

Status of the Development of Renewable Energy Projects in the Republic of Panama

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Abstract. The Republic of Panama plans to expand its power generation park by including renewable energy. Currently, more than half of the Panamanian power generation park is comprised of hydroelectric power and the rest is completed by thermoelectric plants, but other energy sources such as wind, solar, geothermal and peat are available. This paper reviews the current status of the Panamanian power generation park, recent renewable energy developments, the legal framework and incentives in place for these projects, and the renewable energy resources available in the country. Finally, some hypothetical renewable energy projects are evaluated, to initially assess their economic feasibility. It can be concluded from this paper that: 1) hydro power is the only renewable currently in the Panamanian power generation park and comprises most of the future projects, 2) wind power is the other renewable with most potential in Panama, with the second-largest number of projects, 3) solar, geothermal and peat resources are available in Panama but there are no current developments to include them as part of large-scale power generation, 4) initial evaluation of two hypothetical hydroelectric and wind projects shows economic feasibility under the given assumptions; however, the project feasibility is dependent on specific site conditions.

Key words

Panama renewable power generation

1. Introduction

The Republic of Panama is located in Central America, with borders to the North with the Caribbean Sea, to the South with the Pacific Ocean, to the East with Colombia and to the West with Costa Rica. It has a population of 3,322,576 inhabitants, according to the 2010 census, over 70% of them living in urban areas.

Panama has, since recent years, been subject to appreciable economic growth fuelled by extensive public investment in large infrastructure projects, such as the construction of new highways, the expansion of Panama City's coastal line or the Panama Canal Expansion megaproject; and large private investment in the areas of real-estate, tourism, banking, among others, and particularly in the energy and power sector.

Panama has been traditionally dependent on hydro and thermal power for the supply of its energy demand, but recent private developments have begun to make use of the country's other natural resources, such as wind, in conjunction with the government's plan to reduce its dependency on imported hydrocarbons, as well as make the current energy grid more efficient. As of 01/05/2010,

the Environment National Authority (Autoridad Nacional del Ambiente, ANAM) had 118 Clean Development Mechanism (CDM) projects within its portfolio, most of which from the private sector.

The purpose of this article is to describe the current status of the power generation park in the Republic of Panama and future expansion plans, as well as describe the current renewable energy developments, legislation and incentives, available resources, and present sample hypothetical case studies for individual renewable power generation projects in the country.

2. Electrical Power Generation Park in Panama

A. Current Status

By the year of 2008, the installed electrical power capacity of the Panamanian National Interconnected System (Sistema Interconectado Nacional, SIN) was 1,501 MW, whereas the maximum demand (excluding self-generating consumers) was 1,065 MW [1].

The power generation sector in Panama is comprised of several independent producers, with three companies providing approximately 70% of the power generation capacity: AES Panamá (33%); EGE-Fortuna, S.A. (20%) and BLM Corp, S.A. 55% of the Panamanian generation park capacity comes from hydroelectric plants and 45% from thermoelectric plants. The composition of the power generation park is shown on Figure 1.

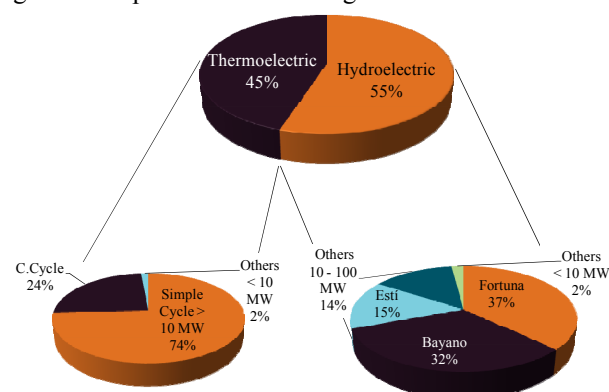


Fig. 1. Panama SIN Power Generation Park Composition (Source data from [1])

The hydroelectric power generation park is comprised of several dams, three of which account for 86% of the total installed hydroelectric capacity: Fortuna (300 MW –

37%), Bayano (260 MW – 32%) and Estí (120 MW – 15%) [1].

The thermoelectric power generation park is comprised mostly of simple cycle turbines operating either on bunker fuel, marine diesel or light diesel, which account for 76% of the installed thermoelectric capacity, and one combined cycle fuelled by marine diesel. The average heat rate (weighed on installed capacity) for the Panamanian thermoelectric power generation park is approximately 10,400 BTU/kWh, or an equivalent 33% efficiency, based on higher heating value (source: own estimations, based on fuel consumption in USgallons/MWh from Reference [1]).

B. 2009-2023 Expansion Plan

The projections for growth of energy demand in Panama in the period of 2009 to 2023 involve three scenarios: low, medium and high demand with projected loads of 1.85 GW, 1.88 GW and 1.96 GW in the year of 2023, respectively [1].

The Panamanian Empresa de Transmisión Eléctrica S.A. (ETESA) expansion plan will include ongoing and future projects in both existing energy conversion processes in the country, such as hydroelectric power and liquid-fuelled thermal power plants, and new energy sources such as wind power, natural gas and coal. In wind power alone there are twenty-nine (29) projects with provisional licenses for a total of 4.4 GW, but only three (3) of them showed significant progress [1].

Table I shows the number of most-likely candidate projects for future construction and startup in Panama, along with the total installed capacity and average construction cost, according to the ETESA expansion plan.

Table I. – Potential Panamanian Power Generation Projects

Category	Potential Projects	Installed Capacity MW	Average Investment Cost USD/kW
Wind Power	4	474	1,549
Hydroelectric Power	23	1,022	2,241
Thermal - Medium-Speed Motor - Liquid Fuel	2	150	1,333
Thermal - Combined Cycle - Natural Gas	3	500	1,250
Thermal - Combined Cycle - Diesel	2	400	1,238
Thermal - Gas Turbine	2	150	833
Thermal - Diesel Turbine	1	100	930
Thermal - Coal Steam Cycle	2	400	1,800
Thermal - Steam Cycle	1	130	569
TOTAL	40	3,326	-

As can be seen, the future installed capacity, if all of the potential projects are completed, will widely exceed the country's local energy demand. It is within the

government's objectives to promote Panama as an energetic centre for the Americas, and it is currently developing plans to expand the existing transmission lines and construct new interconnecting lines between the Central American Nation and its neighbors, such as Colombia, in order to export excess energy.

3. Clean Development Mechanism (CDM) Projects in Panama

A. Current CDM Portfolio

Following the incentives set upon the Kyoto Protocol for carbon emission reduction (CER) projects, both private and government entities have sponsored an appreciable number of CDM developments in recent years, in the areas of: hydroelectric power, wind power, energy efficiency, energy from biomass, methane capture, transportation and reforestation.

At the date of 01/05/2010, the number of registered CDM projects in Panama totalled 118, with approximate CERs of 44.5×10^{12} equivalent tonnes of CO₂/year, according to the ANAM [2]. The CDM project breakdown by number of projects, and CERs by project type are given on Figure 2.

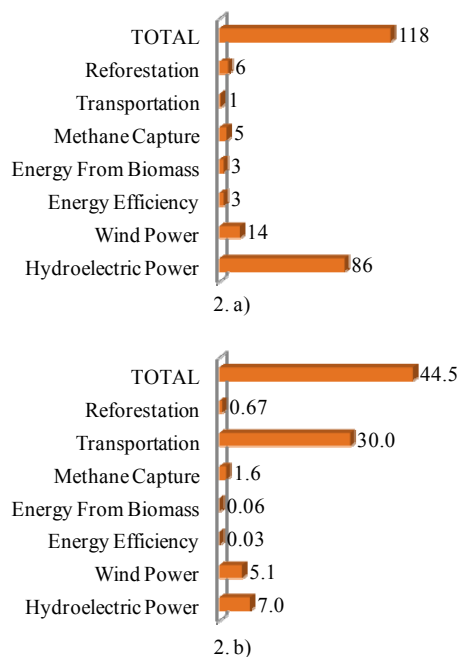


Fig. 2. Panama CDM Portfolio Breakdown. 2.a) By number of projects, 2. b) By CERs/year (10^{12} tonnes eq. CO₂)

As can be seen on Figure 2, the vast majority of registered CDM projects in Panama are for hydroelectric power generation, followed by wind power generation. On the other hand, the largest carbon emission reduction comes from one transportation project: the Panama Canal Expansion, which accounts for 30×10^{12} equivalent tonnes of CO₂/year.

A small number of projects were focused on substituting traditional energy sources for biomass, but up to 01/05/2010 there were no solar or geothermal power generation projects in the CDM portfolio.

4. Legal Framework and Incentives for the Development of Renewable Energy Projects in Panama

A. General Electric Sector Legal Framework

Law No.6 of February 3rd 1997, with modifications from law-decree No.10 of February 26th 1998, establishes the institutional and regulatory framework for the electric utility sector in the Republic of Panama. The main aspects of this law are the establishment of:

- 1) the entity in charge of determining the state policies and review the preparation of expansion plans in the electric sector,
- 2) regulations for the creation and operation of public electric companies,
- 3) the modalities for participation of private companies in the electric sector,
- 4) the structure of the Panamanian electric sector,
- 5) dispositions pertaining to the tariffs, customers of the electric sector, acquisition of real-estate and utilities,
- 6) sanctions, and
- 7) final dispositions pertaining to the conservation of the environment, promotion of renewable or non-conventional sources and energy conservation.

The dispositions for the participation of national, foreign or mixed capital companies in the Panamanian electric sector are given in Title II, Chapter V. Private participation can be in three modalities [3]: 1) buying shares of State-owned electric companies, 2) concessions, or 3) licences.

The buying of shares was regulated, as per this law, in blocks of over 51% of State-owned thermoelectric generation and distribution companies, or up to 49% of hydroelectric generation companies.

The construction and operation of hydroelectric and geothermal power generation, as well as power transmission and distribution are subject to concessions no longer than 50 years for hydroelectric and geothermal power generation, and 25 years for power transmission and distribution, which can be extended in terms no longer than the original concession.

The construction and operation of power generation plants of different types to those subject to concessions are subject to licenses. The terms of each license are determined on a case-by-case basis.

B. Renewable Energy Incentives

The basis for the promotion of renewable energy is given on Title VIII, Chapter II of Law No.6 of February 3rd 1997. As a first incentive, the power transmission company is required to give a five percent (5%) preference in the evaluated price to new and renewable energy sources in each tender to purchase energy and power. The distribution companies are required to give the same preference when performing direct purchases

[3]. The new and renewable energy sources are defined in this law as: geothermal, wind, solar, waste-to-power and hydroelectric, the latter limited to 3MW of continuous power in the average hydrological year.

Further incentives for renewable energy developments are established in Law N°45 of August 4th 2004, which include the following [4]:

- 1) New and renewable energy sources, as well as mini-hydroelectric power plants up to 10 MW installed capacity are not subject to distribution or transmission charges when selling directly or occasionally,
- 2) new and renewable energy sources, as well as mini-hydroelectric power plants in the range of 10 to 20 MW installed capacity are not subject to distribution or transmission charges for the first 10 MW of installed capacity for the first 10 years of commercial operation,
- 3) exemption of taxes on all imports of equipment, machinery, materials, or others required for construction, operation and maintenance of particular new and renewable energy power plants of up to 500 kW installed capacity,
- 4) fiscal incentive for new and renewable energy projects up to 10 MW installed capacity, equivalent up to twenty-five percent (25%) of direct investment, based on equivalent tonnes of CO₂ emission reductions per year calculated for the term of the license or concession, which can be used for payment of revenue tax (Impuesto Sobre la Renta) during the first 10 years of commercial operation, as long as the project is not benefitting from other incentives.
- 5) fiscal incentive for new and renewable energy projects over 10 MW installed capacity, equivalent up to twenty-five percent (25%) of direct investment, based on equivalent tonnes of CO₂ emission reductions per year calculated for the term of the license or concession, which can only be used for payment of up to fifty percent (50%) of the revenue tax (Impuesto Sobre la Renta) during the first 10 years of commercial operation, as long as the project is not benefitting from other incentives.
- 6) fiscal credit applicable to the revenue tax (Impuesto Sobre la Renta) for a maximum of five percent (5%) of direct investment in works that would later on become public-use infrastructure, such as roads, bridges or other.

The amount of incentives given as result of greenhouse gas emission reductions will be based on a reference price per equivalent tonne of CO₂ per year and a baseline in equivalent tonnes of CO₂ per year per MW-hour, and is applicable if the generating company does not gain benefits from CO₂ trading.

The baseline emission factors and reference price for the calculation of incentives to new, clean and renewable energy projects are specified on Resolution AN N° 2700-Elec of June 24th 2009.

The baseline in tonnes of equivalent CO₂ per MWh is according to Table II.

The reference price per tonne of equivalent CO₂ is calculated for each project based on the average of the

series of the 12 months of the year in which the power generation facility which is subject of the license or concession enters operation, using the data from Thomson Reuters Carbon Community. By the date of the resolution, the reference price per tonne of equivalent CO₂ for the year 2009 was set at 24.02 US dollars, solely for the calculation of incentives according to Law No. 45 of 2004.

Table II. – Baseline Emission Factors [5]

Type of Project	Credit Periods		
	First Period 2008-2014	Second Period 2015-2021	Third Period 2022-2028
Wind and Solar	0.673	0.673	0.673
Rest of Projects	0.568	0.462	0.462

5. Available Natural Energy Resources in Panama

As the result of several studies in the last decade, a potential for power generation has been identified in Panama, in the following resources: hydro energy, wind energy, solar energy and peat.

A. Hydro Energy

As can be seen on Figure 2, the vast majority of renewable power generation projects are of the hydro power type. The hydroelectric power potential is one of the better characterized, with a hydroelectric study catalogue comprising approximately 180 projects including better handling schemes of existing reserves, as well as medium, mini and micro projects, which represent an available inventoried hydro potential of 3040.27 MW [1]. The three provinces with the highest hydro power potential in Panamá are Bocas del Toro, Chiriquí and Veraguas, as can be seen on Figure 3.

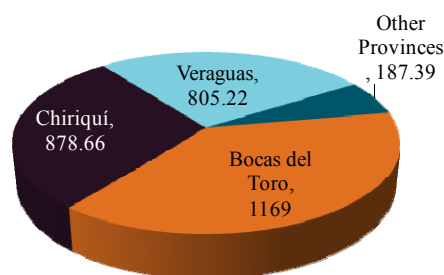


Fig. 3. Hydro Power Potential (MW) per Province

Out of the 3040.27 MW, 2010.21 MW are currently in projects in different stages of pre-feasibility, feasibility and design, and 1030.06 MW are in survey level.

B. Solar Energy

Upon review of the Solar and Wind Energy Resource Assessment (SWERA) data, the annual average amount of solar resource available to tilted and horizontal flat-

plate collectors is between 4.0 and 6.0 kWh/m²/day in most of the Panamanian territory. Figure 4 shows the annual average solar radiation that can be used by tilted flat-plate collectors. The solar radiation that can be used by a horizontal flat-plate collector is essentially the same as shown on Figure 4, since the country is located in the tropics.

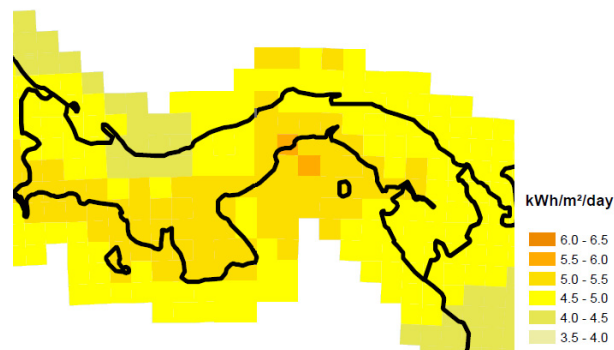


Fig. 4. Panama Annual Average Flat Plate Tilted at Latitude Solar Map. Adapted from [6]

The use of solar PV collectors in Panama has traditionally been limited to small communities or farms with no access to electricity, as alternative to diesel generators.

On the other hand, the potential for concentrating solar applications in Panama is very limited, since the direct normal annual average solar radiation is lower than 3 kWh/m²/day in most of the Panamanian territory.

C. Wind Energy

The S-shape of Panama makes it a favourable spot for wind energy development, since the entire length of its Caribbean coast is exposed to the trade winds. Also, the Panamanian climate makes wind power a potential complement to hydro power, since the wind intensity is highest during the drought months, when hydro power potential is at its lowest.

A study by ETESA, UNDP and Lahmeyer International generated the Panama wind resource map shown on Figure 5. As can be seen on Figure 5, the highest wind power potential (shown on the blue areas) are certain places of the Central Cordillera, such as Cerro Tute, the eastern coast of Los Santos, the Caribbean coastline of Bocas del Toro, Colón and Veraguas, and the Las Perlas archipelago, with average annual wind speeds of over 7 meters per second at 40 meters above ground level. It is precisely in the areas of the Central Cordillera, and Los Santos coast where current wind power developments are located.

D. Geothermal

The potential for geothermal power in Panama has been studied in several occasions since the 1970's, and five (5) main areas for potential geothermal power generation have been evaluated since: Barú-Colorado, Valle de

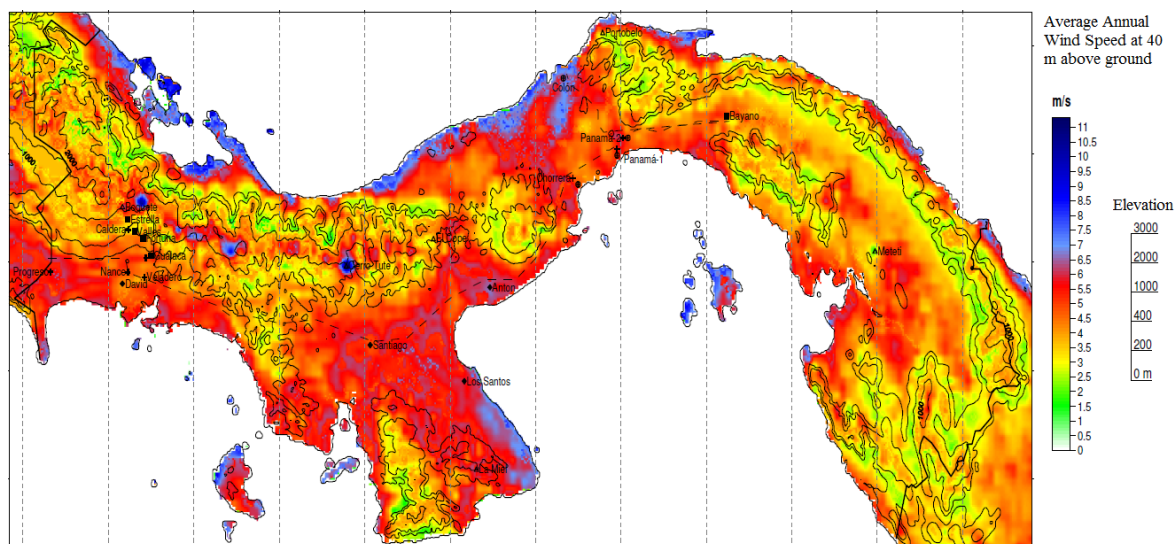


Figure 5. Average Annual Wind Speed at 40 m Above Ground Level. Adapted from [7]

Antón, Coiba Island, Tonosí and Chitre de Calobre. The different studies varied in conclusions, placing the entire geothermal potential for Panama between 100 MW and 450 MW. A more recent evaluation from the firm West Japan Engineering Consultants, Inc., estimated the geothermal potential for the Barú-Colorado area at 24 MW and for the Valle de Antón area at 18 MW [8]. Since then, private companies have shown little interest in geothermal power generation.

E. Peat

Even though peat is not a renewable energy source (it is classified as intermediate), it can nonetheless be considered a potential alternative to imported hydrocarbon and coal fuels.

A study financed by the Agency for International Development (AID) identified a large deposit of good-quality and potentially usable peat, located at the North-west of Panama, near Changuinola. The amount of usable peat resource was estimated at around 118 million tonnes with 35% humidity, or enough to supply fuel for a 30 MW power plant for a period of over 30 years [9]. The Changuinola peat characterization is shown on Table III.

Very limited information is available after said study, as private companies have shown little interest in exploiting the peat resource in Panama.

6. Hypothetical Case Studies for Renewable Power Generation in Panama

In this section, different hypothetical renewable power generation projects are evaluated in order to show how the information contained in this paper could be used to initially assess economic viability using open software such as RETScreen4-1 (2010-09-22 release) from RETScreen® International, and identify the impact of Panamanian government incentives on the project cashflow. The types of projects and capacities considered are based on the currently proposed future projects.

Table III. – Changuinola Peat Characterization [9]

Volatile matter	62% (dry weight average)
Ash	4% (dry weight average)
Organic matter	96% (dry weight average)
Humidity	85 – 95% (approximate variation)
Heating value	10,000 BTU/lb (dry average) 8,824 – 11,310 BTU/lb (variation)
pH	3.5 – 4.8 (approximate variation)
Density	0.1 g/cm ³ (approximate)
Absorbance	1400% - 2400% (approximate)
Ash fusion temperature	2270°F (initial, reducing) 2310°F (initial, oxidizing) 2640°F (fluid, reducing) 2670°F (fluid, oxidizing)

These evaluations should be considered as very rough estimates of potential returns from renewable power generation projects in Panama, and not as thorough evaluations, given that accurate cash-flow analysis is dependent on site-specific conditions, such as capacity factor, availability of land, access roads, distance to transmission lines, environmental impacts, among others specific to each potential site.

A. Methodology and Assumptions

Two renewable power generation technologies (hydroelectric and wind) were evaluated using RETScreen4-1 with the general assumptions given on Table IV, to estimate the pre-tax internal rate of return. Following this, the tax was calculated taking into account the incentives on section 4-B of this paper and the post-tax internal rate of return was estimated. Inflation and carbon trading were not considered in the evaluation.

Geothermal and peat-fuelled power generation are not evaluated due to lack of data in the consulted literature, which is required to estimate the resource extraction costs (in the case of geothermal, data related to the wells, and in the case of peat, data required to estimate peat mining). Solar power generation was studied in [10] for houses and commercial buildings and was not found to

be a competitive alternative to grid electricity where the electric grid is available.

Table IV. – General Assumptions

Contracted energy price	72.55 USD/MWh (Note 1)
Contracted power price	14.50 USD/kW-month (Note)
Baseline GHG emission factor	As per Table II
Transmission and distribution losses	17.42% [1] (Note 2)
Debt ratio	0% (for initial evaluation)
Revenue tax	30%
Target internal rate of return	>10%

Notes: 1. Estimated average for 2009-2023 period [1].
2. Including management process losses.

B. Hypothetical Case Study 1: Small Hydroelectric

A 10 MW installed capacity hydroelectric plant was considered in Bocas del Toro with a project life of 25 years. Various undergoing projects of this type and scale in Panama are envisioned to work on an energy contract for around 30% of the installed capacity, and complement with an additional power contract; so this scheme was assumed for this project.

The investment cost was estimated at 22 MMUSD based on the average construction cost on Table I, and operation and maintenance costs were assumed at 5.0 USD/kW-year [1]. Using RETScreen, a pre-tax internal rate of return of 13.1% was estimated. The post-tax internal rate of return was estimated at 11.8% when applying incentive number 4) on section 4-B of this paper. In contrast, if said incentive was not applied, the internal rate of return would have been 10.7%.

C. Hypothetical Case Study 2: Wind Farm

A hypothetical 50 MW installed capacity wind park was considered in Santiago, with a project life of 25 years. A 40% capacity factor was assumed (typical for wind speeds above 6 m/s, taking into account the best available turbine model). For this type of project, only an energy contract was assumed, consistent with [1], and a 5% increase in the contracted energy price was considered as incentive.

The investment cost was estimated at 78 MMUSD based on the average construction cost on Table I, and annual operation and maintenance costs were assumed at 3.5 MMUSD. Using RETScreen, a pre-tax internal rate of return of 12.0% was estimated. The post-tax internal rate of return was estimated at 10.0% when applying incentive number 5) on section 4-B of this paper. In contrast, if said incentive was not applied, the internal rate of return would have been 8.9%.

D. Sensibility Analysis

For the hydroelectric plant, the project ceases to be economically feasible when (all other assumptions equal) the investment cost exceeds 2,600 USD/kW. On the other hand, a 10% reduction in the investment cost would increase the post-tax internal rate of return by 1.3%.

For the wind farm, the project is already at the limit of economic feasibility with the originally assumed investment cost of 1,549 USD/kW. On the other hand, a 10% reduction in the investment cost would also increase the post-tax internal rate of return by 1.3%.

E. Other Notes

It is important to note that the previous evaluations do not consider the impact of economic benefits from carbon trading or adoption of a “spot” sales strategy, which could highly impact the project returns.

On the other hand, new energy sources not currently developed could be promoted if further official policies (other than the existing tax or energy price incentives) were adopted as part of a national strategy.

7. Conclusion

It can be concluded from this work that:

- 1) Hydro power is the only renewable currently used in the Panamanian power generation park and comprises most of the future CDM projects,
- 2) Wind power is the other renewable with most potential in Panama, with the second-largest number of CDM projects,
- 3) Solar, geothermal and peat resources are available in Panama but there are no current developments to include them as part of large-scale power generation.
- 4) Initial rough estimates of returns for hypothetical small hydroelectric and wind farm projects show internal rates of return of over 10% for both projects. Government incentives increased the post-tax internal rate of return by over 1% for the given assumptions; however, the project feasibility is dependent on specific site conditions that impact the investment cost (i.e. distance to transmission lines).

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