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Perspectives for Distributed Generation with Renewable Energy in Latin America and the Caribbean

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Perspectives for Distributed Generation with Renewable Energy in Latin America and the Caribbean

Analysis of Case Studies for Jamaica, Barbados, Mexico, and Chile

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Abstract

This paper deals with how to promote **distributed generation (DG)** done with **renewable energy (RE)** in emerging markets of **Latin America and the Caribbean (LAC)**, with the purpose of increasing competitiveness and achieving sustainable economic growth. The paper defines DG as "electricity generation that is connected to the distribution network." This definition implies that DG is i) grid-connected, not off-grid generation; ii) located at customer premises or close to the load being served; and iii) implemented on a smaller scale than that of utility-scale plants connected to a transmission grid.

The paper argues that the key **rationale** for promoting renewable DG in LAC is to reduce the cost of electricity for a country as a whole. By doing so, renewable DG also directly contributes to competitiveness and economic growth. However, renewable DG also provides many other benefits that may represent viable rationales for countries to promote it: reducing global environmental externalities (greenhouse gas [GHG] emissions); reducing local environmental and social externalities; supporting development of a new "green" industry; increasing energy security; reducing system losses and unnecessary generation capacity; increasing access to energy; and developing a green brand. In certain circumstances, these other rationales may create net economic benefits for a country, and may justify paying some premium on electricity costs.

The paper examines **four case studies in the Caribbean (Jamaica and Barbados) and Latin America (Mexico and Chile)** to assess what these countries are or are not doing, and why, in promoting renewable DG. These cases are also assessed in the light of the experience of **Denmark**, which has the world's highest share of DG (over 50 percent of electricity generation), mostly done with wind and cogeneration. Denmark's experience suggests that, if a society is willing to pay a premium for its electricity, it can reach a high penetration of renewable DG, thus reducing GHGs, increasing energy security, and even fostering successful RE equipment manufacturing for the local and global market.

The paper finds that all LAC countries considered have some viable options for renewable DG plants on a commercial scale (plants with the main purpose of selling a continuous flow of electricity: particularly small hydro, biomass cogeneration, wind, and biogas). Renewable DG implemented on a small scale (plants with the main purpose of generating for self-consumption and selling excess electricity, particularly solar photovoltaic [PV]) is viable in countries with very high costs of electricity generation, and where concessional financing is available (such as Barbados). In other countries, however, small-scale renewable DG is currently not viable.

Generally, the four countries considered have already developed (or are on the way to developing) their viable renewable DG potential on a commercial scale, though each in a different way depending on market structure. In Jamaica, the utility is regulated based on least cost planning and a regime for third party generation has been created. Barbados recently approved an RE Policy for a Sustainable Energy Framework. In Mexico, there are auctions for new generation. Finally, Chile established limited and technology-neutral targets that can be met with the most cost-effective technologies.

The four countries are also showing caution in how they allow non-viable renewable DG on a small scale to contribute to their energy mix. Barbados offers a pilot Renewable Energy Rider (RER) that pays avoided cost. Jamaica provides a Standard Offer Contract (SOC) that pays avoided cost plus a limited premium for the economic benefits of RE. Mexico is implementing its first grid-connected small RE systems with net metering based on new model contracts. Meanwhile, Mexico is developing a methodology to estimate the net economic benefits of deciding how much RE should be developed in the future and what prices should be paid for it. Chile is considering net metering programs but still has not decided the exact terms for them. No country, in any case, has set rates for small-scale distributed RE at levels that will ensure the financial viability of systems that are not economically viable. In this, emerging markets of LAC have shown wisdom, thoughtfulness, and restraint, especially when compared to other more aggressive approaches adopted in Europe and North America.

Based on the encouraging experience of the countries examined, this paper makes five recommendations on how to promote cost-effective distributed RE that can contribute to the competitiveness and growth of emerging markets in LAC.

1. **Define DG clearly and appropriately, based on system size.**

   The first step in effective policymaking is setting country-specific boundaries regarding the objectives of the policy. For clarity, DG should be defined based on its interconnection with the distribution network. Additional definitions of capacity or technology type can be provided for further clarification if desired, but would not, on their own, clearly define DG.

2. **Ensure that power systems are developed based on least cost generation.**

   Least cost planning should be the cornerstone of any policy because all countries have options for distributed RE that are least cost but not all are being implemented. Ensuring that all options that make sense in each country are identified, assessed, and implemented will help set priorities correctly, starting with the win-win options. This can be done

   - For commercial-scale renewable DG, through effective regulation and market design. In vertically integrated markets (such as Jamaica and Barbados), effective regulation means:
     - an obligation on the utility to demonstrate that its generation expansion plans are least cost, and a duty on regulators to check and enforce that obligation;
     - an obligation on the utility to purchase from third parties when the cost is lower.

     In liberalized markets (such as Mexico and Chile), effective market design means:
     - non-discriminatory treatment of RE in selling energy and capacity;
     - auctions to award additional capacity and/or energy at least cost.
   - For small-scale renewable DG, through well-designed feed-in tariffs. This paper defines feed-in tariffs not as subsidies, but simply as standing offers to purchase power at some predetermined

price, for a predetermined period of time, and subject to certain technical requirements. Well-designed feed-in tariffs:

- set the price at no more than actual avoided cost;
- set the term at least equal to the useful lifetime of systems;
- prefer net billing to net metering (to separately measure and bill the electricity bought by a customer and excess electricity sold by a customer);
- cap individual and total eligibility.

3. **Neutralize threats to efficient DG.**

Just because least cost generation makes sense is no guarantee that it will happen. In practice, even excellent projects may be threatened by inertia, inadequate grid rules, and cumbersome permitting and planning processes that increase transaction costs.

Effective policy will anticipate these threats, and preempt them:

- A mix of **obligations and incentives can help combat inertia**:
  - explicit obligations to consider reasonable RE options in least cost planning;
  - obligations on utilities to purchase power from third parties (independent power producers [IPPs]) when this is at some margin below their avoided cost;
  - limited RE portfolio standards that are technology neutral and gradual in implementation;
  - cost recovery tariff mechanisms that ensure suppliers can recover the efficiently incurred capital costs of developing RE.
- Grid codes can be updated to **make it easy and safe to connect to the grid** with renewable DG. They should include technical and operating standards, reasonable restrictions, and fair prices to charge for grid use.
- **Streamlined, standardized permitting and planning approaches** can reduce transaction costs and ensure that viable projects are developed in reasonable time:
  - one-stop-shops for obtaining all required permits;
  - technology-specific processes for environmental and construction permits;
  - pre-established contents of Environmental Impact Assessments;
  - technology-specific standards for allowed impacts;
  - cut-off sizes for renewable DG that can be installed without permits.

4. **Consider if paying more for power may increase competitiveness and growth.**

After everything is in place for win-win options to take place, countries should examine if there are any circumstances where paying a premium is justified on a cost–benefit basis. Economic considerations are important. Does paying a premium actually create net economic benefits to the country? That is, are economic benefits greater than economic costs? Political considerations are just as important. Will voters accept paying more? Will they reelect politicians who make them do so?

Paying a premium for electricity may be justified, for example, in the following cases:

- **To increase system resilience and energy security**. There should be a prudent diversification of which primary sources of energy are used, and which locations these sources are obtained from. Alternative tools for energy security (forward contracts) should also be considered.
- **To develop a green economy and create green jobs**. Creating a new green economy and green jobs is often used as an argument to subsidize manufacturing or services but is subject to risks. To mitigate those risks, countries should consider helping a new green economy develop only if there is a strong potential domestic market for that technology, and the country has (or could develop in the future) the industrial capabilities required to manufacture or service certain technologies.
- **To reduce local and global environmental externalities**. If a government decides that it is worthwhile paying more to make the environment more sustainable, it should at the very least treat local and global environmental externalities differently:
  - Domestic consumers would capture the full benefits of reducing **local environmental and health externalities**; therefore, it may be argued that they should pay the entire cost;
  - However, domestic consumers would only obtain a fraction of the benefits of reducing **global environmental externalities** (GHGs); therefore, governments of emerging markets should be careful before deciding that their citizens pay the entire cost of reducing GHGs. Win-win options that reduce GHGs while also saving the country money should be promoted first. Other options have an additional cost that from a global perspective may be justified and may represent an efficient solution. Emerging markets should seek concessional financing and grants from international organizations, or industrialized countries, to develop those projects. While the Clean Development Mechanism (CDM) is struggling, Nationally Appropriate Mitigation Measures (NAMAs) are emerging as a new framework.
- **To promote a country's branding**. Sustainable products may be sold at a premium; sustainable tourism destinations may likewise be marketed at a premium. However, that premium should not be borne by the population of an emerging market.
- **To increase access to energy**, thus reducing energy poverty and increasing social inclusion.
- The **determination of what premium is justified** is likely to prove difficult and controversial. Governments should tackle this on a step-by-step process that:
  - First, involves key public and private stakeholders, and determines which items deserve a premium or not;
  - Second, develops a methodology for determining the premium to be paid;
  - Third, assesses economic costs and benefits to the country.

5. Avoid the trap of paying too much

Even when a country decides that paying a premium is worthwhile, the premium should not be loosely set and customers should not end up paying too much. Three key ways to avoid this trap are:

- **To create disaggregated, cost-reflective tariff structures**. The premium should be added to the tariff component that is affected by the benefit created by distributed RE. For this to happen, there must be different components for different services: provision of energy, connection to the distribution grid, and provision of backup and stand-by capacity. For example, a solar PV system (without battery) may save on energy (fuel costs) but will not save on those other services.
- **To always set total caps on feed-in tariff programs**. The fact that some premium may be justified should not mean unlimited eligibility for feed-in tariffs. Otherwise, the premium may affect the quality of service and create unpredictable and unsustainable costs that ultimately are borne by customers. A country should decide what total quantity is justified to provide the desired level of a certain benefit.
- **To always prefer net billing to net metering**. Net metering is equivalent to setting feed-in tariffs at the retail rate (i.e., the commercial tariff). That is the same rate that should decrease in order to increase competitiveness and create sustainable economic growth. By implementing net billing, a country would use bidirectional meters to apply a cost-benefit justified premium to electricity sold by generators, but no more than that.

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Introduction: Outlining Scope, Definition, and Rationale

This introduction defines the scope of the analysis of distributed generation of renewable energy to increase competitiveness and achieve sustainable economic growth in emerging markets of LAC. Then, it defines DG based on interconnection with the distribution network. Finally, it presents the key rationales for implementing renewable DG in emerging economies.

Scope of the Analysis: Renewables, Emerging Markets in LAC, Competitiveness, and Economic Growth

This paper focuses on DG that is

- **Done with RE** technologies that are appropriate for DG (wind, small hydro, solar, industry cogeneration, biomass cogeneration, biogas, landfill gas to energy, waste to energy);
- **Done in emerging markets of the LAC region**;
- **Done with the purpose of increasing competitiveness and achieving economic growth**.

The main focus of this paper is on renewable DG in an accommodation stage of development: a stage where renewable DG is "accommodated into the current market with the right price signals, [and] centralized control of the network remains in place" (IEA, 2002). That is, this paper tries to identify as a priority the immediate opportunities to implement renewable DG in existing systems of LAC countries, where the largest share of electricity is provided by centralized generation. In the future, as technological progress and cost reductions increase the economic viability of more renewable DG options, and as networks need to be replaced, countries could move toward the following two stages of DG development (IEA, 2002):

- A decentralization stage (which only Denmark has reached, with DG representing over 50 percent of generation), where service is optimized by decentralized providers using shared communication systems, but local distribution companies still retain control of the network.
- A dispersal stage (which currently no country has reached), where DG would meet electricity demand with limited recourse to centralized power generation, and coordination between local systems would be in place rather than control of one entire system.

Defining Distributed Generation Based on Its Location in the Network

There is no universally accepted definition of DG. Various definitions have been formulated based on location in the network, type of technology, installed capacity, environmental impact, or ownership. Except for the first (location in the network), "none of these definitions can adequately capture the range of plants that can be subsumed under the heading of DG, nor do they provide a satisfying description of their common characteristic" (Bauknecht and Brunekreeft, 2008).

This paper adopts the definition of DG by the Office of Gas and Electricity Markets (OFGEM, 2002) of the United Kingdom: "**electricity generation, which is connected to the distribution network, rather than high voltage transmission network,**" as is instead the case of utility-scale generation. DG's connection to the distribution network implies that it is located at customer premises or in close proximity to the load being served. It also implies that it consists of "typically smaller generation, such as renewable generation, including small hydro, wind and solar power, and smaller Combined Heat and Power (CHP)" (OFGEM, 2002). Finally, it implies that DG is not off-grid, but grid-connected.

Defining DG based on its connection to the distribution network requires, in turn, **defining the distribution network**. This is different from one country to another, depending on the size of each country's power market. The definition could be based on a voltage cut-off level for large and small countries, or simply refer to whatever each country defines as transmission and distribution based on voltage. For example, Mexico defines distribution networks as those with voltage between 2.4kV and 34.5kV (SENER, 2010a).

Depending on market size and network characteristics, DG may be a different size in different countries. A system of the same installed capacity could be DG in one country and utility-scale generation in another. Assuming the voltage of distribution systems reaches a maximum of 110kV, the maximum installed capacity of DG plants that could be connected to those systems would be in the range of 100MW to 150MW (Bauknecht and Brunekreeft, 2008). In smaller markets, however, voltage (and therefore installed capacity of DG) would typically be lower.

Table 1. Main Types of Distributed Generation

	Small Scale	Commercial Scale	
Connection	Customer load	Customer load	Distribution network
Sale of electricity	Excess generation	All generation	All generation
Sectors	Residential, non-residential	Non-residential	Non-residential
Main RE technologies	Solar PV, wind, hydro	Industry cogeneration (CHP)	Solar, wind, hydro, biomass cogeneration
Approximate size	Up to 100kW	Up to 1MW	Above 1MW

Small-scale DG is typically connected to a customer load and sells only excess generation after self-consumption. Sometimes, however (for example, in Barbados), a utility buys all of the electricity generated by small DG and discounts it from customers' bills (either using the same retail rate or a different rate; Barbados uses a different rate based on avoided cost, as described in more detail below).

Commercial-scale DG is typically directly connected to the distribution network and sells all electricity on a continuous basis, either as a byproduct of industrial processes (industry cogeneration/CHP, where heat is captured and used to generate electricity that is sold back to the grid through a customer load connection) or from plants specifically built for commercial supply of electricity.

Table 1 also shows typical renewable DG technologies and approximate size of plants for each type. Given the definition of DG adopted, however, technology types and installed capacity are likely to be different depending on each specific context.

Rationale for Renewable DG in Emerging Economies: Reducing Electricity Costs and Other Benefits

Before looking at *what* specific countries in LAC are doing regarding renewable DG, this section makes a few working hypotheses as to *why* they may or may not be implementing it.

One key rationale for implementing renewable DG in emerging markets may be **to reduce the cost of electricity to customers**. Especially in countries that depend on expensive imported fossil fuels (such as Caribbean countries), renewable DG may represent an attractive alternative to generate electricity at a cheaper cost using domestic natural resources. Reducing the cost of electricity to customers requires renewable DG that is **economically viable**, defined as renewable DG that reduces the cost of electricity supply to the country as a whole.

Reducing the cost of electricity to the country as a whole means that the cost of generating one kilowatt-hour (kWh) required by a DG plant must be lower than the cost required by utility-scale plants. RE technologies that supply firm power (i.e., power that is provided without interruption and that can be dispatched as base load) should be compared with the all-in cost of generation of conventional plants (i.e., a cost that includes both fixed expenditure in capital and variable expenditure in operations and maintenance). RE technologies that provide non-firm power (such as wind, which provides intermittent power) should only be compared with the variable components of the cost of generation of conventional plants (because when a non-firm RE plant is built, firm capacity is still necessary for backup and stand-by).

Reducing the cost of electricity to the country as a whole also means that all, and not just some, customers must enjoy a reduced cost of electricity. In particular, households or businesses that develop renewable DG plants should not enjoy a benefit in reduction of electricity costs at the expense of households or businesses that do not. For example, in countries where tariffs are high, solar PV systems are not economically viable (they cost more than other available generation options), but they may be **commercially viable** (they cost less than the retail tariff and therefore save money to those who implement them). If the retail electricity rate is paid for excess electricity that customers with a solar PV system sell back to the grid, those customers will save money on their bill. However, other customers who do not install a renewable DG system may actually have to pay higher bills because the system as a whole is buying some of its electricity at a higher price compared to other cheaper alternatives.

Renewable DG provides other benefits that may represent valid rationales for countries to promote it. However, pursuing some of them requires caution because they may end up increasing costs to a country as a whole. The following are the primary other benefits (and reasons why they should be pursued with caution):

- **Reducing global carbon dioxide (CO_2) emissions**. Renewable DG technologies displace GHG emissions. However, only economically viable RE does so while also reducing electricity costs.

When governments plan and implement Nationally Appropriate Mitigation Actions (NAMAs),[1] they may promote win-win RE options that abate GHGs while also saving the country money, as suggested by the United Nations Framework Convention on Climate Change (UNFCCC): "economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties" (UNFCCC, 1992). However, they may also be tempted to promote RE that increases net costs to the country.

- **Reducing local environmental and social externalities**. Renewable DG avoids emitting substances that pollute the local air and environment. It also poses fewer siting problems, even compared to large-scale renewable plants that require displacing people, such as large hydro. Countries can capture the entire benefit of reducing local externalities (this is not the case for global externalities).
- **Helping a new green industry develop**. Implementing DG to promote domestic manufacturing, installation, and maintenance of RE equipment may create net economic benefits when the domestic market is large enough and there are sufficient industrial capabilities. However, creating an obligatory market for DG, or subsidizing private companies that manufacture RE equipment, risks creating more economic costs than benefits, particularly when manufacturing unexpectedly locates to other countries. The case of Spain (Bloomberg, 2010)[2] is emblematic of how an excessive feed-in tariff program backfired. The recent case of solar PV manufacturers in the United States (Washington Post, 2011) that went bankrupt, leaving taxpayers to bear the cost of government loan guarantees, illustrates the risks of excessive financial support to domestic RE manufacturing.
- **Increasing energy security**. Increasing the share of generation that relies on primary RE sources available domestically reduces dependency on imported fossil fuels and enhances the resilience of the power system to external disruptions. However, many renewable DG technologies (such as wind and solar energy) can only supply non-firm power and require firm power for backup and standby. Not all countries have RE sources that can provide base load power at a competitive cost (such as hydro, which Mexico has, but Barbados does not). Also, there may be ways other than RE to achieve energy security in a cost-effective way, through a prudent diversification of the generation mix (including both RE and conventional options), development of infrastructure (such as building terminals to import Liquefied Natural Gas [LNG], like Chile did), and use of commercial instruments (such as forward contracts).

[1] Nationally Appropriate Mitigation Actions were created by the Bali Action Plan (2007) within the United Nations Framework Convention on Climate Change. They are voluntary projects or programs to reduce greenhouse gases that governments of developing countries (or non-Annex I countries of the UNFCCC) undertake in a way that is consistent with the country's economic and social development. NAMAs may also be financially supported by industrialized countries (or Annex I countries of the UNFCCC) or international organizations.

[2] In 2007, a law created a Feed-In Tariff at US¢44 per kWh for 25 years for solar PV (10 times the 2007 average wholesale price of US¢4), without setting any cap. The target was to obtain 400MW of solar power by 2010 and promote the domestic manufacturing industry. The results were 3,500MW installed by 2008 and €126 billion in obligations to over 50,000 solar entrepreneurs who often bought equipment abroad.

- **Reducing system losses and unnecessary capacity**. Since renewable DG is located at (or close to) loads being served, it avoids all or most of the losses incurred in the network. For this, the generation cost of conventional benchmarks with which renewable DG is compared should be grossed up for system losses in that particular country (e.g., if the conventional benchmark is US$0.10 per kWh and losses are 10 percent, the benchmark should be US$0.11 per kWh). Also, renewable DG can respond to projected demand in a more incremental and less uneven way than large-scale conventional plants that need to be built in one block but may take some time to be fully utilized.
- **Developing a green brand**. Developing a green image for a country or a region may provide economic benefits, such as the sale of sustainable products at a premium or the development of sustainable tourism destinations. However, pursuing green branding may also imply additional costs that risk being borne by the local population or that may not be justified by the benefits created.

Current Status

This section takes a closer look at what four countries in the LAC region are doing regarding renewable DG (**Jamaica** and **Barbados** in the Caribbean, and **Mexico** and **Chile** in Latin America).

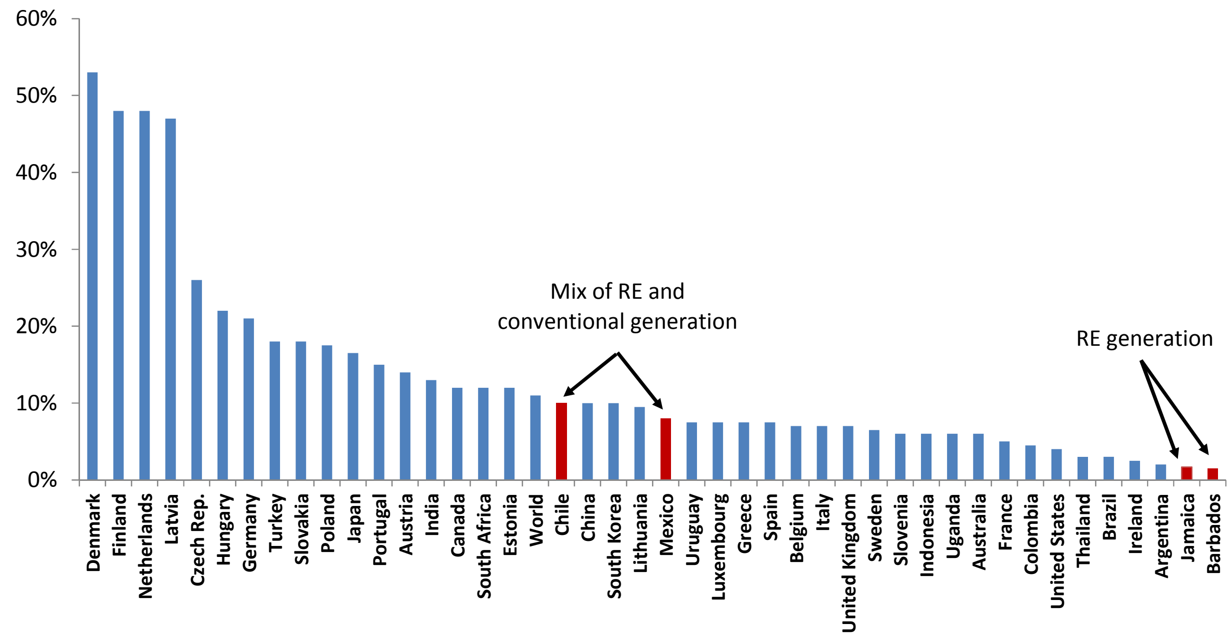
To promote small renewable DG, Jamaica and Barbados recently launched feed-in tariff programs. **This paper defines a feed-in tariff not as a subsidy**, as that term is commonly (and incorrectly) used, but simply as a standing offer to purchase power at some predetermined price, for a predetermined period of time, and subject to certain technical requirements. This definition is consistent with the labels that Jamaica and Barbados have given to their feed-in tariff programs (Standard Offer Contract, and Renewable Energy Rider, respectively), precisely to avoid giving the impression that they are a subsidy.

Mexico and Chile have experience in developing renewable DG on a commercial scale and are setting up frameworks to develop it on a small scale.

How Much DG Are Countries Worldwide Doing? How Much Is Renewable?

Figure 1 shows an estimated share of DG in various countries throughout the world (WADE, 2006). For Jamaica and Barbados, only renewable DG is considered. For other countries (including Chile and Mexico), DG done with conventional energy is also considered.

Figure 1. Share of DG as a Percentage of Total Generation (%)



Sources: Jamaica: Ministry of Energy and Mining, 2008.[3]
Barbados: CIRP, 2007; BL&P, 2010b.[4]
Other countries: authors' elaboration of: World Alliance for Decentralized Energy (WADE), 2006.

In particular, Figure 1 shows that:

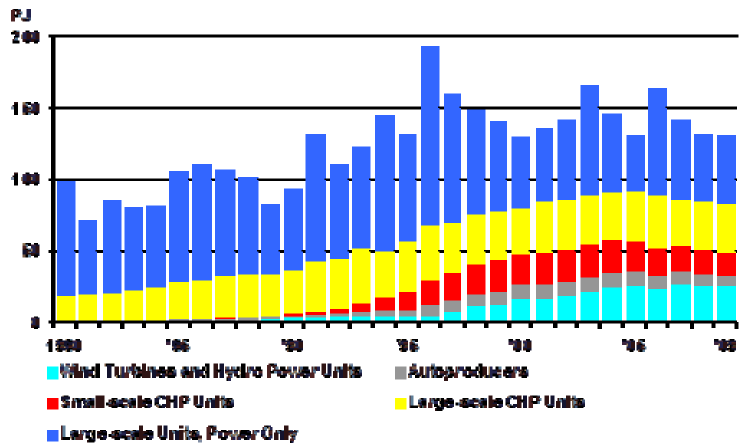
- **Chile and Mexico** are the Latin American countries with the highest share of DG (about 10 percent and 8 percent of total generation, respectively); however, this is a mix of RE and conventional generation.
- **Jamaica** has about 1.7 percent, considering only biomass cogeneration and a few solar PV systems.
- **Barbados** has about 1.5 percent, considering only biomass cogeneration and a few solar PV systems.[5]

[3]Bagasse cogeneration estimated at 1.4 percent based on 23MW of plant and an assumed 30 percent capacity factor; and solar PV estimated at approximately 0.3 percent based on early implementation of the Standard Offer Contract.
[4]Biomass cogeneration estimated at 1.2 percent and solar PV estimated at approximately 0.3 percent based on early implementation of the Renewable Energy Rider.
[5]It should be noted that penetration of solar water heaters (SWH) is high in Barbados, and the systems are domestically manufactured by a successful local industry. Solar water heaters are not dealt with in this paper given they do not generate electricity and therefore do not fall within the scope as defined for this paper. However, they can displace electricity bought from the grid and are a very cost-effective solution for heating water.

Figure 1 also shows that **Denmark** has reached an advanced stage in DG, with over 50 percent of generation (WADE, 2006). A brief summary of Denmark's experience, which represents the state of the art in DG today, may help put things in context while analyzing the experience of the four LAC countries in renewable DG.

Denmark: The Experience of the World's Most Advanced DG Market

Figure 2. Evolution of Electricity Generation by Type in Denmark, 1980-2009 (PJ)



Note: "Large-scale units" refers to coal, gas, and oil generation.
"Autoproducers" refers to wind and CHP for self-consumption only.

Source: Danish Energy Agency, 2011

Denmark's DG is mostly represented by wind energy and industry cogeneration (with a smaller share of hydro) and was developed between the early 1980s and today by a mix of compulsory targets and subsidies for RE. Accommodation and then decentralization of DG for supplying power started in the 1980s. In 1985, Denmark voted out nuclear power. Decentralization (1980s to date) came after a centralization phase (1950s through 1970s), which had reversed a decentralized tradition that since the early 20th century had seen small- and large-scale power supply systems coexist (Raven and Van der Vleuten, 2006).

A series of four energy plans aimed to make Denmark more self-sufficient in primary energy resources and more resilient to external shocks of the kind that took place in the 1970s. In particular, the second energy plan (1981) mandated that wind supply 8.5 percent of demand by the year 2000.The third energy plan (1990) mandated that power generators reduce emissions of CO_2 (−20 percent), sulfur dioxide (SO_2, −60 percent), and nitrogen oxide (NOx, −50 percent) by the year 2000 compared to 1988. The fourth energy plan (1996) mandated a further reduction of CO_2 (−50 percent) by 2030 compared to 1998. The plans also imposed taxes on generation producing emissions of CO_2 and sulfur (Danish Energy Agency, 2011).

A law to promote RE created a complex structure of feed-in tariffs by technology, with rates up to about US$0.11 per kWh for wind and solar PV, and US$0.13 per kWh for biogas (SRES Legal, 2010; Rets Information, 2010).[6] These rates are higher than the avoided costs of coal and gas-fired generation, which are estimated at about US$0.04 and US$0.07 per kWh, respectively (EWEA, 2001).

Feed-in tariffs of other European countries reach higher levels. Germany's for wind and small hydro are about US$0.13 per kWh and for solar PV US$0.43 per kWh (Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, 2009). Spain's for solar PV in 2007 was US$0.44. Denmark's residential tariffs are the highest in the European Union (€0.25-0.29 per kWh, followed by Germany at €0.25-0.26 per kWh). Denmark's industrial tariffs are in the middle range: €0.10 per kWh, which is higher than France at €0.07 per kWh, but lower than Italy at €0.14 per kWh or Germany at €0.13 per kWh (European Union, 2011).

Denmark's experience suggests that, if a society is willing to pay a premium for its electricity, it can reach a high penetration of renewable DG, reducing GHGs, increasing energy security, and even fostering successful RE equipment manufacturing for the local and global market, like in the case of Vestas, which began building wind turbines in 1979 (Vestas, 2011).

Analyzing the DG Experience of Four LAC Countries

This section looks at the experience in DG (particularly with RE) of Jamaica, Barbados, Mexico, and Chile. Each case study is structured as follows:

1. A brief description of the country's power sector context.
2. An estimate of the economic and commercial viability of renewable DG options. A distributed RE technology is considered economically viable when its generation cost (US$ per kWh) is lower than that of centralized conventional generation, and therefore can reduce a country's overall cost of electricity supply. A distributed RE technology is considered commercially viable when its generation cost is lower than the tariff and therefore can save money for customers that implement it.

   Unless provided by other sources, generation costs for RE are estimated as follows:

   $$\textit{Generation costs (US\$ per kWh)} = \frac{\textit{Annualized capital and O\&M costs (US\$)}}{\textit{Annual energy output (kWh per year)}}$$

   where annualized capital and operation and maintenance (O&M) costs are calculated over a system's useful lifetime (20 years, unless otherwise specified), given a certain discount rate (similar to a mortgage payment), and annual energy output is calculated by multiplying installed capacity in kilowatt (kW) by 8,760 hours per year by an estimated capacity factor (percent).

[6] Note that these rates decrease after a certain number of years. For example, that for solar PV decreases by 33 percent (to DKK0.40, or US$0.07 per kWh) after the first 10 years and for the subsequent 10 years.

Costs of conventional generation, which provide the benchmark for assessing the viability of RE generation, are grossed up for system losses in each country, considering that distributed RE could avoid those losses. The appropriate benchmark for firm RE technologies is the all-in cost of conventional generation (including capital and fixed O&M costs) because these technologies can replace base load power. For non-firm or intermittent RE technologies, the appropriate benchmark is just the variable portion (fuel, and variable O&M) because these technologies cannot replace base load power.

3. A description of the policy and regulatory framework for RE and for DG.
4. An analysis of strengths and weaknesses of each country's policy and regulatory framework for renewable DG.

Jamaica

Small-scale renewable DG in Jamaica is provided with a reasonable feed-in tariff program based on avoided cost, limited eligibility, and good metering arrangements. This program could be further improved by extending the term of the feed-in tariff to system lifetime (from 5 to 20 years) and calculating avoided cost in a way that recognizes RE's potential contribution. Other RE is implemented at utility scale on a competitive, least cost basis.

Context: A Vertically Integrated System with High Costs and Prices of Electricity

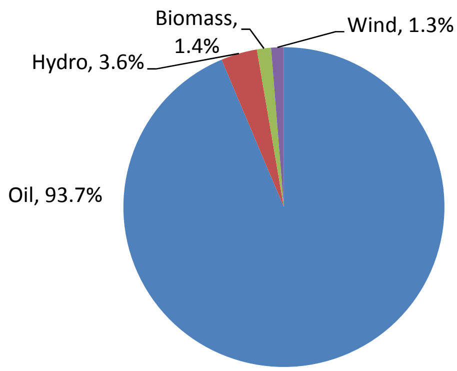
Jamaica Public Services Company, Limited (JPS) is a vertically integrated power company with exclusive rights to transmit, distribute, and supply electricity in Jamaica (Office of Utilities Regulation [OUR], 2001). Generation is provided for the most part by plants owned by JPS itself (625MW, including steam, gas turbines, combined cycle turbines, diesel, hydro plants, and wind, all connected to the transmission network). The rest of generation is provided in part by IPPs through power purchase agreements (PPAs) for capacity and energy (191MW of steam, medium speed diesel, and slow speed diesel plants) or only energy (20.7MW wind farm, connected to the transmission network) (OUR, 2010a). In addition, grid-connected sugar companies have about 23MW of plant (mostly burning bagasse), and other industries and hotels have another 18MW of thermal capacity (Ministry of Energy and Mining, 2008).

The Office of Utilities Regulation, a multi-sector regulatory agency, regulates the public supply of electricity (OUR, 2000). The OUR establishes policies and procedures for least cost expansion planning (OUR, 2006), directly prepares least cost expansion plans, and manages and administers procurement of new generation from IPPs (OUR, 2010a).[7]

Jamaica's **electricity generation is mainly oil-based**, as shown in Figure 3. Hydro and wind provide about 3.7 and 1.3 percent of electricity, respectively (OUR, 2010a).

[7] Based on an agreement (2007) between the Government of Jamaica and Marubeni, the then-majority shareholder of JPS (80 percent, with the remaining 20 percent owned by the Government). Marubeni sold half of its shares to Abu Dhabi National Energy Company in 2009.

Figure 3. Electricity Generation in Jamaica by Source, 2010



Sources: OUR, 2010a. For biomass cogeneration: Ministry of Energy and Mining, 2008.[8]

Jamaica's **electricity generation costs** are high, mainly as a result of the high cost of imported fossil fuels. In 2011, the short-run avoided cost of conventional generation was estimated at about US$0.24 per kWh (US$0.22 per kWh if only considering the variable portion of that)[9] (Castalia, 2011). The OUR estimates that, thanks to the future commissioning of plant running on LNG, Jamaica's long-run avoided cost could fall to just US$0.093 per kWh (OUR, 2010b). Grossed up for system losses (as high as 23.7 percent in 2009 [OUR, 2010a]), these benchmarks would become US$0.33, US$0.31, and US$0.13 per kWh, respectively.

Electricity tariffs in Jamaica are also high, estimated at US$0.39 per kWh for residential and small commercial customers (Castalia, 2011; OUR, 2011).[10] High tariffs are a serious concern in Jamaica because they affect the life of residents as well as the competitiveness of Jamaican-based businesses.

Viability of Renewable DG: Good Options at Commercial Scale, Not Yet at Small Scale

Figure 4 compares the cost of generation of RE technologies that can be developed on commercial or small-scale DG (horizontal bars) with costs of generation of conventional technologies (vertical lines, white labels) and current tariffs (vertical line, grey label).

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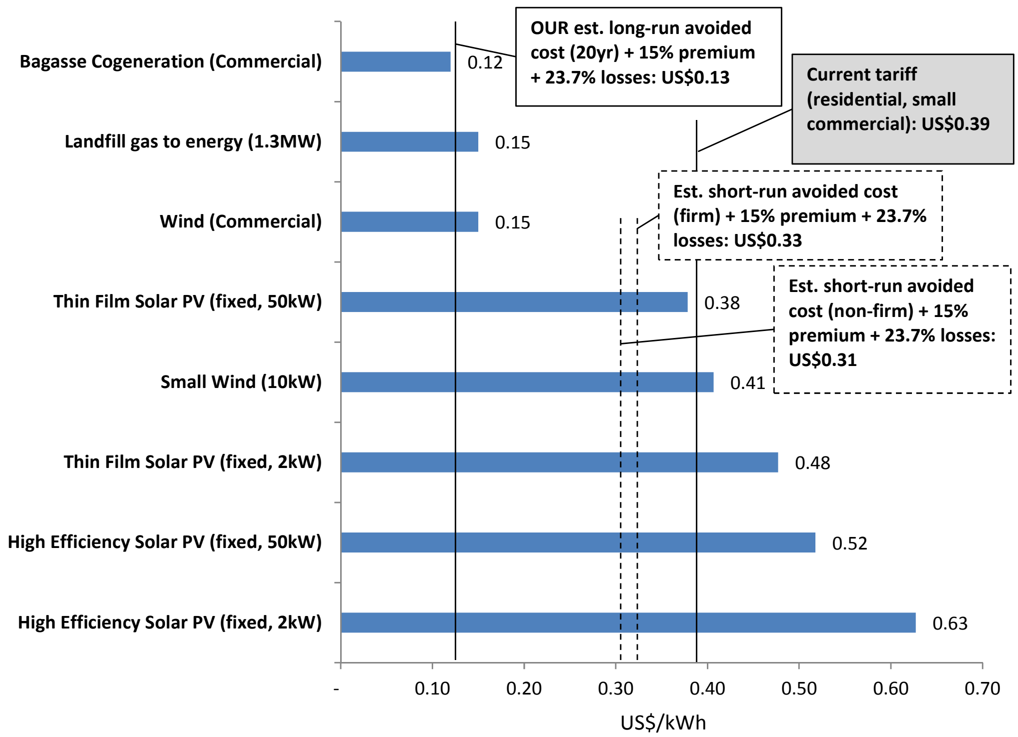
[8]Based on 23MW installed (Ministry of Energy and Mining, 2008) and assuming a 30 percent capacity factor.

[9]Average marginal cost of generation of the existing system (US$0.22 per kWh, weighted average of oil-fired steam plant and combined cycle plant) plus capital cost of deferred capacity (US$0.02 per kWh, based on a natural gas combined cycle plant).

[10]Tariff levels are estimated based on the new tariffs (2011) and adjusted using the fuel and IPP charge and exchange rate adjustment for April 2011, given a base exchange rate of US$1:J$86, actual exchange rate of US$1:US$85.7, a target heat rate of 10,470 kJ/kWh, and target losses of 17.5 percent.

Figure 4. Viability of Renewable DG in Jamaica (US$ per kWh)



Source: Castalia, 2011.[11] Losses 23.7%, premium for RE 15%: OUR, 2010a.

Generation costs of conventional technologies are grossed up by 15 percent, as determined by the OUR for "external benefits, sometimes intangible, having to do with fuel supply diversity and environmental advantages of these application over their conventional counterparts" (OUR, 2010a); as well as for system losses of 23.7 percent (as noted above). Figure 4 shows that:

- **Commercial-scale RE is economically viable**. **Bagasse cogeneration, landfill gas to energy, and commercial-scale wind** could generate electricity at a cost that is lower than the current conventional generation benchmark. **Small hydro** is a viable RE option in Jamaica, but it is connected to the transmission network; also, most available hydro resources are already used.
- **Small-scale RE is not economically viable (but some is almost commercially viable)**. Solar PV options all generate electricity at a higher cost than the estimated short-run avoided cost; however, it is possible that the cheapest and most efficient solar PV systems may generate at a price that is slightly less than the retail tariff. These systems could be commercially viable, meaning they would

[11] Key assumptions: bagasse cogeneration (60MW, 85 percent capacity factor, US$3,000/kW installed cost, 12 percent discount rate); landfill gas to energy (1.3MW, 80 percent capacity factor, US$3,800/kW installed cost, 12 percent discount rate); wind (2MW turbines, 30 percent capacity factor, US$2,640/kW installed cost, 12 percent discount rate); small wind (10kW, 30 percent capacity factor, US$6,000/kW installed, 15 percent discount rate); solar PV (2-50kW, 19-21 percent capacity factors, US$4,000-6,000/kW installed, 15 percent discount rate).

save money to those implementing them. To be economically viable, the capital cost of solar PV would need to decrease to about US$3,200 per kW installed, or concessional financing should be made available (11 percent interest rate). Small wind is also almost commercially viable. To be economically viable, its capital cost would need to decrease from about US$6,000 to about US$4,000 per kW installed (or obtain similar concessional financing).

Framework for Renewable DG: Feed-In Tariff at Avoided Cost for Small Renewable DG; Competition and Least Cost Planning for All the Rest

There is **no official definition of DG in Jamaica**. Based on the authors' experience in the country, DG is generally considered to be plants other than those at central locations of JPS or IPPs. Small hydro plants owned by JPS (which generated about 3.7 percent of 2010 electricity) are considered distributed generation. The Wigton Wind Farm is considered utility scale. However, based on this paper's definition, none of these plants are connected to JPS's distribution system. The OUR defines transmission as either 138kV or 69kV lines, while the distribution system operates at 24kV, 13.8kV, and 12kV (OUR, 2010a). Therefore, a plant that in larger systems could be developed as commercial-scale DG is developed as utility scale in Jamaica and directly connected to the 69/138kV lines.

New plant is commissioned based on least cost expansion plans prepared by the OUR. The OUR runs competitive auctions for tranches of new capacity above 15MW; for additions between 100kW and 15MW, there can be direct negotiation of a PPA with JPS. Capacity from cogeneration plants (such as a diesel-powered cogeneration from Jamaica Broilers Group [OUR, 2010a]) can be contracted without competitive bidding regardless of size (OUR, 2005).

The only plants connected to the distribution system are those of sugar companies, other industries, and hotels, all for **self-generation**. These plants are not part of the OUR's least cost planning (although cogeneration by bauxite companies "is being contemplated as an option for satisfying a proportion of the capacity requirement for the electricity sector" [OUR, 2010a]).

For systems up to 100kW, a **Standard Offer Contract** is available from JPS. The SOC's main features are as follows (JPS, 2011):

- **Term**: 5 years
- **Eligibility**: cap on individual systems (maximum installed capacity 100kW), as well as on total systems eligible (3 percent of peak demand)
- **Feed-in tariff rate**: long-run avoided cost as estimated by the OUR (US$0.093 per kWh), plus the 15 percent premium, for a total of US$0.11 per kWh
- **Metering arrangement**: net billing. Net billing separately measures electricity bought by the load where the DG system is connected, and electricity generated and sold by the DG system, and bills each flow of electricity separately, applying the retail tariff to electricity purchased, and another tariff (in Jamaica, based on avoided cost plus a premium) to electricity sold.

Analysis: A Sound Framework that Could Be Improved for Small-Scale Renewable DG

Jamaica's electricity framework is generally oriented toward reducing electricity costs, which are one of the key economic concerns in the country. New power generation in Jamaica is developed based on least cost (whether large or small scale); and least cost generation is directly enforced by the OUR. Viable hydro, biomass cogeneration, and wind projects have been implemented this way, and mostly interconnected to the transmission system.

The SOC framework has a number of strengths:

- **It caps individual and total eligibility**. This makes quantities of DG, and especially their cost, predictable and limits the share of intermittent generation on the grid to preserve quality and reliability of service. Without a total cap, there could be operational problems as the share of intermittent generation increases without the network being prepared to integrate it. There could also be financial problems as JPS commits to buying too much electricity. Customers could end up paying more if there were no cap because JPS would recover the cost of an unlimited program that procures unnecessary generation.
- **It is based on avoided cost plus a limited premium**. The feed-in tariff granted is equal to the OUR's estimate of Jamaica's long-run avoided cost plus a 15 percent premium that the OUR considers economically justified. The feed-in tariff is not set at a level that would recover the entire generation cost of systems like solar PV. Such a level would be around or much above retail rates, increasing costs to the country (it would use more costly generation options).
- **It works on net billing**. This allows electricity generated by small producers to be paid for at no more than the cost that would be required by utility-scale producers. This way, the country as a whole is guaranteed least cost power. If there were net metering (which just spins a meter backward), JPS would have to supply some of the system's electricity at the retail rate, which is much higher than the cost it could generate at using conventional plants. Customers would have to bear the additional cost, exacerbating the effect of expensive power on households and businesses.

Jamaica's SOC could be improved in a couple of ways:

- **By revising the avoided cost calculation**. Using the OUR's long-run avoided cost (US$0.093 per kWh) does not accurately estimate current costs that small-scale renewable DG could avoid because the lower-cost natural gas plants used for that estimate have yet to be built. Also, the criteria for determining a 15 percent premium for RE are unclear.
- **By extending the term**. Five years is much less than the typical lifetime of a small-scale RE system, such as solar PV. This creates uncertainty of recovering even that small portion of these systems' cost. It also increases transaction costs because it puts in place an agreement to provide energy for a much shorter period than what could be done if the full lifetime of systems were considered.

Considering these possibilities, eligible suppliers could be given two options:

- A feed-in tariff at the long-run avoided cost but for a period of 20 years;
- A feed-in tariff at the current short-run avoided cost for a few years (e.g., three) and then reset at actual avoided cost on an annual basis until 20 years.

Barbados

Thanks to concessional financing provided by the government with the support of the Inter-American Development Bank (IDB), some small-scale renewable DG with solar PV is already viable in Barbados. The electric utility has recently started offering a pilot Renewable Energy Rider at avoided cost, with limited eligibility, and net billing. There are viable options for commercial-scale renewable DG, but they are more likely to be implemented at utility scale in Barbados. Also with support from the IDB, the government is working with the regulator and the electric utility to put into place a Sustainable Energy Framework (SEF) so that viable options may be implemented based on least cost planning by either the utility or (for a limited amount of opportunities, such as biomass cogeneration and waste-to-energy) IPPs.

Context: A Vertically Integrated System with High Costs and Prices of Electricity

Barbados Light & Power (BL&P) is the country's sole electricity provider. It is a vertically integrated electric utility responsible for the generation, supply, and distribution of electricity. IPPs are not prohibited, but no license has been issued. The SEF includes a proposed legal reform that would make it easier for IPPs to obtain a license: a ministerial order would be required instead of an Act of Parliament.[12]

BL&P is regulated by the **Fair Trading Commission (FTC)**, an independent government entity. In addition to utility regulation, the FTC is responsible for competition law and general consumer protection.

BL&P generates **all electricity from fossil fuels**, as shown in Figure 5 (BL&P, 2010a); however, it is planning a 10MW (utility-scale) wind farm in Saint Lucy. There is also a small share of biomass cogeneration for self-consumption (IDB, 2010). Barbados imports almost all its fossil fuels; it has oil reserves, but consumes ten times what it produces.

Generation costs and tariffs are high, like Jamaica's, and similarly are a concern for households and businesses. Based on a study conducted for the IDB and the Government of Barbados in 2010, assuming oil prices of US$100 per barrel, the estimated avoided variable cost of generation of diesel-fueled plants (grossed up for system losses of 6.6 percent) is US$0.21 per kWh, while the estimated long-run marginal cost of low-speed diesel plants is about US$0.19 per kWh (IDB, 2010). The residential tariff is estimated at about US$0.31 per kWh; the commercial tariff is estimated at US$0.27 per kWh (IDB, 2010).

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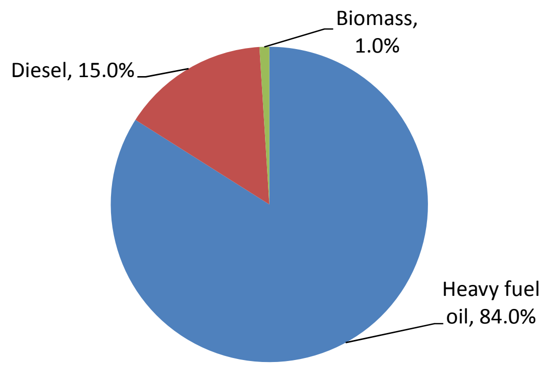
[12]The license granted to BL&P by the Electric Light & Power Act (ELPA, 1907) is not exclusive, but BL&P is the only entity licensed. The ELPA requires an Act of Parliament to authorize other commercial suppliers, though no license is needed for self-supply and sale of excess generation.

Figure 5. Electricity Generation in Barbados by Source, 2009

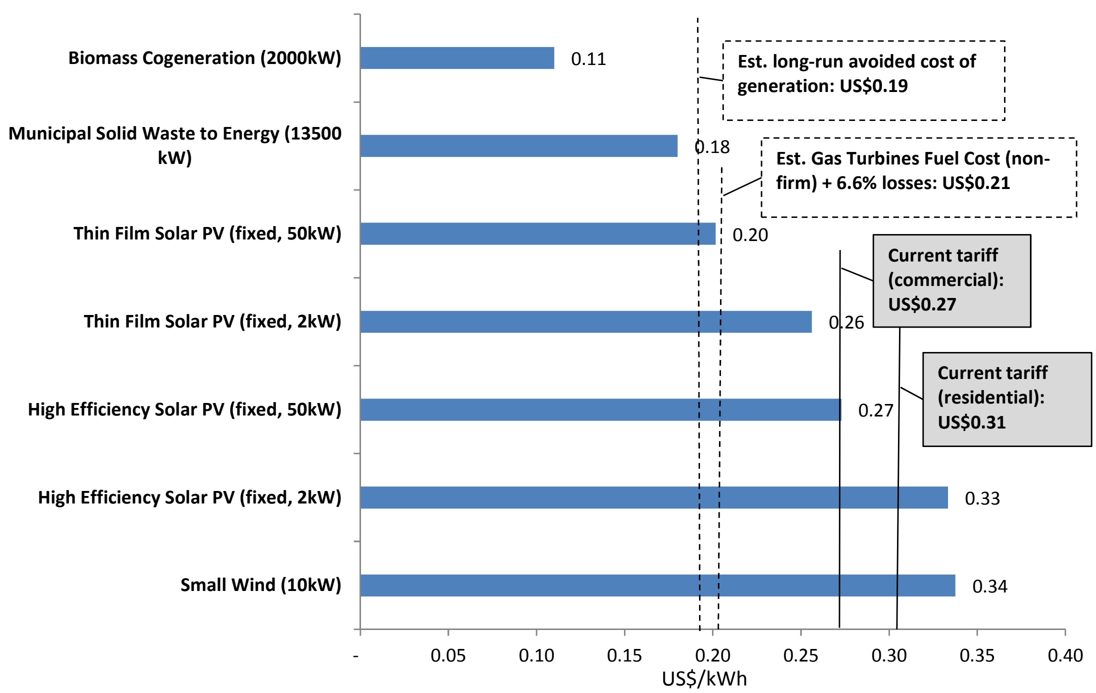


Source: BL&P, 2010a. For biomass: CIRP, 2007.

Viability of Renewable DG:
Good Options on a Commercial and Small Scale Thanks to Concessional Financing

Figure 6 compares costs of generation for renewable technologies (horizontal bars) with those of conventional technologies (vertical lines, white labels) and tariffs (vertical lines, grey labels).

Figure 6. Viability of Renewable DG in Barbados (US$ per kWh)



Note: Discount rates: 5% for small-scale DG; 12% for commercial-scale DG and conventional generation.

Source: IDB, 2010.

Figure 6 shows that:

- **Commercial-scale renewable DG is viable**. Biomass cogeneration and waste-to-energy are economically viable because they could generate electricity at less than the long-run avoided cost of conventional generation. They are also commercially viable, as they generate at a cost that is less than the tariff. A sugar factory, for example, could both sell its electricity competitively and save on its bill.
- **Thanks to concessional financing, the cheapest small-scale renewable DG is viable**. The best solar PV systems, of a size that a business could implement (50kW), have a long-run marginal cost of US$0.20 per kWh (assuming a capital cost of US$4 per Watt installed, a capacity factor of 21 percent, and a 5 percent discount rate). Thanks to a loan from the IDB, approved within the development of the SEF, the government is implementing a US$10 million Smart Fund that will provide subsidized loans at about this rate to businesses based in Barbados to implement small distributed RE systems (as well as energy efficiency projects). More expensive solar PV systems are not far from being viable (assuming capital costs of US$5-6 per Watt installed) and would become viable once costs are in the range of US$4 per Watt installed. Small wind in Barbados has lower capacity factors (about 20 percent) compared to larger scale wind (about 30 percent) and would need larger decreases in capital costs (from US$6,000 to US$3,000) to become viable.

As the prices of small-scale renewable DG decrease, there will be more options for Barbados to reduce its overall cost of generation. Meanwhile, even small-scale renewable DG that is not *economically* viable can be *commercially* viable (cost less than the tariffs). The following section analyzes what this means.

Framework for Renewable DG: Barbados toward a Sustainable Energy Framework

Regarding **commercial-scale renewable DG**, public and private stakeholders have recently been taking important steps to assess and implement economically viable projects:

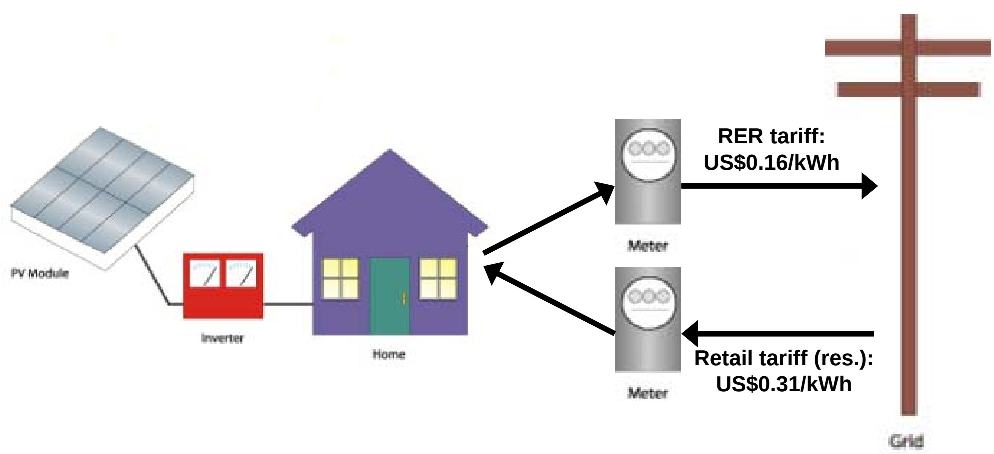
- There is no explicit requirement that BL&P do least cost generation expansion. However, the utility has consistently commissioned new capacity based on least cost, has planned a 10MW wind farm that is economically viable (FTC, 2010), and has explored how to reduce generation costs by buying biomass or waste-based electricity from third parties.
- With support from the IDB as part of a policy-based loan, in September 2011 the government approved an RE Policy (IDB, 2011a) that requires BL&P to do least cost planning, including viable RE options, and to purchase power from third parties when this is lower cost than the utility's own avoided cost. The recent RE Policy requires the FTC to check and enforce these requirements on the utilities, and that any cost savings be passed on to customers.
- As noted, Barbados' SEF also includes a proposed change in legislation to make it easier and quicker for IPPs to apply for and obtain a license. Waste- and biomass-based generation are economically viable in Barbados and, given the nature of the feedstock, IPPs would be more likely to develop such projects.

Regarding **small-scale renewable DG**, BL&P has also been proactive in exploring how it could contribute to saving fuel costs. Since 2010, BL&P has provided a pilot RER that allows customers to develop grid-connected small PV and wind (BL&P, 2010b). The FTC's approval of the RER (which happened within BL&P's latest rate case, in 2010) represented another step in creating Barbados' SEF. The RER's main features are as follows (BL&P, 2010b):

- **Term**: 2 years
- **Eligibility**: cap on individual systems (maximum installed capacity 5kW for small customers, 50kW for large customers), as well as on total systems eligible (1.6MW, approximately 1 percent of peak demand, or 200 systems, whichever occurs first)
- **Feed-in tariff rate**: short-run avoided cost of generation, with a floor (US$0.16 or 1.8 times the fuel clause adjustment [which covers fuel costs], whichever is highest)
- **Metering arrangement**: net billing, using bidirectional meters to separately measure and bill the electricity bought and sold

Figure 7 illustrates the functioning of Barbados' RER. Jamaica's SOC has the same functioning, although with different rates, as explained above.

Figure 7. Functioning of Barbados' Standard Offer Contract



Source: Authors' elaboration.

Analysis: Sound Sustainable Energy Framework for Commercial- and Small-scale Renewable DG

RE options that could be implemented as DG in larger systems are likely to be implemented at utility scale in Barbados, either by BL&P or (for a limited amount of opportunities, given market size) by IPPs. Thanks to the joint efforts of the government, the FTC, BL&P, and the IDB, the framework for implementing utility-scale RE is being effectively created based on least cost planning to include viable RE.

The RER is well designed in that (like for Jamaica) individual and total capacity is capped, the rate is set at avoided cost (with a sophisticated calculation by BL&P, which compares time-of-day generation by PV and wind, as well as the dispatching of its own plants based on the load curve), and net billing is the metering arrangement. The recently approved RE policy calls for further improvement in this framework by:

- **Extending the term of the RER**: Two years is too short compared to the useful lifetime of systems (even shorter than Jamaica's five years for the SOC).
- **Developing a disaggregated, cost-reflective tariff structure**: In Barbados, many electricity tariffs are bundled together in one rate (US$ per kWh) for different services: supply of energy, but also connection to the distribution grid, and provision of back-up and stand-by capacity for having electricity even when intermittent distributed RE is not generating. Some solar PV systems are already commercially viable (costing less than the tariff) although not economically viable (costing more than avoided cost of generation). Therefore, the current tariff structure may give customers (in particular, residential ones) an incentive to self-generate, for example with solar PV, to avoid paying the tariff. However, by not paying that tariff (which includes also services other than supply of energy) they would be enjoying services provided by the utility, without actually paying for them. This would ultimately make other customers without a system pay the cost for those other services.

Since the RER is being offered on a pilot basis, there is an opportunity to improve it once it is replicated, building on existing strengths of the original pilot program design and taking into consideration any lessons learned.

Mexico

DG has been used in Mexico since the 1990s, when reforms were introduced to allow private participation in generation. On a commercial scale, several renewable DG options are already economically and commercially viable. They have been planned and effectively developed based on least cost, as mandated by Mexican law for any new generation. On the other hand, small-scale renewable DG is currently not viable in Mexico, and its implementation for now is limited to a few pilot initiatives. Since 2008, Mexico has been creating a framework that sets targets for RE and mandates, among other things, that net economic benefits of RE be considered when planning how much RE plant to develop and how much to pay for it. The framework is currently evolving, and it remains to be seen how net economic benefits will be assessed when setting future RE targets.

Context: A Single-Buyer Market with Low Costs and Prices of Electricity

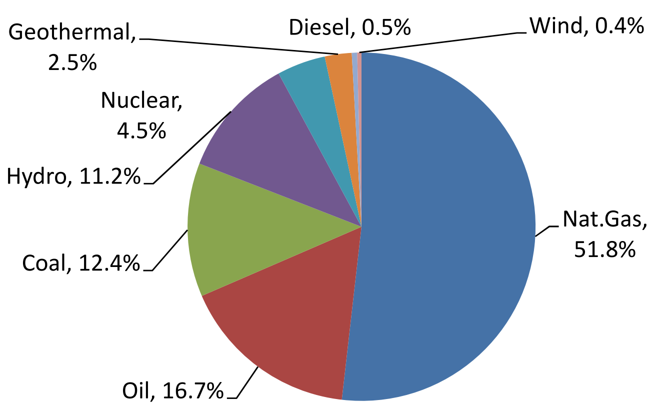
Power generation, transmission, and distribution in Mexico are dominated by the **Federal Electricity Commission** (CFE, or Comisión Federal de Electricidad), which acts as a single buyer for **IPPs**. The state-owned company Luz y Fuerza del Centro (LyFC) initially operated in the central region of Mexico but was taken over by CFE in 2009. Currently, CFE has a monopoly for transmission and distribution; however, reforms were made to incentivize private participation in generation (including IPPs and cogeneration). CFE now includes IPPs in its expansion planning, and most new capacity has been installed through PPAs with IPPs (SENER, 2010a).

The main agencies in charge of energy policy and regulation in Mexico are the **Ministry of Energy** (SENER, or Secretaría de Energía), the **Energy Regulatory Commission** (CRE, or Comisión Reguladora de Energía), and the **Ministry of Finance** (SCHP, or Secretaría de Hacienda y Crédito Público). Their responsibilities are as follows:

- **SENER:** National energy planning and policymaking
- **CRE:** Regulating IPP participation in the electricity sector, establishing payments for contracts between RE generators and CFE, and issuing permits for IPPs to operate
- **SCHP:** Setting electricity tariffs based on proposals by CFE and CRE

Fossil fuels are the predominant source of power generation in Mexico, accounting for 81 percent in 2009: mainly natural gas, oil, and coal, as shown in Figure 8. Renewables represented about 14 percent of total generation in the same year (mainly hydro, followed by geothermal and wind). CFE accounts for about 64 percent of installed capacity (total of 60.4GW for the entire country) and 59 percent of total generation (total of 268.2TWh). IPPs account for 29 percent of total electricity generation, and 19 percent of the total installed capacity of the National Electricity System (SEN, Sistema Eléctrico Nacional). Self-generation and cogeneration account for the rest (SENER, 2010a).

Figure 8. Mexico Power Generation by Technology, 2009



Source: SENER, 2010a.

Electricity generation costs in Mexico are low. According to CFE figures, the levelized costs of the main power generation technologies (combined-cycle gas and supercritical coal) are approximately US$0.08 and US$0.06 per kWh, respectively. The levelized cost of generation of large scale hydropower is about US$0.09 per kWh (Johnson et al., 2009). Grossed up for losses (17.9 percent; SENER, 2010a), these conventional benchmarks for renewable DG are US$0.09 and US$0.07 per kWh, respectively.

Table 2. Average Electricity Tariffs in Mexico (2010)

Categories	Rates (US$, 2010)
Residential	0.09
Medium enterprise	0.11
Large industrial	0.09
Commercial	0.20
Services	0.14

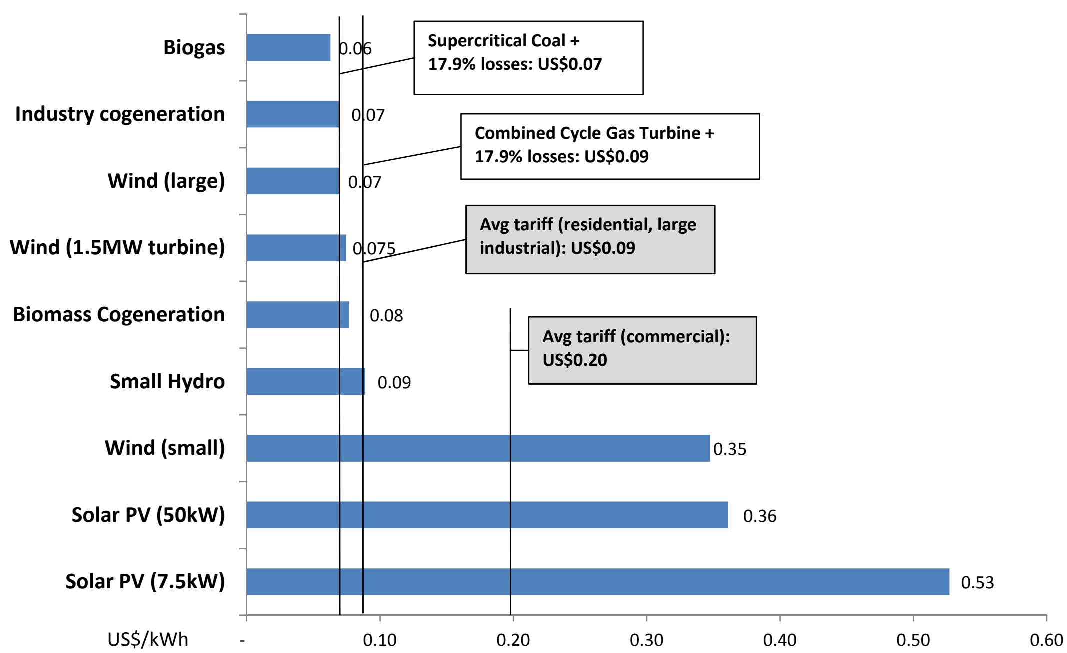
Note: exchange rate US$0.08 per MXP.
Source: SENER, 2010a.

Electricity tariffs are also relatively low, especially for customers in the residential, large industrial, and medium enterprise categories, as shown in Table 2. Commercial tariff categories face higher rates, which may hinder their competitiveness.

Viability of Renewable DG: Good Options at Commercial Scale, None at Small Scale

Figure 9 illustrates the economic and financial viability of commercial- and small-scale renewable DG projects in Mexico.

Figure 9. Viability of Renewable DG in Mexico (US$ per kWh)



Note: Small wind: assumed US$6,000/kW, 30% capacity factor, 12% discount rate.
Source: For Fossil Fuel Technologies, Biogas, Industry Cogeneration, Wind (large), Biomass Cogeneration, and Small Hydro: Johnson et al., 2009. For Solar PV: information from Mexican system providers.[13] For 1.5MW wind turbine: IDB, 2011b.[14]

[13] US$6,000 (7.5kW) and US$4,000 (50kW) per kW installed, 18 percent capacity factor, 12 percent discount rate.
[14] US$960/kW, 35 percent capacity factor, 25 years, 6 percent discount rate provided by IDB concessional financing.

Figure 9 shows that:

- **Commercial-scale renewable DG is mostly viable**, although wind needs concessional financing, grants, or carbon finance.
  - **Biogas, industry cogeneration, biomass cogeneration, and small hydro** (firm technologies) are competitive with either coal or combined cycle gas turbines (CCGT) when grossed up for 17.9 percent losses. Biogas might also be developed on a small scale in some cases, although its levelized cost would probably be higher.
  - **Large wind** is cheaper than the all-in cost of CCGTs, but since it is a non-firm technology, it would probably just be competitive with CCGT's variable cost of generation. Wind projects in Mexico have relied on carbon finance and grants to cover the gap in viability with conventional generation.
  - **1.5MW wind turbines** manufactured locally in Mexico with support from the IDB (IDB, 2011b), and obtaining concessional financing from the IDB (as low as 5 percent), could also be viable.

- **Small-scale solar PV and wind are not viable**. Small wind and solar PV are not economically or commercially viable since their generation costs are above the costs of natural gas generation and the residential, large industrial, and commercial tariff. According to authors' local sources, capacity factors for solar PV are lower in some regions of Mexico (18 percent) compared to Caribbean countries (up to 21 percent). Costs of solar PV would need to decrease dramatically, or efficiency increase dramatically, for this technology to be viable. Solar PV would not be viable even costing US$2,000 per kW installed and reaching capacity factors of 23 percent. Only concessional financing at rates similar to those offered by the IDB for wind could make it viable.

Framework for Renewable DG: Evolving from Financial to Economic Least Cost

Traditionally, Mexico has planned and implemented new generation based on financial least cost. However, recent laws and regulations have begun creating a new framework with targets for RE, calling for economic costs and benefits to be considered as well. This framework is still being defined, as explained in detail below.

The **Public Service Electricity Law** (Ley del Servicio Público de Energía Eléctrica) of 1975 (article 36-BIS), which is the main law governing the sector, mandates that public electricity provision be least cost (Justia Mexico, 1975). CFE is responsible for elaborating and executing the least cost expansion plan, and SENER reviews it.

Mexico's **National Energy Strategy** of 2010 establishes that the participation of clean energy technologies increase to represent 35 percent of total generation capacity by 2025 (SENER, 2010c).

The **Law on Renewable Energy Development and Financing for Energy Transition Law** (LAERFTE, or Ley de Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética), otherwise known as the RE Law, was approved in November 2008 (Cámara de Diputados, 2008). The RE Law sets out the following institutional responsibilities:

- SENER is to develop a special program for RE and a methodology to include RE in expansion plans considering their net economic benefits.
- CRE is to define maximum and minimum prices to be paid to RE generators.
- CFE is required to receive reasonable excess electricity, consistent with the operating and economic conditions of system.

The regulation of the RE Law (SENER, 2009a) specifies that net economic benefits be considered when compiling an RE inventory (which SENER is in charge of), as well as when deciding what prices should be paid for RE generation (which CRE is in charge of).

To comply with requirements of the RE Law, CRE and SENER have issued the following:

- **Model contracts for interconnection of small- and medium-scale RE** prepared by CRE and published by SENER (SENER, 2010b). The resolution defines DG as generation that is connected to the SEN (i.e., not off-grid) but not directly interconnected to the transmission network (i.e., connected to the distribution network).
- **A special program for RE** issued by SENER (SENER, 2009b). This program sets targets for RE integration by 2012. It states that RE should contribute 7.6 percent of installed capacity, and 4.5 to 6.6 percent of generation. The breakdown of the target includes wind, small hydro, cogeneration, biogas, and geothermal; however, solar is not included. Also, there are no specific targets for DG (just a mention of its role in electrifying 2,500 communities).

Analysis: Viable DG Is Already Happening, But the Future Is Unclear

Commercial-scale DG is well advanced in Mexico based on the regulatory environment established in the early 1990s. Although commercial-scale DG has an effective framework already, it could change over time.

To develop large-scale RE generation in Mexico, CFE holds competitive auctions to procure RE from IPPs. CFE has been purchasing power through auctions since the early 1990s. The same process and rules have been used for conventional and renewable generation. All IPPs must obtain operations licenses from CRE. PPAs are signed between CFE and the IPP. Because of the mandate to purchase least cost power, which is set by law, CFE has used concessional financing (i.e., loans at a below-market rate provided by international organizations) or carbon finance (i.e., carbon credits) to offset any incremental costs of RE; in particular, to cover the viability gap for wind projects.

However, the 2008 RE Law and its 2009 Regulation mandate that the net economic benefits be considered when evaluating RE projects, both with respect to quantities to be included in an inventory and to prices that should be paid for RE generation. The first national RE integration targets set after the RE Law are based on projects already considered by CFE in its 2008 expansion plan. They are for technologies that are already viable (small hydro, cogeneration, biogas, wind, and geothermal). SENER is still working on a methodology to determine the net economic benefits of RE to set updated targets after 2012. Likewise, CRE is working to establish a price cap and floor, and specific RE quantities to incorporate into future bidding documents for RE generation, based on net economic benefits.

The final result of SENER's and CRE's work remains to be seen. While many in principle may agree that RE creates some economic benefits, it may be more difficult to agree on the details:

- **Which economic benefits should be included in the methodology for planning and implementing new generation?** In particular, should only local or also global externalities be considered? If global externalities were also considered, should Mexico pay to avoid them given the country would get only a fraction of any benefit? Or should the international community pay, as it has for example for wind?
- **How should economic costs and benefits be valued?** Valuation will involve estimating a per-kWh value for benefits such as energy security and reduced health problems from local emissions of particulate matter. Some economic costs and benefits (especially when dealing with human life and future generations) may be more problematic to value.

Meanwhile, international organizations such as the IDB are supporting the local manufacturing of wind turbines, which are marginally viable in the country. Capacity factors for wind are very high in the country; so high that they have led to problems for turbines at some sites. Mexico has a large potential market for wind and the necessary industrial capacity to serve it. Technical assistance and concessional finance for this technology seem justified to help it make the final technical and economic progress it needs to contribute to Mexico's clean energy matrix in an economically viable way (IDB, 2011b).

The Mexican government has also made progress on a framework for small-scale DG; however, this framework is still in its pilot stage and evolving. Using CRE's model contracts, CFE can enter into interconnection agreements that provide feed-in tariffs at retail rates using a net metering arrangement. These contracts are applicable for all RE systems that have a capacity up to 500 kW and that are interconnected to the distribution network at voltages up to 69 kV (SENER, 2010b). There is no cap on the overall eligibility for this program (total number of systems, total installed capacity).

The first example of grid-connected small-scale DG using a feed-in tariff in Mexico is CFE's **Grid Interconnected Photovoltaic Neighborhood Program in Mexicali** (Baja California). This project was implemented through an agreement between CFE and the State Government of Baja California. It entails installing 220 affordable houses, equipped with solar PV modules for self-generation and sale of excess electricity to the grid (as well as efficient appliances and energy saving lights). Each household system is equipped with bidirectional meters to measure separately the electricity sold to and bought from CFE. In spite of using bidirectional meters, both flows are billed at the retail rate, as in net metering (Comisión Estatal de Energía, 2011).

CFE's program represents a positive step in that it allows customers that are self-generating to sell excess electricity to the grid and it involves a feed-in tariff that is not set at the level that would make solar PV financially viable (at least US$0.36 per kWh, or more, as shown in Figure 9). Since for now this program covers a negligible portion of generation, its implementation has a limited impact both in operational and financial terms, but can provide useful information for replication on a larger scale. When this happens, this program should be improved by:

- **Providing an overall cap on eligibility, consistent with updated targets for RE based on their net economic benefits**. This will allow knowing in advance how much intermittent capacity will be on the network and how much it will cost.
- **Using net billing to pay a price that is economically justified based on the net economic benefits that will be decided**. The bidirectional meters that are installed already allow this. Net billing will show customers with an eligible PV system that they buy electricity at the retail price but that they sell it at avoided cost to avoid imposing additional costs (over and above any that the government may decide are economically justified for the country) on customers without a PV system. The Mexicali project highlights 50 percent in savings on bills of eligible customers but does not clarify that other customers will ultimately pay for those additional costs, without this additional cost having been assessed as economically justified.

Chile

Since the 1980s, Chile has opened its market to private power generation, which, in turn, has facilitated DG development. However, little DG has actually been done with RE. Renewable DG is only viable on a commercial scale, but it is too expensive on a small scale. Since 2004, the government has been creating a framework to promote renewable DG on a commercial scale with a mix of incentives, targets, and competition. The framework for small-scale renewable DG is still in the works, with some uncertainties.

Context: A Competitive Electricity Market with Relatively High Electricity Prices

The Chilean electricity sector is a **competitive market**. Generation, transmission, and distribution were unbundled in the 1980s. The privatization process was completed by the end of the 1990s and is regarded to have improved the performance of the electricity sector. Generators can sell their electricity to distribution companies, unregulated clients, or on the spot market. The Sistema Interconectadodel Norte Grande (SING) and the Sistema Interconectado Central (SIC) are the two largest interconnected systems. Distribution companies in Chile operate under public service concessions and are responsible for providing service within their areas at regulated tariffs (CNE/GTZ, 2009).

The main electricity sector entities in Chile are the **National Energy Commission** (CNE, or Comisión Nacional de Energía), part of the Ministry of Energy; the **Superintendent of Electricity and Fuels** (SEC, or Superintendencia de Electricidad y Combustibles); and **Load Economic Dispatch Centers** (CNE/GTZ, 2009). The following are the main responsibilities of each agency.

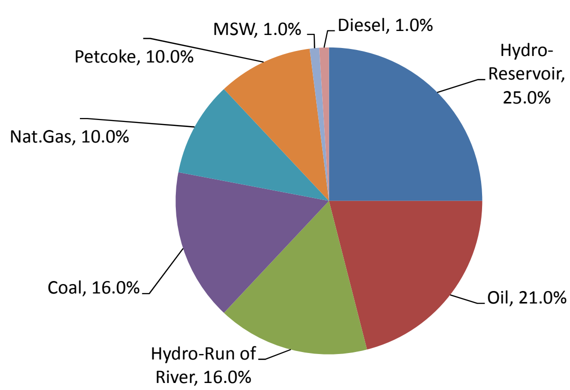
- **CNE:** Develop and coordinate energy sector plans, policies, and norms. Advise the Ministry of Economy on setting regulated distribution tariffs.
- **SEC:** Supervise compliance with energy sector laws, regulations, and technical standards.
- **Load Economic Dispatch Centers:** Coordinate operation of generators and transmission lines in each electric system.

Chile depends on **hydropower and imported fossil fuels** for its electricity generation, as shown in Figure 10. Given its limited domestic fossil fuel resources, Chile imports 58 percent of its primary energy sources (oil, coal, and gas). Because of disruptions in fuel supply from Argentina and severe droughts from 2008 to 2009, Chile switched from natural gas to oil, coal, and LNG (building two new terminals). Currently, Chile is expanding its coal power capacity (CNE/GTZ, 2009; CNE, 2008b).

Long run **electricity generation costs** are estimated at US$0.05, US$0.06, and US$0.08 per kWh for coal, natural gas, and diesel generation, respectively (PNUD/ENDESACO, 2010). Grossed up for losses, which are low in Chile (having decreased from 21 percent in 1992 to 8 percent in 2007; IEA, 2009), only the diesel benchmark increases just slightly (to US$0.09 per kWh). The spot price in the SIC in March 2011, however, was US$0.20 per kWh (US$0.22 per kWh grossed up for losses; SYSTEP, 2011).

Chile has the **second highest electricity tariffs in the southern cone** after Uruguay. In 2011, residential electricity tariffs were about US$0.18 per kWh. Industrial tariffs were approximately US$0.12 per kWh, which are also high for the Latin American region (compared to Argentina or Peru) and could have negative implications for the competiveness of industries in Chile (Montamat, 2011). The average tariff in SIC and SING in May 2011 was US$0.11 per kWh (SYSTEP, 2011).

Figure 10. Chile Power Generation by Technology

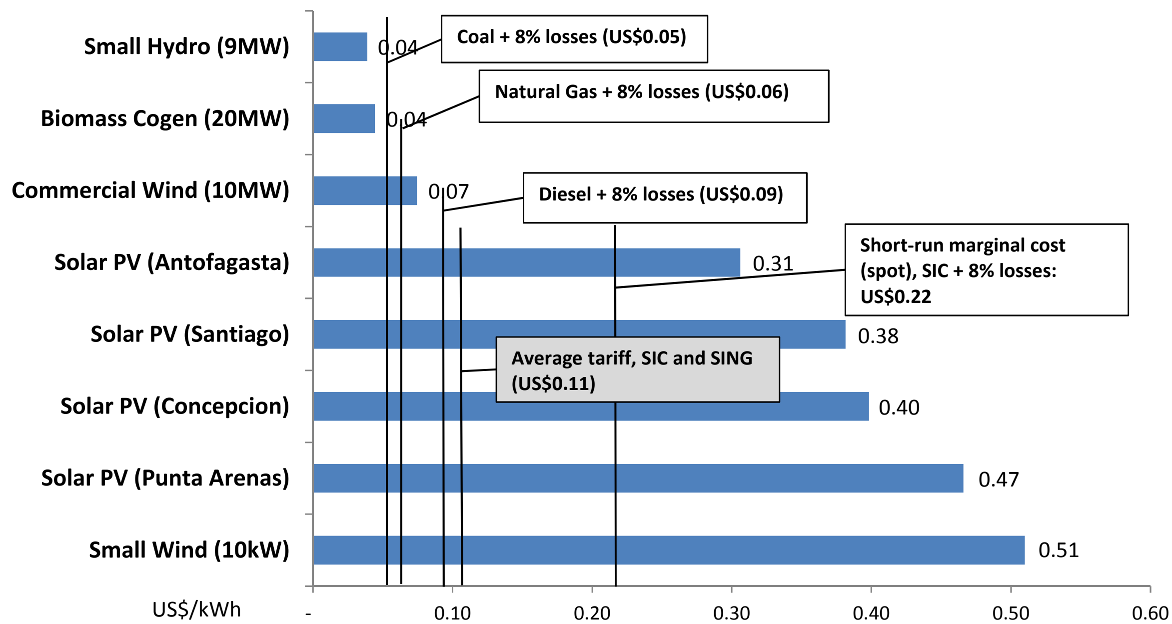


Source: CNE/GTZ, 2009.

Viability of Renewable DG: Good Options on Commercial Scale, None on Small Scale

Figure 11 shows the economic and financial viability of commercial- and small-scale DG renewable energy projects in Chile.

Figure 11. Viability of Renewable DG in Chile (US$ per kWh)



Sources: For commercial wind, biomass cogen, small hydro, coal, natural gas, and diesel: PNUD/ENDESACO, 2010. For small-scale wind: Almonacidand Nahuelhua, 2009. For solar PV: Rudnick, 2010; NREL, 2011 (10% discount rate).[15] *For tariffs and spot price in SIC: SYSTEP, 2011.*

Figure 11 shows that:

- **Small hydro and biomass cogeneration are viable on a commercial scale.** Costs are below those of conventional coal.
- **Commercial-scale wind is almost viable.** Compared with the variable cost of natural gas, commercial-scale wind is not viable. Compared with diesel, however, commercial-scale wind could just be viable if the variable portion of the diesel benchmark were considered.
- **Solar PV is not viable.** Costs of generation of solar PV are estimated to be between US$0.31 and US$0.47 per kWh based of capital costs of about US$4,000 per kW (Rudnick, 2010). Given Chile's geography, capacity factors are very different depending on the latitude at which a solar PV system is installed. Using the PV Watts tool of the National Renewable Energy Laboratory (NREL), capacity factors range between 19 percent in Antofagasta in the north of Chile to about 15 percent

[15] Capital costs of €3,000 (US$4,000) per kW installed. Capacity factors of 19 percent (Antofagasta), 15 percent (Santiago and Concepción), and 12 percent (Punta Arenas).

in Santiago or Concepción in the center to 12 percent in Punta Arenas in the extreme south of the country. As it stood in March 2011, to be competitive with the spot price, capital costs of solar PV installed in the north of the country should fall to about US$2,700 per kW installed.

- **Small wind is not viable.** At US$0.51, small wind is not economically or commercially viable.

Framework for Renewable DG: Comprehensive Framework for Commercial-Scale DG, Still in the Works for Small-Scale DG

In Chile, commercial-scale DG has been developed to some extent in a competitive setting; however, it has come mostly from conventional sources, in spite of the existence of viable RE options. Recent initiatives by the government have tried to rebalance this situation more in favor of RE.

A comprehensive framework is in place to ensure the effective development of commercial-scale DG in Chile (whether renewable or conventional). Distribution networks are clearly defined based on voltage: up to 23kV (CNE, 2008c). A decree requires operators of distribution networks to allow interconnections of up to 9MW (Herrera, 2009). Non-conventional renewable energy (NCRE, which excludes hydro above 20MW) is exempt from interconnection fees up to 9MW and is eligible for partial exemption for interconnection fees up to 20MW. Laws also offer a price stabilization mechanism in the spot market for plants up to 9MW (Law 19.940, 2004). Long-term PPAs are allowed between DG and distribution companies (Law 20.018, 2005).

However, development of *renewable* DG has been limited. DG in Chile has been mostly fossil fuel-based and its relative share has declined in recent years. In 2006, DG made up approximately 11 percent of Chile's total power generation (WADE, 2006). By 2008, DG had fallen to 7 percent of total generation, and approximately 90 percent of that was from thermoelectric generation, with only 10 percent from hydro and wind power (CNE, 2008b).

Recently, the Chilean government has been promoting RE through several avenues. A **Renewable Energy Law** (Law 20.257; Congreso Nacional, 2008) was passed in March 2009 to promote NCRE projects. This law established a limited renewable portfolio standard (RPS), mandating that NCRE provide 5 percent of electricity sold in the SIC and SING systems between 2010 and 2014, increasing 0.5 percent per year to reach 10 percent by 2024. Furthermore, the government has commissioned various assessment studies for key RE sources (wind, solar, biomass, and surface geothermal reconnaissance), prepared a national action plan to mitigate climate change that includes objectives for RE, created financial incentives, and supported research and development for RE (IEA, 2009).

For small-scale DG, the framework remains under development. There is **no legislation or regulation governing small-scale DG**. Small-scale generators are not allowed to interconnect to the low-voltage system (Herrera, 2009). However, **four draft bills** for net metering (Bills 6424, 6650, 6793, and 6998-1) are currently under consideration in the Chilean Congress. According to the most recent reviews available (Danilo, Kipreos, and Watts, 2010), none of the draft bills provides a solid and comprehensive framework to develop small-scale DG and they try to cover too much.

- **Objective**: Some draft bills state that their objective is to contribute to reducing greenhouse gases in Chile's electricity matrix; others that it is to eliminate barriers to small-scale RE; others that it is to increase the share of domestic energy resource in the country's energy mix for energy security.
- **Term**: None of the bills specifies the term for which net metering rates should be available. One mentions that excess electricity may be rolled over to the subsequent month, but only on a 12-month timeframe.
- **Eligibility**: None of the draft bills clarifies which types of customers would be eligible. None specifies an overall cap to eligibility, apart from one that proposes a very high cap (10 percent of peak demand). Some individual caps are mentioned (100kW and 20MW for small hydro). Only one draft bill covers technical requirements.
- **Rate**: One bill states that the proposed rate would be the *retail price* offered by distribution companies, although in the preamble it refers to distribution companies' *average cost* of purchasing electricity. Another bill proposes using the existing low-voltage retail tariff charged by distribution companies.
- **Metering arrangement**: Most bills refer to net metering but provide no clear definition of how it would work or who would own the meter.

Analysis: A Mix of Competition, Targets, and Incentives for Commercial Scale; An Unclear Framework for Small Scale

The framework in place for **commercial-scale renewable DG** looks well designed, at least in theory. There are viable options to generate electricity with renewable DG on a commercial scale in Chile, and there is now more information available on key primary RE resources. The RPS is technology neutral: it allows commercial suppliers to comply with their general obligation by picking the cheapest options. Also, the RPS is limited and only gradually increasing: it should allow enough time for the best projects to be identified, assessed, and developed. Finally, there is no discrimination against RE in Chile's competitive setting: commercial generators using RE can sell to distribution companies, unregulated customers, or on the spot market just like conventional generation.

However, the extent to which this framework will be successful in increasing the share of viable renewable DG remains to be seen. Also, the process for interconnecting commercial-scale DG is carefully designed, but it has been known to be difficult and lengthy (CNE/GTZ, 2009). Water permits have also been reported to be difficult to obtain.

On the other hand, the framework for **small-scale renewable DG** is non-existent. None of the draft bills under consideration seems appropriate to provide it, in spite of their efforts to make it possible to sell excess electricity to the grid. Overall, the draft bills define objectives, terms, metering arrangements, rates, and eligibility in an unclear way. They have not been advancing in the legislative process, perhaps unsurprisingly, given that there are currently no viable options for small-scale DG in Chile.

On the other hand, not all rules and processes for small-scale renewable DG should necessarily be provided by law. Draft bills might have a better chance of progressing if they:

- State that their **objective** is to contribute to greater energy security, which is consistent with CNE's Energy Policy (CNE, 2008a), by allowing the use of all electricity generated, even that from small systems that use RE sources.
- State that the **rate** should be determined:
  - based on the actual avoided cost;
  - using bidirectional meters to avoid increasing power bills of households and companies alike, while letting them sell any electricity they do not use and get paid a fair price for that;
  - for a period equal to the useful lifetime of systems.
- State **individual and overall caps for eligibility** to obtain certainty on quantities and costs of the program.
- State that **regulations would specify the detailed terms** of the net metering program and other documents would specify technical requirements.

Summary Analysis of Renewable DG in Jamaica, Barbados, Mexico, and Chile

Table 3 summarizes the strengths, weaknesses, opportunities, and threats (SWOT) of the four countries' frameworks for renewable DG.

Table 3. SWOT Analysis of Renewable DG in Jamaica, Barbados, Mexico, and Chile

Strengths	Weaknesses
Jamaica, Barbados, Chile, and Mexico are **already developing what is viable without imposing additional subsidies** like industrialized countries. **Least cost generation** is ensured in Jamaica, Chile, and Mexico (with different sector structures), and effectively implemented in Barbados by utility (including RE). Jamaica, Barbados, and Mexico **allow excess electricity from small-scale RE to be sold.** Jamaica and Barbados offer **net billing, feed-in tariffs at avoided cost, and a total cap on eligibility.** Jamaica offers a **premium for recognizing economic benefits of RE.**	Jamaica and Barbados **offer terms for SOC and RER that are too short** for small-scale renewable DG. Jamaica's **avoided cost calculation is too low**, as it does not recognize the full contribution of RE. Barbados' **tariff structure may offer inefficient incentives** for small-scale RE. There are **no total caps** for small-scale renewable DG eligible for feed-in tariffs in Mexico or in Chile's draft bills. Mexico offers (and Chile is considering) **net metering instead of net billing.** It is **not possible to sell excess RE** in Chile.
Opportunities	**Threats**
Current options exist to reduce costs through commercial-scale RE in all countries. **Additional viable options should arise** as capital costs decrease for small-scale RE (such as solar PV). The **recently approved RE policy** in Barbados mandates least cost generation with RE, integration of IPPs, longer term for RER, and improved tariff structure. Mexico is **completing an RE framework**: methodology on economic benefits of RE, model contracts and metering arrangements for small-scale RE, new targets. Chile is **developing a framework for small-scale RE** to sell excess electricity to the grid (net metering bills).	**Inertia**: People only do what they already know, unless they are induced to change. **Inability to connect to the grid to sell power**: Grid rules are not designed to accommodate DG. **Burdensome planning and permitting, and high transaction costs**: "New" projects pose unknown problems for first time.

In spite of some weaknesses, the overall picture is encouraging. Generally, the four countries have already developed (or are on the way to doing so) viable renewable DG on a commercial scale, in different ways depending on market structure. The four countries are also showing caution in how they allow non-viable renewable DG on a small scale to contribute to their energy mix: Barbados pays avoided cost; Jamaica pays a limited premium for economic benefits; Mexico is considering only recognizing net economic benefits; and Chile has still not decided whether they should contribute at all. No country has set feed-in tariffs at a level that will ensure the financial viability of projects that are not economically viable. In this, emerging markets of LAC have shown wisdom, thoughtfulness, and restraint, especially compared to more aggressive approaches adopted in Europe and North America.

Table 3 also introduces the following **opportunities** for renewable DG:

- **Current options already exist to reduce costs through commercial-scale RE in all countries**. Before regretting that non-viable options are not being promoted (subsidized) enough, stakeholders in these (and other similar) countries should make every effort to make sure all viable ones are assessed and developed.
- **In the future, additional options may arise as capital costs are expected to decrease for small-scale RE**. As they set up frameworks to promote cost-effective RE on any scale, countries should plan ahead to allow any option that becomes viable to be effectively assessed, built, and dispatched.

The table also presents the following **threats** to renewable DG:

- **Inertia**. Just because something make sense is no guarantee that it will happen. People (and especially institutions) often tend to only do what they already know, unless they are persuaded (e.g., through effective public education, awareness, and capacity building) or required to do something different. For example, a traditional utility may interpret a regulatory obligation to do least cost planning as just including conventional generation options. A traditional regulator may just check that the utility considers that spectrum of options, not realizing that other non-conventional (RE) options may be competitive already. Fortunately for Barbados, BL&P is doing least cost planning, including viable RE options on small and large scale, even without being required to do so. Other countries may be less fortunate.
- **Inability to connect to the grid to sell power**. Sometimes (like in Chile) there are no rules that allow households and businesses to sell excess capacity of their small distributed technologies to a utility (either a vertically integrated one like in Barbados or a single buyer in a competitive setting like in Mexico) or that require a utility to purchase that power even if the utility saves costs or pays no more than the actual avoided cost. This means that if a household or business does not require the full electricity generated by an RE system, it has no way of fully using that generating capacity. Therefore, that system becomes more costly.
- **Burdensome planning and permitting, and high transaction costs**. Obtaining all the required environmental and construction permits may be such a difficult and lengthy process that even viable projects are not implemented, either because they are blocked in the bureaucratic process or because transaction costs increase to a point that they are no longer viable.

Recommendations: How to Promote Competitive DG

The following recommendations explain how to build on strengths, improve on weaknesses, realize opportunities, and avoid threats. This section proposes five recommendations to promote cost-effective DG that can contribute to emerging markets' competitiveness and growth.

1. **Define DG clearly and appropriately, based on system size**. The first step in effective policymaking is setting country-specific boundaries regarding the objectives of the policy.
2. **Ensure that power systems are developed based on least cost generation**. Least cost planning should be the cornerstone of any policy, before any other factors are considered. Ensuring that all options that make sense in each country are identified, assessed, and implemented will help set priorities correctly, starting with win-win options.
3. **Neutralize threats to efficient DG**. Just because least cost generation makes sense is no guarantee that it will happen. In practice, even excellent projects may be threatened by inertia, inadequate grid rules, and cumbersome permitting and planning processes that increase transaction costs. A well-designed policy will anticipate these threats and preempt them.
4. **Consider if paying more for power may increase competitiveness and growth**. After everything is in place for win-win options to take place, countries should examine if there are any circumstances where paying a premium is justified on a cost–benefit basis.
5. **Avoid the trap of paying too much**. Even when a country decides that paying a premium is worthwhile, the premium should not be loosely set.

The order of these recommendations matters. The starting point should be a definition. Then, the cornerstone rule: least cost planning. After that, ensuring that this cornerstone rule is followed in practice, so that all win-win options are implemented. Only at that point should other options that require a premium be considered. After deciding that some premiums may be justified, it is important to avoid getting carried away.

Define DG Clearly and Appropriately, Based on System Size

Each country should clearly define what DG is, primarily based on the only criterion that is subject to no doubt: location within a network. DG should be defined as that generation connected to the distribution network. In turn, distribution networks should be defined based on voltage. Other definitions (on installed capacity, technology types) would be welcome, but only if they represent additional specifications after the network location criterion is well defined.

Mexico provides a good example of how to define DG well. As described above, the country first clarifies that DG is not off-grid, but grid-connected generation. Then, it states that it is what is connected to the distribution network, not directly to the transmission network. After that, it defines small DG based on capacity (up to 30kW) and interconnection at a tension lower than 1kV (SENER, 2010b).

Ensure Power Systems Are Developed Based on Least Cost Generation

Continuous processes and flexible rules that allow least cost generation options to be identified, assessed, and implemented are better than fixed rules or targets regarding what should and should not be done.

All countries considered (those with high and low costs and tariffs alike) have several viable renewable DG options. Currently, most of those options are on a commercial scale; however, small-scale options might also make sense as costs decrease and technology evolves. Some small-scale options are already viable thanks to conditional financing from international organizations, such as the IDB, which is helping these options transition to full viability. It takes time to develop policies and regulations and, once they are developed, it takes time to implement the changes. Setting fixed targets today risks having to implement projects that are not least cost, or that are not needed, for the sake of meeting a target. Conversely, fixing targets today also risks excluding projects that are not least cost today, but may reach that point shortly or before rules can be changed. For this, processes and rules should embed least cost and be open to change. This ensures that the regulatory framework is not only strong and clear in achieving intended results, but also flexible in adapting to new needs and opportunities.

Ensuring least cost generation in an effective way will involve different provisions, depending on whether commercial- or small-scale renewable DG is considered. As explained below, effective regulation and market design is appropriate for commercial-scale DG, while feed-in tariffs are appropriate for small-scale DG.

Commercial-scale DG: effective regulation and market design. In vertically integrated markets (such as Jamaica and Barbados), there should be:

- **An obligation on the utility to demonstrate that its generation expansion plans are least cost, and a duty of the regulator to check.** These obligations (which Barbados is about to implement thanks to the recently approved RE policy) are generally preferable to having the regulator develop expansion plans itself (like in Jamaica). Utilities are likely to know better how to develop expansion plans, and regulators are likely to be better at checking, contracting specialized skills as needed.
- **An obligation on the utility to purchase from third parties when the cost is lower.** Although economies of scale often mean that a utility will be able to develop the cheapest options itself, even in small systems it is always possible that there may be projects that the utility is unwilling or unable to develop. For example, a sugar factory or a waste recycling facility may be ideally placed to develop RE plants that an electric utility would not be as well placed to operate. Contracting power from third parties carries some transaction cost, but it should be at some margin below the utility's avoided cost.

In liberalized markets (such as Mexico and Chile), there should be:

- **Non-discriminatory treatment of RE in selling energy and capacity**. In market models (such as Chile's), competition should be fair. RE that is cost-competitive should be subject to the same rules that govern commercial supply of conventional electricity on the spot market, directly to large (unregulated) customers, or through long-term PPAs. Capacity should be recognized when an RE technology can (provided there is adequate availability of primary energy resources) supply firm power. For example, this could mean recognizing a capacity credit for biomass cogeneration based on reliable crop forecasts, if it is already recognized for small hydro based on reliable hydrology forecasts.
- **Auctions to award additional capacity and/or energy at least cost**. In single-buyer models (such as Mexico's), combining publication of estimated avoided cost and competitive auctions for energy and capacity may be an effective way to get the cheapest price for good quality service. Auctions may be used for many purposes. Chile, for example, is considering them as an effective tool to reach the objectives it has set.

All markets, regardless of structure, should **ensure that investors can recover costs and make a reasonable return**, while bearing directly (and not transferring to customers) the costs of non-performance. Ensuring the reasonable financial viability of operators is imperative to obtain good quality service at a reasonable cost. If investors are only forced to reduce costs but are not enabled to cover costs, and on top of that be profitable, they will reduce costs in other ways, most likely at the expense of quality and reliability. This is especially important in vertically integrated markets, where there is no automatic selection of operators based on profitability. It could mean giving a utility the option of obtaining the regulator's approval of an RE investment (or a PPA for an RE plant) before it is implemented, getting tariffs approved to recover the investment, and earning a reasonable profit. In liberalized markets, conditions to compete should not be so stringent that they attract no investors (or only attract the worst ones).

Small-scale DG: well-designed feed-in tariffs. Feed-in tariffs need not be defined as subsidies. Technically, they are a standing offer to purchase power from small-scale systems at some predetermined (but not necessarily fixed) price, for a predetermined period of time, and subject to certain technical requirements. They are a standardized tool for implementing projects that transaction costs would make it impractical to implement on an individual basis. Therefore, the purpose of a feed-in tariff should not be to promote the viability of this or that specific technology. Rather, they should be a streamlined tool that allows owners of small-scale systems to:

- Sell excess electricity they generate but do not need;
- Be remunerated for their contribution at a reasonable and economically efficient cost.

Like auctions, to an even greater extent, feed-in tariffs reduce transaction costs compared to individual negotiations. Well-designed feed-in tariffs

- **Set the price at no more than the avoided cost**. It is possible to give consumers two options in terms of which avoided cost they choose: the current estimate of long-run avoided cost (if they think that future actual costs will be lower) or the short-run avoided cost to be updated annually based on actual value (if they think that future actual costs will be higher).
- **Set the term at least to the useful lifetime of systems**. This will reduce uncertainty faced by consumers. It will also reduce transaction costs for whoever buys their electricity, instead of renewing or reissuing interconnection agreements once they have expired after too short a period.
- **Prefer net billing to net metering (consistent with offering no more than avoided cost)**. Net billing allows the two flows of electricity (that generated by the consumer and sold to the grid, and that consumed and bought from the grid) to be separately measured and billed. Net metering, instead, just spins a meter backward and forces a utility to purchase power at the retail price (which is higher) instead of cost. This means that, if a supplier is to remain financially viable, it must be allowed to recover those higher costs; ultimately, a supplier will recover those costs from customers by increasing their bills.
- **Cap individual and total eligibility**. Assuming that DG is to be connected to the distribution network, it needs to be of a size consistent with the voltage of the distribution network. Even for distribution networks within the largest systems, with the highest voltage (110kV), this will mean about 100MW to 150MW, as noted above. Capping total eligibility to an amount that the system can handle allows the quality, stability, and reliability of service to be preserved. A total cap can increase once the system is upgraded, but the two things should happen in that order in the interest of quality of service.

Neutralize Threats to Efficient DG

Provided that a framework is in place for win-win renewable DG projects, it should be further strengthened by neutralizing possible threats that may prevent even sensible projects from happening. To do this, countries should

- Combat inertia with obligations and incentives;
- Make it easy and safe to connect to the grid with a Grid Code;
- Use streamlined, standardized permitting and planning approaches.

Combat Inertia with Obligations and Incentives

Utilities, developers, and regulators may continue considering only one part of the spectrum of generation options unless explicitly required to also include viable RE options. To address this problem, a mix of obligations and incentives can work:

- **Explicit obligation to consider reasonable RE options in least cost planning** (like in Barbados). This would require whoever is in charge of planning to look at the viable RE potential available and compare it with conventional generation options under various fuel cost scenarios.
- **Obligation to purchase power from third party RE generators at some margin below avoided cost** (also like in Barbados). This would require vertically integrated utilities to buy electricity from other developers that provide it at a cheaper cost. To avoid creating stranded assets (i.e., building too many power plants that become redundant but the cost of which must be recovered), the obligation should just relate to capacity that is required to replace old plants or meet additional demand. Otherwise, consumers would be made to pay (through tariffs) the cost of building unnecessary capacity.
- **Limited RE portfolio standards that are technology-neutral and gradual in implementation**. These would require some limited contribution by RE, consistent with a country's endowment of viable RE options. Not specifying which technologies would be eligible (like in Chile) would leave the freedom to choose the least cost options. Being gradual would allow sufficient time for viable RE projects to be identified and assessed. Ideally, similar portfolio standards would be accompanied by increased and site-specific information about the country's RE resources. Auctions can be a very effective tool to implement targets at the least cost.
- **RE cost recovery mechanisms alongside fuel recovery mechanisms that allow recovery of the capital costs of renewables**. When power companies build RE plant instead of conventional plant, they trade fuel costs for capital costs. Many utilities (especially in the Caribbean) are allowed to pass any fuel costs that are reasonably incurred through to customers. However, they are often not allowed to do the same for capital costs, which are higher for RE. Providing certainty of cost recovery of reasonable RE projects (assessed within a least cost plan) would give the necessary comfort utilities may need to commission RE plants.

In addition, **public education, awareness, and capacity building** are key to mitigating the inertia of public and private actors, as they stimulate better knowledge of the costs and benefits of different RE options. Promoting **energy efficiency** also ensures that owners of DG systems are not only generating electricity in an innovative and cost-effective way, but also consuming it intelligently.

Make It Easy and Safe to Connect to the Grid with a Grid Code

Grid codes are often not designed to interconnect RE, particularly on a distributed scale. System operators may be legitimately concerned that interconnecting RE may affect the quality of service. As a result, even viable options may not be allowed to connect to the grid. Updated Grid Codes should be prepared to include

- **Technical and operating standards**, applying to all generators at all scales.
- **Restrictions**, but only those that are necessary to ensure safety, reliability, and stability of service. Regulators would have a duty to check (in cooperation with technical entities or specialized

consultants) that no undue limitations to competition are being introduced under the appearance of technical requirements.
- **Fair prices that system operators are allowed to charge for grid use** based on cost and including a reasonable return.

Improving the capacity and quality of the grid should be pursued in parallel, so that increasing DG may be incorporated in an effective and sustainable way.

Use Streamlined, Standardized Permitting and Planning Approaches

Viable RE projects may get stuck indefinitely in a country's permitting and planning process because these processes are not designed to deal with something new, such as a wind farm. Transaction costs to obtain all necessary permits may increase to a point that the viability of the projects is jeopardized. To avoid this problem, countries should

- **Establish one-stop shops for obtaining all required permits** to reduce transaction costs and simplify the process. This does not necessarily mean eliminating the responsibilities of some entities to give them to others: simply, the entity that is best placed to do so may act as a coordinating agent for others.
- **Establish technology-specific processes** for environmental and construction permitting and planning of RE projects.
- **Determine a pre-established content of Environmental Impact Assessments** (activities to be assessed; potential impacts resulting from activities; actions to be undertaken to mitigate, remedy, or avoid potential impacts; demonstration of financial capacity to carry out those actions as needed).
- **Set technology-specific standards to comply with regarding impact levels**. It should be clear what level of impact (such as noise) will always be permitted or always prohibited. Anything in between should be dealt with on a case-by-case basis.
- **Establish a cut-off size for small-scale systems** that would not require environmental impact assessments or permitting/planning authorizations, to avoid having to carry out detailed studies for small projects.

Consider Paying More for Power May Increase Competitiveness and Growth

In some circumstances, paying a premium for electricity may be justified on a cost–benefit basis, particularly if it increases competitiveness and economic growth. Economic considerations are important. Does paying a premium really create net economic benefits to the country? That is, are economic benefits greater than economic costs? Political considerations are just as important. Will voters accept paying more? Will voters reelect politicians who make them do so? If paying a premium is economically justified and/or politically accepted, the potential for renewable DG increases. The important thing is that all costs and benefits be assessed based on a clear methodology, and that they be clearly communicated to the public.

Paying a premium for electricity may be justified, for example, in the following cases:

- **To increase system resilience and energy security**. There should be a prudent diversification of which primary sources of energy are used and which locations these sources are obtained from. Avoided costs of stocking fossil fuels could be considered as a measure of enhancing resilience or energy security (particularly for small island countries in the Caribbean, where space is limited and frequent shipments are required). Alternative tools for energy security (forward contracts) should also be considered.
- **To develop a green economy and create green jobs**. Creating a new green economy and green jobs is often used as an argument to subsidize manufacturing or services, but this is subject to risks described above. To mitigate those risks, countries should consider helping a new green economy develop only if there is a strong potential domestic market for that technology (such as solar water heating in Barbados [Perlack and Hinds, 2003], which was promoted by the government when almost no system was in place; or wind in Mexico, where the market, in spite of recent progress and many sites under development, can be considered still in its incipient stage) and if the country has (or could develop in the future) the industrial capabilities required to manufacture or service certain technologies.
- **To reduce local and global environmental externalities**. If a government decides that it is worthwhile paying more to make the environment more sustainable, it should at the very least treat local and global environmental externalities differently:
  - Domestic consumers would capture the full benefits of reducing **local environmental and health externalities**; therefore, it could be argued that they should pay the entire cost. Key local externalities include:
    - Health costs attributed to secondary emissions (sulfur dioxide, nitrogen dioxide, and particulates);
    - Environmental costs linked to pollution of water or other natural resources.
  - However, domestic consumers would only obtain a fraction of the benefits of reducing **global environmental externalities** (GHGs); therefore, countries should be careful before deciding that their citizens should pay the entire cost of reducing GHGs. Carbon abatement cost curves (such as the one in Figure 12 for Barbados) help identify win-win options (those with a negative cost, which reduce GHGs while also saving the country money) that should be promoted first. Other options have an additional cost that may be justified from a global perspective and may represent an efficient solution compared to an international reference for the value of reducing one ton of GHGs. Emerging markets should seek concessional financing and grants from international organizations or industrialized countries to develop those projects. While the Clean Development Mechanism is struggling, NAMAs are emerging as a new framework.
- **To promote a country's branding**. Sustainable products (from sugar, to coffee, to clothing) may be sold at a premium; sustainable tourism destinations may likewise be marketed at a premium. However, that premium should not be borne by the population of an emerging market. Rather,

it should be paid by tourists or customers. If the premium turns out to be too much and drives tourists elsewhere, it should be reduced to a more acceptable level instead of being passed through to the population.

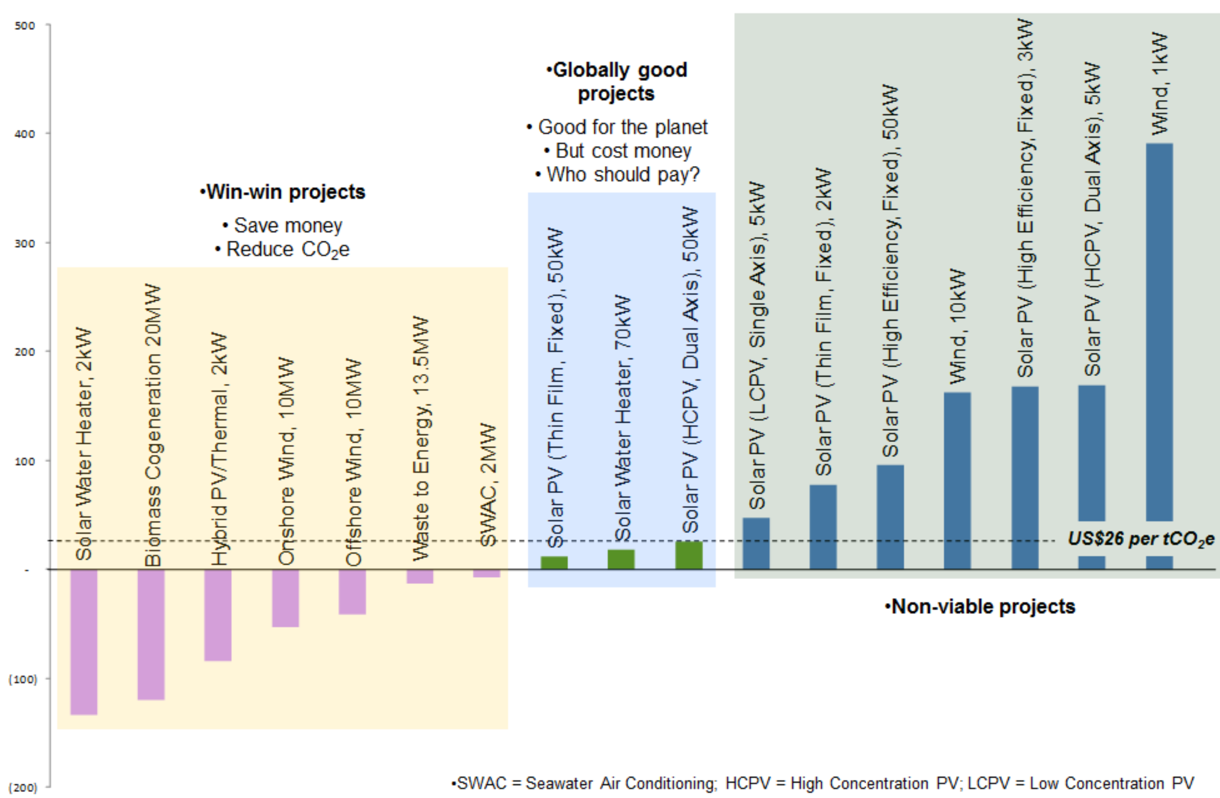
- **To increase access to energy**. Some consumers may be required to pay more so that others in remote or poor areas can be provided electricity service. This way, paying a premium may allow reaching objectives of reducing energy poverty and increasing social inclusion.

The **determination of what premium is justified** is likely to prove difficult and controversial. Governments should tackle this on a step-by-step process that

- First, involves key public and private stakeholders and determines which items deserve a premium or not;
- Second, develops a methodology to determine the premium to be paid;
- Third, assesses economic costs and benefits to the country.

The above considerations should be included in a policy dialogue that is not limited to law making, but also implements concrete actions to pursue other broadly shared rationales for promoting DG and identifies the most appropriate settings (including public–private partnerships).

Figure 12. CO_2 Marginal Abatement Cost Curve for Barbados, 2010



Source: IDB, 2010

Avoid the Trap of Paying Too Much

Even when a country decides that paying a premium for commercial or small-scale DG is worthwhile, it should ensure that it is only paying what is cost-benefit justified. The following are three key ways to avoid this trap for renewable DG.

- **To create a disaggregated, cost-reflective tariff structure that charges separately for separate services.** In some circumstances, a country might grant a premium to small-scale DG in the amount of a few cents per kWh. The premium should be added to the tariff component that is affected by the benefit created by a RE technology. For example, supply of energy (sale of electricity measured in kWh) would be the right tariff component where any premium should be added for solar PV because solar PV avoids fuel costs. Solar PV does not avoid the cost of being connected to a distribution system or having backup and stand-by capacity when the sun is not shining. For this, tariff structures should charge separately for provision of energy, distribution, and backup/stand-by capacity. Otherwise, by implementing renewable DG, customers may be enjoying services they do not pay for and force other customers to bear those costs. Barbados' RE policy calls for such a tariff structure.
- **To always set total caps for feed-in tariff eligibility.** Some premium might be justified by increased energy security or environmental sustainability or another benefit. However, this should not mean unlimited eligibility for feed-in tariffs. Otherwise, it may affect quality of service and create unpredictable and unsustainable costs that ultimately are borne by customers. A country should decide what total quantity is justified to provide the desired level of energy security or to achieve the desired local environmental sustainability (Mexico's attention to local economic benefits for setting updated targets and prices for RE seems to move in this direction).
- **To always prefer net billing to net metering.** Paying some premium might be justified on a cost–benefit basis under a broad economic perspective; however, net metering is equivalent to setting feed-in tariffs at the retail rate (i.e., the commercial tariff). That is the same rate that should decrease in order to increase competitiveness and create sustainable economic growth. By forcing the purchase of power at the retail price, instead of avoided (economic) cost, a country imposes additional costs on its households and businesses. By implementing net billing instead, a country would use bidirectional meters to apply a cost–benefit justified premium to electricity sold by generators but no more than that.

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