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# Long-term scenario alternatives and their implications: LEAP model application of Panama's electricity sector

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## HIGHLIGHTS

- This paper models Panama's electricity sector using the LEAP model platform.
- Four scenarios are developed and analyzed.
- Impact analysis includes: system cost, global warming potential, resource diversity index.
- Panama can achieve a sustainable grid with existing technologies and costs.
- There is an tradeoff between the resource diversity and global warming potential.

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## ABSTRACT

Panama recently enacted a new law, which aims to promote wind energy by mandating long term power purchase tenders. The implications of this new law lend some uncertainty to Panama's electricity development pathway. This paper quantitatively analyzes the current status of power generation in Panama, and explores various potential future scenarios and the associated impacts on the system marginal cost, global warming potential, and resource diversity index. To this end, this study applies the scenario development methodology developed by Schwartz in the context of the energy-economic modeling platform 'Long-range Energy Alternative Planning' (LEAP). Four scenarios are developed and analyzed. The Business as Usual scenario extrapolates the electricity generation trend that has been observed over the last decade; it is compared to three alternative scenarios which have more specific objectives. Scenario 1 encourages climate mitigation without incorporating new technologies in the generation mix, Scenario 2 maximizes resource diversity, and Scenario 3 minimizes global warming potential. For each scenario, the composition of the electricity generation profile, system marginal cost, global warming potential, and resource diversity is predicted quantitatively. These scenarios to not attempt to forecast likely developments, but rather illuminate the tradeoffs that different development pathways entail.



## 1. Introduction to Panama's electricity context

In April 2011, Panama enacted Law 44, which aims to promote wind power and diversify the country's electricity mix. Given the new flexibility for accelerating wind power development under Law 44, there is greater opportunity to guide the course of electricity generation development. The high electricity prices combined with high forecasted electricity consumption growth in the upcoming 15 years make the Panamanian electricity market an attractive proposition for new generators. The new legal framework combined with the large demand growth rates create potential for dramatic changes in the electricity generation portfolio. However, the form these changes will take and their implications remain uncertain. As such, this paper explores the economic and environmental implications of potential development pathways by evaluating four scenarios. These four scenarios illustrate different narratives for Panama's electricity market development; the modeled results of each of the scenarios illuminate their economic and environment impacts and their tradeoffs.

Panama is a country of 3.8 million people and has a GDP of 36 billion USD (WorldBank, 2013). With no proven petroleum or natural gas reserves or production (EIA, 2013a, 2013b, 2013c), Panama imports 1.7 billion USD of fuels each year (IRENA, 2009) mainly from Argentina, Chile, Colombia, Curacao, the United States and Venezuela.

Panama's electricity use of 1735 kWh per capita is more than double the Central American average (848 kWh/capita), is comparable with the Latin American average (1946 kWh/capita), but is

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smaller than the global average (2728 kWh/capita). As expected in a developing country with a relatively low per capita consumption relative the global average, Panama has a relatively high electricity consumption growth rate. The total electricity demand in Panama grew at an average rate of 4.97% per year in the period from 2002 to 2012 (ETESA Empresa de Transmisión Eléctrica, 2009a, 2009b).

In 1997–98 the Panamanian government restructured the state-owned vertically integrated electricity provider, the Instituto de Recursos Hidráulicos y Electrificación (IRHE, Institute of Hydraulic Resources and Electricity Supply), and in doing so unbundled generation from transmission and distribution. The purpose of market-oriented reform, like many other Latin American countries at that time, was to improve the quality, reliability, efficiency, affordability and access to electricity services. The Entidad Reguladora de Servicios Publicos (ERSP, Independent Regulatory Entity) was created to oversee tariffs and service quality. The Empresa de Transmisión Eléctrica, S.A. (ETESA, Electric Transmission Company, SA) was created for provision of high voltage transmission including network expansion planning, building, and reinforcement (ETESA Empresa de Transmisión Eléctrica, 2009a, 2009b). The Centro Nacional De Despacho (CND, National Dispatch Center) was created as a branch of ETESA to operate the spot/balancing market transactions (ETESA Empresa de Transmisión Eléctrica, 2009a, 2009b). Since the restructuring in 1998, many new generators have entered the Panama electricity markets. Currently AES Panamá owns 22%, Enel Fortuna owns 13%, and Bahiá las Minas Corporation owns 13%, and AES Changuinola S.A. owns 10% of installed capacity. The remaining 24 generators operational in 2012 own between 0.1% and 7% of installed capacity each.

From 1998–2001 ETESA managed power tenders by purchasing electricity from the generators. In 2002 new regulation allowed distribution companies to conduct their own power tenders by purchasing electricity directly from generation companies through bilateral contracts or in the spot/balancing market. This process resulted in a lack of investment in new installed capacity. As such, ETESA was reinstated as the body responsible for organizing centralized procurement of power on behalf of distributors based on minimum levels of contracting, long-term contracts, and a standardized power-purchasing process.

Panama's electricity generation is primarily derived from hydro power, with the balance provided by fossil fuel generators including fuel oil, coal, and diesel. Installed capacity by the end of 2012 consisted of 63% hydro power plants and 37% fossil fuel plants, while generation consisted of 76% hydro and 24% fossil fuels. Note that generation from Autoridad del Canal de Panamá (ACP), which is primarily used to operate the Panama Canal is not included in these values. Although this high percentage of hydro generation mitigates the high costs and greenhouse gas emissions associated with fossil generation, it also contributes to grid reliability issues. For example a power shortage was announced in May 2013 as a result of drought in a third of the county.

Hydro generation in Panama has been increasing steadily between 2008 and 2011, but began to rise more quickly in 2012 as shown in Fig. 1. With an additional 250 MW of hydro generation coming online in 2012, and even more hydro capacity expected in 2013, this increase in hydro generation is expected to continue. Fossil fuel generation has also been increasing steadily over the time period from 2008 to 2011, however experienced a correction in 2012 due to the additional hydro resources that were deployed.

Analogous to the rest of Central America, Panama's electricity generation mix changed substantially from the 1980s to 2000 as a result of the reforms in the electricity sector. Namely, hydroelectric projects were more prevalent in the 1980s as a result of the state-owned electricity provider's planning and decisions. However as private investors began deploying plants, the share of oil- and diesel-based generation increased due to their relatively low investment costs, short construction periods, viable deployment in small modules, high efficiencies, and competitive fuel costs. This trend was observed throughout Central America where the overall hydro and geothermal generation share decreased from 90% in 1990 to 60% in 2000, while diesel generation increased from nonexistent to 30% (Lacaros and Cayo, 2010). In Panama's case, other forms of thermal generation such as gas plants and steam turbines were also developed.

Although hydro power supplies the majority of generation in Panama, the high diesel and oil fuel prices drive electricity costs in Panama. Fig. 2 shows the range bid prices of the various types of generators. The bid prices reflect the price that each generator submitted to the system operator; the minimum bid price reflects the lowest price that a particular type of generation bid in 2012 while the maximum is the highest. The bid price is not equivalent to the price the generator received for its power; this is determined by the market clearing price. The cost sub-section in Section 3 provides a more detailed discussion of the prices that generators receive. As shown in Fig. 2, run-of-river hydro is a price taker in the market, meaning that it generally submits bids at $0/MWh, and receives the spot market price for generation. The one coal plant bid an average of $71/MWh in 2012, the two reservoir hydro plants bid an average of $170/MWh and $209/MWh, and 13 fuel oil and diesel generators bid an annual average of between $148/MWh and $371/MWh in 2012.

The daily weighted average system marginal cost increased steadily from an annual average of $97/MWh in 2005 to $232/MWh in 2008, as shown in Fig. 3. Prices fell again in 2009 to $153/MWh, but then began to rise again to $177/MWh in 2010 and $222/MWh in 2011. Although prices fell again in 2012 to $193/MWh due to the increasing deployment of hydro capacity, there is a clear upward trend in electricity prices over the last 7 years. This pattern in Panama's system marginal cost corresponds to the share of hydro versus fossil fuel generation and liquid fuel prices. For example, the peak in the system cost in 2008 correlates with the oil price shock when world oil prices rose from $50 per barrel in early 2007 to $140 per barrel in the summer of 2008 (EIA, 2013a, 2013b, 2013c).

The culmination of trends including high electricity consumption growth rates, high dependence on hydro, increasing fossil fuel generation, and increasing system marginal costs creates an incentive to alter the course of electricity generation development.

However until recently, the National Public Services Authority was limited in their ability to direct the evolution of the electricity mix. According to electricity service regulations in Panama, generation technology discrimination is prohibited, meaning that energy bids are open to all prospective generators equally. However, in April 2011, Panama enacted Law 44, which aims to promote wind power and diversify the country's electricity mix. Under Law 44, ETESA is responsible for purchasing wind power bids from long term (15 year) wind power purchase tenders. The law intends to provide a stable revenue stream for wind operators and therefore a more competitive energy market for wind power developers. Law 44 also provides tax incentives in the form of accelerated equipment depreciation and import tariff deductions to further increase the fiscal incentive and competitiveness of wind power in the electricity market.

Under the new wind only tender law, ETESA received eight bids from four different companies ranging in price from $90/MWh to $120/MWh. Four new projects were awarded to Unión Eólica Panameña (UEP) starting at $95/MWh for a total of 158 MW. UEP plan to build the Penonomé Project in Coclé Province consisting of 22 Goldwind 2.5 MW turbines. This is the first 55 MW phase, which is planned to be followed by 220 MW by mid-2014 and 337 MW the following year.