International Review of Civil Engineering (I.RE.C.E.), Vol. 4, n. 1
January 2013

Public- Private Partnership Model for Developing Sustainable Hydroelectric Power Plants in Brazil

João da Rocha Lima Júnior[1], Claudio Tavares de Alencar[2], Sérgio Alfredo Rosa da Silva[3], Eliane Monetti[4]

Abstract – *In this article, the Brazilian Model for Public-Private Partnership (PPP) is described. It was conceived envisaging investments for the completion of new electric sustainable power plants. The objective is to present the main drivers in Brazilian regulatory system for private investors in what relates to risks configuration and investment decision-making, either Brazilian or foreign ones. We analyzed the investment in 5 Brazilian power plants that altogether constitute an electric power-generating complex in Juruena River, in the state of Mato Grosso, in Brazil. According to the results, we can conclude that the present legal framework is able to support investment in small hydroelectric and sustainable power plants, considering the existence of Engineering Procurement Contracts (EPC) for the completion phase and of Power Purchase Agreements (PPA) for the operational phase as well.* ***Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved.***

Keywords*: public-private partnership; electric power supply; Sustainable hydro-electric power plants; Brazilian legislation*

I. The Institutional Scenario of Public – Private Partnerships in Brazil (PPP)

The institutional mechanisms in Brazil follow its federative political regime, with the legal framework being first defined at the federal level, with further breakdowns at state and city levels Brazil [1]. It also happens to the mechanisms that rules partnerships between public and private agents Brazil [2].

The main federal law related to public-private partnerships – PPP - establishes a series of aspects to be observed, such as contractual modes and their bidding processes; financial limits for applying the contracts; tax policies; the quality of offered services; governance and monitoring, collaterals among stakeholders.

According to Alencar [3], either those contracts addressed for rendering services directly to the population (so called sponsored concessions agreements), or those aimed at meeting, directly or indirectly, the needs of public administration (administrative concessions agreements) are allowed in Brazil. In both cases, PPPs are seen as feasible solutions, mainly when the services can not be paid off exclusively through tax mechanisms, thus, requiring government investment or other kind of public offset.

The winner proposal is chosen using one out of three different criteria: the least public counter–rendering, the lowest tariff and also a combination of both with the best technical proposal, like Alencar [4] also informs. Nevertheless, it is worth pointing out the presence of a Management Committee, made up of the main agencies of federal public administration. This Committee has the attribution of establishing priorities among designs under study, as well as developing the respective bidding processes. At state level, the laws have the same structure, despite differences in operational aspects.

The discussions conveyed in the Brazilian Congress pointed out that the main role of the federal legal framework was to encourage and regulate private investments in those areas where government achievements could be accomplished with private agent's actions by means of Brazilian government offsets.

This is not the only mechanism which the Brazilian State makes use of to attract the participation of private agents, as detailed later on. Regulatory mechanisms with the minimum price assurance and long-term contracts, together with the availability of special loans also play a relevant role for encouraging private investments in those areas in which the Brazilian State is not able to supply by itself the needs for services or infrastructure.

II. The Electric Power Market and the Small Hydroelectric Power Plants (SHPP)

General Aspects

The Brazilian electric power market is divided into three big areas: generation, transmission and distribution. The activities in these areas are developed by private and public agents and regulated and monitored by a set of

Manuscript received and revised December 2012, January 2013 *Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved*

legal entities linked directly to the Brazilian Government, like the ANEEL – **A**gência **N**acional de **E**nergia **El**étrica (the National Electric Power Agency), or indirectly, by means of the participation of its agents among its business partners, like CCEE – **C**âmara de **C**omercialização de **E**nergia **E**létrica (the Chamber of Electric Power Commercialization). While ANEEL is responsible for regulating and monitoring the electricity market, CCEE is responsible for making the commercialization of electric power feasible in an interconnected system on a national basis, as recommended by Goldenberg and Mielnik [5]. Moreover, the main agents in the generation and transmission markets are state-owned companies, underscoring the presence of the State in this market, presence that should be limited to acting as a granter and regulator agent for such activities.

The search for greater participation of private agents in this market led to privatization processes in the 90s, mainly focused on energy distribution. In 2001, a serious crisis in energy supply brought about the restructuring of this sector, when new public agents were included not only for the activities of planning and monitoring the system, but also in programs aiming the attraction of private investment as a way to accelerate its sustained growth.

As a result, Brazil has got a System of Electric Power on a national basis, with a strong State presence - the conceding power -, for ruling and regulating the commercialization of electric power, as well as its generation and transmission.

The government has been attracting private agents in this market mainly through two complementary mechanisms: first, by acting on the power commercialization market and second, by means of a set of programs fostering the construction of new electric power plants. In both processes the government acts not only in regulatory, but also in economic-financial aspects, such as supporting processes for providing prices for the commercialized power, offering long-term loans and specific regulatory processes.

This is the scenario where the PROINFA – **Pro**grama de **In**centivo a **F**ontes **A**lternativas (Program for Fostering Alternative and Renewable Sources of Electric Power) fits in. It is addressed to the diversification of the production of electric power matrix in Brazil, encompassing wind power, biomass and hydraulic sources (Small Hydroelectric Power Plants, with a capacity of up to 30 MW- SHPP).

Through this program, the Brazilian government promotes the introduction of a minimum volume of energy associated to each of these sources by means of private agents and assures the purchase of the energy produced for 20 years.

The Electric Power Market

The commercialization of electric power is developed according to a set of specific rules, in a market managed and regulated by the CCEE. There are two contracting environments for electric power, according to Figure 1: ACR – **A**mbiente de **C**ontratação **R**egulada (Regulated Contracting Ambience) and ACL – Ambiente de Contratação Livre (Free Contracting Ambience). It is up to the CCEE to keep track of the contracted movements and of the amounts of energy actually traded, in that the occasional differences are identified and sold out in the short-term market, valued at a Spot Price PLD (also called **P**reço de **L**iquidação das **D**iferenças or Price for the Settlements of Differences), as established by Mines and Energy Ministry [6].

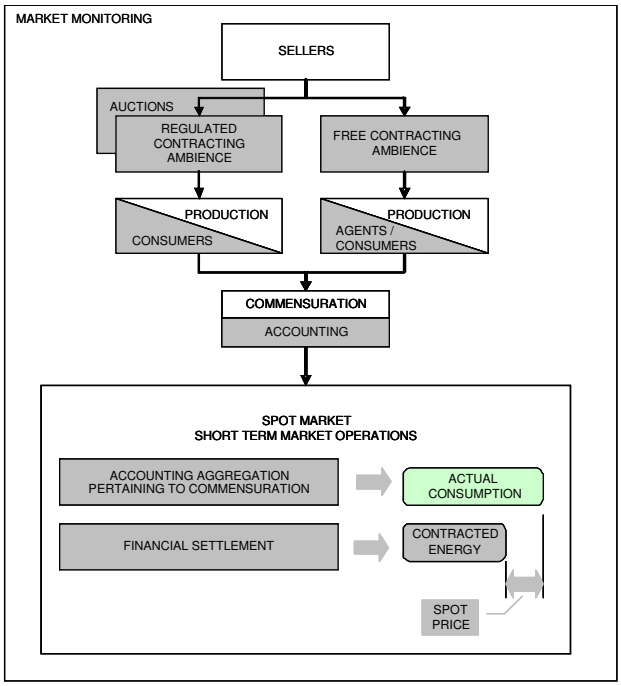

Fig. 1. basic structure of commercialization ambience

The SHPPs can act in both contracting environments, in that the contracts with the Brazilian government are bound to the regulated contracting environment and can serve as collateral for a SHPP to offer its exceeding power in the free contracting environment.

In this fashion, a SHPP has the option of supplying its energy in the regulated environment within specific preset levels and also act in the free environment (ACL), offering its exceeding power at free prices. As independent producing agents, SHPPs can also act exclusively in the free market.

Power commercialization in the regulated environment is carried out with power auctions, in which the government defines price limits. These auctions are divided into two categories: those held to sell the electric power generated by new Power Generation undertakings (new power) and those held to sell electric power generated by the existing Power Generation undertakings (old power). The main difference between the categories lies on the paying back status: while the old ones have

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

been already paid off, the new ones have not reached the break-even point. As a result, price limits can be lower for the new ones when compared to the new ones.

Specifically for the SHPPs fitting in the PROINFA, ANEEL can arrange for exclusive commercialization auctions for a period of up to 5 years as of the date when it starts operating. This creates better conditions for transferring the acquisition costs of this energy to the practiced prices of these distributors.

The PLD is used to value transactions conducted in the short-term market. Its composition takes into account the amounts of energy dispatched by the operation of the Interconnected System and its respective sources, whether hydroelectric or thermoelectric, and their respective costs.

The Construction of SHPPs

The construction and operation of SHPPs follow established rules that go beyond the regulation and established rules of the Brazilian Electric System, e.g., their impact on the local environment. The basic steps required, pointed out in Faria [7] for the construction of a SHPP, shown in Figure 2 are the following:

- Assessment of the Conceptual Design;
- Registry at ANEEL;
- Obtaining a Previous Environmental Permit
- Development of the Design;
- Construction Permits: installation, basic design and the permission of use of hydria resources;
- Plant construction and implementation of its environmental programs;
- Issuing of the Operation Permit.

It is important to mention that the registry of the proposed SHPP with ANEEL is not enough for the interested party to obtain the right to exploit a specific hydria resource. This will only be valid if the interested party simultaneously obtains the previous environmental permit. Only after obtaining this permit, should the basic SHPP design be conducted, which will consolidate the prerequisites established as of the procurement of the Previous Environmental Permit.

As of the elaboration of the basic design, the interested party must obtain three registers or permits: that of the design itself, with ANEEL; the construction permit, with the environmental agency and that related to hydria resources, with the respective administrative agency.

In possession of these licenses, even not having begun the construction of the SHPP, the interested party can participate in power auctions promoted by ANEEL, through the CCEE, and request access to governmental funding lines for its construction. The actual commercialization of electric power generated by the SHPP can only be carried out after the issuing of the Operation Permit to be issued by the environmental agency and ANEEL.

In the Appendix

Fig. 2. process to develop and construct a Small Hydroelectric Power Plant (SHPP).

III. The Investment Decision-Making

Once the historic cycle of State investment is over, the business involving the construction of HPP [*Hydroelectric Power Plants*] in general (and particularly investments in SHPP's) has been carried out by means of the total participation of private investment or loans contracted by investors, according to market movements, following project finance schemes described by Bonomi; Malvessi [8] and Finnerty [9].

Every investment decision-making implies understanding and accepting the [profitability v risks] binomial envisaged for the enterprise. Investments in SHPPs must be analyzed considering the market risk, where many of the variables fluctuations can not be easily mitigated, taking into account not only the imperfections in Brazilian economy, but mainly bureaucratic hindrances due to state interferences in investments. Without constituting an economic paradox, investments in SHPP are essentially configured as real estate: [i] – investments are protected by assets that tend to preserve the amount invested in long-term cycles; [ii] – assets whose market value tends to be steady and [iii] –investments which tend to offer income according to conservative standards, producing homogeneous revenue flows, even considering the long run.

Similar to those investments in commercial buildings with the purpose of receiving income, risk exposure is concentrated on market failure, such as demand and prices: the occupancy rate and rental value for office markets and power demand and competitive prices for SHPP markets. As a result, the open market risk for selling electric power may keep investors away of providing new power plants.

Being capital-intensive, investments with long payback have their profitability highly affected by income variation, as operational costs are small when compared to the revenues. Even when small variations happen in revenues levels when compared to the first expectations, losses in the profitability tend to be significant, especially when they last for long cycles. On the other hand, when they happen in short term cycles, they bring about losses on profitability that can only be compensated by aggressive performance in long cycles, demanding speculative growth rates. This hypothesis is not sensible for investment decision-making as it should consider speculative scenarios, a paradox in both market and economic behavior.

The same sensitivity occurs when actual construction costs are higher than those of the initial budget, even considering the variation constrained within a limited interval. In SHPP, as in real estate, the protection granted by pre-established construction cost is a determining factor in the investment decision-making. It happens

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

because any variation in budget will end up in over investing, that cannot be paid back, as demand does not react to investment costs but solely to competitive market prices.

For investing in SHPP, private investors need the existence of tools to overcome or mitigate risks related to: [i] – the growth in construction costs and [ii] – the variation of market demand at competitive prices.

Considering the nowadays status in civil construction sector and the expectation for the economic behavior in mid-term, it is worth considering steady costs for the builder, as construction costs do not tend to grow differently from inflation patterns, usually measured by IGP – **Í**ndice **G**eral de **P**reços (*General Prices Index*). Contracts for civil construction for a SHPP can be dealt using the EPC (**E**ngineering **P**rocurement **C**ontract) model, within a turnkey agreement, considering long term adjustments according to the actual inflation, as power prices also tend to vary according to the same behavior. Both the constructor and the investor will be pleased with turnkey price adjustments. On one hand, the constructor will be exposed to growing construction costs beyond inflation levels, while the investor cannot be exposed to such risk, as it cannot be mitigated by means of electric power price adjustments.

On the other hand, the investor will only be pleased with a turnkey agreement, which represents risks for the builder, although inherent to his activity. The investment will be safe only if protected by a completion bond, given that the risk of the fulfillment of the contract without claims does not depend on the mode of contracting, but on the builder's behavior.

Return on private investment in SHPP is necessarily in the long term and dependent on demand and price risks. As operational costs are of little relevance compared to the revenues, their impact can be overlooked in risk analysis. For determining expected returns**,** three variables are open and their behavior establishes the limits of investment risks: [i] – that of long-term power demand, [ii] – that of market prices and their stability and [iii] – that of taxes over produced revenue.[1] Taking into account the long payback investments in SHPP represent, the investment shall be refused if these variables are considered open.

Mitigating these risks would imply:

[i] Selling electric power over the long-term to a specific consumer, even if at a less competitive price, just to assure demand and price;

[ii-a] contracting the sale at a specific price over the long term;

[ii-b] contracting the sale at a adjustable price, according to a general inflation index, and subject to realignment, according to an occasional tax variation in the future;

[iii] And, as to tax increases, there are no direct legal mitigating means, making necessary that purchase agreements state that tax increases will automatically be replicated in prices.

The question is: "How can the State ensure for the private investor a way of mitigating the return risks of investing in SHPP, considering that the State needs the partnership but is not capable of making the ends meet using the tax revenues?"

Risks related to investment distortion are solved with private rules between investors and builders, through EPC contracts, but those risks derived from return distortion can not be mitigated in a commercial relation, taking into consideration that it is difficult to achieve mitigation in markets of free-competition prices. If it is considered possible to celebrate contracts for selling future energy in an open market, even using specific rules in an attempt to mitigating risks, any depression in future prices could bring about claims based on the recovery of economic balance of the contracts, thus, bringing up risks only solved by means of court settlements.

Other aspects, no longer risk-related but capable of keeping private investor away from SHPP investments as well, are:

[i] The hurdle rate for private investment can not be reached considering current construction costs and electric power prices;

[ii] The risk-free rate in Brazil has been among the highest ones in the international market. It inhibits long-term investments as capital, even foreign ones, are pushed into public bonds, see BNDES (National Bank for Economic and Social Development) [10].

IV. How Investment is Structured

In light of the above concepts and evidences, the State structured a set of rules aiming the attraction of private investment in SHPP, in which the problems of risk and attractiveness are competently solved. This set has been so accepted by the market that the offer of investment funds for the sector today is greater than projects to absorb them. This fact can even cause an unbalanced configuration [supply v demand] later on, but considering the State carries on its commitment, the risks will be laid only on its side, protecting private investments. [2]

[i] Instead of the State and private investment providing funds concurrently into a capital account[3] as usually seen in a PPP agreement, the State participates indirectly, offering long-term loans within the PROINFA

1 In Brazil, the tax theme is always relevant in risk analysis. As the government has been not capable of keeping costs under control, public policies end up adopting the easiest way out of increasing taxes.

2 The risk for private investments is for the State not to follow contract rules, which has already happened to hydroelectric power plants in the past.

3 This arrangement is different from those usually adopted in PPP agreements, protected against those risks related to State relations, as they have been erratic in Brazil.

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

[*Program Fostering Alternative Sources of Electric Power*] framework, by means of the BNDES [*National Bank for Economic and Social Development*]. The loan is limited to 70% of construction budget and an interest rate below the hurdle rate prevalent in the market, in Reais. Not being a partner, the State not only is protected against risks derived from increasing construction costs but also ensures a spread over assigned funds, keeping away from investment governance as well. The State's part does not come from treasury funds but from BNDES funding system, according to standards suitable for the bank. This arrangement enables private investment (30% of investments) to reach, even receiving just part of the revenues, a suitable internal rate of return, even if compared to international patterns. In light of the current risk free rate that has been imposed by the Brazilian Central Bank for the transactions of public bonds in the secondary market, hurdle rates for investors in all segments of the economy are high, which penalizes the funds offered by the BNDES in rendering competitive rates of return for the 30% of private own capital assigned to SHPP.

[ii] The State does not offer any support or impose any rules with respect to EPC contracts. It is not necessary as Brazilian civil construction sector is mature enough to deal with its own risks and to build suitable protection and mitigation systems, Ariztía and Watts [11]. As argued in Borges [12], an EPC contract in turn key regime and also protected by a completion bond is required for the safeguard of the BNDES, as a project financer, against interest and default risk, as it depends exclusively on the revenues.

[iii] Eletrobrás, the State power company, supported by PROINFA legislation, buys part of the minimum guaranteed power supply, for the period of 20 years, at contracted demand and price. As a result, the project may be settled, as the private investor can envisage the 20-year long revenue flow, the usage extension of a power concession agreement.

Montero and Rudinick [13] tell us that the power purchase is regulated in a PPA [*Power Purchase Agreement*] containing standardized clauses, such as:

- The contracted price, defined by means of an auction;
- The monthly payment for the preset purchase;
- A readjustment of the contracted price, according to inflation indexes, once a year;
- Price revisions are allowed only due to *force majeure* or the occurrence of new technology that could benefit the producer, capable of reducing the price. Neither market failure nor economic balance are mentioned, nor even adjustments to reach market prices.

According to Barroso et ally [14], another relevant aspect of the public-private partnership, is that the State assumes the investment-related market risks: at the demand side, because the volume of power purchase is contracted; at the price side, because it is contracted for the 20-year long period, adjusted at inflation levels, usually using IGP, which is the best one to refer to investments, including foreign ones.

For the investors, the remaining risks are:

- the behavior of the IGP during the 20-year operational cycle .As price adjustment is made just once a year, there is a price loss within the cycle. This loss is measured in the reference currency and can be forecasted when decision-making takes place. Nevertheless, in case real inflation reaches high levels in yearly cycles, the investor will not be compensated for the losses, even if market prices will certainly be adjusted in periods smaller than 12 months, to compensate for extreme inflationary losses. The only protection against this risk is by claiming for reconfiguration of the economic balance of the Power Purchase Agreement, dealing with the inflation increase as a *force majeure* item;
- In the case of foreign investments, there is no exchange risk protection, given that price adjustments (that drive revenue flow) occur according to IGP, even considering implicit losses derived from the discrete 12-month cycle in price adjustment.

There would be no reason for the State to take these risks. If so, we would be dealing with an indirect system of the State being financed by private investors, at interest rates equal to the hurdle rates for such projects, instead of a PPP structure.

V. How the Funding is Structured

Taking into consideration the singularities of the Brazilian tax law and the impossibility for investment funds to have their operations financed, the modeling of the investment structure tends to be very similar for any SHPP as demonstrated in Figure 3 and recommended in Delloitte [15].

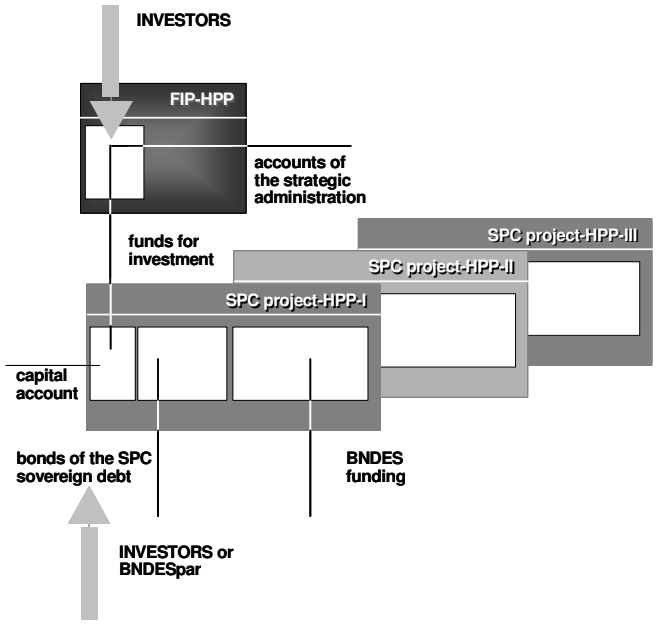

Fig. 3. SHPPs' investment structure in Brazil

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

▪ Investment funds are joined into a FIP – Fundo de Investimento em Participações, which is an equity fund. According to the tax point of view, the income derived from a FIP structure is tax-free, as the revenues that come from all the SPC – **S**pecial **P**urpose **C**ompany clung to the FIP structure are considered as dividends for the investors.

The FIP administration is isolated from that of the operations, and able to invest in different SHPPs in any participation proportion, enabling, therefore, the development of an investment portfolio with a natural risk dilution. The FIP isolates investors (shareholders) from operational administration risks, including legal risks. The FIP is not allowed to act like a company, thus, its structural administration must be outsourced.

The FIP are treated as investor pools, whose allocated funds are managed by an agent (financial company or asset manager) authorized by the CVM – **C**omissão de **V**alores **M**obiliários [Securities Commission]. FIP's investment strategy is defined in regular shareholders' meetings and rendered operational by managers, according to the policies of purchasing and selling assets, attracting funds and also handing out results. The FIP does not run labor risks, which, in Brazil should be carefully considered.

▪ Yet in the business environment, this structure enables great flexibility in the funding setting, allowing even shared investment among different investors of different SHPP within the portfolio. Resources for the completion of SHPP can come from BNDES (70%), being the 30% remainder made up of both FIP CAPITAL and investors within the SPC, according to the management strategy. It is possible to attract investors by means of issuing bonds from the sovereign debt, with fixed or variable revenue, which can also be subscribed in the BNDES system by means of BNDESpar[4].

▪ In the operational cycle, when there is a decrease in the interest rate, the FIP can leverage investors' return, insofar as price decreases linked to this economic indicator are not foreseen in the PPA. As the revenue flow is steady, the implicit revenue flow for FIP shares is stabilized at the original level, enabling, therefore, under this circumstance, share appreciation. When there is an increase in the interest rate, shares depreciate, and price compensation is not foreseen. In this sense, the investor runs the normal long-term investment risks in any economy segment, in that here, there are no means of mitigating the effects of an interest rate decrease.

In the case of share appreciation, a Private FIP (private equity fund) can be registered to be offered at BOVESPA – **Bo**lsa de **V**alores do **E**stado de **S**ão **Pa**ulo (*São Paulo Stock Exchange*) , enabling original investors a leveraged way out.

▪ One manner of driving funds for the SPC completion can be that of securitizing the cash flow defined in the PPA. This modeling is equivalent to the issuing of a bond of the sovereign debt, in that in the current market there are no differences concerning costs or solution quality. A differential can occur if there are funds of implemented receivables, formatted by funders interested in establishing a portfolio of receivables of disperse risk, situation in which an SPC does not incur costs or the onus of formatting the issue of sovereign bonds, and all that is required is selling a fraction of your cash flow derived from the PPA on the market.

VI. The Juruena Complex of Hydroelectric Power Plants

The constitution of the Juruena complex of generation power plants results from an investment partnership between a private company (Linca) and an Equity Fund (FIP Energia SHPP, which, together have undertaken, by means of a Special Purpose Company, Juruena Participações e Investimentos S/A, an electric power generating complex with total installed capacity of 91.4 MW, made up of 5 small hydroelectric power plants (SHPPs) on the Juruena River in the State of Mato Grosso.

The Cidezal (17 MW), Parecis (15.4 MW), Rondon (13 MW), Sapezal (16 MW) and Telegráfica (30 MW) are the SHPPs belonging to the complex, run-of-river power plants, in the Nothwest of the State of Mato Grosso with global capacity factor of 88%, and contracted power supply of 704,391 MWh/ per annum.

The project improves the stability of the power transmission and distribution systems for CEMAT, the public service power distribution concessionaire in the State of Mato Grosso, as identified by the ONS - **O**perador **N**acional do **S**istema (*National System Operator*).

The complex has a Purchase Agreement to sell electric power (PPA), signed with Eletrobrás within the PROINFA.

The Project was devised and developed based on a structure for attracting private investments through the FIP, in which private funds are apportioned among shareholder investors seeking long-term profitability for their investments.

This capital paid into the FIP structure is transferred to JURUENA (Juruena Participações e Investimentos), the holding company responsible for the project completion, leveraging necessary funds for its fulfillment.

The Project is supposed to take R$ 513.8 million[5] in overall investment. From this amount, shareholders intend to apportion 30% (R$ 154.1 million), the remainder (R$ 359.7 million) being obtained through direct financing from BNDES and indirect financing via agents that transfer BNDES funds, including Banco do

4 This procedure does not integrate the Proinfa. The investment decision-making depends on BNDESpar, according to its own investment criteria.

5 1 US$ - 2.05 R$

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

Brasil.

Shareholders have signed an EPC with turnkey agreement with an important constructing company in Brazil, with prices readjusted according to IGP index and clauses relating to insurance and collateral.

Associated to the Project, a Completion Bond was also issued by an important insurance company.

Funding

The BNDES has created a special program to fund projects within the PROINFA scope, where it has demonstrated up to 80% participation in the funding of investments that can be financed, with a 2% basic spread and a 1.5% risk spread premium for direct operations and a funding period of up to 14 years, the longest payback term being of 12 years.

For its funding, JURUENA counted on the longest amortization period for paying the long-term loan in a mixed funding operation combining BNDES direct funds (50.5% of the overall required fund, amounting to R$ 259.5 million) and indirect funds transferred by different banks, including BANCO DO BRASIL (R$100.2 million, equivalent to 19.5% of the total required investment). In fact, the borrowers were the 5 SPCs associated to each different SHPP.

The collateral guarantees offered were:

- Cross-SPC solidarity (to work for the project as a whole);
- Pawn of the emerging ANEEL authorization rights;
- Pawn of SPC shares;
- Pawn of the Power Purchase Agreements already signed with Eletrobrás;
- Chattel mortgage of equipment;
- A completion bond of 100% of the funding value;
- A reserve account considering the due interests in different periods: 4 months for January to June 2009; 5 months for July 2009 to December 2010, and 3 months during the rest of the operation.

Construction phase

Based on the referential scenario used for the construction cycle, **R$ 513,782 thousand** is the total investment required for the **5 SHPPs,** including the concession grant. The plants' implementation cycle will take 26 months, with expected cash flows presented in Table I.

TABLE I (in the appendix)

Operational phase

According to the operational patterns expected for the operational cycle and considering 12% for the real yearly hurdle rate (above inflation measured by IGP), the Net Present Value (NPV) for the 5 SHPPs of the Juruena Complex is of R$ 587,166 thousand.

The referential scenario drawn for the 20-year operational cycle includes the parameters shown in Tables 2 and 3. The scenario variables for which distortion were admitted within preset frontiers are: revenues, operational costs, transmission costs, in addition to inflationary losses resulting from tax adjustments in annual cycles.

We can see that these variables are set within boundaries, in which each one fluctuates randomly. Considering these limits, the results (indicators) will be presented as intervals, considering laboratory samples, just like in Hughes [16], constructed from the exploration of multiple scenarios with inflation, revenues, operational an transmission costs fluctuations. Actually, we are applying here a Monte Carlo simulation in order to generate confidence intervals for the average of the Juruena Complex's rate of return aiming to compare it with foreigners and domestic investors' hurdle rates.

The hurdle rate for medium, big and institutional investors recognized in the Brazilian market, seeking income in safe and homogeneous infrastructure projects' flow, is roughly 12% a year, effective above the inflation rate. See Rocha-Lima and Alencar [17], Aguiar and Alencar [18].

Table 2 contains the variables, supply tariff and assured energy [possible variation from -4% to 2% in relation to the referential scenario], for calculating the expected operational revenue.

Table 3 presents the operational costs parameters estimated to the Juruena Complex 5 small power plants. [admitted variation from -4% to 8% for transmission costs and 0% to 4% for operational costs, both in relation to the referential scenario].

The boundaries of fluctuation were set up, not only in table 2, but also in table 3, to allow us to generate lab samples with which to simulate the rate of return volatility as the project's performance changes.

Taking these frontiers into account for a Monte Carlo simulation, the results are treated statistically and shown in figure 4.

TABLE II (in the appendix)

TABLE III (in the appendix)

Expected results

The internal rate of return for the overall cycle, is of 13.44% annually, including 26 months for the power plants completion (R$ 513,782 thousand of investment demand) and 20-year long cycle for the complex operation. Considering the fluctuations in revenue generation, inflation (between 2% and 12% annually), operational and transmission costs related, the rate of return would not be below 12.83%, considering reliability of 90%.

Figure 4 illustrates a laboratory sample for this rate of

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

return, showing the boundaries of the average confidence zone**,** when disturbances are carried out for each power plant in the complex, individually. Any particular disturbance in one specific power plant can be compensated by any other power plant in the complex, by bringing about risk-mitigating effects.

By simulating the portfolio behavior to market risks, along with the inflation rate and operational management cost fluctuations, we can build measurable lab samples with a certain degree of reliability. As mentioned before, these bands of quality indicators or confidence levels indicate the degree of risk for investing in such Brazilian sustainable power plants portfolios.

Concerning foreign investments, which are unprotected from exchange hedging, we must still analyze such indicators taking into account the Brazilian risk index (300 points, what means we must reduce the rate of return 3% and compare it with foreigner investments attractiveness) see Rocha-Lima and Alencar [19] and the risks related to the migration of funds from a developed economy to a developing one.

In even more aggressive scenarios, in the segment we analyzed, investment opportunities in the Brazilian market outperform equivalent investments in the U.S. or European markets. In addition, further exemplifying this investment opportunity, we even adopted a 300-point margin for the Brazilian–risk index and still the Brazilian SHPP portfolio outperformed international hurdle rates for this kind of investment.

In the appendix
Fig. 4. A Laboratory Sample for the Return Rate on Investment

As a result, investment in this 20-year power plant portfolio would present an annual income rate (yield) as shown in Figure 5. All data shown in the chart refer to investment basis, i.e., revenues are deflated for the basis in accordance with the inflation rate, varying between 2% and 12% annually. As we can figure out in the chart, payback occurs in the eighth year of the Complex operation.

In the appendix
Fig. 5. Profile of Annual Revenue – Yield Curve

VII. Conclusion

Achieving power projects frequently demand great sums of investment during the construction phase, along with a long-term for producing returns. The public sector, the traditional investor in such projects, has been decreasing investments in the sector, not meeting Brazilians' need. Situations alike can be noticed in many other on-developing economies, where the public sector is not able to provide, by itself, all the expected long-term power demand to allow economic grow as planned.

As a result, the needed sustainable power supply must be provided considering the participation of private capitals in such ventures, as developed economies have already been doing in different economic sectors. On the other hand, private investments need the (risk v return) attractive. As it is not possible to increase returns in infrastructure, the only way is to reduce risks, achieved just when the public sector takes part of that risk.

In special for sustainable electric power generation projects, Brazil has proposed a legal framework which enables public-private partnerships, by providing new environment in which risks are weakened, and absorbed by the State. The model provides a steady regulatory environment, in which a healthy competition in prices is encouraged, along with a guaranteed power supply.

In emerging economies, the environment's stability and the predictability for the long-term returns flow are drivers for private investors decision-making. In this way, the Brazilian electrical model creates the Regulated Contract Environment – ACR and establishes that each generation company shall firm a long-term contract of electric power supply, considering agreements over price and supply. The market risk mitigation, as drawn by PROINFA – **Pro**grama de **In**centivo a **F**ontes **A**lternativas (Program for Fostering Alternative and Renewable Sources of Electric Power), is a crucial factor to attract the private capital for the sector's sustainable projects.

In order to apply such model in other countries it is necessary to design an appropriate legal framework, particularly in what concerns to the situation of the Regulated Contracting Ambience and the Free Contracting Ambience as well.

In relation to the funding mechanism considered in the model, there are no restrictions to apply it in all countries where the legal framework and financial and capital markets are similar to the ones discussed in the paper.

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

References

[1] Brazil. *Constituição da República Federativa do Brasil*. Establishes rules for contracting public-private partnership by public administration. Law nº 11,079, December 31th, 2004.

[2] Brazil. *Constituição da República Federativa do Brasil*. Creates The Public-Private Partnership Committee. Law nº 5,385, March 4th, 2005.

[3] Alencar, C.T. Highway concessions in Brazil: an analysis towards the feasibility of the securitization. *Journal of Financial Management of Property and Construction*, Glasgow, *UK, v.5., n.3, p.159-172, December, 2000.*

[4] Alencar, C.T. *Derivation of Funds for Investments in Infrastructure Enterprises: The Securitization Feasibility in Highway Concessions and Independent Power Project Concessions in Brazil*, Ph.D Thesis, Department of Civil Construction and Engineering, Polytechnic School, University of São Paulo. São Paulo, Brazil, 1998.

[5] Goldenberg, J.; Mielnik, O. Electricity regulatory reform and sustainable development in Latin America. *Energy for Sustainable Development*. Bangalore*, v.3, p.17-26, March, 1997.*

[6] Mines and Energy Department. *Power Sector Institutional Model*. Brasília. Available in http://ucel.eln.gov.br/gse, 2003.

[7] Faria, V.C.S. *The Project Finance Role on Power Project Financing; The Case of Cana Brava Hydroelectric Power Plant*. MSc. Thesis - COPPE, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, 2003.

[8] Bonomi, C.A.;Malvessi, O. *Project Finance in Brazil*. (Atlas publishing, 2002, São Paulo).

[9] Finnerty, J. D. *Project Finance: Financial Engineering Based on Assets*, (Nova York, 1996).

[10] National Bank for Economic and Social Development. *Long Term Interest Rate (LTIR)*. Rio de Janeiro. Available in http://www.bndes.gov.br, 2006.

[11] Ariztía, R. Watts, D. The Electricity Crises of California, Brazil and Chile: Lessons to the Chilean Market. *Proceedings of Lescope'2002, The 2002 Large Engineering Systems Conference On Power Engineering*, p.7-12. Santiago, Chile, 2002.

[12] Borges, L. F. X. Covenants: Guarantee Instruments in Project Finance. Rio de Janeiro. *National Bank for Economic and Social Development Review, v.6., n 11. p.117–136, 1999.*

[13] Montero, J.P.;Rudnick, H. Second generation electricity reforms in Latin Amarica and the California Paradigm. *Journal of Industry, Competition and Trade*, *Holanda, n.2. p.159-172*, 2002

[14] Barroso, L.A.; Blanco, A.; RUDNICK, H. Twenty Years of Reestructing and Reform in Argentina, Brazil and Chile. *IEEE Power & Energy Magazine*, *New York, p.50-59, july-agost, 2005.*

[15] Delloitte Touche Tomatsu Emerging Markets. Sustainable power sector reform in emerging markets: financial issues and options. Washington, D.C. *Joint World Bank/USAID Policy Paper*, *188p. June, 2004.*

[16] Hughes, W. T. Risk Analysis and Asset Valuation: A Monte Carlo Simulation Using Stochastic Rents. *The Journal of Real Estate Finance and Economics. v.11, n.2, p.177-187, 1995.*

[17] Rocha-Lima, J. Alencar, C.T. The Office Buildings Market in São Paulo: Time Cycles to Absorb Vacant Space and to Recover Investment Attractiveness According to the Brazilian Macroeconomic Performance. *Journal of Financial Management of Property and Construction. v.11, n.1, p.59-71, 2006.*

[18] Aguiar, F.L.; Alencar, C. T. Risk Mitigation for the Private Power Projects Investors in Brazil – The Guarantees Structure**.** *Proceedings of CIB W107. Construction in Developing Economies International Symposium "Construction in Developing Economies: New Issues and Challenges"*, Santiago, Chile, 2006.

[19] Rocha-Lima, J. Alencar, C.T. Foreign Investment and the Brazilian Real Estate Market. *International Journal of Strategic Property Management. v.12, n.2, 109-123, 2008.*

Authors' information

All four authors are members of the University of São Paulo Polytechnic School Real Estate Research Group. They have got their PhD in the year 1985, 1998, 1998 and 1996 respectively. Research in real estate deals with the following themes: planning, management, business, marketing, economics and sustainability. Their researches and studies are focused on the development of systems in order to allow the improvement of the whole decision process in the sector. This upgrade of the decision process is supposed to be conducted by an advance of knowledge related to planning techniques involved in all segments of the management tissue. Taking into account the main features of the sector and the particularities of its economic insertion and impacts on sustainability, in addition, considering the dimension and duration of the real estate projects, RES drives its researches to the planning methods and routines emphasizing the risk analysis of the projects and companies, besides, the group has a line of research toward the funding mechanisms for the construction sector.

[1]First author

Full name: João da Rocha Lima Júnior
rocha.lima@poli.usp.br
Academic title/degree: Full Professor / PhD
Working place: University of São Paulo - Polytechnic School
Department: Civil Construction
Research field: Real Estate and Economics
Post address: Avenida Prof. Almeida Prado – Travessa 2, no. 83
Cidade Universitária
São Paulo - SP - Brazil
Postcode: 05508-900

[2]Second author

Full name: Claudio Tavares de Alencar
claudio.alencar@poli.usp.br
Academic title/degree: Assistant Professor / PhD
Working place: University of São Paulo - Polytechnic School
Department: Civil Construction
Research field: Real Estate and Economics
Post address: Avenida Prof. Almeida Prado – Travessa 2, no. 83
Cidade Universitária
São Paulo - SP – Brazil Postcode: 05508-900

[3]Third author

Full name: Sérgio Alfredo Rosa da Silva
sergio.alfredo@attglobal.net
Academic title/degree: Assistant Professor / PhD
Working place: University of São Paulo - Polytechnic School
Department: Civil Construction
Research field: Real Estate and Economics
Post address: Avenida Prof. Almeida Prado – Travessa 2, no. 83 Cidade Universitária
São Paulo - SP - Brazil
Postcode: 05508-900

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

[4]Forth author

Full name: Eliane Monetti
eliane.monetti@poli.usp.br
Academic title/degree: Assistant Professor / PhD
Working place: University of São Paulo - Polytechnic School
Department: Civil Construction
Research field: Real Estate and Economics
Post address: Avenida Prof. Almeida Prado – Travessa 2, no. 83
Cidade Universitária
São Paulo - SP - Brazil
Postcode: 05508-900

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

Appendix

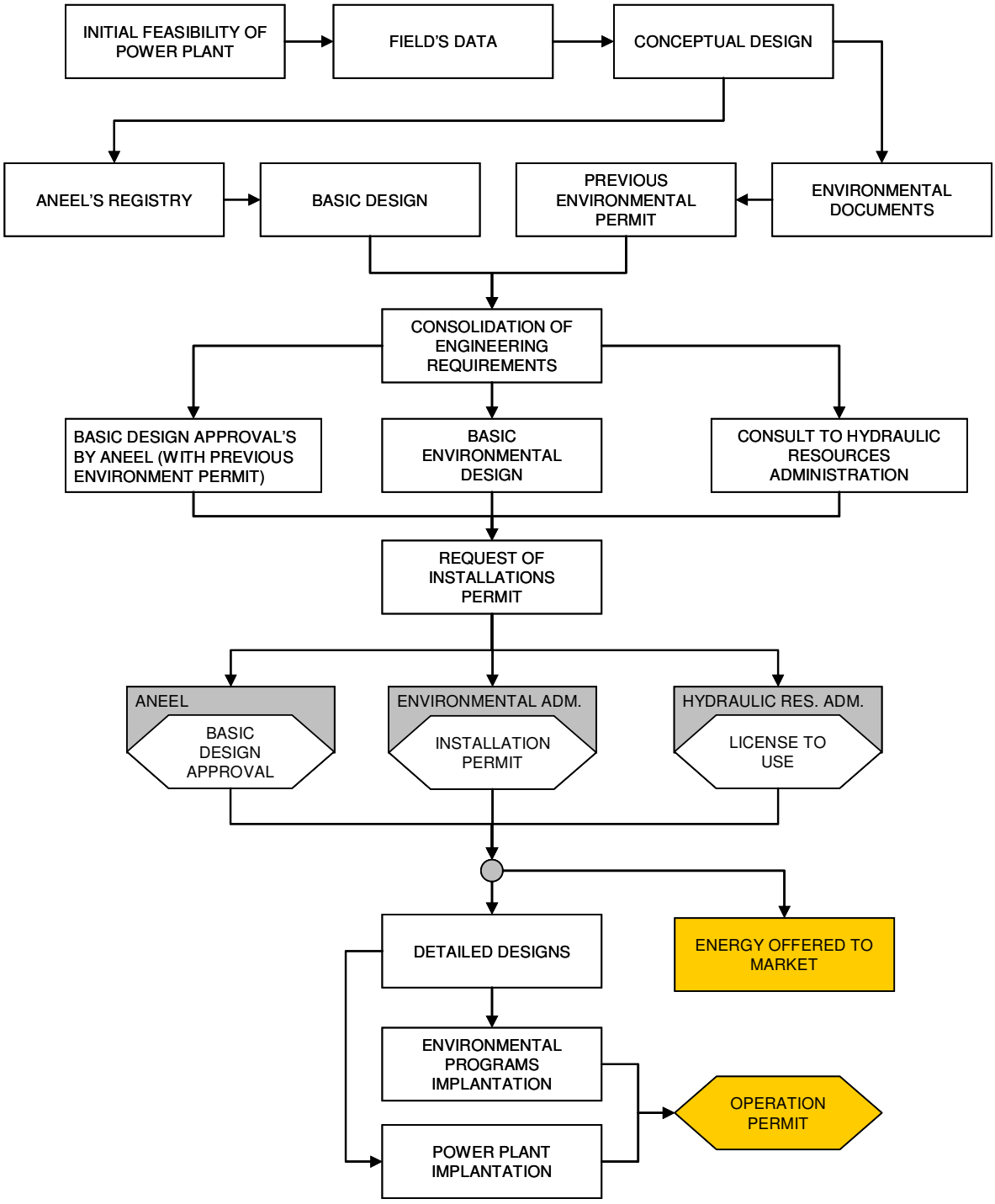

Fig. 2. process to develop and construct a Small Hydroelectric Power Plant (SHPP).

Manuscript received and revised December 2012, January 2013
Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

TABLE I

JURUENA COMPLEX

CONSTRUCTION PHASE

EPC, ASSEMBLAGE, TRANSMISSION SYSTEM, DESIGN, INSURANCE AND LOTS

in R$ thousand

Month	PAYMENT FOR CONCESSION GRANT	EPC			DESIGN INSURANCE AND LOTS	CONSTRUC--TION COSTS TOTAL	CASH FLOW	
		CONSTRUCTION AND MANAGEMENT	ELETRO-MEC ASSEMBLAGE	TRANSMISSION SYSTEM			MONTHLY	ACCRUED
0						0	0	0
1	29,620	9,368	9,065	0	6,510	24,942	54,562	54,562
2	0	2,475	4,898	0	6,510	13,883	13,883	68,445
3	0	14,377	0	0	2,440	16,817	16,817	85,262
4	0	21,752	32,208	1,252	2,440	57,653	57,653	142,915
5	0	17,135	10,290	7,577	2,440	37,442	37,442	180,357
6	0	22,689	13,658	2,463	1,340	40,150	40,150	220,506
7	0	17,986	9,096	2,692	1,340	31,114	31,114	251,620
8	0	16,652	4,950	4,449	1,340	27,391	27,391	279,012
9	0	17,441	6,299	5,168	1,340	30,247	30,247	309,259
10	0	16,258	1,906	5,284	1,340	24,787	24,787	334,046
11	0	31,341	13,639	7,756	1,340	54,075	54,075	388,121
12	0	15,077	3,950	6,914	673	26,615	26,615	414,736
13	0	12,779	3,787	5,018	673	22,257	22,257	436,993
14	0	13,438	5,138	2,854	673	22,103	22,103	459,096
15	0	1,384	4,292	1,459	673	7,809	7,809	466,905
16	0	1,194	4,308	694	673	6,869	6,869	473,774
17	0	952	4,674	780	673	7,079	7,079	480,853
18	0	761	3,294	1,039	673	5,766	5,766	486,619
19	0	727	2,270	1,917	673	5,588	5,588	492,207
20	0	612	1,663	1,352	673	4,300	4,300	496,508
21	0	356	1,447	1,067	673	3,543	3,543	500,050
22	0	424	1,260	0	673	2,357	2,357	502,407
23	0	372	948	0	673	1,993	1,993	504,400
24	0	223	356	0	2,673	3,252	3,252	507,652
25	0	211	204	0	2,673	3,088	3,088	510,741
26	0	195	173	0	2,673	3,041	3,041	513,782
27	0	0	0	0	0	0	0	513,782
28	0	0	0	0	0	0	0	513,782
29	0	0	0	0	0	0	0	513,782
30	0	0	0	0	0	0	0	513,782
TOTAL [1-26]	**29,620**	**236,177**	**143,775**	**59,734**	**44,476**	**484,162**	**513,782**	

TABLE II

JURUENA COMPLEX

OPERATIONAL CYCLE SCENARIO

SUPPLY TARIFF AND ASSURED ENERGY

in R$ thousand and MWh/year

	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5 AND SO ON	DISTURBANCE OF THE REVENUE
SUPPLY TARIFF	0.131	0.131	0.131	0.131	0.131	
ASSURED ENERGY	558,085	669,700	669,700	669,700	669,700	
REVENUE GENERATION	**73,148**	**87,778**	**87,778**	**87,778**	**87,778**	- 4%
						+ 2%

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

TABLE III

JURUENA COMPLEX

OPERATIONAL CYCLE SCENARIO

OPERATIONAL AND TRANSMISSION COSTS, TRANSFERS TO ANEEL AND INSURANCE

in R$ thousand/MWh

	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5 AND SO ON	FACTOR OF DISTURBANCE CONSIDERED
	STRESSED SCENARIO					
GROOS OPERATIONAL REVENUE	71,431	85,716	85,716	85,716	85,716	
OPERATIONAL COSTS (% OF REVENUE)	**3%**	**3%**	**3%**	**3%**	**3%**	0 points
						+ 2 points
OPERATIONAL COSTS	2,143	2,571	2,571	2,571	2,571	
TRANSMISSION COSTS (R$ / KW installed / month)	**1,890**	**2,062**	**2,062**	**2,062**	**2,062**	- 4%
						+ 8%
TRANSFERS TO ANEEL (% OF REVENUE)	**0.5%**					
INSURANCE (% OF REVENUE)	**0.5%**					

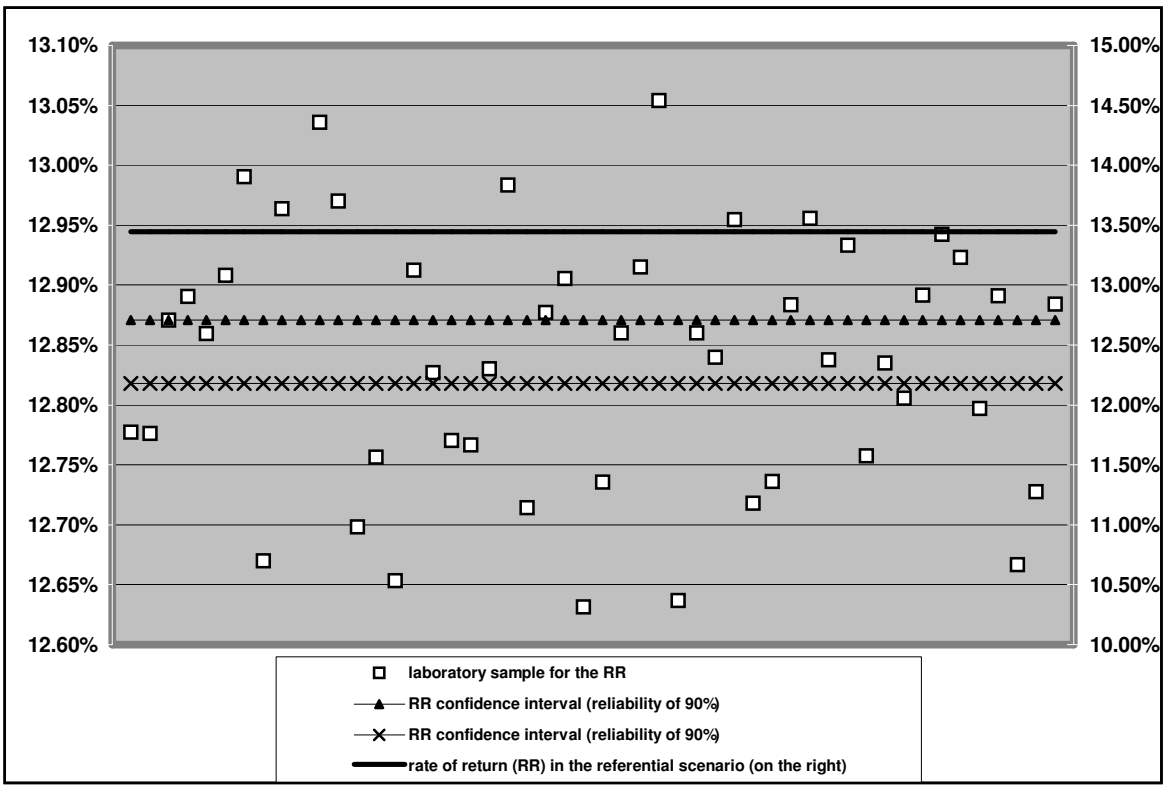

Fig. 4. A Laboratory Sample for the Return Rate on Investment

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved

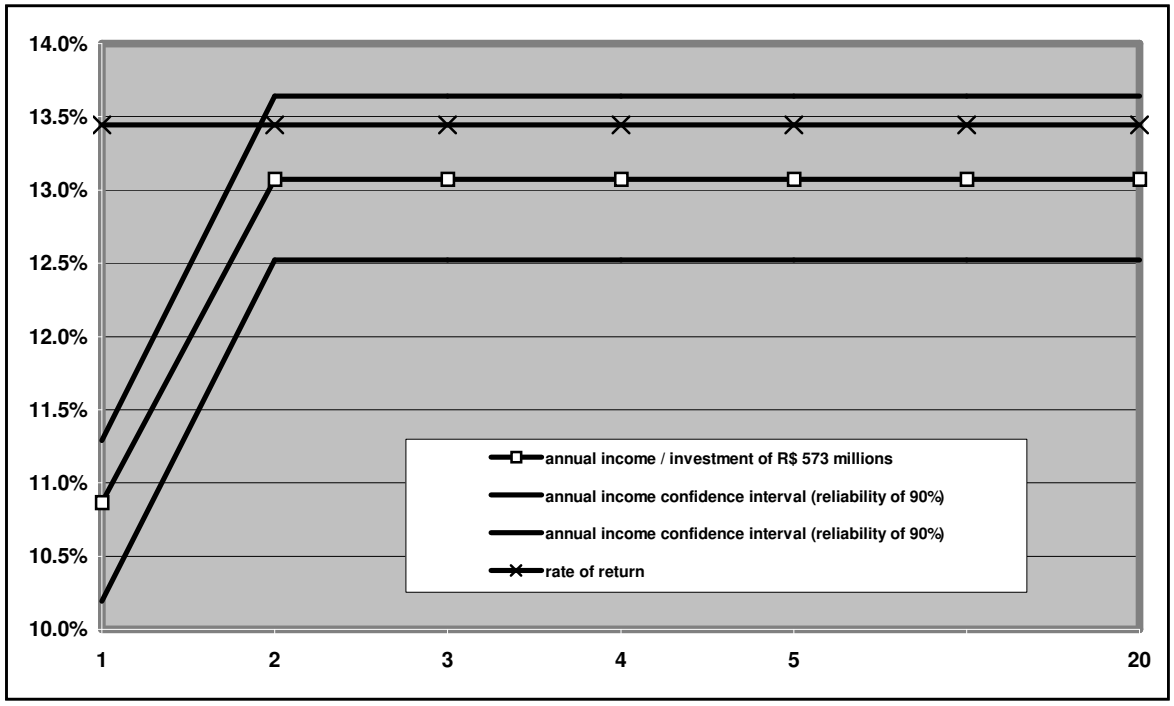

Fig. 5. Profile of Annual Revenue – Yield Curve

Copyright © 2010 Praise Worthy Prize S.r.l. - All rights reserved