmission System Planning, Reliability, and Operations: Report on Phase 2*, prepared for the New York State Energy Research and Development Authority (Albany, NY: 2005).
23. Such undersea cables have been proposed for several locations in the Caribbean, including the Dominican Republic; however, the most beneficial interconnections are generally seen as being in the Lesser Antilles, per Franz Gerner and Megan Hansen, *Caribbean Regional Electricity Supply Options: Toward Greater Security, Renewables and Resilience* (Washington, DC: World Bank, 2010).
24. University of Hawaii, Hawaii Natural Energy Institute, *Oahu Wind Integration Study: Final Report*, prepared for the U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability (Honolulu: February 2011).
25. Figure 4.3 from Organismo Coordinador Del Sistema Eléctrico Nacional Interconectado de la República Dominicana (OC), "Informe Diario" (Santo Domingo: 6 March 2013).
26. Figure 4.4 from 3TIER, *Full View Wind Assessment: Dominican Republic*, prepared for the Worldwatch Institute, 16 July 2010.

27. Figure 4.5 and 4.6 from Ibid.
28. Figure 4.7 from Ibid.
29. Figure 4.8 from Ibid.
30. Figure 4.9 from OC, *Informe de Operación Real Del Año 2012* (Santo Domingo: 15 February 2013).
31. Figure 4.10 from OC, *Memoria 2013* (Santo Domingo: 2014).
32. Biomass industry representative, Santo Domingo, personal communication with Worldwatch, 25 April 2013.
33. Idem., July 2012.
34. Milligan and Kirby, op. cit. note 21.
35. Ibid.
36. Ibid.
37. M. Ahlstrom, *Short-term Forecasting: Integration of Forecast Data into Utility Operations Planning Tools,* presented at the Utility Wind Integration Group/NREL Wind Forecasting Applications to Utility Planning and Operations, St. Paul, MN, 21–22 February 2008; K. Rohrig, ed., *Entwicklung eines Rechenmodells zur Windleistungsprognose für das Geboet des deutschen Verbundnetzes*, Abschlussbericht Forchungsvorhaben Nr. 0329915A, gefördert durch Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit (BMU) (Kassel, Germany: 2005).
38. Table 4.1 from International Renewable Energy Agency (IRENA), *Electricity Storage and Renewables for Island Power* (Abu Dhabi: May 2012), p. 12; IEA Energy Technology Systems Analysis Programme and IRENA, *Electricity Storage Technology Brief* (Bonn: April 2012), p. 15; thermal storage costs calculated based on data from D. Biello, "How to Use Solar Energy at Night," *Scientific American*, 18 February 2009.

Chapter 5. Technological Pathways for Meeting the Dominican Republic's Future Electricity Demand

1. Senabris Silvestre, "Cuatro empresas ofrecieron construir plantas a carbón," *El Día*, 17 October 2013.
2. Worldwatch Institute, *Powering the Low-Carbon Economy: The Once and Future Roles of Renewable Energy and Natural Gas*, Worldwatch Report 184 (Washington, DC: 2010).
3. National Council for Climate Change and the Clean Development Mechanism, *Climate-Compatible Development Plan of the Dominican Republic* (Santo Domingo: 2011).

Chapter 6. Assessing the Socioeconomic Impacts of Alternative Electricity Pathways

1. U.S. Energy Information Administration (EIA), "Levelized Cost of New Generation Resources," in *Annual Energy Outlook 2011* (Washington, DC: 2011).
2. World Bank Energy Sector Management Assistance Program (ESMAP), "Model for Electricity Technology Assessment (META)," https://www.esmap.org/node/3051; Christoph Kost et al., *Levelized Cost of Electricity: Renewable Energies* (Freiburg, Germany: Fraunhofer Institute for Solar Energy Systems, 2012).
3. This analysis assumes that fuel costs are free for sugarcane bagasse cogeneration, since many sugarcane producers currently have their own generation yet do not utilize all of their bagasse; if these producers were to build up generation capacity, they would be able to supply their boilers with currently unused bagasse at virtually no cost. For other biomass resources, however, a market would need to be created for biomass waste. Because this assessment considers only bagasse-fed generation, it assumes that the fuel cost is zero.
4. Jonathan Koomey and Florentin Krause, "Introduction to Environmental Externality Costs," in *CRC Handbook on Energy Efficiency* (Berkeley, CA: Lawrence Berkeley Laboratory, 1997).
5. National Energy Commission (CNE) and Ministry of the Environment and Natural Resources, *La Evaluacion Ambiental Estrategica del Plan Energetico Nacional (2010-2025*), Final Report (Santo Domingo: 15 October 2010).
6. Blacksmith Institute, "The World's Worst Polluted Places. The Top Ten" (New York: 2007).
7. Olav Hohmeyer, *Social Costs of Energy Consumption: External Effects of Electricity Generation in the Federal Republic of Germany* (New York/Heidelberg: Springer-Verlag, 1989).
8. ExternE - External Costs of Energy, "Methodology," www.externe.info/externe_d7/?q=node/1; U.S. National Research Council, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use* (Washington, DC: National Academy of Sciences: 2010).
9. Kseniya Lvovsky et al., *Environmental Cost of Fossil Fuels: A Rapid Assessment Method with Application to Six Cities*, Environment Department Papers #78 (Washington, DC: World Bank, 2000).

10. U.S. National Aeronautics and Space Administration, "Effects: The Current and Future Consequences of Global Change," http://climate.nasa.gov/effects.
11. Ramón Bueno et al., *The Caribbean and Climate Change: The Costs of Inaction* (Somerville, MA: Stockholm Environment Institute and Global Development and Environment Institute, Tufts University, May 2008); J.E. Hay et al., "Small Island States," in Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: Impacts, Adaptation and Vulnerability*, report of Working Group II (Cambridge, U.K. and New York, NY: Cambridge University Press, 2001).
12. Hay et al., op. cit. note 11.
13. Chris W. Hope, *The Social Cost of CO2 from the PAGE09 Model*, Economic Discussion Papers No. 2011-39 (Kiel, Germany: Kiel Institute for the World Economy, 2011); World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided*, prepared by the Potsdam Institute for Climate Impact Research and Climate Analytics (Washington, DC: 2012); IPCC, *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* Special Report (Cambridge, U.K.: Cambridge University Press: 2011).
14. Table 6.1 from EIA, "International Energy Statistics: Total Carbon Dioxide Emissions from the Consumption of Energy (Million Metric Tons)," www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8, viewed 28 October 2013, and from World Bank, "Dominican Republic," http://data.worldbank.org/country/dominican-republic, viewed 12 December 2014. Energy-related CO_2 emissions include emissions from coal and petroleum consumption and from flaring of natural gas.
15. U.S. Congress, Office of Technology Assessment, *Studies of the Environmental Costs of Electricity* (Washington, DC: 1994).
16. Open EI, "Transparent Cost Database," http://en.openei.org/wiki/Transparent_Cost_Database.
17. International Renewable Energy Agency (IRENA), *Renewable Energy Technologies: Cost Analysis Series* (Abu Dhabi: 2012).
18. EIA, *Annual Energy Outlook 2013* (Washington, DC: 2013).
19. Central Bank of the Dominican Republic, *Report on the Dominican Economy: January-December 2013* (Santo Domingo: April 2014), p. 28.
20. Bloomberg New Energy Finance and Frankfurt School – United Nations Environment Programme (UNEP) Collaborating Centre for Climate & Sustainable Energy Finance, *Global Trends in Renewable Energy Investment 2013* (Frankfurt: 2013).
21. IRENA, *Renewable Energy Jobs: Status, Prospects & Policies: Biofuels and Grid-Connected Electricity Generation* (Abu Dhabi: 2011) pp. 7–8.
22. Figure 6.11 from Ibid.
23. Figure 6.12 from Max Wei, Shana Patadia, and Daniel M. Kammen, "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the US?" *Energy Policy*, vol. 38 (2010), pp. 919–31.
24. Ibid.
25. U.S. Central Intelligence Agency, "The World Factbook," https://www.cia.gov/library/publications/the-world-factbook/geos/dr.html, viewed 26 August 2013.
26. South Pacific Applied Geoscience Commission (SOPAC) and UNEP, "Environmental Vulnerability Index," www.sopac.org/index.php/environmental-vulnerability-index.

Chapter 7. Sustainable Energy Finance in the Dominican Republic: Barriers and Innovations

1. Figure 7.1 calculated using Bloomberg's Fixed Mortgage Loan Calculator, www.bloomberg.com/personal-finance/calculators/mortgage/, viewed 27 June 2013.
2. Bloomberg New Energy Finance and Frankfurt School – United Nations Environment Programme (UNEP) Collaborating Centre for Climate & Sustainable Energy Finance, *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014).
3. Ibid.
4. Figure 7.2 from Multilateral Investment Fund (MIF) and BNEF, *Climatescope: Dominican Republic, 2014* (Washington, DC: 2014).
5. Ibid.

6. Figure 7.3 from World Bank, "Data: Dominican Republic," http://data.worldbank.org/country/dominican-republic, viewed 29 November 2014.
7. World Bank, "Ease of Doing Business in Dominican Republic," in *Doing Business 2014*, www.doingbusiness.org/data/exploreeconomies/dominican-republic/.
8. Table 7.1 from Ibid. and from World Economic Forum, *The Global Competitiveness Report 2013–2014* (Geneva: 2013).
9. Moody's, "Moody's Rates Dominican Republic's 2024 Bonds B1," press release (New York: 17 April 2013).
10. JP Morgan – Latin America Emerging Markets Research, "Dominican Republic Trip Notes – Willingness to 'Fix the Fiscal' Remains Strong" (Santo Domingo: 2013), https://markets.jpmorgan.com/research/email/-oshvs0l/GPS-1184304-0.
11. RBC Caribbean, *Caribbean Economic Report* (Port of Spain: November 2013), http://www.rbc.com/economics/economic-data/pdf/Caribbean.pdf.
12. Worldwatch calculation based on World Bank, "Dominican Republic," http://data.worldbank.org/country/dominican-republic, and on RBC Caribbean, *Caribbean Economic Report* (Port of Spain: April 2015).
13. "Fitch Affirms AES Dominicana's IDR at 'B'; Outlook Stable," *BusinessWire* (New York: 10 July 2013).
14. Ibid.
15. Héctor Guiliani Cury, "Estrategia de Solucion Global a La Crisis del Sector Electrico: El Caso Dominicano," Asociación Dominicana de la Industria Eléctrica (ADIE) Fifth Annual Electricity Forum, 26 November 2014, adie.org.do/index.php/parks/presentaciones/v-foro-anual-adie.
16. ADIE, "Informe del Sistema Eléctrico" (Santo Domingo: October 2014).
17. E. Fieser, "Venezuela Gets $1.9 Billion as Dominican Republic Pays Debt," Bloomberg.com, 29 January 2015.
18. Biogen, personal communication with Worldwatch, Santo Domingo, 25 April 2013.
19. ADIE, "The Electricity Sector in the Dominican Republic" (Santo Domingo: 21 June 2010).
20. JP Morgan – Latin America Emerging Markets Research, op. cit. note 10.
21. ADIE, op. cit. note 16.
22. "Fitch Affirms AES Dominicana's IDR at 'B'; Outlook Stable," op. cit. note 13.
23. MIF and BNEF, op. cit. note 4.
24. Table 7.2 from World Economic Forum, op. cit. note 8.
25. M. Lindstein, *Financing Renewable Energies* (Frankfurt: Kreditanstalt für Wiederaufbau (KfW), 2005).
26. International Finance Corporation (IFC), personal communications with Worldwatch, 2013.
27. Ibid.
28. President of the Renewable Energies Business Association, personal communication with Worldwatch, June 2011.
29. Banco BHD, personal communications with Worldwatch, Santo Domingo, September 2013.
30. Banco Central de la Republica Dominicana, "Reglamento de Evaluacion de Activos" (Santo Domingo: April 2004).
31. Ibid.
32. Sidebar 8 from the following sources: United Nations Framework Convention on Climate Change (UNFCCC), Clean Development Mechanism (CDM), "Los Cocos Wind Farm Project," Project Design Document Form (Bonn: 6 April 2012); EGE Haina, "Financial Quarterly Report: EGE Haina Reports First Quarter 2013 Net Income of US$26.6 Million; Revenues of US$174.1 Million," press release (Santo Domingo: 31 March 2013); Organismo Coordinador, personal communication with Worldwatch, Santo Domingo, 12 August 2013; "Renewable Energy News Latin America Focus 2012," renews, 9 August 2012, http://renews.biz/wp-content/assets/reNewsAmericas_LatinAmerica2012-small2.pdf. The repayment calculation does not include interest payments on the initial investment as the project was not financed through the provision of debt. IRR calculation from UNFCCC CDM, "Los Cocos Wind Farm Project: Financial Indicators," at https://cdm.unfccc.int.
33. Banco BHD, op. cit. note 29.
34. Ibid.
35. World Bank, "Data: Lending Interest Rate (%)," 20 June 2013, http://data.worldbank.org/indicator/FR.INR.LEND?order=wbapi_data_value_2011+wbapi_data_value+wbapi_data_value-last&sort=desc.
36. Biogen, op. cit. note 18.

37. Table 7.3 from Dan Coughlin and Kim Ives, "Wikileaks Haiti: The PetroCaribe Files," *The Nation*, 1 June 2011.
38. Table 7.4 from Richard W. Caperton, *Leveraging Private Finance for Clean Energy* (Washington, DC: Center for American Progress, Global Climate Network, November 2010).
39. "Dominican Republic Receives Financing for US$704.8 Million from Petrocaribe," *Diario Libre*, 16 July 2013, www.diariolibre.com/movil/noticias_det.php?id=393097.
40. Fieser, op. cit. note 17.
41. J. Leite, "Dominican Republic Sells $2.5 Billion of Bonds to Refinance Debt," Bloomberg.com, 20 January 2015.
42. Petrocaribe, "The Dominican Republic Fosters Alternative Energy Sources with Savings Derived from Petrocaribe," press release (Caracas: 11 August 2007).
43. Government of the Dominican Republic, *Law No. 112-00* (Santo Domingo: 2000).
44. U.S. Department of Energy, "Loan Programs Office: Our Projects," http://lpo.energy.gov/our-projects/.
45. Shakuntala Makhijani, *Jamaica Sustainable Energy Roadmap: Pathways to an Affordable, Reliable, Low-emission Electricity System,"* (Washington, DC: Worldwatch Institute), p. 121.
46. Development Bank of Jamaica, personal communication with Worldwatch, November 2012.
47. Figure 7.4 from Rubén Jiménez Bichara*, Sector Electrico: Situacion Actual y Perspectivas* (Santo Domingo: CDEEE, 17 October 2012); Milton Morrison, "Perspectivas globales y recomendaciones para mejorar el sector eléctrico" (Santo Domingo: ADIE, 31 January 2013).
48. S. Bakker et al., "The Future of the CDM: Same, But Differentiated?" *Climate Policy*, vol. 11, no. 1 (2011).
49. Sohel Pasha, "UNFCCC Regional Collaboration Centre (RCC)," presentation to the Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS) Resource Mobilistaion Forum (Christ Church, Barbados: 11 July 2013).
50. Ibid.
51. M. Carr, "UN Emission Credits Surge as Developers Delay Carbon Claims," Bloomberg.com, 9 April 2013.
52. UNFCCC, CDM, "UNFCCC Partners with Non-profit Organization to Boost Participation in Clean Development Mechanism Projects in the Caribbean," press release (Bonn: 25 July 2013).
53. Ibid.
54. UNFCCC CDM, "Project Search," http://cdm.unfccc.int/Projects/projsearch.html, viewed 7 November 2013.
55. Table 7.7 from Ibid.
56. Jaap Smink, "Carbon Credit Basics, Process and CDM Inventory," presentation to the Petroleum Corporation of Jamaica and the Jamaican Ministry of Science, Technology, Energy and Mining, 22 June 2011.
57. Sidebar 9 from UNFCCC, Clean Development Mechanism website, cdm.unfccc.int/, and from Global Environment Facility (GEF) Small Grants Programme, "Dominican Republic," https://sgp.undp.org/index.php?option=com_countrypages&view=countrypage&country=43&Itemid=204.
58. GEF, "What Is the GEF," www.thegef.org/gef/whatisgef.
59. GEF, "GEF Data Mapping Portal," https://www.thegef.org/gef/gef_projects_funding.
60. Ibid.
61. Ibid.
62. Table 7.8 from GEF Small Grants Programme, https://sgp.undp.org/index.php?option=com_sgpprojects&view=allprojects&country=DOM&Itemid=211.
63. The GEF Small Grants Programme, http://sgp.undp.org/index.php?option=com_sgpprojects&view=allprojects&limit=100&limitstart=100&paging=1&Itemid=211.
64. UNFCCC, "Financial, Technology and Capacity-building Support," http://cancun.unfccc.int/financial-technology-and-capacity-building-support/new-long-term-funding-arrangements/, viewed 25 February 2013.
65. UNFCCC, "NAMA Registry," http://www4.unfccc.int/sites/nama/SitePages/Country.aspx?CountryId=52.
66. NAMA Database, "Tourism NAMA in the Dominican Republic," www.nama-database.org/index.php/Tourism_NAMA_in_the_Dominican_Republic.
67. UNFCCC, "NAMA Seeking Support for Implementation: Tourism and Waste in the Dominican Republic," https://unfccc.int/files/cooperation_support/nama/application/pdf/nama_implementation_dominicanrepublic_tourism_waste_v1.pdf.

68. UNFCCC, op. cit. 65.
69. International Finance Corporation (IFC), personal communication with Worldwatch, Washington, DC, May 2013.
70. Rene Maldonado and Maria Luisa Hayem, *Remittances to Latin America and the Caribbean in 2012: Differing Behavior Across Subregions* (Washington, DC: MIF, 2013).
71. Ibid.
72. Ibid.
73. Ibid.
74. Julia Hawkins, "Financing Sustainable Energy: An Optimistic View from Niki Armacost," Ashden Blog, 11 July 2012, www.ashden.org/blog/financing-sustainable-energy-interview-niki-armacost.
75. Inter-American Development Bank (IDB), *Financing Sustainable Energy Through Remittance Flows in Haiti and the Dominican Republic* (Washington, DC: December 2009).
76. Ibid.
77. JP Morgan – Latin America Emerging Markets Research, op. cit. note 10.
78. Ibid.
79. K. Neuhoff et. al. *Structuring International Financial Support to Support Domestic Climate Change Mitigation in Developing Countries* (London: Climate Strategies, September 2009).
80. R. Potopsingh, "Greening the Energy Sector: Benefits for the Job Market," presentation at University of the West Indies, Kingston, Jamaica, 27 November 2012.
81. Table 7.9 from Caperton, op. cit. note 38.

Chapter 8. Policies to Harness Sustainable Energy Opportunities in the Dominican Republic

1. K. Hamilton, *Scaling Up Renewable Energy in Developing Countries, Finance and Investments Perspectives* (London: Chatham House, 2010).
2. *Constitution de la Republica Dominicana* (Santo Domingo: 2010).
3. Secretaría de Estado de Medio Ambiente y Recursos Naturales (SEMARENA), *Segunda Comunicacion Nacional* (Santo Domingo: 2009).
4. "Discurso del Dr. Rafael Alburquerque de Castro Vicepresidente Constitucionale de la Republica Dominicana," United Nations Framework Convention on Climate Change Conference of the Parties, Sixteenth Session in Cancun, Mexico , 9 December 2010, http://unfccc.int/files/meetings/cop_16/statements/application/pdf/101209_cop16_hls_dominican_republic.pdf.
5. Lisa Friedman, "After an All-Nighter, Doha Talks Veer Toward an Uncertain End," *E&E News*, 7 December 2012.
6. Table 8.1 from U.S. Energy Information Administration (EIA), "International Energy Statistics" (Washington, DC: 2013).
7. World Resources Institute, "Climate Analysis Indicators Tool" (Washington, DC: 2013).
8. Office of Climate Change of the Dominican Republic, *A Journey to Sustainable Growth* (Santo Domingo: 2011), p. 3.
9. United Nations Development Programme (UNDP), "Barbados Declaration on Achieving Sustainable Energy for All in Small Island Developing States (SIDS)" (New York: 8 May 2012).
10. National Energy Commission (CNE), "Law 57-07" (Santo Domingo: 2007).
11. CNE, *National Energy Plan of the Dominican Republic, 2004–2015* (Santo Domingo: July 2004).
12. National Council for Climate Change and the Clean Development Mechanism (CNCCMDL), *Climate-Compatible Development Plan for the Dominican Republic* (Santo Domingo: 2011).
13. Consejo Economico y Social, Pacto Eléctrico website, http://pactoelectrico.do.
14. Ibid.
15. Organismo Coordinador, personal communication with Worldwatch, Santo Domingo, 12 August 2013.
16. Dominican National Congress, "Law No. 100-13" (Santo Domingo: 30 July 2013).
17. CNE, personal communication with Worldwatch, Santo Domingo, September 2013.
18. Biogen, personal communication with Worldwatch, Santo Domingo, 25 April 2013.
19. Renewable energy developer (anomymous), personal communication with Worldwatch, Santo Domingo, 2013.

20. Biogen, op. cit. note 18.
21. Energy & Climate Partnership of the Americas (ECPA), "OAS and DR Technical Specialists Seek to Create Awareness on the Use of Renewable Energy and Energy Efficiency in the Country," 30 March 2015, http://www.ecpamericas.org/News/Default.aspx?id=1176&archive=1.
22. T. Beierle and J. Crawford, *Public Participation in Environmental Decisions* (Resources for the Future), cited in S. Nakhooda, S. Dixit, and N.K. Dubash, *Empowering People: A Governance Analysis of Electricity; India, Indonesia, Philippines, Thailand* (Washington, DC: World Resources Institute, 2007).
23. Nakhooda, Dixit, and Dubash, op. cit. note 22.
24. Ministry of Energy and Mines, personal communication with Worldwatch, Santo Domingo, December 2013.
25. Jens Lausten, *Energy Efficiency Requirements in Building Codes, Energy Policies for New Buildings* (Paris: International Energy Agency, 2008).
26. CNE, *Informe de auditoría energética de SENASA* (Santo Domingo: June 2011).
27. Dirección General de Reglamentos y Sistemas (DGRS), Ministerio de Obras Publicas y Comunicaciones (MOPC), Republica Dominicana, "Reglamento para instalaciones electricas en la edificación Parte 1, M-003," www.mopc.gob.do/dgrs/files/R-003%20INSTALACIONES%20ELECTRICAS.pdf; DGRS, MOPC, "Reglamento para instalaciones electricas en la edificación Parte 2, M-010," www.mopc.gob.do/dgrs/files/R-010%20INSTALACIONES%20ELECTRICAS%20PARTE2.pdf.
28. CNE, op. cit. note 10.
29. DGRS, MOPC, "Reglamento para el diseño y la construcción de instalaciones sanitarias en edificaciones, R-008 Decreto No. 572-10," www.mopc.gob.do/dgrs/files/R-008%20INSTALACIONES%20SANITARIAS.pdf.
30. World Bank, "Project Information Document (PID) – DO Electricity Distribution Rehabilitation Project" (Washington, DC: 2008).
31. Ibid.
32. SIE, personal communication with Worldwatch, Santo Domingo, November 2013.
33. Stephan Nielsen, "Smart Meters Help Brazil Zap Electricity Theft," *Bloomberg BusinessWeek*, 8 March 2012.
34. Ibid.
35. Thomas Smith, "Electricity Theft: A Comparative Analysis," *Energy Policy*, vol. 32 (2004), pp. 2067–76.
36. Ibid.
37. Ibid.
38. B. Bathia and M. Gulati, "Reforming the Power Sector" (Washington, DC: World Bank – Public Policy for the Private Sector, 2004).
39. World Bank, *Implementation Completion and Results Report (IBRD-72920)* (Washington DC: 22 September 2009).
40. Ibid.
41. Ibid.
42. M. Golden and B. Min, "Theft and Loss of Electricity in an Indian State" (London: International Growth Centre, 4 January 2012).
43. World Bank, op. cit. note 39.
44. Operation Khanyisa website, 2013, www.operationkhanyisa.co.za.
45. "More Large Consumers Charged with Electricity Theft, Names Given," DominicanToday.com, 11 April 2006.
46. World Bank, op. cit. note 30.
47. "Fitch Upgrades AES Andres Dominicana, Itabo Dominicana and Haina to 'B'," *Business Wire*, 25 January 2011.
48. Moody's, extract from an issuer comment on Dominican Republic, "Dominican Republic Ends Stand-by Agreement with IMF, a Credit Negative," 20 February 2012, www.alacrastore.com/research/moodys-global-credit-research-Dominican_Republic_Ends_Stand_by_Agreement_with_IMF_a_Credit_Negative-PBC_139942.
49. "The Dilemmas Facing Danilo Medina," Univision News, 2012, http://univisionnews.tumblr.com/post/23489304411/challenges-facing-new-president-dominican-republic-danil.
50. Table 8.3 from CNE, personal communication with Worldwatch, Santo Domingo, September 2013.
51. Pellerano and Herrera, "Executive Summary of Tax Reform Law 253-12" (Santo Domingo: 2012).

52. Ibid.
53. Virginia Castillo, "El Estado exonera pago carburantes a empresas," *El Día*, 13 August 2013.
54. Pellerano and Herrera, op. cit. note 51.
55. Table 8.4 from Ministerio de Hacienda, "Ley No. 57-07 Sobre Incentive al Desarrollo de Fuentes Renovables de Energía y de sus Regimenes Especials" (Santo Domingo:2007), http://www.hacienda.gov.do/departamento_legal/ley_incentivos_tributarios%5CLey%2057-07%20sobre%20Energia%20Renovable.pdf.
56. Table 8.5 from Paul Gipe, "Tables of Feed-In Tariffs Worldwide," Wind-Works.org, www.wind-works.org/cms/index.php?id=92.
57. Mark Konold, "A Triumvirate of Progress for the Dominican Republic's Energy Sector," ReVolt (Worldwatch Institute blog), 1 August 2011.
58. CNE, personal communication with Worldwatch, Santo Domingo, July 2012.
59. Table 8.6 from CNE, personal communication with Worldwatch, Santo Domingo, March 2014.
60. Ibid.
61. Table 8.7 from Ibid.
62. CNE, op. cit. note 58.
63. CNE, "La CNE inaugura edificio corporativo 'energéticamente eficiente'" (Santo Domingo: 29 March 2012).
64. "Net Metering in Dominican Republic Shows Results," *PV Magazine*, 4 July 2013.
65. CNE, op. cit. note 58.
66. Ibid.
67. Ministry of the Environment and Natural Resources, "Ley General Sobre Medio Ambiente y Recursos Naturales 64-00" (Santo Domingo: 2000).
68. EGEHiD, personal communication with Worldwatch, Santo Domingo, July 2012.