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ANALÝZA BRAZILSKÉHO HYDROELEKTRICKÉHO SEKTORU SE ZAMĚŘENÍM NA POTENCIÁL MALÝCH VODNÍCH ELEKTRÁREN

DIPLOMOVÁ PRÁCE

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ANALYSIS OF BRAZILIAN HYDROELECTRICITY SECTOR WITH FOCUS ON SMALL HYDRO POWER PLANTS POTENTIAL

THESIS

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Abstract

Financing of private energy projects in Brazil has grown substantially during the final years of the 20th century, especially in the electricity sector. As traditional public sources of finance have dried up, they have not been replaced in equal measure by private funds and, in consequence, Brazil and other hydropower powers are experiencing a sharp decline in new "greenfield" hydro powerplants. The thesis provides an overview of the main issues and challenges related to the private financing of hydropower projects in Brazil.

The main aim of the thesis is the analysis of Brazilian hydroelectricity sector with focus on private financing possibilities of small hydro power plants. Hydropower faces many difficulties caused by the site specific nature of projects, high construction risk and long construction periods, capital intensive nature, unpredictable output, complex concession process, and environmental sensitivities. The thesis describes the difficulties and suggest some partial solutions.

The mission of the thesis is encourage private investors to consider some potential investment in this area. Give them necessary basic information and data to start constructing and managing a hydro power plant including latest Brazilian legal framework. The description and analysis also covers a range of market characteristics, regulatory and concession environments and financial structures.

Abstrakt

Privátní financování energetických projektů v Brazílii podstatně vzrostlo na sklonku minulého století, hlavně v sektorech výroby, přenosu a distribuce elektrické energie. Tradiční veřejné zdroje vysychají a nebyly zatím adekvátně nahrazeny privátními prostředky. V důsledku toho jsme svědky strmého poklesu tempa výstavby vodních elektráren nejen v Brazílii, ale ve všech hydroelektrických velmocích.

Diplomová práce poskytuje přehled výše uvedených sektorů a výzvy do budoucna spojené se soukromým financováním hydroelektrických projektů v Brazílii. Cílem této práce je analýza brazilského hydroelektrického sektoru se zaměřením na potenciál malých vodních elektráren. Brazílie je stále otevřenější soukromému financování hydro projektů. Získání tohoto druhu energie je však spjato s mnoha těžkostmi. Každá vodní elektrárna je jiná. Díky specifickým stavebním podmínkám se každý projekt stává konstrukčně riskantním, relativně zdlouhavým, kapitálově náročným a s nepředvídatelnými výsledky. Koncesní proces je také velmi náročný a zdlouhavý. Diplomová práce podrobně popisuje tyto procesy a navrhuje varianty řešení.

Posláním této diplomové práce je dodat odvahu soukromým investorům k investování prostředků v této oblasti. Dát jim nezbytné základní informace k výstavbě vodní elektrárny. Deskripce a analýza této práce pokrývá charakteristiky brazilského trhu s elektrickou energií, jeho regulatorní a koncesní rámec a možnosti financování hydroelektrických projektů v Brazílii.

PODĚKOVÁNÍ

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Abbreviations and Acronyms

ANEEL	National Electricity Regulatory Agency
BOT	Build, Operate, Transfer
BOO	Build, Own, Operate
BNDES	Brazilian National Development Bank
CAPE	Energy Policy National Council
CCEE	Electric Power Trade Board
CMSE	Power System Monitoring Committee
CONAMA	Brazilian Environmental Council
DNAEE	Regulatory Agency under the Ministry of Mines and Energy
EIA	Environmental Impact Assessment
ECA	Export Credit Agencies
ECLAC	Economic Commission for Latin America and the Caribbean
EPC	Engineering, Procurement and Construction
EPE	Energy Research Enterprise
GDP	Gross Domestic Product
GW	Gigawatt
GWh	Gigawatt–hour
IADB	Inter–American Development Bank
IBAMA	The Brazilian Institute for Environment and Renewable Resources
IMF	International Monetary Fund
IPP	Independent Power Producer
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt–hour
MDB	Multi Development Bank
MME	Ministry of mines and energy
MW	Megawatt
MWh	Megawatt-hour
ONS	Independent System Operator
PBA	Environmental Basic Project
PPA	Power Purchase Agreement
PROINFA	Alternative Energe Resources Incentive Programmeme
PRS	Power System Regulations
RIMA	Report of Impact on Environment
SHP	Small Hydro Power Plant
SIN	Interconnected National System
SINTREL	National Electric Transmission System
TW	Terrawatt
TWh	Terrawatt-hour
WEM	Wholesale Energy Market

Introduction

Energy has been a central concern to humankind throughout its history. The adequate provision of energy services has become especially important for economic development since the Industrial Revolution. In recent decades, energy issues have become a fundamental component of the conceptual and strategic discussions on sustainable development worldwide. The world’s electricity consumption increased two times faster than world's population during the last 20 years. Therefore, it is necessary to produce more energy per capita because the global accelerating economic growth is closely connected with higher energy demand. Hydro energy represents a method how to produce cheap energy sustainably.

The thesis is focused on economics of hydro energy and possibilities of new small hydropower plants in Brazil. Author is convinced about necessity of new energy generators in the area. The already accelerating economic and population growth does not give other possibilities. Historically, focus was more at big projects but future is open to smaller facilities. The following text opens a discussion on this topic and analyses major positive and negative aspects of small hydropower plants.

The aim of this thesis is to find out if there are appropriate conditions for private investors to develop a small hydropower plant in Brazil. Author described and analyzed Brazilian energy market with focus on rules and conditions of private project financing. Author tries to find sustainable energy model for other countries and future generation model as well. The thesis describes trends in world's hydro energy.

In today's world, the growing need for energy and especially electricity is indisputable, not only in Brazil. Nevertheless, resources are limited and it is inevitable to search continuously for new sources of energy and improved ways of producing electricity. Many scientists rack their heads over new energy resources (e.g. nuclear fusion) which would solve the growing energy needs. However, for the next few decades the humankind has to get along with the already existed resources. In addition to that, there is a new requirement for producing energy and it is environment friendliness, represented mainly by minimizing CO_2 production and therefore reducing global warming. Hydro energy production fulfills this requirement.

The thesis starts with a concise overview of the Latin American economy, especially Brazilian economic background, and energy related aspects of the international development.

The next chapter is focused on energy industry matters. It embarks with general description of hydropower's role in electricity generation and continues with deeper focus on Brazil's energy generation, especially on hydropower.

The next two parts are focused on detailed analysis of Brazilian energy market and legislation of private financing and discussing types and possibilities of private financing in Brazilian economy conditions. The background, objectives and scope of the analysis are summarized in this section. The analysis of the Brazilian energy market consists of:

- types of new hydropower plants financing,
- administrative background and obstructions,
- regulatory framework and concession arrangements,
- other information and data devoted to energy matters.

The last section of the thesis consists of conclusions of the described issues and proposed recommendations on the main issues. The document provides insight for potential private investors and should encourage them in the challenge of mobilizing financing for hydropower development in Brazil.

The thesis abstracts of detailed insight to environmental issues and potential disputes about impact of small hydropower plant to environment. Author is conscious of negative small hydropower plants impact, however, hydro energy generation belongs to the environmental friendly generating solutions.

Price analysis is also not a part of the text. Rates and table of charges are continuously changing. The same is happening with exchange rates. Therefore, market price analysis does not belong to the following principal matters.

Despite some general findings, the thesis also abstracts of comparing Czech and Brazilian energy related aspects. Both are very individual and any comparison would bring only a description of two completely separated systems. On the other hand, some general findings are applicable to The Czech Republic.

1 Economy background

1.1 THE LATIN AMERICAN ECONOMY

The economy of Latin America comprises about 500 million people living in 20 states and territories. Latin America[1] is home to 7 % of the world's population and contributes 8.7 % of global GDP [7]. The biggest trade and economy bloc in South America is Mercosur, comprising Brazil, Argentina, Uruguay, Paraguay and Venezuela. Associate states include Chile, Colombia, Peru, Bolivia and Ecuador. Its purpose is to promote free trade and fluid movement of goods and peoples.

Table 1: GDP 2005 (out of 181)

World Rank	Country	GDP [bill US$]
10th	Brazil	795,7
22nd	Argentina	533,7
29th	Colombia	337,2
43rd	Chile	193,2
50th	Peru	167,2
51st	Venezuela	163,5
70th	Ecuador	57,0
90th	Uruguay	34,3
96th	Paraguay	28,3
101st	Bolivia	25,6
157th	Guyana	3,4

Table 2: GDP 2005 per capita (PPP 2) (out of 181)

World Rank	Country	GDP per capita
50th	Argentina	14,109
56th	Chile	11,937
65th	Uruguay	10,028
68th	Brazil	8,584
81st	Colombia	7,565
96th	Venezuela	6,186
97th	Peru	5,983
105th	Guyana	4,612
107th	Paraguay	4,555
113th	Ecuador	4,316
125th	Bolivia	2,817

Source: Wikipedia (http://en.wikipedia.org/wiki/Latin-America) - Latin American economies 2006

According to ECLAC [7], an economic growth rate of 5.3 % is estimated for 2006. If this growth is confirmed, the GDP per capita for the region will have

[1] The term is correctly used when referring to those territories whose national languages come from Latin.

expanded in average 3.8 % per annum in the last 4 years, which is significant when compared to the region's economy performance in the recent period. The average annual growth rate was only 2.2 % between 1980 and 2002.

In addition, the economic growth has been followed by a reduction in the external vulnerability indicators, by the drop in inflation, in unemployment and in public deficit and by interest rates relatively low for the region of Latin America. Moreover, differently from the beginning of the economic recovery in 2005, the growth has been led mainly by domestic demand. In the first quarter of 2006, the growth was 5.5 % in relation to the same period of previous year. In 2005, the GDP for the region grew 4.5 %, after expanding 5.9 % in 2004 [31].

IMF and ECLAC have optimistic expectations for the Latin American economy in the next years. As of early 2007, Latin America is experiencing great economic development, with Venezuela, Argentina and Peru growing their economies by over 7 % per annum [15].

1.2 BRAZIL'S ECONOMY OVERVIEW

Brazil is one of the largest economies in the world, but it is still a developing country. The fifth largest country in territorial extension, it covers an area in excess of 8.5 million km^2 (108 times more than The Czech Republic) and its population has reached recently 185 million inhabitants. Brazil comprises 26 states and the Federal District of Brasilia, the capital city [6].

Brazil became the leading Latin American economy in 2006 (GDP total), ahead of Mexico, and ranked eleventh in the world. The Gross Domestic Product estimate for 2006 was US$ 795,7 billion [3], as shown above, places its economy among the biggest in the world, mainly when its production is measured by purchasing power parity, then the GDP is almost double.

According to preliminary data release from the Brazilian Central Bank, GDP downgraded to 2.7 % in 2006. Brazil's 2.3 % in 2005 growth was the lowest of Latin America only ahead of Haiti. For 2007, the estimate among a hundred leading businessmen and analysts is that the economy will grow by a sluggish pace 3.5% in 2007. We can not forget that the growth of GDP is at least partly caused by population growth across the whole continent. The situation of GDP per capita is not so rosy but the total growth trend is irrefutable.

Inflation for 2006 paced to 4 % and another increase is estimated for 2007, the official Central Bank target is 4.5 %. Private analysts also estimate that the basic lending rate in Brazil, Selic[1], currently at 13.25 % should keep dropping to 12.00 % next December. Brazil had a record US$ 46 billion trade surplus in 2006, with exports reaching US$ 137.4 billion and imports US$ 91.4 billion [6]. Exports jumped 16.2 % over 2005 and imports 24.2%. The strong boost in imports is attributed to the strong Brazilian real, which appreciated last year 8.1% against the US dollar. The exports' goal for 2007 is US$ 143.5 billion. After recently approved plans of United States of America and The European Union in aid of bigger share of bio fuel in an energy matrix, the trade surplus is expected to be even higher [3].

Brazil is largest trading partner of the EU amongst the Latin American countries. It was the leading source of EU imports from the LAC countries in 2005. Although Mexico was the leading destination for EU exports in 2005, with 16.8 billion Euro, Brazil had almost the same result with 16.0 billion Euro. Direct foreign investment in Brazil in 2006 was US$ 16 billion and should remain in the same range in 2007. The biggest foreign investors in the Latin America region from EU are Holland and Spain, with 14% e 10% of the total sum invested [3].

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[1] SELIC is the Brazilian Central Bank's system for performing open market operations in execution of monetary policy (REPO rate in The Czech Republic).

Table 3: Basic economy indicators of Brazil

	2001	2002	2003	2004	2005	2006	2007(f)
GDP growth (in %)	1,3	1,9	0,5	4,9	2,3	2,7(f)	3,5
Inflation (CPI)	7,7	12,5	9,3	7,6	3,7	4,0	4,5
Trade balance (US$ billion)	2,7	13,1	24,8	33,7	44,7	46,0	49,5
Foreign direct investment	24,7	14,1	9,9	8,7	10,2	16,0	16,0

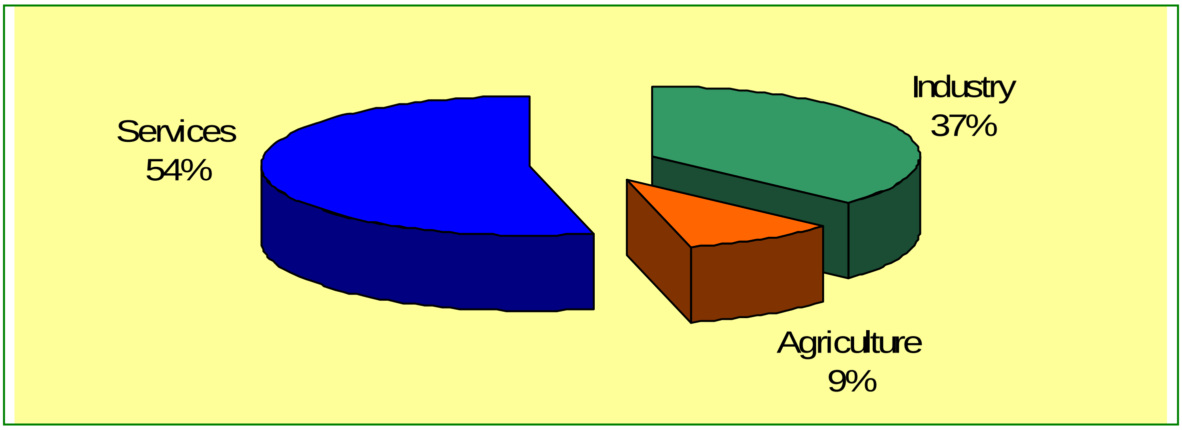
Source: BNDES - annual financial results (2005), Author's Annotation

The country's regional economic development does not show a uniform distribution. The Southeastern region with Sao Paulo and Rio de Janeiro contributes 58% to the total production (1/10 of total area, 1/3 of people) [30]. Such regional economic concentration has been gradually reduced with the increase of industrial investments in the Northern regions and the growth of agribusiness in the Central and Western regions. The Brazilian development bank has made great effort to wipe off the greatest inequalities by development project financing.

The total labor force of Brazil is 89 million (2004) [25]. From 2001-03 real wages fell and Brazil's economy grew, on average only 2.2% per year [3], as the country absorbed a series of domestic and international economic shocks. That Brazil absorbed these shocks without financial collapse is a tribute to the resiliency of the Brazilian economy.

Sectoral distribution of GDP is not typical for developing countries. The most astonishing is a small share of agriculture on the total product despite Brazil is known as agricultural country. Brazil's GDP is created in agriculture by 9%, in industry by 37% and in services by 54% in 2005 [6].

Chart 1: Sectoral distribution of GDP



Source: BrazzilMag - Brazil, a Superpower in Agriculture 2005

The industrial sector, in which energy sector belongs to, bears a significant role in the composition of the total production of the country accounting almost for 40 % of the GDP, with a diversified industry - provided with a high degree of technology in some sectors - enabling it to export to the various parts of the world.

Brazil is rich in natural resources. It has some of the largest iron ore deposits in the world and is now one of the biggest gold producers. It is the world's largest producer of tin, quartz and niobium and one of the three largest producers of iron ore, manganese and tantalum. The Brazilian steel industry, now mostly under private ownership after extensive privatization, ranks among the seven largest in the world. Self-sufficiency in petroleum consumption in recent years has been around 90 %. In the year 2006, Brazil reached full sufficiency in petroleum from own resources [4].

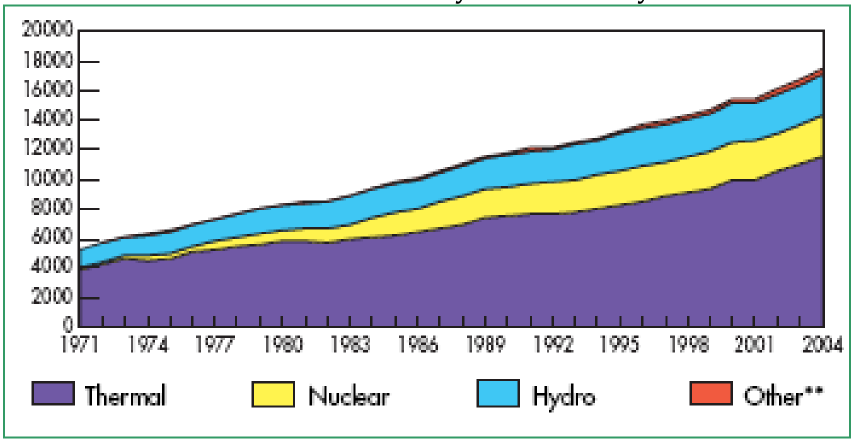
2 Electricity and power production

2.1 GLOBAL HYDROPOWER'S ROLE

Hydropower is a well-established technology that uses water without depleting it. It converts the kinetic energy of flowing water-using turbines into electricity. It is the most reliable renewable energy and emits very low greenhouse gases. Hydro energy has these major advantages [1]:

- it is renewable
- it produces negligible amounts of greenhouse gases
- it is the least costly way of storing large amounts of electricity
- it can easily adjust the amount of electricity produced to the amount demanded by consumers

Chart 2: Evolution of World Electricity Generation by Fuel from 1971 to 2004[**]

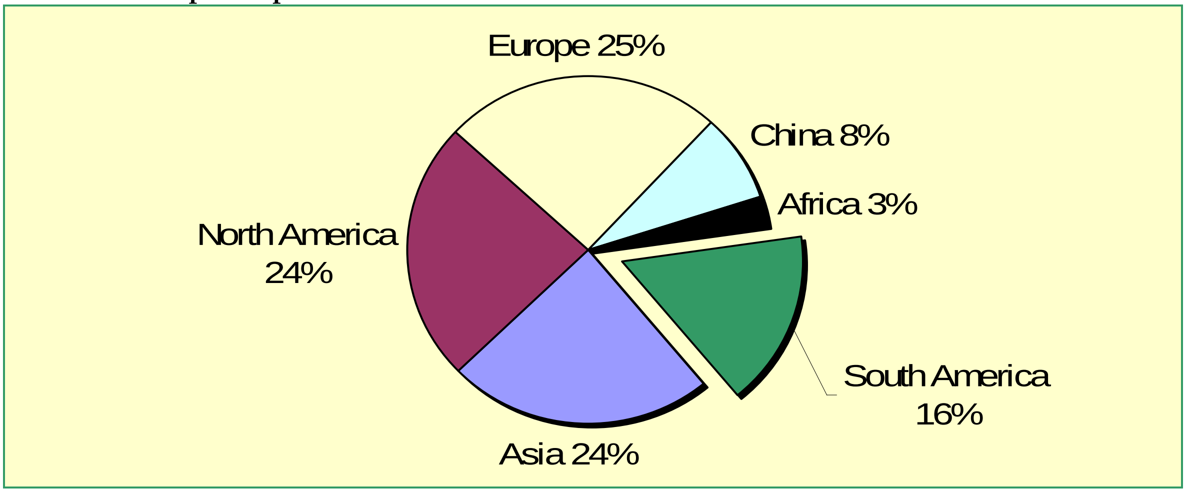


Source: The IEA - Key World Energy Statistics - 2006

Hydropower accounts for nearly one quarter of the world's electricity production, with a total some 650,000 megawatts installed (year 2000) [26]. Detailed figures are unavailable, but there appear to be more than 135,000 MW of hydro currently under construction or in the final planning stages.

[**] Other includes geothermal, solar, wind, combustible renewable and waste

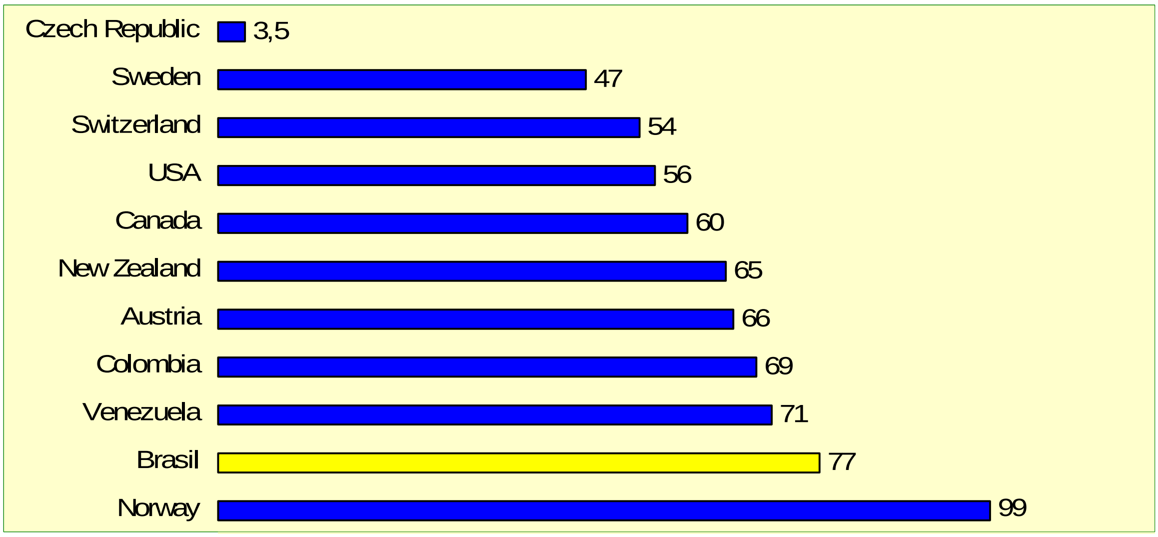
Chart 3: World power production



Source: The World Bank - Financing of Private Hydropower Projects - 2000

However, this statistic tends to be dominated by some very large public sector projects in a few countries such as China. The figure masks the fact that in many areas with significant hydro potential the rate of hydropower development has slowed appreciably in recent years. For example, in India the proportion of hydro capacity has dropped from 42 % to under 25 % in 20 years [17].

Chart 4: Role of hydro energy in total energy generation



Source: IAEA, Brazil: A Country profile on sustainable development 2006, Author's Annotation

Hydropower is a widely distributed resource with potential on all continents. However, the level of exploitation varies greatly, with relatively limited undeveloped resources remaining in North America and Europe; whereas large untapped potential still exists in South America, Asia and Africa. The regions with the largest untapped resources are also the parts of the world in which the greatest growth in electricity demand will be experienced in the next century. Proper development of hydropower resources could meet needs for clean renewable energy to address concern over global warming.

Table 4: Producers of hydroelectricity

Producers World	TWh	% of hydro
China	354	12.6
Canada	341	12.1
Brazil	321	11.4
United States	271	9.7
Russia	176	6.3
Norway	109	3.9
Japan	94	3.3
India	85	3.0
Venezuela	70	2.5
Sweden	60	2.1
Czech Republic	1,5	0,2
Rest of the World	925,5	32.9
World	2 808	100.0

Source: IEA, Key world energy statistics, 2006 (data for 2004) and author's annotation

Table 5: % of hydro el. generation

Country	% of hydro
Norway	98.8
Brazil	82.8
Venezuela	71.0
Canada	57.0
Sweden	39.6
Russia	18.9
China	16.1
India	12.7
Japan	8.8
United States	6.5
Czech Republic	3,5
Rest of the World[1]	14.2
World	16.1

Hydropower accounts for 19% of the world electricity supply, utilizing one third of its economically exploitable potential has been developed up to date. The

[1] Exclude countries with no hydro production

table below brings out the fact that several states with rich hydro potential have developed very little of it.

Table 5: Comparison of hydroelectricity net exploitable potential

Country	Exploitable Potent.(GW)	Installed Cap. (GW)	Pot. Utilized (%)
Norway	47	27	58
Canada	160	65	41
Brazil	200 - 260	82	31 - 41
China	310	56	18
India	150	23	17

Source: Indian's Ministry of Power - Electricity scenario 2005

In the literature, several types of hydropower potentials may be found [18]:

- **The (gross) theoretical potential** based on computations of the potential of water flows, without taking into account technical, economical, and environmental constraints.
- **The technically feasible potential** or the net exploitable potential. This is the amount of hydropower that could be developed from a technical point of view. Economical and environmental constraints are not considered.
- **The economically feasible potential** (170 GW in Brazil). This is the amount of hydropower that could be developed based on economical constraints. Environmental constraints are not considered.

Exploitable potential means technical hydropower potential in a country. For Brazil, it is additional up to 200 - 260 GW. However, some other sources talk about lower estimations. On all continents, there remain new resources to be harnessed for the production of clean, hydro energy. Countries like Norway, Canada, and Brazil have all been utilizing more than 30% [32] of their hydro potential whereas India and China have lagged far behind.

It is important that the future arise of hydropower energy comes primarily from the worldwide trend toward deregulation of the power sector, which means that the development and ownership of new power stations has passed into the hands of the private investors whose commercial priorities tend to favor other forms of generation energy.

2.1.1 Types of hydro projects

For the purposes of the thesis, it is necessary to briefly summarize the main features of the different types of hydro project. Hydro can be classified as either [26]:

- Run–of–river
- Storage
- Pumped storage

Run–of–river

These projects fall naturally into two categories:

- Upland projects that use the natural fall of the river to create the necessary head, which is then commanded by tunnel, canal or surface conduit. These are typically high–head, low–flow schemes.
- Lowland projects that are sited at barrages on the more mature, lower reaches of rivers, where they rely solely upon the head created by the barrage. These are typically low–head, high–flow schemes.

Run–of–river schemes form the majority of privately funded hydropower projects currently under construction and in an advanced stage of planning. Most SHP projects are based and built in accordance with this type of classification.

Storage

Storage projects use a dam to provide all or part of the generating head. If there is a reasonably steep fall on the river downstream, the additional head will generally be commanded by tunneling. Where there is no natural head to command downstream, the powerhouse is located immediately below the dam, usually on the surface but sometimes underground or occasionally within the dam body itself.

There are relatively few privately financed storage schemes being developed at present. Compared to the run–of–river alternatives, the ratio is less than one to five.

Pumped storage

The benefits that pumped storage brings to a system are essentially the same as for conventional storage but with the added benefit that pumping constitutes an immediate on demand load that enhances the system operator's ability to run a thermal plant at maximum efficiency.

While there are a number of pumped–storage schemes owned by private utilities, and others are being planned. The main obstacle appears to be uncertainty over the value and pricing of the ancillary benefits.

2.1.2 Environmental impact of hydro energy

Hydro projects have the advantage of avoiding emissions of greenhouse gases (a topic to discussion) [29], SO_2 and particulates. Their social impacts, such as land transformation, displacement of people, and impacts on fauna, flora, sedimentation and water quality can be mitigated by taking appropriate steps early in the planning process. Whilst a question remains over the advantage of smaller hydro schemes over larger ones (owing to the former's greater total reservoir area requirement), it is believed that generally hydropower is competitive, when all factors are taken into account.

The environmental concerns in Brazil are tending to continue creating a negative image over hydro as a whole, although these are primarily triggered by projects with large storage reservoirs, not by SHP projects. Contrary to popular belief, there are some voices that storage and even small run-of-river hydroelectric power generation can also seriously damage the climate [1].

The green image of hydropower as a benign alternative to fossil fuels could be false. Hydroelectric dams produce significant amounts of carbon dioxide and methane, and in some cases could produce more of these greenhouse gases than power plants running on fossil fuels.

This is because large amounts of carbon tied up in trees and other plants are released when the reservoir is initially flooded and the plants rot. Then after this first pulse of decay, plant matter settling on the reservoir's bottom decomposes without oxygen, resulting in a build-up of dissolved methane. This is released into the atmosphere when water passes through the dam's turbines.

2.2 COMPARISON OF THERMAL AND HYDRO PROJECTS

In terms of the ability to raise finance to support a project there are marked distinctions between hydro and other forms of power generation. In making such a comparison it is easy to see why hydro has fallen out of favor since liberalization of the power sector because it is perceived to be capital intensive, slow to implement and risky. This trend is clearly demonstrated in the table:

Table 6: Thermal versus hydro - main differences

	Thermal	Hydro
Capital Cost ($/kilowatt)	400–1,400	800–3,000
Operating cost	high	low
Construction risk	low	high
Construction time	2–4 years	3–6 years
Project life	15–25 years	>50 years
Decommissioning costs	yes	unlikely
Site influence	low	high
Technology	changing	mature

Source: The World Bank - Power Project Finance —Experience in Developing Countries 1998 Author's annotation

Hydro can be characterized in the following way [22]:

- Very site-specific with no two projects being the same, and usually a number of possible ways of developing each site.
- The high percentage of civil works (typically 70 % by cost) means that it is difficult to accurately predict end costs.

- High construction risks due to the nature of the works, with extensive exposure to geological conditions, flooding, access problems, etc.
- Uncertain energy production and vulnerability to wider water management issues that can constrain the flow available for generation.
- High capital costs but low operating costs, and very long plant life
- Environmental costs clearly identified and fully internalized, in a way that is not the case for thermal plant.
- Extreme sensitivity on environmental and resettlement issues for reservoir schemes.

The most distinctive feature of hydro is there is no such thing as a standardized solution. The concept of standard frame sizes that dominates the development of thermal plants does not exist in hydro where the number of variable parameters introduced by the different characteristics of each site rule out any standardized solution.

This deterioration in the apparent attractiveness of hydropower is not as a result of any change in its underlying economics. Hydro still remains a sound long-term investment whose lifetime is almost indefinite compared with the 20 years life cycle of a typical thermal power station. Nevertheless, what have changed are the criteria by which projects are selected for development, with the emphasis now being on the ability to finance a project from private sources. In consequence, the bias has been toward low-cost thermal projects, particularly gas fired plants, which are relatively easy and risk free to construct, and whose limited life span comfortably matches the short tenor of most commercial lending.

Data shows that of the 239 privately financed power projects that reached financial closure over the period 1996–98 on the World, hydro accounted for only 7 % by capacity [26] , with the market being dominated by oil/gas (53 %) and coal (36 %). When only the larger projects that have been the subject of limited recourse financing are considered, the hydro element drops to 5 %, with thermal plants accounting for over 90 % by capacity, to hydropower detriment.

These low figures are strongly at variance with the present position hydro occupies in the world generating mix, where it accounts for about 20 % of installed capacity.

2.2.1 Brazilian national interests

The other issue to consider in analyzing the debate over different energy sources is related to the secondary economic effects of the respective investment structures. In terms of employment and job creation, thermoelectricity is less favorable to hydroelectric energy, especially in their construction phases. The number of employees per billion dollars of investment is less than 1000 for thermo power, while it reaches 5000 for hydroelectric plants in Brazil.

Very important fact is a support of Brazilian national economy, reduction of unemployment and over employment. About 20 % of a hydro project goes for equipment, most of which is produced in Brazil by multinational and national companies, while about 80 % is tied to civil construction, infrastructure, engineering and administrative costs. The state electric company and domestic private-sector companies control most of the latter expenditures. The result is a high degree of national participation, despite technological dependence, because of the equipment that is used.

The situation for thermal power is completely the reverse. Equipment expenditures account for 80 % of the investment costs, and the imported turbo-generator that is required to run the facility represents a high percentage of this value; consequently, the share of national components in the project is small.

It is unlikely that thermal plants will be replaced in bulk at the same rate by new, publicly financed hydro. Public sector hydro is declining and the balance of new generating plant being promoted by the private sector is perhaps forty to one in favor of thermal. If current trends continue, the role of hydro in global electricity production will inevitably decline.

2.3 COST PROFILE OF PRIVATE HYDROPOWER PROJECTS

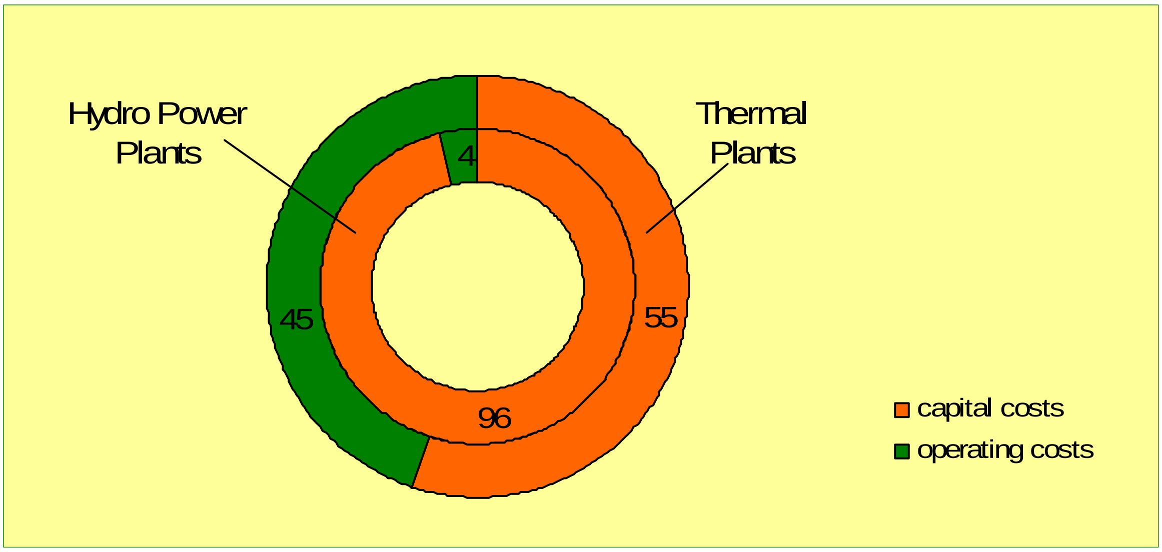
The key issues in the financing of private hydropower projects are ability to finance a project and affordability. The average construction costs of hydropower plants are between $ 1,100/kW (Latin America) and $ 1,400 - 1,800/kW (Africa, India, Turkey, Canada), with exceptions both of higher and lower construction costs. Although the operating costs of hydro are minimal and the project life almost infinite, there are multiple cost related factors that make hydro difficult to finance on a private basis, particularly when compared to equivalent thermal projects.

These include the following [26]:

- **High Capital Costs**

The specific cost of a hydropower station ($/kW) is typically 100 to 300 % more than a thermal power station [27], depending upon the site characteristics and the type of thermal plant.

Chart 5: Capital intensity - comparison



Source: PEREIRA, M. Power sector developments in Brazil 2005

This gap widens when private financiers require fixed price, because the contingency that has to be priced in for hydro is much higher than for thermal power projects. Furthermore, private development invariably implies higher equity returns and higher interest costs so that the capital-intensive nature of hydro is magnified relative to its thermal competitor. For thermal projects, capital charges may constitute less than half of the tariff.

- **High Front-End Costs**

All private projects have to internalize their front-end costs. These include transaction expenses for legal, financial and due diligence services; they also include engineering costs, technical and environmental consulting fees, environmental mitigation and the developer's own expenses. These soft costs are generally much higher for hydro than for thermal plants, because of the longer time that hydro takes to prepare for private financing and its greater complexity. As an indication, surveys among lately finished hydropower plants shows that on average the soft costs[1] for the candidate projects, including financing charges, were 45 % compared with 25 to 30 % for a typical thermal project.

- **Long Construction Period**

Most hydro projects of any size will take four to five years to construct. This is to be compared to less than two years for a gas fired power station, or three to four years for other types of thermal power station. The longer construction period increases the interest and equity returns during construction (considered above as a component of soft costs). However, the late start to the revenue stream also adds to the perception of project risk, and in turn increases the risk premium in the financing charges.

- **Limited Availability of Export Credit Financing (ECA)**

The high civil work content of most hydro schemes severely limits the availability of export credits. Generally, the ECA element will be no more than one

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[1] It includes interest over the longer construction period, more burdensome environmental impact assessment, project preparation requirements, and larger margins to cover the heavier project risks.

third of the direct project costs, which may be only 20 % of the total funding requirement. In contrast, the majority of the finance for thermal power stations is in the form of ECA credits. The low proportion of ECA funding for hydro not only increases the financing gap, but it also makes it more difficult to raise commercial funds, which are usually piggybacked onto ECA loans. Where commercial loans are available they are often expensive and of short tenor.

- **Mismatch of Loan Tenor and Asset Life**

For both thermal and hydropower projects the tenor of available ECA credits and commercial loans is considerably less than the asset life. For thermal projects, loans may extend for up to 12 years from the commissioning date, compared to an asset life of perhaps 20 years. The accelerated repayment required is reflected in higher initial tariffs than would be the case if the project were publicly financed. For hydropower projects, the effect is exacerbated, since loan tenors are the same while asset life is conventionally assumed to be 50 years or longer.

- **Peak and Baseload Plant**

Most hydro plants are intended to operate in the medium to upper range of the load curve, while many thermal IPPs are operated at high capacity factor near base load. In practice, this makes it misleading to compare energy costs without recognizing that the value of midrange and peak energy is usually significantly higher than base load generation. Tariff comparisons should always be based on the quality of the energy supplied.

2.4 ENERGETICS IN LATIN AMERICA

Latin America has been unique among regions because of its high reliance on hydropower in meeting electricity generation needs. All Central American countries except Nicaragua have a high share of hydropower in electricity generation. Special problems in this area are dry seasons with almost no precipitation from November to May and annual fluctuations of available water. This volatility is partly mastered by large storage plant reservoirs but small run-of-river hydro has no effect.

The countries of Latin America have also other varied energy resources, including oil (13 % of world's reserves), natural gas (5.4 %), coal (1.6 %), biomass and other renewable resources. The countries produce 4.4 % of the world's primary energy supply, 9.2 % of global crude oil production. Only hydropower provides an economic option for further power expansion. There is already installed 21% of the world's hydroelectricity power [11, 21].

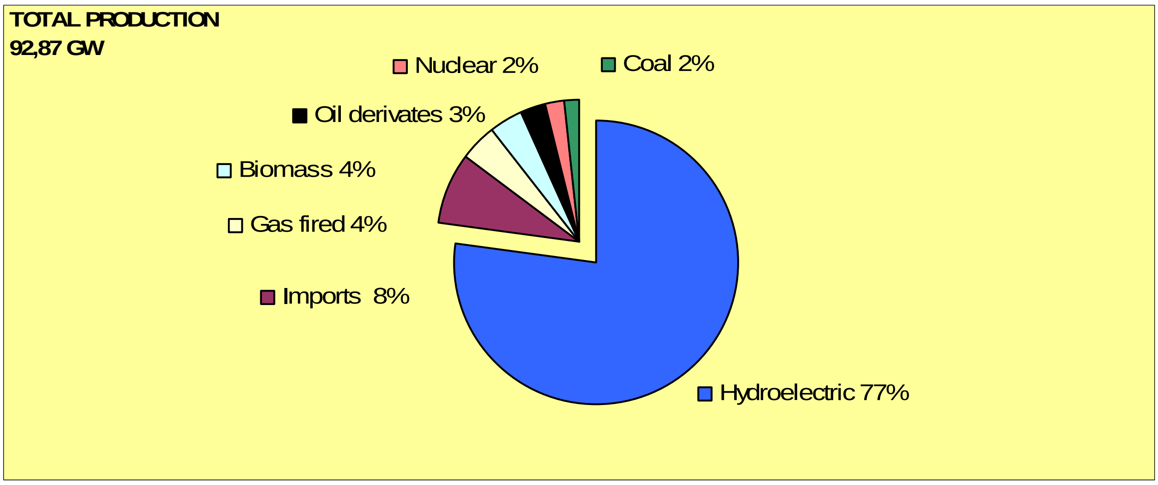
The bio fuels sector has also seen accelerated growth in the last few years with Brazil currently the world's second largest producer and largest exporter and consumer of ethanol from sugar cane. However, in some of the poorest Latin American countries between 30 and 40 % of the population still lacks access to modern electricity services [31]. Since 2005, the rise in oil prices has generated two different trends in Latin America: expanding surpluses in exporting countries and widening deficits in net oil importers, thereby degrading their terms of trade.

Therefore, the challenge faced by many countries in Latin America is that they must increase their energy generation and consumption to raise living standards, while at the same time creating a high quality financial, regulatory and policy environment to stimulate innovative technologies to produce clean energy.

2.5 BRAZIL'S ELECTRIC POWER SECTOR.

Brazilian electric system in 2005 holds a generating capacity of 92.87 GW (55 % of Latin America [15]), distributed in 1.479 facilities. Hydroelectricity is Brazil's second largest source of energy, providing 33 % of the nation's primary energy consumption [3]

Chart 6: Brazilian electricity generation



Source: OECD/IEA, 2006 - The energy situation in Brazil (2006)

The total capacity is likely to reach 100 GW by the end of 2008. Total energy production was 399 TWh in 2005. Hydroelectricity generated 340 TWh, equivalent to 77.1% of total electricity generation. The rest includes imports from Argentina and Paraguay (8.3%), almost 40 TWh, gas-fired generation (4.1%), biomass (3.9%), oil derivatives (2.8%), nuclear (2.2%), and coal (1.6%) [30]. Brazil does not export any electricity.

There are 337 plants up to 30 MW in operation and about 100 are bigger than 30 MW, from which 23 plants are larger than 1000 MW. More than 80% of Brazil's hydro capacity today is in plants that are 500 MW or larger. The Itaipu hydroelectric power plant, largest in operation in the world, is a binominal undertaking developed by Brazil and Paraguay on the Paraná River. The installed power of the plant is 12.600 MW with 18 generator units of 700 MW each [16].

Table 7: Distribution of hydropower plants by power range in Brazil

Power range (MW)	No. of Plants	Capacity (MW)	Power (%)
Up to 30	337	1,509	2.4 %
From 31 to 100	29	1,667	2.7 %
From 101 to 500	36	9,219	14.9 %
From 501 to 1,000	8	5,365	8.7 %
Above 1,000	23	44,260	71.4 %
Total	**433**	**62,020**	**100 %**

Source: ANA-Agência Nacional de Águas; The Evolution of water resources man. in Brazil - 2002

The Brazilian power sector is characterized by an overwhelming reliance on hydropower. There is a significant hydroelectric potential, which is slowly being harnessed as a source of energy. In years of normal precipitation, as it was already mentioned above, 77% of the country's electricity comes from a network of hydroelectric dam. In favorable hydrological years, the hydropower plants are able to supply the electricity demand without load support from conventional thermal power plants. In many years, the thermal power plants remain idle.

The increasing necessity of exploring water potentials distant from the consumption centers conducted to the creation of a national interlinked transmission system, which presently operates with around 81 thousand kilometers of transmission lines [4].

Conventional thermal generating sources provided only a small part of Brazil's electricity supply. Brazil has 7,000 MW of installed, natural gas-fired electricity generating capacity, providing around 4 % of Brazil's electricity supply. [25].

Brazil has also two nuclear power plants, the 630 MW Angra-1 and the 1,350 MW Angra-2. State-owned Electronuclear operates both plants. A third, 1,350 MW plant, Angra-3, remains partially constructed. Lacks of funds and political support have delayed completion, but the Brazilian government announced that it would have made an ultimate decision about the plant before the end of 2006. Unfortunately, there is still no decision about the completion at the beginning of 2007 [30].

2.5.1 Electricity supply and demand

The Brazilian electricity system is accounting for almost 40% of electricity consumption in Latin America [25] and Brazil is the largest energy consumer in South America and 10^{th} largest energy consumer in the world accounting for about 2.1% of the world's annual total energy consumption [25].

About 54 million consumers were responsible for 365 TWh in 2003 from which 320 TWh was produced by hydro plants [18]. Electric energy consumption in 2005 was 4.48% over 2004. Demand for electricity, is about 20% of the total demand for energy [1]. Almost 95% of Brazilian households have access to electricity. Lack of electricity is a rural problem mainly in the Amazon area. While total energy consumption is high for the region, Brazil's per capita energy consumption and energy intensity are comparable to the South American regional average.

The average annual percentage growth in electricity demand during 1990-2000 was 4.2%, dropping sharply by -6.2% in 2001 due to the power crisis caused by under average precipitation. It caused severe financial problems for electricity companies. Electricity demand growth during 2002-2003 was 5.4%, indicating a recuperation of economic activity after the economy crisis. Over the last two decades, power consumption has risen much faster than the Gross Domestic Product (GDP), which is the result of demographic growth concentrated in urban areas, efforts to increase power supply and the modernization of the economy. The electric-power market is experiencing growth approximately 4.5% per year.

Brazil is a developing country relying heavily on electricity, with a 1.6 income elasticity (meaning that a 5% annual GDP growth - a long-term possible trend - calls for a 5*1.6 = 8% increase of the electricity supply); higher than the 1.1 world average.

Consumption of electricity is not equally distributed along the country. The Southeast including Rio de Janeiro consumes 57% of the total electricity in Brazil—32% by São Paulo state alone. The industrial sector is the major consumer of electricity (54%) followed by the residential (26%) and commercial (16%) sectors. Public lighting is estimated to account for approximately 3% of total consumption [25].

2.6 HYDROPOWER IN BRAZIL

Hydropower has played a key role in the socioeconomic development of Brazil and has been a major and mature industry; it was responsible for more than 90% of the electricity generated in the country during the 1990s. Brazil is the world's second largest producer of hydropower, after Canada. The country has immense hydroelectric resources, namely three great river systems—the Amazon, the Parana, and the Sao Francisco

Hydro energy sector is considered one of the world's largest, competent and technically efficient. It is benefited by the country's geography, which presents topography intense in plateaus with big water availability, allowing the use of a powerful source of renewable energy at low cost. This situation provides comparative advantages in relation to other countries, dependent mostly upon thermoelectric generation. Brazil has 14% of the world's renewable fresh water [1]. It has made hydropower the overwhelming source of electricity in Brazil.

Table 8: The hydropower share in the Brazilian installed power capacity

1970	1980	1990	1998	2005
84% 8.7 GW	88% 27 GW	91% 44.9 GW	91% 56.0 GW	77% 72 GW

Source: Author's Annotation - Collected Data

The hydro boom in Brazil started between 1975, when installed capacity was only 18.5 GW, and 1985, when it reached 54 000 gigawatts [21]. Then dams construction became more difficult due to the economic downturn and debt crisis, and growing criticism of dams for their social and environmental impacts. However, hydropower is likely to account for a smaller percentage of that larger power pie: officials estimate that by 2008, hydropower will provide 75 % of national energy. Hydropower dominates electricity generation, and large hydropower dams dominate this sector.

The Amazon hydrological basin has the largest share of the total potential (40 %), followed by the Paraná (23 %). Much of this technical potential remains untapped, and despite uncertainties (e.g. possible climatic changes, increasing doubts about the potential economic contribution from the Amazon basin and the already overwhelming dependence on hydropower), hydropower will continue to be a major source of electricity generation in Brazil for decades to come.

2.6.1 Problems of Brazil's hydropower

Brazil’s heavy reliance on hydroelectricity has caused problems in the past, especially during years of below-average rainfall. In 2001, Brazil faced a critical electricity shortage due to insufficient rainfall and years of limited investment in the country's power sector.

Slowly growing generation capacity

During the 1990s, power demand, because of a growing economy and a rising standard of living, had been consistently outstripping increments in generation capacity. In 2000, electricity consumption was about 58 % higher than it was in 1990, while installed generation capacity grew about 32 % during the same period. Analysts had long predicted that this demand growth, if not supported by capacity growth, had the potential to lead to shortages.

Long transmission

Another problem with hydropower is its concentration in the north of the country, far from the main consumption areas (approximately 44%, is located in the Amazon hydrological basin, and 10%, is located in the Northeast region). Long distances involve high transmission costs as well as high losses. Since most of the economically feasible hydropower resources closer to the main consumption areas have already been exploited, any major new scheme could have significant environmental implications and additional costs for transmission infrastructure expansion.

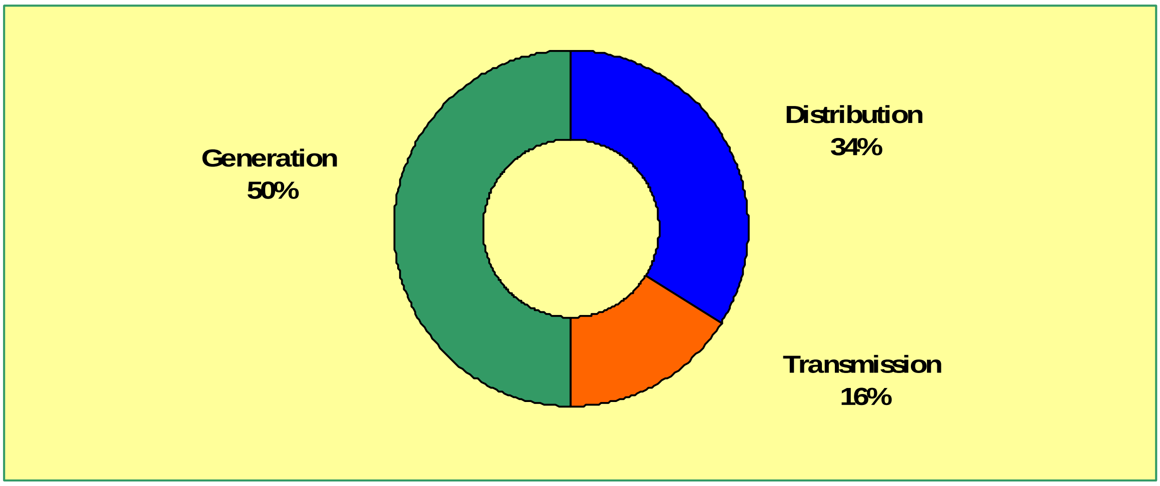
Projects inefficiency

Amazonia is generally flat, which means large areas need to be flooded for each hydropower plant. The best sites can provide reasonable power density, for example, the 4245 MW Tucuruí dam with 1.48 W/m2 (2.91 W/m^2 in the future) [25]. However, there are examples of extreme inefficiency; for instance, for the 250 MW Balbina Dam, near Manaus, 2346 km^2 were flooded, giving a power density of 0.10 W/m^2. The average world's hydropower plants power density is 2.95W/m^2 but the number has been improving last years because of better technology and growing environmental consciousness.

2.6.2 Brazil's hydropower future

Brazil has the largest hydropower development programme of the Latin American countries with more then 15 new major capacity additions, totaling 9.75 GW, under construction, and nearly 5 GW at the planning stage. It is estimated that Brazil will need $6 billion / year in investment to deliver the projected annual generating capacity growth of 3 %, which means about 3.1 GW [32]. However, this estimations could dramatically change in case of new legislation is implemented.

Chart 7: Sector Investments - Share of individual expenditures



Source: Pereira, M. *Power Sector Developments in Brazil*, Stamford 2005

New power auctions in 2006 offered new hydro generation concessions, but those plants are not likely to be online before 2010. According to the planning studies by the Ministry of Energy and Mines more than 60 hydro projects will be implemented between now and 2010, with capacities of more than 30 MW each. Belo Monte, with a planned capacity of 11,182MW on the Xingu River in the Amazon region, will be one of the largest hydro plants in the world. In 2003, Brazil had over 7 GW of hydro capacity under construction, including a major (4.12 GW) extension of capacity at Tucuruí and two additional 700 MW units at Itaipú [22].

However, Brazil plans to increase the percentage of its energy derived from natural gas. Currently, natural gas sources provide 3 % of the country's energy, but are expected to compose 21 % of Brazil's consumption by 2020. Logically, it has some consequences to hydropower. It will not develop as rapidly, and thus decline in its percentage share of the market. Brazil's ten-year expansion plan (1994 - 2004) demonstrated an annual growth of 4.9 % from 1999 to 2004, where the projected per capita consumption in 2004 reached 1950 kWh annually [31].

Table 9: Long-Term Evolution of Available Generation Capacity

2005	2010	2015	2020	2025
72 GW	82,9 GW	110,4 GW	123,8 GW	152,6 GW

Source: WB - Hydro and Thermal Power Sector Study 1997

3 Private financing of hydropower

3.1 EVOLUTION OF ENERGY SECTOR PRIVATE FINANCING

The basic question is whether private or public ownership is better. Private ownership is often recommended because it allows a better allocation of capital, at least in economic books. Nevertheless, there is no dogmatic answer. Public ownership may be preferred for large investments because of easier funding such big projects. Otherwise, more transparent financing connected with higher efficiency and bigger flexibility speaks for private financing and private ownership of new hydro dams. Forms of cooperation between public and private sector are being created for connection of the advantages from both sectors.

In the same way, the international comparison of the performance of public-owned or private-owned utilities say little about the benefits of ownership because the national circumstances play a much bigger role than ownership, be it the availability of cheap coal in South Africa, of cheap nuclear power in France or of cheap hydro in Canada.

These are the most significant advantages of private financing [26]:

- Public ownership brings economies of scale and lower financing costs
- Private ownership brings better governance rules and competition

In the last century the production and provision of electric power in most countries was the responsibility of the public sector. In either situation, the funding of new projects was based on the financial strength of the utility or the creditworthiness of the government. The trend of power industry deregulation at the end of 20th century was a fundamental shift in the way projects are financed.

Private sector projects are generally financed as stand-alone entities through special purpose companies called Independent Power Producers (IPPs) created specifically for the purpose of developing, owning and operating the project. Whereas thermal power projects are generally BOO (Build, Own and Operate) most hydropower schemes are eventually transferred back to the state or the utility, and the concession is therefore granted on a BOT (Build, Own, Transfer) arrangement. The financing of private power projects is generally through sponsor's equity and debt raised on a non-recourse basis on the strength of the revenue stream and securities provided by the project itself. Lenders have little or no recourse to the underlying balance sheet on the project promoter if things go wrong. Under such arrangements, financiers naturally take a close interest in the robustness of the project, particularly when (like hydro) it involves uncertain output and high construction risks. Typical debt / equity ratio for hydro projects 70 % / 30 % in the region of Latin America [28].

For thermal power, the traditional source of debt has been the export credit agencies. However, for the typical hydro project ECA credits are unlikely to account for more than 30% of total project cost. With equity accounting for perhaps another 30%, this leaves 40% of the overall project cost including financing to be sourced from a development bank or by commercial loan.

3.1.1 Public-Private Partnerships

Many types of hydro project are proving to be difficult or even almost impossible to finance entirely in the private sector, and yet traditional sources of public funding are no longer available. The solution to this problem may well be a combination of public and private funding, with the public sector providing in effect the minimum needed to bring the private financiers to the table. This can be achieved in a number of ways, by either:

a) **Hybrid Projects** where the project is effectively divided into separately financed public and private elements. An example is when a dam is being publicly financed under concession terms and the private concessionaire is financing the powerhouse. Another example is the retrofitting of a powerhouse by the private sector, to an existing publicly owned dam.

b) **Lease-Purchase Arrangements** under which public money is injected into the project in the form of lease-purchase payments during the construction phase to reduce the amount of private funding required. This has the effect of reducing the amount of private finance needed (and overall cost of the project) making it affordable.

Under both of these arrangements, ownership and effective control of the project remains in the hands of the public sector utility. To date there is little actual experience of implementing projects under these arrangements.

The trend has been toward the funding of individual projects on a limited recourse basis where the lender relies on debt servicing on the revenue stream of the project in question, with little or no security being provided by the sponsoring organizations. Under such conditions, it is inevitable that financiers become much more closely concerned about the viability of the project itself, rather than the strength of the sponsors to whom they would have little recourse if things go wrong.

The past has been dominated by projects financed in the public sector, usually under concession arrangements. The future will be driven by private finance, and projects will have to stand on their individual merits in a world that is geared toward quick commercial returns. However, it is evident that in the future the public sector must continue to play an important role in the development of all but the smallest hydropower projects.

Otherwise, small hydropower projects often have additional features that make them less profitable and thus more difficult to finance than larger projects.

Several of the cost components involved in developing hydropower do not change proportionally with project size. For a large project, the feasibility study normally accounts for 1 – 2 % of total costs, while for a small project it may well amount to 50 % of the cost [14].

3.2 KEY PLAYERS

The parties involved vary, depending on how the project is financed and on dimension of a project. In most cases, a project involves several parties.

Sponsor

The sponsor is the government agency or utility that is promoting a project. A private company that requires power may be the sponsor, but it may not want to build or own the plant. For large hydropower projects, the sponsor will normally be the national government or a government agency that wishes to improve the power supply situation and to control the development of the power sector. For small hydropower projects the role of the sponsor is often less important.

Developer

The developer is the most important participant in the development project. They must secure the necessary permissions for the development, sign contracts with consultants, contractors and equipment suppliers, arrange a power purchase contract and secure the necessary financial resources.

Lenders

Normally a bank or other investment institution will provide the majority of the financial resources needed, often in the order of 60 - 80 %. The lenders may be agencies established for the specific purpose of facilitating investment, e.g. the World Bank. They will provide financing at more favorable terms than can be obtained on the private market. Private agencies such as commercial banks and insurance companies can also provide funding for hydro projects.

Investors

In most projects, bank loans will provide some proportion of the financial resources required. However, the last 20 – 30 % of the financing, the equity capital, must be provided from other sources.

Possible investors:

a) Power utilities that wish to influence or control the electricity supply in an area.
b) Industrial companies that wish to have access to power production utilities.
c) Local industry or local government agencies that provide venture capital to promote electrification in their area.
d) Financial institutions that are interested in long-term investments.

Power purchaser

A power purchaser will normally be a national or regional power utility or distribution company. It is also possible that the power will be sold directly to an end user, or to a power broker. The agreement between the developer and the user is spelled out in detail in the Power Purchase Agreement (PPA). It describes the amount of power to be supplied, prices and the price regulation agreement, and penalty clauses that come into effect if the conditions are not fulfilled. The PPA is extremely important for project development. It is the lenders' main security that the project will be able to pay its debts.

3.3 FINANCING OPTIONS IN HYDROPOWER SECTOR

As was already mentioned before, there are more forms of financing of hydropower sector. It comes in one of the three distinct forms:

- Refinancing of existing hydro assets through sale or securitization
- Upgrading or rehabilitation of existing schemes
- Construction of new "greenfield" projects.

While the first two categories are clearly important, they nevertheless represent a limited market that can have no significant impact on the overall global generating energy mix. Therefore, the thesis focuses on the problem of attracting private investment to new projects. However, for completeness all three options are reviewed below.

3.3.1 Refinancing of Existing Assets (privatization)

In general, a completed hydro scheme represents a very durable, low risk asset that is not particularly demanding in terms of either operation or maintenance. Refinancing is a mechanism for releasing the investment locked into these projects through either the sale of equity or a leasing arrangement, or by using the revenue stream for raising debt on the capital market. The approach is equally applicable in both the public and private sectors.

Different approaches have been adopted to the privatization of existing hydropower assets, ranging from their outright sale to the granting of a concession without any transfer of ownership. In some cases an hybrid formula has been adopted, for example in Argentina and Brazil, where the concessionaire owns the powerhouse but rents the dam and water conduits from the state, which imposes operating rules for the reservoir and thereby retains control over the multipurpose aspects of the project.

3.3.2 Upgrading and Rehabilitation

The capital-intensive nature of hydro projects, combined with their long lifetime and relative robustness, has reached another category of investment opportunities in existing projects that have simply been underinvested through either neglect or lack of resources, and require further funding for rehabilitation and upgrading to bring them to full production.

This market is attracting the attention of private investors because it is more easily financed than greenfield projects, as expenditure is mainly on equipment and it generates an earlier cash flow stream. A further advantage is that it usually avoids major civil construction risk. On the other hand, there are issues relating to the assumption of responsibility for the existing works by the incoming concessionaire, and for this reason, he may seek to ring fence his liabilities, leaving gaps that are difficult to cover.

3.3.3 Greenfield Developments

As already indicated, the number of successful closures on new start private hydro projects has been disappointingly low, but there is evidence that the level of activity is increasing as developers seek to diversify toward renewable energy sources. New hydro is difficult to finance because it has an unfavorable risk profile, long payback periods and an unusually high proportion of local costs that are not eligible for export credits. The extent to which these factors concern potential investors is demonstrated in a recent survey of investor attitudes to new hydro projects. According to a survey conducted by The World Bank, the main reasons given for reluctance to invest to new hydropower plants are:

- substantial completion risk
- delayed revenue earning leading to the projects being "earnings dilutive"
- the mismatch between tenor of loans available and the revenue stream
- concerns over environmental opposition.

3.4 HYDRO AND THERMAL REGULATORY ISSUES AND CONCESSION ARRANGEMENTS

Private hydro poses a number of specific regulatory issues that arise from the fact that hydro energy entails the exploitation of unique natural resources that would generally be regarded as the property of the state and it often needs significant public sector involvement to ensure that projects are commercially viable and consistent with wider development objectives. Unlike thermal power projects, which can be built and operated essentially in isolation, an individual hydro scheme has to be seen in the broader context of the river basin where there may be multiple water uses and other hydropower projects to be considered.

The award of any concession is complicated by the lack of project definition in the early stages. Where concessions are invariably based on the sale of energy to the host utility the public sector has a role in determining the acceptability of the proposed tariff, but this can be a difficult area if the project is not sufficiently defined to be accurately evaluated at the time of concession award. Under such circumstances, the finalization of the tariff tends to be delayed until after the concessionaire has completed his project studies, or in some cases the project itself, which raises concerns over transparency.

Tariff structure is important. For thermal IPP's, revenue is generated approximately equally between Capacity Charges, which effectively cover the capital investment and other fixed costs, and Energy Charges, which cover fuel and marginal operating costs. If this approach were applied to hydro, the tariff would consist almost exclusively of Capacity Charges. In practice, this is seldom the case, and most hydro tariffs to date have been based heavily on Energy Charges. The relative costs of peak and base load energy are often ignored and in general the premium value of peaking energy and the ancillary benefits that hydro provides, particularly from storage schemes, are being overlooked in off take contracts because in the public sector such services were simply available. However, this may change as the deregulated industry learns to cope with patterns of load flow and plant operation that increasingly stress transmission systems because hydro projects that formerly provided reserves now tend to be operated to maximize "real power" revenues.

3.5 TREND IN THE PRIVATE HYDRO MARKET

Certain trends are becoming apparent. These are not only dictated by the perception of developers, but also by the attitudes of the organizations that provide the funding and guarantees upon which the financing of private projects is dependent. In particular, there is a significant growth trend toward run−of−river projects. While this might in part be influenced by the perception that dams present a greater completion risk than tunnels (not necessarily true), it is undoubtedly primarily driven by the wish to avoid the delays, costs and adverse publicity associated with the perceived negative environmental impact of large reservoirs.

There has been a negative attitude toward large hydro projects on environmental grounds, often without regard to the difference between run−of−river and storage schemes. The trend toward smaller, run−of−river hydro projects is an understandable response by the private sector to ease the already difficult problem of attracting private finance to greenfield projects, but it is not necessarily conducive to maximizing the benefits of hydropower.

4 Analysis of Brazilian hydroelectricity sector with focus on small hydro power plants potential

This chapter will demonstrate an opportunity and chances for potential private investors on the Brazilian hydropower market.

Private financing of infrastructure projects in Brazil has grown substantially during the 1990's after major privatization, especially in the electricity sector. While private financing has been notable in thermal power development, the universe of successfully financed private hydropower projects has so far been very limited due to their capital intensity, complex risk profiles and administrative matters. It is likely that a framework for private financing of thermal power projects may fall short of addressing all the challenges of private hydropower development.

In Brazil, in a simplified way, both private and government-owned companies operate in generation, transmission, and distribution of electricity. Eletrobras, which is controlled by the federal government, and three other state-owned companies account for one-half of generation capacity, while more than two-thirds of the distributors are privately owned. The transmission grid is run by a group of producers, transmission and distribution companies, and the government through the Ministry of Mines and Energy.

In recent years until 2001, there has been insufficient investment in the electricity sector and the future role of hydro powering as the aftermath of the Bolivian gas crisis 2006 - 2007 is uncertain for the time being. Hydroelectricity could regain its already lost glory. Electricity demand is expected to grow at the pace of 4 % - 5 % per year until 2012 (depends on real GDP results), despite the reductions following the rationing programme implemented in response to the power crisis in 2001. The tight relationship between GDP growth and electricity growth highlights the importance of having enough capacity available on time. The average investment over 1990-2002 was 2 GW / year (about 2.5% per year of the installed capacity) whereas a minimum of twice that figure would have been needed to sustain GDP growth. This large discrepancy between the potential needs and what was actually invested is at the root of the 2001 crisis. Reservoirs were progressively depleted, leaving no flexibility in case of reduced rainfalls

Accordingly, Brazil's power margin between capacity and average demand began to decline in 2004, and the trend is expected to accelerate in the coming years. The country's power margin fell from estimated 12% in 2005 to 6% in 2006. Brazil is suffering from a lack of investment in infrastructure as a result of recent regulatory changes and inadequate price signals and needs increase private sector investments in electricity sector.

4.1 ELECTRICITY AND POLITICS

The government of newly reelected President Luis Inacio Lula da Silva faces difficult choices in forging a successful, long-term energy policy. There is no question that state-sponsored intervention in national energy businesses benefits many segments of the population and can be used as a tool of social policy. However, such intervention potentially creates a significant strain on the national treasury. The more governments force their state industry to provide fuel supplies or electricity at prices below international market levels, the more likely it will put long-term strain on the national treasury. In addition, such indirect subsidies can prompt other industrial investment that is uneconomic and requires additional support to be competitive for sustained operation. These conditions are not good news for private investors.

The energy sector has the potential to be productive for the overall economy. However, in Brazil, downstream energy businesses can become a significant drain on national budgets, depending on product pricing policies. When consumer prices are based on market levels and the infrastructure is modern and well maintained, it is possible to obtain a return on capital in the 10 % to 15 % range. However, if consumption is subsidized, equipment inefficient, and infrastructure poor, then the potential losses can be significant, with product subsidies taking up a substantial portion of the national budget.

Inefficient domestic industries, surviving only by the use of domestically subsidized energy supplies, subtract value from such natural resources. Sector development growth that features heavily subsidized prices will have definitive consequences for investment, efficiency, and long-term profitability of the energy sector. Use of market prices and standards will show both consumers and investors a different set of incentives for investments and use, with consequent changes in the value added to crude oil and natural gas. Low prices, by contrast, can distort demand by leading to investments that are uneconomic in the long run, by discouraging the efficient use of energy, or by creating lost opportunity cost for domestic crude oil and gas production that might have been sold at international prices but instead was utilized to produce domestic products.

The electoral mandate of the president Lula government showed a clear preference for a slow down in the energy sector reform process. But the his decision could leave the country exposed to another serious crisis by failing to address several critical issues facing the country's energy sector in the coming decades. This energy policy dilemma mirrors that of many large energy-importing countries. Expensive government intervention in the energy sector can stimulate the economy and help redistribute income inside society. However, it can also become a burden, preventing a country from reaping efficiency gains needed to compete internationally.

Perhaps the most significant feature of the Brazilian energy picture today is the fact that state energy giant Petrobras was only partially privatized and was left with a dominant position in key areas of the country's energy economy. This uncertain situation of partial reform has discouraged private sector investment, calling into question whether the Brazilian government will be able to finance the expansions that will be needed in the energy sector to sustain strong economic growth in the years to come.

4.2 POWER SECTOR ORGANIZATION

The Brazilian government began to restructure the electricity sector in the mid-1990s, with the creation of a new regulatory agency, ANEEL. The government also established a national transmission grid operator, National System Operator (ONS), and a wholesale power market.

The Brazilian Power Sector is a complex system, and is not responsible to take energy as a commodity. Same state infringement is distinguishable. Privatization and deregulation can not be in contradiction with the global goals of energy sustainability and control of the greenhouse gas emission. There must remain state supervision. The reason is the tendency to private investments in thermoelectricity instead of hydro that is renewable.

These are the main players of Brazilian power sector:

Ministry of Mines and Energy (MME)

MME is responsible for energy policy implementation, power sector expansion, policies concession and regulation formulation.

Power National Agency (ANEEL)

ANEEL was created by the Ministry of mines and energy in December 1996 as the regulatory authority. The Agency was established as part of a state reform process to perform the role of the regulatory and inspection body in the electric energy sector. Its responsibilities include price regulation surveillance and competitive behavior, technical regulation and standards, distribution, transmission and generation of electricity and awarding concessions.

Although it is not involved in operational activities, it is responsible for overseeing the market to ensure correct operation. ANEEL also develops government electricity policy. ANEEL's stated mission is "to provide favorable conditions for the electric energy market to develop in an environment of balance among industry players and to benefit society." [5]

Power Sector Regulations - Pool (PRS)

The competition in the electric industry has been introduced in 1998 by departing from the rate of return pricing philosophy to a market-based price. In this approach, an auction mechanism at the generation side seems to be the best alternative to accomplish such goal. Then, the electric energy is seen as a commodity that is traded in the cash and futures market. This system was known as wholesale energy market.

This system was replaced by a pool of consumer power distribution concessionaires, who are forced to purchase new generation capacity in order to meet the forecasted market growth. This new "principle of force" is a good step for generators but reduce autonomy of distribution companies. However, this market restriction could lead in favor of renewable hydro energy.

The New system contemplates:

- obligation to buy and sell all new generation capacity
- registration of bilateral contracts
- rules for commercialization, accountancy and settlement
- financial warranty related to the amounts marketed
- mediation of subjects among the members
- contract of independent auditing to do inspections

- rules for the treatment of the hydrological risks

National System Operator (ONS)

ONS was created in 1998 with the aim of operating the Interconnected National System (SIN - Sistema Interligado Nacional) and of managing the transmission system. The ONS is a non-profit privately owned entity controlled by the power producers. It follows rules and guidelines established by its members and ratified by ANEEL.

It is responsible for the co-ordination and control of bulk power generation, transmission installations in the interconnected electric system, reliability, safety and global optimization. Its objective is to optimize power generated on hydropower generation in five independent river basins, each run by a different company.

Energy Policy National Council (CAPE)

CAPE is responsible for energy policy formulation according to other public policies

Director of the National Dep. Of Waters and Electrical Energy (DNAEE)

DNAEE is a regulatory organ of the conceding authority, using his prerogatives and taking into account the necessity of reviewing, updating and consolidating the provisions relating to the General Conditions of Supplying Electrical Energy. The DNAEE will be responsible for assessing the request and sending it to the Ministry of Mines and Energy, which will decide on the implementation of rationing.

Energy Research Enterprise (EPE)

EPE is responsible for planning and developing studies under MME coordination. It elaborates studies for the generation and transmission expansion plans involving both short and long term, identifies the potential of energy resources, and implements the Energy information national system. It also develops feasibility and environmental studies for power plants.

Electric Power Trade Board (CCEE) -

CCEE is responsible for administration of all the contracts in the regulated contracting environment accounting and settlement of contract differences.

Power System Monitoring Committee (CMSE)

CMSE is responsible for identifying deviations from the planning or the supplying risk criteria allowing corrective actions in order to mitigate deviation effects.

Generation, Transmission and Distribution companies

There are also many generation, transmission and distribution companies, both public and private:

- Generation - 11 companies (15 % private by energy produced)

  Generation companies are holding a concession or permit for the exploration of electric energy generation public services.

- Transmission 26 companies (17 % private by energy transmitted)

  Transmission companies are holding a concession for the exploration of electric energy transmission public services.

- Distribution 64 companies (80 % private by energy consumed)

  Distribution companies are holding a concession for the exploration of public services of electric energy distribution.

Privatization of the state-owned generating assets stalled. State-owned Electrobras is the largest generating company in Brazil, controlling over half of total installed capacity. Other state-owned companies control most of the remaining capacity. The largest private generating company is Tractebel Energia with its 900 employees. It is responsible for almost 8 % of generated electricity.

The company has an installed capacity of 5,860MW in 7 hydroelectric and 6 thermoelectric power plants.

Transmission companies are the owners of transmission lines and transformer equipment (voltage alteration), transporting large amounts of energy between the centrals and the points close to the large consumption centers. Although private capital participation is possible, state owned companies control the largest part of the system. National transmission grid consists of two large grids (one in the north, one in the southeast) and numerous smaller systems in isolated regions. In total, Brazil's high voltage (greater than 230kV) distribution network contains some 64,000 kilometers of transmission lines.

While state-owned companies still control most generating and transmission assets, distribution is largely in private hands. Distributors are the owners of transmission lines and transformer equipment delivering energy to final consumers. Approximately 75% of the companies in this segment are private. 70 % of the generated capacity is sold though distribution companies and their regulated auctions. They are carried out every year and are valid for contractual period. The main criterion for contracting in auctions is the smallest tariff ($/MHz). The rest 30 % is sold though direct negotiation between generation company and a big customer (metallurgy, steelworks, car industry etc.). New capacity contracting run on regulated auctions every year as well. It is traded 20 years ahead to allow auction winners enough time to build plants and to have project finance. The main facts are summarized in the table:

Table 11: The new electric power industry structure in Brazil

Segment	Situation	Regulation
Generation	Competition	Deregulation
Transmission	Natural Monopoly	Regulation
Distribution	Natural Monopoly	Regulation
Trading	Competition	Deregulation

Source: WADE - National Survey of Decentralized Energy, 2003/2004

4.3 NEW ELECTRICITY SECTOR MODEL

A new model for the electricity sector, which should solve the unsatisfactory situation, was approved by Brazilian Congress in March 2004, which creates a "pool" on the electricity market. It aims to match electricity demand and supply capacity through long-term contracts, which will replace on a competitive basis the "initial contracts" inherited from the 1990s before privatization of the distribution segment took place. Generation companies may sell to either the free or the regulated market, or to both; those that wish to sell to the free market must pay a fee to the regulated market pool.

Demand in the regulated market comes from captive consumers while demand in the free market comes from large consumers that decided to leave the regulated market already. The free market is relatively small as yet but there is a strong movement of potentially free consumers towards the free market. Distribution companies and free consumers are required to contract up to 100% of their 5 years future demand. Distribution companies must supply their consumers with power procured in public auctions conducted by ANEEL. These projections are submitted to the new created Energy Planning Agency (EPE).

Potentially free consumers have to produce a previous warning to their distribution company before moving into the free market, in order to avoid the risk of a surplus of power among distribution companies. These projections are submitted to the new created Energy Planning Agency (EPE).

The price ceiling for new hydro projects in the first power auction based on the new model, which took place on December 16, 2005 – almost two years after the new model was approved by Congress – was set at US$ 50.4 per MWh. New hydro generation plants were awarded contracts with an average price US$49.9 per MWh depending on the year, while thermal generation was granted average prices about 15 % higher. Power auctions in 2006 offered new hydro generation concessions, also for small hydropower plants, but those plants are not likely to be finished by 2010.

To be pragmatic just from the beginning of this analysis, there are still monopoly elements. Electricity is not a pure commodity because of the security of supply imperative; competition is difficult to implement in a system dominated by large hydro power plants, the system needs central coordination. The growing trend toward lower risk and more profitable thermal power plants and a some decline of market share in hydropower development are a result of difficulty in attracting private financing to hydropower schemes.

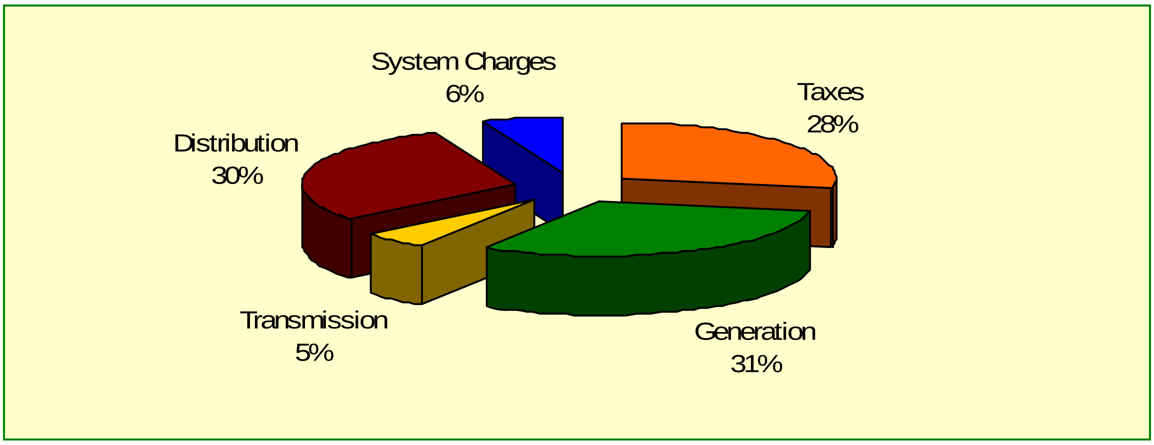
4.3.1 Newest course of events

The year 2006 was distinguished by a significant advance in the consolidation of a new regulatory landmark for the sector. Two auctions were held for the sale of energy, one for the already existing energy and the other for new energy, which is expected to be delivered from 2008 to 2010, in accordance with the dates forecasted for the completion of plants. In addition to guaranteeing the investments that will ensure confidence in the supply of energy necessary for the country's development, such auctions promoted a dispute, won by those that offered a lower price, allowing a low-priced tariff for consumers.

Power tariffs and prices

Before Brazilian power sector reform, tariffs were well below the opportunity cost of new power. Fearful that high prices would lead to gross inflation (risk in Brazil after the hyperinflation of the 1980s), reformers used initial contracts that progressively released the low-cost existing power to be sold at its opportunity cost. Moreover, transmission tariffs were fixed well below their opportunity costs. The effect of this policy has been a continuous increase in the average tariff for consumers

Chart 8:TariffStructure



Source: ANEEL [5] - 2005

Power prices are definitely a part of politics in Brazil. While expenditures for one electricity unit are clear, the total price of the unit on the market is different.

Table 10: Electricity Prices 2005 (US$/MWh)

Industrial	Residential - households	Average
120.40	140.60	130.50

Source: Eletrobrás Boletim de Tarifa 2005 – Tariff Bulletin 2005

Power tariffs in Brazil are generally low, lower than could be on totally deregulated market. Partly because there is over capacity of electricity at least until 2008 as a consequence of energy rationing after energy crisis in 2001 and partly because electricity prices were used as a tool of social policy. Moreover, it reflects the historical reliance on cheap hydropower that was built by the state sector and is largely amortized.

4.4 SMALL HYDROPOWER PLANTS (SHP)

When we consider the huge existing potential of SHP in Brazil, their total number is small. The unsatisfactory share less than 1 % of total produced energy can be related to the high generation cost of these sources when compared to large hydropower and thermo power. Furthermore promoting SHP still has faced the challenge of the country's huge hydropower potential.

We start with a definition of small hydropower plants (SHP). However, there is no international consensus on the definition of small hydropower. In China, it can refer to capacities of up to 25 MW and in Sweden small means up to 1.5 MW. However, a capacity of up to 10 MW total is becoming the generally accepted norm by many associations and commissions connected with small hydro powers [12], but not in Brazil. The Law 9648 from 1998, change the concept of SHP, raised the limit from the previous level of 10 MW to 30 MW of installed capacity. The law settles that the hydropower stations needs to have the area of the reservoir limited to 3 km^2, to be called SHP.

Most small hydropower plants are of the run-of-river configuration generally and therefore do not incorporate water storage reservoirs. This minimizes costs and environmental impacts associated with flooding.

SHP's require a simple license, which can be granted for a length of time that allows reasonable repayment of the investment, up to a maximum of 35 years. Table 13 gives one system for classification of hydropower plants in Brazil.

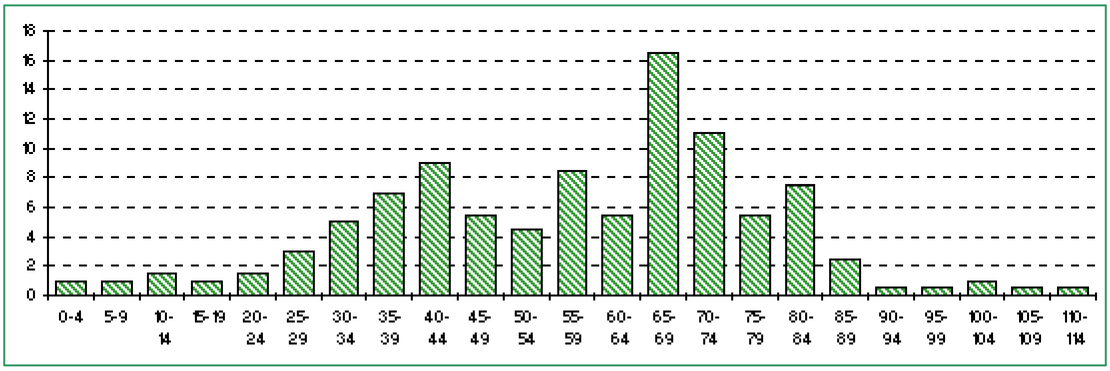
Table 12: Hydropower plant classification by capacity

Category	Installed Capacity (kW)
Micro	up to 100
Mini	100 to 1,000
Small	1,000 to 30,000

Source: USAID Programmes: Leader, Brazil Clean Energy and Energy Efficiency - 2002

Until the fifties Small Hydropower Plants were important generation options, as shown by figure, which summarizes the range of installations by age. The primary role of SHP built over the last decades has been in the electrification of isolated areas. Currently there are 331 plants in operation with an installed capacity of 902.1 MW [28]. Between 1998 and 2002, 82 plants with a total capacity of 1,323 MW, were approved. Therefore, there is an assumption that share of small hydro power will be increasing.

Chart 9: Distribution of Brazilian SHP's by Age



Source: World Commission on Dams - The Evolution of Small Hydropower Plants in Brazil 2000

Under centralized energy planning, implemented through regional and state utilities SHP gradually ceded to large-scale projects. The situation seems to be changing with privatization and new regulations making the planning of generation expansion flexible [28].

Despite the investment incentives and the large number of permits issued under electricity law (3.9 GW from 1998 to March 2004), the building of additional capacity has remained very limited in recent years. However, it is expected that a number of new plants will be constructed within the scope of the first phase of PROINFA (analyzed later in the text). Altogether, the potential for small-scale hydropower plants is quantified at 7 to 14 GW throughout Brazil. It is estimated that 700 MW alone can be developed by expanding and improving existing plants and reactivating dormant power stations. Promotion of small hydropower plants by various incentives have been used to stimulate the construction of new small hydropower plants in recent years: [30]

- At most 50% of the normal tariffs are to be paid for electricity transmission and distribution, whereby a discount of as much as 100% has granted for small hydropower plants.
- Exemption from compensation payments for flooded areas and from tax payments for water use.

- Consumers with a demand of 500 kW or more (or 50 kW for isolated supply) can negotiate agreements freely.

On a global scale, the relation between small hydropower plants and large hydropower was 1:20 in 1995. For the year 2010, this relation is expected to be 1:18.

Table 13: Ratio between small and large-scale hydropower generation

	1995	2010
Europe	1:10	1:11,5
Asia	1:7	1:10
Latin America	1:132	1:100

Source: Http://www.europa.eu.int/comm/energy_transport/atlas/htmlu/hydfpot2.html

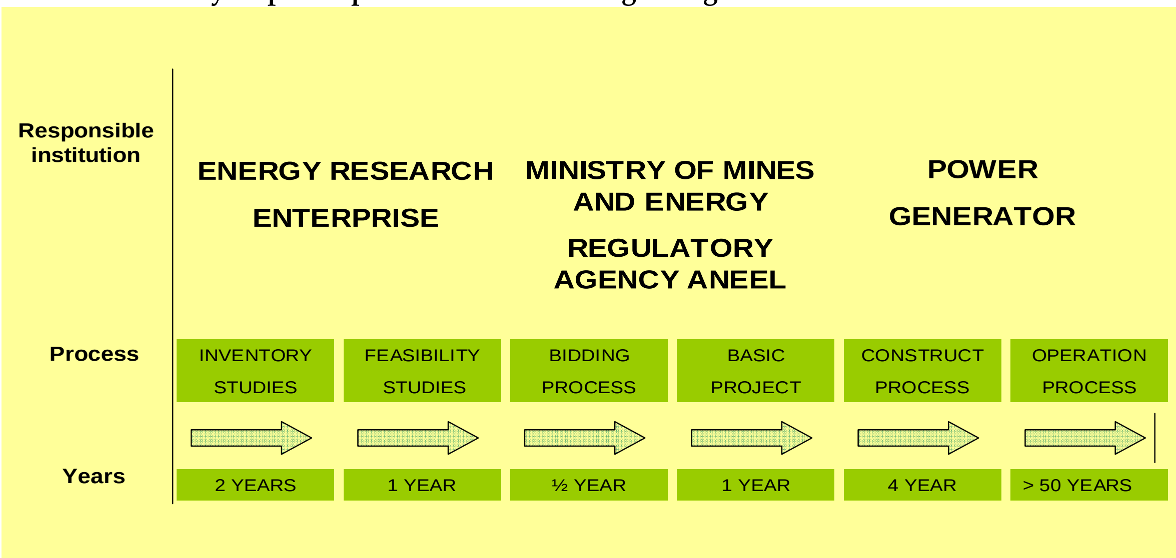
An investment in a small hydropower scheme incurs costs as well as earns income over the life of the project. The costs include a fixed component - the capital cost, insurance, taxes other than the income taxes, rates etc. and a variable component operation and maintenance expenses, salaries, income tax etc.

In Brazil dominated by big hydropower projects today, the future will bring an increased market penetration of small hydropower. The role played by private suppliers in generation is still negligible on total power generation in Brazil and with few exceptions; they consist of small hydropower units in particular. The projects are built usually with BNDES funding.

4.5 SMALL HYDROPOWER PLANT IMPLEMENTATION

In Brazil, when an investor makes a decision to create small hydropower facility, there is a typical procedure similar to the chart below:

Chart 10: Small hydropower procedure from the beginning



Source: PEREIRA, M. - Power Sector Developments in Brazil 2005, Author's annotation

4.5.1 Inventory and Feasibility studies

The process of creating a new hydro power plant starts with looking for a suitable location. It should accomplish these fundamental requirements:

- proximity of main transmission grids and places of consumption
- satisfactory construct conditions (infrastructure, environmentally valueless surroundings)
- sufficient hydro conditions (water flow)

These issues examine Energy Research Enterprise, which identifies the energy resources potential and conducts inventory and feasibility studies afterward. The environmental impact study (EIA) is a necessary and most exacting part of inventory studies. Private investor can not choose a place arbitrarily. This period lasts up to 3 years. If a place is found inopportune, a potential project is rejected and the process starts again.

4.5.2 Bidding process

If all inventory and feasibility studies confirm suitability of a place, the half-year bidding process starts. Ministry of Mines and Energy and ANEEL are responsible for this procedure. The Brazilian government offers a place under beforehand known conditions and waits for the best bidding price or the tendered site will be awarded to the bid with the highest Ranking Criterion. The criterion is calculated according to the formula where minimum future generation capacity and minimum upfront fee are calculated.

Bidder

It could be all domestic and foreign legal entities as well as joint ventures and consortiums of such entities may participate in the public competition. It is necessary for foreign investor to have a representation in Brazil. A Bidder can participate in the tendering procedure for any site, but only with separate offers. Foreign bidders submit audit report from a renowned audit institution registered for audits. The audit report shall contain information on the overall economic situation of the bidder in the last year. The audit reports have to be positive.

Concession Period

The Water Concession is granted by ANEEL for a period of 25 - 35 years on as build-operate (BO) basis beginning on the day of first delivery of electricity, which may not be later than three years after the day of signature of the Concession Agreement. The Concessionaire has the right to apply for an extension of the Concession Period.

Purchase of Electrical Energy and Applicable Tariffs

The Market Operator is purchasing the electrical energy produced from the small hydropower plants. ?The tariffs are the Feed in tariffs published with the decision of the Energy Regulatory commission. The buying up energy tariffs are known before the construction itself. The price is lowering with bigger amount of electricity.

Obligations of Concessionaires

The Concessionaire is required to fulfill the following obligations:

- Preparation of a project documentation for the small hydro power plants
- Provision of all necessary rights and licenses for construction and operation of the hydro power plant according to the legislation of Brazil.
- Construction of the power plant and all necessary auxiliary systems according to the project documentation.
- Management, operation and maintenance of the power plant and the auxiliary systems during the Concession Period
- Transfer of ownership of all objects of the small hydro power plants and the land of their location after the expiration of the concession period.

4.6 REGULATORY FRAMEWORK

The Brazilian government realized the stability of a regulatory framework is crucial for attracting the investors and creating a competitive environment. Nowadays the regulatory framework is not barrier for private investors anymore. Author still could find some administrative obstacles but the newest modification of the law framework is a good base for potential investors.

4.6.1 Historical Regulatory Framework Development

From 1971 to 1993, tariffs were set by the Federal Government in a manner that gave the publicly owned state utilities little incentive to reduce costs or increase efficiency. By the early 1990s the power sector was virtually bankrupt, and faced with a load growth of 7 % a year the government had little alternative but to embark on a major reform of the industry.

The restructuring process began in March 1993 with the passing of Law 8631 aimed at restructuring the power sector to encourage the resumption of investment. Under this Law, the concept of a common tariff was dropped and each utility was entitled to charge on the basis of "full cost recovery plus a reasonable return on investment. Subsequently Decree 915 from September 1993 allows private sector participation in the generation of electricity, either for auto production[1] or for the sale of energy to the utility. The state has left private generators to establish their own off take contracts where they can. Such contracts will often not be a sufficient basis for securing the necessary debt. This was the first time in The Brazilian power sector history when private investors were allowed to participate.

In 1993, Decree 1009 created a national transmission system, SINTREL, incorporating the principle of freedom of access to any supplier or off taker irrespective of location, on payment of a wheeling charge. Thereafter it became possible for suppliers and consumers to enter into off take contracts without regard to location.

In 1995, the "Concession Law" (No. 8987) established the principle that private parties may supply public services, and set out the conditions. The most important changes for concession authority of this law are shown below:

- To regulate the granted service and to investigate it permanently
- To intervene in the installment of the service and to extinguish the concession
- To ratify the readjusts and to accomplish the revision of the tariffs
- To take care for the good quality of the service
- To motivate the competitiveness
- To stimulate the formation of consumers’ associations

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[1] It means making electricity for own needs. It's a case of big consumers of energy.(e.g. steel or engineering industry)

Law n. 9427 of December 26, 1996 creates the regulatory agency (ANEEL). It is a special autarchy, with own juridical personality and totally independent from the government.

In parallel, the "Independent Power Producers" Law (No. 9074) set out the terms under which IPP concessions are awarded through a public bidding process for a maximum of 35 years. In 1997, restrictions were lifted on the participation of foreign companies. The process of reform continues with the Decree 2003, which is aimed at providing more transparency in the regulatory and tariff setting processes for independent power producers and auto producers. Law n. 9648 of May 27, 1998 and Decree n. 2655 of July 2, 1998, which create the wholesale energy market (MAE) and the independent system operator (ONS).

Over the last years a number of decrees have continue been enacted to establish the exact role and powers of the new power sector regulator, ANEEL, which oversees the operation of the "newly" created wholesale energy market. In the Law 9648 from 1998 were created the following main incentives for plants up to 30 MW, which can be classified as SHP:

- can sell energy directly to any consumers with load over 500 kW
- can use the transmission and distribution system with discount of at least 50% in the transmission and distribution charges
- Can use special funds to produce energy in isolated systems, mainly in the north of Brazil.

4.6.2 Newest changes

In July 2003, Ministry of Mining and Energy issued a proposal for a new regulatory framework. After some months of discussion and interaction between companies (public and private) and Brazilian government was approved the new model in 2004 through the Laws 10.847 (creation of Energy Research enterprise - EPE) and 10.848 (on power trade at the wholesale energy market) Through

Decrees 5.175 and 5.184 were created The Power System Monitoring Committee and Energy Research Enterprise.

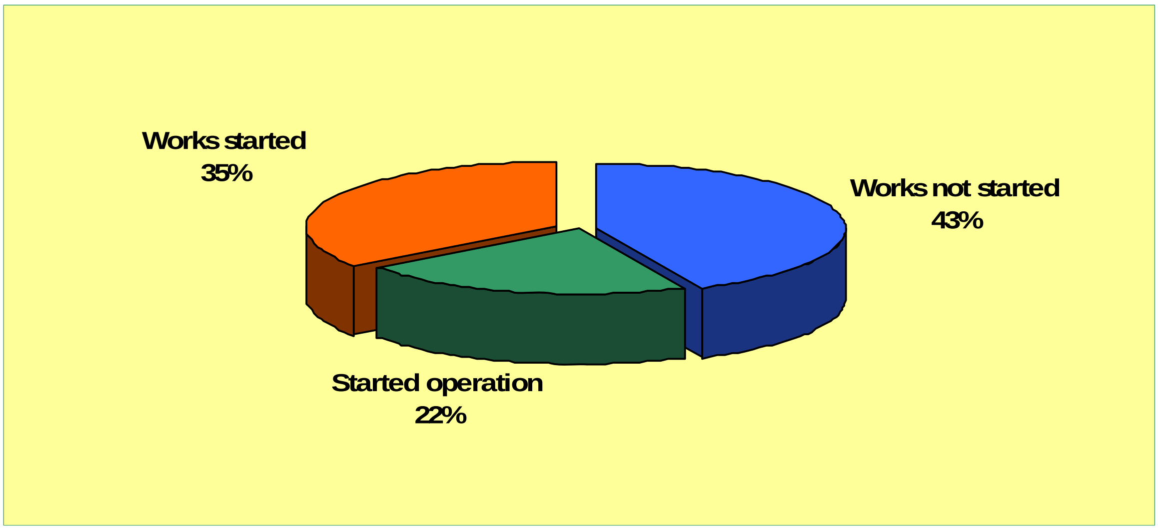
These are the main new points in the new regulatory framework:

- Distribution companies must purchase 100% of their energy through centralized auctions
- Market for generators were segmented between existing energy and new energy
- New concessions for hydro plants will be awarded in a lowest tariff scheme with long term standard PPA and Previous environmental license issued
- Concessions already awarded in the previous auction scheme (Highest yearly installments - UBP) might be compensated in the auctions

4.7 CONCESSION ARRANGEMENTS

The procedure of awarding a hydro concession is regulated by ANEEL and hinges around the granting of a license to develop the site.

Chart 11: State of 12 MW of concession awarded since 1997



Source: IAEA *Brazil: A country profile for sustainable development - 2006*

It is not linked in any way to the energy sales arrangements that are a private matter between the developer and the off taker who can be either one of the utilities or an individual consumer (subject to a minimum of 3 MW for hydro projects above 30 MW, and 500 kW for small producers).

Concessions are awarded to distribution companies based on public auctions. Distributors have a prior right to supply consumers in their own supply territory, but large-scale consumers can also enter into contracts with other suppliers. The procedure for granting the license depends upon the size of the project.

Projects above 30 MW

For projects above 30 MW a competitive bidding process is required. It is initiated by a private company undertaking the feasibility study at its own cost. ANEEL then publicly solicits offers from other developers, and after a prequalification process, the feasibility study is made available to them. All qualified parties, including the original proponent, are then given four months in which to prepare bids for the site. The winner is the one that offers the highest premium, in the form of an annual payment, for the right to develop the site. In the event of the original proponent not securing the concession, he is repaid the cost of the feasibility study by the winner.

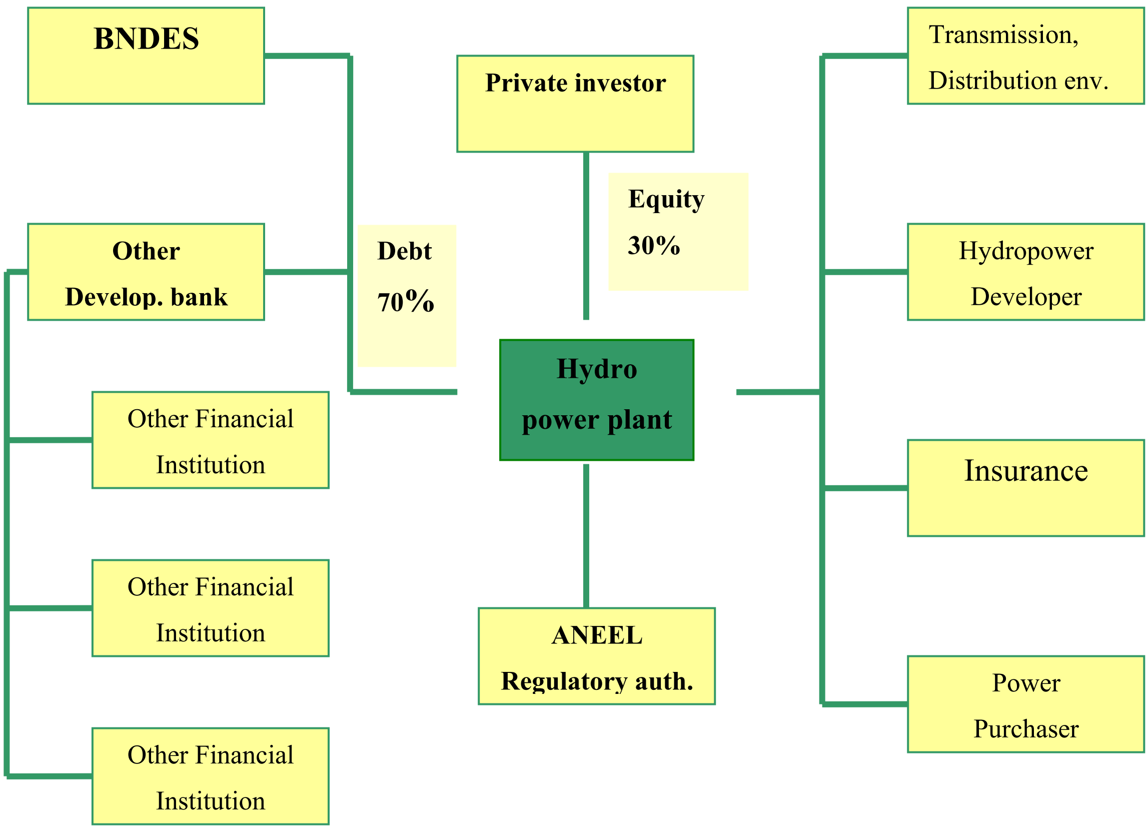
Projects below 30 MW

For small projects, the concession can be authorized without competitive bidding on the basis of a feasibility study undertaken by the proponent and approved by ANEEL. If two or more companies are competing for the same site the position is unclear, but in the interests of creating competition, ANEEL is likely to favor the company with least participation in the market. Site licenses are granted for periods of 30 to 35 years, after which they are renewable by agreement with ANEEL. There is no provision for the transfer of the project back to the state.

4.8 DEBT FINANCING OF HYDROPOWER PLANTS IN BRAZIL

The difficulty of accessing long-term finance is a serious problem. The tenor is important because short-term debt results in very high tariffs in the early years, making it difficult for hydro to compete with thermal plant. Debt typically provided three-quarter of the project costs, and it was raised in the form of direct lending and guarantees from a number of sources. There are shown some possible financing on the following chart of a new hydropower plant scheme.

Chart 14: Typical hydropower financing structure in Brazil



Source: Author's Annotations

Multilateral Development Bank (MDB)

The most important in Brazil is The Brazilian Development Bank, from a distance also The World Bank and The Inter American Development Bank. These public institutions have played an important role in the provision of debt financing projects. Almost each of Brazilians hydropower plants were financed with cooperation with these banks. The other increasingly important aspect of MDB participation is guarantees and insurance facilities. Loan tenors are broadly in line with those of the ECA's.

Export Credit Agency (ECA)

They provide both direct loans and guarantees in support of bank lending under terms regulated by OECD and administered by the appropriate government agencies. This is an accessible form of credit used for power projects in general, but restricted in the volume of support it can provide for hydro schemes because of their relatively low export content. Under new OECD guidelines for private power projects, Export Credit Agency repayments can be extended up to 14 years with a flexible profile. With its relatively low equipment, content hydro offers only limited scope for export credit financing. Generally, the ECA element will be below 30 % of project cost, with equity providing perhaps another 30 %. This leaves still a large financing gap. In Brazil the scope for ECA financing is therefore reduced.

Cofinancing

Cofinancing through bilateral funds is generally in the form of soft loans to the project company, or grants to the government to cover related social and environmental costs. This is a relatively minor source of financing but, like multilateral funds, it is important as a catalyst for mobilizing other sources of debt. In certain economies, government agencies and local public funds, for example from development banks such as BNDES, play an important role.

Commercial banks

In Brazilian market, commercial debt is severely limited in volume, and short maturities for hydro projects make it unattractive. Debt denominated in Brazilian currency carries very high interest rates. Uncovered commercial debt plays only a limited role in the financing of a project, and is likely to remain a secondary source of funding because of its short tenor, relatively high cost and limitations on availability.

- Bond issues

They are widely used in other countries but there has not been registered this type of financing for hydro schemes in Brazil.

There are risks we have to take into account. One of them is Foreign Exchange Exposure. In all of the hydro projects there was virtually no only locally sourced debt, with nearly all of the financing being from international sources in foreign currency. The dangers of this approach have been illustrated recently in a number of Asian countries and can be possible future problem of Brazil as well. Serious devaluation of the local currency has resulted in a situation where neither the utility nor the government are able to maintain foreign exchange payments. By contrast, IPP[1] projects in some countries were generally sourced from local capital markets in local currency, and were not therefore subject to the same pressures.

The other potential problem is the fact that when all debt-servicing obligations have been completed hydro becomes disproportionately cheap, to the point where no other form of generation can compete. In Brazil, this was posing a problem because low-cost energy from existing hydropower schemes was distorting tariff structures and inhibiting the development of new generating facilities. The challenge in financing hydro projects is therefore to achieve some balance between their tendency to be uncompetitive in the short term and over competitive in the longer term.

[1] IPP - Independent power producers

4.9 SUPPORT OF THE BRAZILIAN PUBLIC SECTOR

The public sector support has been always crucial to the financing and administrative of all of the hydro projects, even where public funds have not been directly involved (not many cases). The most obvious support has been the provision of guarantees by the Brazilian government, particularly in respect of payment obligations of the utility, and the provision of funding and guarantees by the MDBs. A significant role has also been played by the ECAs.

In most cases, the projects would have failed without public support. The projects in Brazil would almost certainly not have been financed without the strong involvement of BNDES or IADB.

4.9.1 Brazilian Development Bank

The Brazilian Development Bank is a fully owned federal government company. It is associated to the Ministry of Development, Industry and Foreign Trade. Its objective is a long term financing of endeavors (not only energy sector) that contribute towards the development of the country. It helps private investors to finance up to 70 % of all debt service.

BNDES has been playing an important role in financing expansion and modernization of the electric sector from fifties, but especially after privatization after 1990, allowing the execution of projects that need a long-term maturation and high volume of investments (match to hydro projects perfectly).

During the year 2005, new electric energy generating units financed by BNDES started operations, adding 1.802 MW of installed capacity to the country. These approved financings enabled energy investments of US$ 3.956 million.

Energy operations in generation and transmission segment in 2005

SHP – Financings to 29 projects for small hydroelectric power stations, in the ambit of PROINFA renewable incentive programme. The generating installed capacity reaches additional 763 MW.

In 2005, BNDES approved financing to five new transmission lines, which are already operating, and aggregated 1,222 kilometers to the Brazilian transmission network.

Financial programmes of BNDES suitable for SHP

The financial support lines and the BNDES programmes serve the needs of investments of generation companies of any size, established in the country. The partnership with financial institutions, with agencies established around the country, allows the dissemination of credit, enabling greater access to the BNDES's resources. BNDES uses typical banking criteria for the concession of financing, and it follows the legislation, norms and resolutions that regulate public financial institutions. When a company is controlled by another company or belongs to an economic group, the size classification is granted considering the consolidated gross revenues.

BNDES has been the largest single source of funds in many cases, in the form of debt. To date their guarantee programmes have not been widely used, possibly because they are still relatively new instruments. In addition, the programmes such as those of the World Bank require the counter guarantee of the host government, which relatively creditworthy countries are often not willing to give to private developers.

Involvement of the government could have many forms:

- Participation as an equity holder
- Provision of loans through public financial institutions or the utility, or directly by the government. These have sometimes been funded by

concessionary loans from external agencies. It is the Brazilian model usually used for hydropower.

- Buyout obligations entered into by the government.
- The assumption of hydrological risk through the provision of funds.

There is no specialized fund oriented to small hydro power at this time. But there are some industrial programmes that could be used for this type of endeavor. Renewable oriented programme PROINFA created by Brazilian government supports new hydro, wind and biomass resources.

4.9.2 PROINFA - Programme for renewable resources promoting

The programmeme was introduced with Law 10.438 of 26 April 2002. In two phases, this law provides for the purchase of electricity from plant operators that use renewable energy sources and supply the electricity generated to the interconnected grid. The main objective of this programme is to provide incentives to renewable energy in Brazil, contributing to the development of clean technologies and the improvement of the quality of the environment. The main advantage of PROINFA is to establish incentives to make renewable energy economically competitive in the Brazilian electric sector.

Usually, power projects are financed by the state-owned bank, BNDES. For PROINFA, BNDES finances up to 70% in 10 years, first installment in 6 months after operation start-up. National Development Bank BNDES provides low-interest credits for PROINFA projects on the basis of hydropower.

The following interest rates are applied:

- BNDES direct, TJLP[1] + 3,5% p.a.
- indirectly, through a private bank: TJLP + 2% p.a. + administration fees charged by financial agent.

In the first phase up to the end of 2006, 1,100 MW each of small hydroelectric power systems started operation and supply electricity to the interconnected grid at defined price rates that have been agreed with Eletrobrás (US$ 60 per MWh) for a period of 20 years. The prices determined by the Ministry of Energy must satisfy certain minimum rates that are oriented to the average electricity tariffs for final consumers at least 70% for small hydroelectric power.

In the second phase scheduled to start after the target of 3,300 MW is reached, further projects are to be realised in order to ensure that renewable energies (not including large-scale hydropower) account for a share of 10% of annual electricity demand within a period of twenty years. At least 15% of the annual growth in electricity generation should originate from these sources. The purchase prices, also guaranteed for 20 years by Eletrobrás, are to be oriented to the production costs of new hydropower plants with more than 30 MW. Operators are also be ranted a right to compensation for additional costs up o a remuneration rate fixed by the government outside the electricity purchase agreements.

With the implementation of the PROINFA, Brazil has become the leading market for renewable energies in Latin America. Investors could apply to the end of 2006 but the second phase of the programme is still running. First results confirmed that PROINFA met its commitment to increase the share of renewable energy in Brazilian energy matrix.

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[1] TJLP is the official long term interest rate, equivalent to Libor. Presently, it is 7.5 %

4.10 BRAZILIAN ENVIRONMENTAL LEGISLATION

The Brazilian Environmental Legislation for hydro projects is enforced since 1986 after the publication of the resolutions issued by the Brazilian Environmental Council (CONAMA) . Environmental impact study (EIA) and Report of impact on environment (RIMA) are necessary documents to build and operate a hydropower plant. There was created even stronger regulation of environmental area after the promulgation of the new Brazilian Constitution in 1988. This constitution is the only one in the world that has an entire chapter dedicated to environmental issues.

The Ministry of the Environment and Water Resources is responsible for the coordination of the National Environmental Policy at the federal level. CONAMA is a consulting and deliberating body responsible for defining general environmental regulations and basic criteria and guidelines to implement the Policy, such as environmental and emission standards for ambient quality and pollutants, respectively, and also the general requirements for environmental licensing and for the environmental impact assessment process. The Brazilian Institute for Environment and Renewable Resources (IBAMA) is the federal agency responsible for executing and enforcing the environmental regulations and standards and the environmental permit in the cases defined by law.

IBAMA, the federal environmental authority organism that regulates and controls the environmental licensing process has to issue three permits or licenses for the implementation of big engineering projects as stated in the CONAMA's Resolution. A private investor needs these three licenses to develop and operate small hydropower plant:

The first permit is **the Previous License**, linked to the inventory and viability studies phase, which is issued upon the approval by the environmental authority, of the Environmental Impact Assessment Studies, EIA and Environmental Impact Report, RIMA and the accomplishment of Public Hearings.

The second permit, the one that allows the beginning of construction work at the job site, is the **Installation License**, linked to the design phase, and is issued upon approval by the environmental authority of the Environmental Basic Project, PBA.

The third permit, the one that allows the beginning of operation of the project, is the **Operation License**, linked to the end of the construction phase. It is issued by the environmental authority after a field inspection of the implementation of the environmental plans and programmes foreseen in the Environmental Basic Project.

4.11 GUILMAN–AMORIN PROJECT - AUTOPRODUCTION

Guilman–Amorin hydropower plant have their origins in Decree 915 of September 1993, which was enacted against a background of growing concern on the part of heavy energy consumers regarding the future reliability and cost of energy from the grid. The decree allowed auto producers to form consortia to construct schemes for the supply of their own needs, with any surplus energy going to the utility.

At the time, there were a number of large, publicly financed hydropower projects on which work had simply stopped because of lack of funds. The position on Guilman–Amorin was different—a large steel manufacturer and an iron ore producer entered the project at the beginning without any prior public involvement other than the original studies. In this respect, it is Brazil's first power project sponsored entirely by the private sector. Under the terms of the concession awarded in January 1995, the sponsors have the right to generate energy for their own consumption for 30 years. Additional output is offered to the utility CEMIG[1] on a first refusal basis. CEMIG operates the plant and guarantee a continuous supply of power to meet the sponsor's requirements irrespective of local hydrological conditions.

Concessions for the project were granted by DNAEE, the then regulatory agency under the Ministry of Mines and Energy, which has now been replaced by autonomous Federal Regulatory Agency ANEEL.

4.12 FUTURE PROSPECTS OF SHP IN BRAZIL

The thesis shows the actual situation of SHP projects in Brazil – in Brazil there is around 1.000 MW of studies under development. The proposed contribution of large dams to supply expansion over the period of the plan remains significant.

This view is reinforced by table below, which summarizes the projected expansion of central station generating capacity by type over three periods of the decade.

Table 15: Sources of Expansion of Generation Capacity (estimation) in GW

	1999-2000	2001-04	2005-08	Total
Expansion of large dams	0	3.7	1.9	5.5
New > 500 MW	2.7	4.4	4.8	11.9
New 30-500 MW	0.5	4.5	5.3	10.3
New < 30 MW	0.2	0.3	0.2	0.7
Hydro total	***3.4***	***12.9***	***10.9***	***27.1***

Source: World Commission on Dams - The Future of Large Dams in Latin America 2000

[1] Companhia Energetica de Minas Gerais - CEMIG is one of the largest and most important electric energy utilities in Brazil

The hydro profile is also projected to change significantly. More than 80 % of Brazil's hydro capacity today is in plants that are 500 MW or larger. New dams capacity expansion with plants below 500 MW is greater than with larger plants. What happens with plants of less than 500 MW will thus weigh significantly on the overall growth of hydro and starting to be evident SHP's are starting to play a significant role in the process of energy generation.

Private involvement in the Brazilian energy sector is becoming increasingly important as public funding diminishes. In spite of their environmental advantages, hydropower projects will have to compete for financing on the same terms as other projects, both in public budgets and in the private market. Obtaining finance for small hydropower projects is hard. Small hydro projects face an additional obstacle. Because the investment involved is relatively small, limited recourse project financing is not feasible. The financing situation for small hydro projects may be improved in several ways:

- By government incentives (loans, grants)
- By reducing the risk to the developer and the financier (government guarantees, high quality stream flow data)
- By reducing the development cost (joint development of several projects in an area, hydropower development groups, stepwise development)

Deregulation and privatization of the Brazil electricity sector has been itself part of a wider move toward reducing dependence on the state subsidies and leave private sector invest to power plants facilities. There was much debate about the merits of retaining hydro entirely in the public sector, although in fact Brazil's government considered a range of options that fell between this and full privatization. The great example of this is Guilman - Amorin project described previously. However, contemporary Brazil's government does not support continuing of deregulation and privatization of remaining state-owned companies and is discouraging other private companies from energy sector entrance.

Small projects are likely to continue to be built without much public sector support, but the evidence suggests that continued public support in one form or another will be needed for the medium and larger projects, where much of the global hydro potential exists. BNDES has been playing effective role in financing all this kind of projects.

The BNDES championed the changes that have taken place in the Brazilian power sector over the last decade. Their traditional role of direct lending to the public sector is diminishing and being replaced by a role as facilitator, encouraging private sector investment, particularly in the more difficult areas, as hydro generating electricity definitely is.

Hydro plays a diminishing role in the production of the Brazil's electricity To overcome this trend, Brazilian government, BNDES and the private sector itself will need to work more closely to coordinate their efforts. In conclusion, there is a high potential for further development of small hydropower in Brazil. Small hydro is seen to present a serious alternative to large hydropower projects, which are subject to a complex tendering process and lengthy environmental permitting

5 Conclusions

The demand for water and energy on a global scale is forecasted to increase constantly by tens percents in the near future with accelerating economies and growing population. Brazil is facing fast growing population. However, the economic growth does not show any vertiginous height.

A main deliverable of the thesis is a detailed guide for potential private investors how to penetrate Brazilian bureaucracy and how to get into specific conditions of Latin American country. It reflects Brazilian business culture, informs potential investors about its specifics, and recommends specific ways how to address it. The Brazilian energy model is replicable to other Latin American countries as well.

On the previous pages, historical and future hydro potentials in Brazil were described and analyzed. The findings of the thesis suggest the need for longer-term financing to better suit hydropower characteristics; a helpful regulatory framework and realistic public-private risk sharing arrangements and the careful preparation of projects by the public sector to enable their formulation for development as a private concession. The reality in Brazil is not excellent but the right development is evident.

Author has made following main findings:

- Economic aspects of conditions for private investors are insufficient.
- There are appropriate conditions for small hydropower development in Brazil (exclude economic factor).
- Brazilian energy sector is deregulated but an access to the market is still limited by unfinished privatization.
- Regulatory framework and concession arrangements are prepared for private investors entrance.

- Contemporary political and economic environment do not incline much in favor of private capital in energetics.

Author concludes that there are acceptable conditions for small hydropower plants in Brazil. The electricity sector is in a phase of privatization and deregulation and is open for potential investors. However, the incentives are still low and therefore there are still better opportunities for small private investors in other sectors. Despite detailed economic analysis is not a part of the thesis, accessible data does not show any wide-ranging opportunities for private sector. There is an opposite situation in case of auto producers. If a company create and consume the energy for own needs, it helps to secure the production and hence the investment offers more security and stability to a company.

The electricity prices are generated on the basis of supply and demand in the special regulated "pool". However, the prices are deformed by very cheap energy from huge state owned power dams and therefore it is very hard to compete for small hydro electricity producers. It is a Brazilian way to influence prices on the market.

The power market is regulated by codified regulatory agency, which has strictly divided rights and duties in relation to the market. And because small hydropower projects do not get around financing problems, BNDES through special programmes, as PROINFA, support financing up to ¾ of the total expenditures. Brazil's government, with help of these steps, attracts private investors to share risks and profits on the electricity market.

Large dams had big support lately in Brazil. However, the situation is changing and small hydropower projects have better conditions and possibilities formed by new legal framework and better attitude to this type of projects. There are expectations for the continuing development of small-scale hydropower. They could be used not only as an isolated power source for remote areas that are far from power grids but also as an efficient way of doing business in the future. The biggest disadvantage is evident. Small hydropower plants create also small amount of energy. Therefore, small projects can not substitute activity in large hydropower. They could only supplement the electricity network.

The growing trend towards lower risk, easier to construct thermal power plants and a decline in hydropower development is a result of difficulty in attracting private financing to hydropower schemes and as a result of shortages in public infrastructure financing. The uncovered significant weakness of hydropower is a process of adding new generation capacity. The procedure is very complex and difficult, because the substantial building impact on environment.

Despite these circumstances, small hydro plants have sufficiently encouraging future and it is obvious that evolution of generating devices will follow an example from developed countries. Furthermore, applying the Kyoto mechanism to hydropower will be assumed to facilitate hydropower development in developing countries. The question is whether this incentive will be sufficient for hydro development in a short term.

Ten years ago, it was almost impossible to establish a new hydropower plant in Brazil with private financing support, but economic crisis and energy crisis afterwards in 2001 gave Brazilians the right impulse to simplify the process from easier financing possibilities (BNDES), less bureaucracy, better regulatory framework to comprehensible concession arrangements. Even environmental law, so strict in developed countries, is surmountable problem.

Today, at the beginning of 2007, all developing and developed countries incline to sustainable energy development. For some of them, as for Brazil, it is easier and more common because of good environmental conditions for creating "green" energy. It could be said that Brazil is "green" despite it ever really wanted to be. It only uses accessible sources as every country does. The stir created by many ecological organizations for "green" energy would assumably lead to higher use of hydro energy around the world. However, today's world does not incline much in favor of hydro energy, even in Brazil where many thermal plants are built to diversify sources.

The hypothesis of the Brazil's and Czech's electricity system and market dissimilarity stayed unchanged. The thesis confirmed there are significant differences and material for comparison was very limited. The comparison is not aim of the thesis and the theory of partial similarity was not confirmed.

During data collections, I have analyzed several historical statistics with some future forecast. They were all overestimated, if higher results were desirable and vice versa. I also had to address typical problems with different data on same categories from different "reliable" sources. Author always tried to choose more reliable source but it was a hard decision making processes on some issues.

It would be incorrect to stand only in favor of hydro energy unless more profound knowledge of other generating electricity systems, but all the collected data lead to conviction that hydro potential is still not depleted and has bright future in some forms as small scale hydropower plants.

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Appendix

Appendix A: Glossary of energy related terms

Appendix B: Storage hydro power scheme

Appendix C: Main agents in the Brazilian electricity sector

Appendix D: Hydroelectric related charts

Appendix E: Developed and potential sources of hydro energy in the World

Appendix F: Location of Small Hydro Power Plants in Brazil

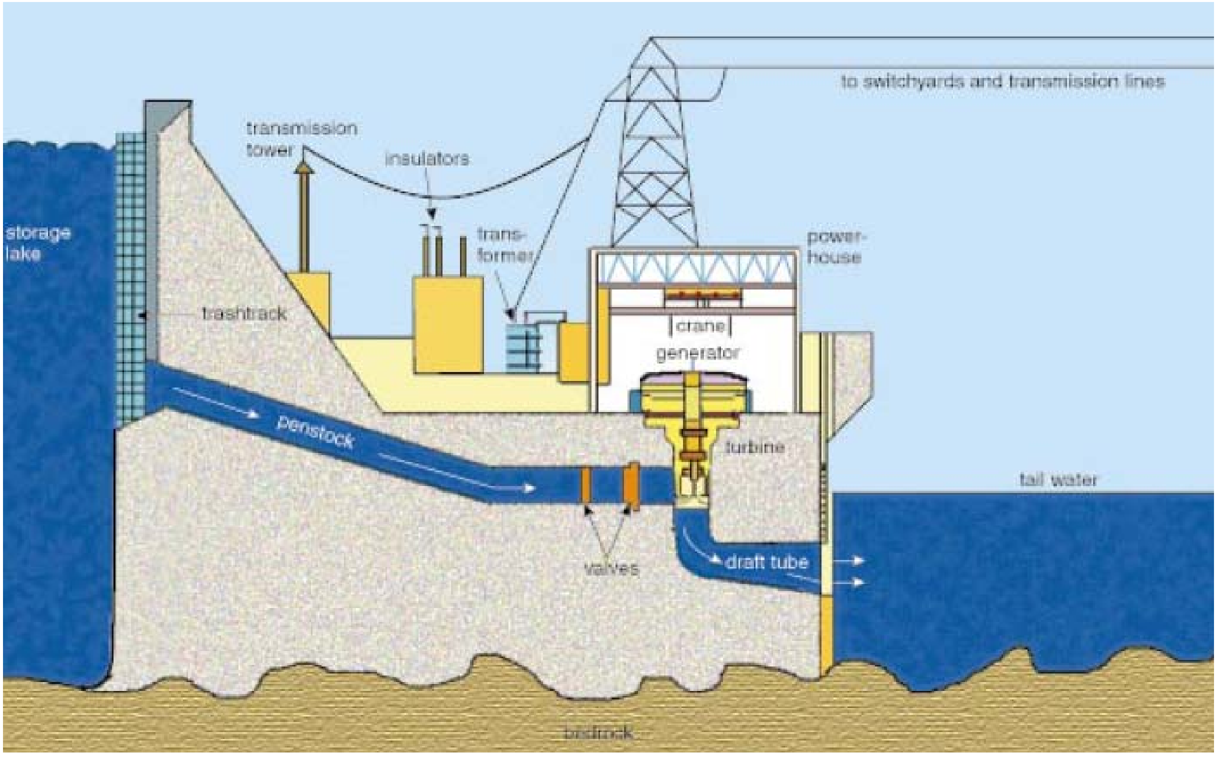
Appendix G: Electricity Supply in Brazil

Appendix A: Glossary of the energy related terms

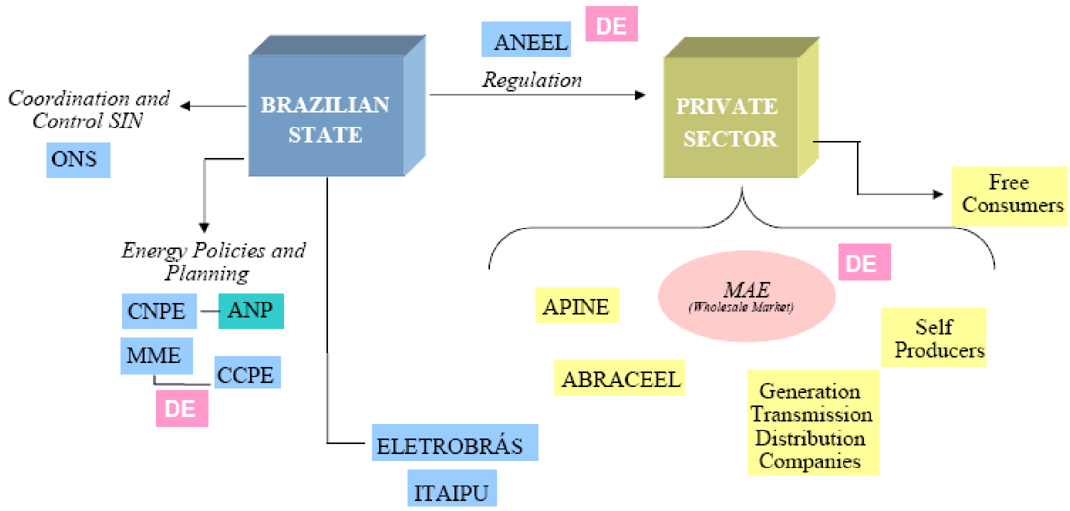
GLOSSARY

ALTERNATING CURRENT	An electrical current in which the electrons flow in alternate directions. For example, in North American electrical grids, the flow reversal is governed at 60 cycles per second (hertz).
BASELOAD	In a demand sense, a load that varies only slightly in level over a specified time period. In a supply sense, a plant that operates most efficiently at a relatively constant level of generation.
CAPACITY	The maximum sustainable amount of power that can be produced by a generator or carried by a transmission facility at any instant.
COMBINED CYCLE	The combination of a gas turbine and steam turbine in an electric generating plant. The waste heat from the first turbine cycle provides the heat energy for the second turbine cycle.
DIRECT CURRENT	An electrical current in which the electrons flow continuously in one direction. Direct current is used in specialized applications in commercial electricity generation, transmission, and distribution systems.
DISCHARGE	The volume of water flowing at a given time, usually expressed in cubic meters/feet per second.
GENERATION	The act or process of producing electrical energy from other forms of energy. Also refers to the amount of electrical energy so produced.
GENERATOR	A machine that converts mechanical energy into electrical energy.
HEAD	The vertical height of water in a reservoir above the turbine. The more head, the more gravitational force that is exerted on the turbine, and the more power that can be produced.
HYDROELECTRIC	The production of electrical power through use of the gravitational force of falling water.
KILOWATT (kW)	A unit of electrical power equal to 1,000 watts (equivalent to about 1.3 horsepower).
KILOWATT-HOUR (kWh)	A basic unit of electrical energy equivalent to one kilowatt of power used for one hour.
LOAD	The amount of electrical power or energy delivered or required at any specified point or points on a system.
MEGAWATT (MW)	A megawatt is one million watts, a measure of electrical power.
MEGAWATT-HOUR (MWh)	A unit of electrical energy equivalent to one megawatt of power used for one hour. Gigawatt-hour (GWh) and Terawatt-hour (TWh) are one billion and one trillion watts of power used for one hour.
OFFPEAK HOURS	Period of relatively low demand for electrical energy, as specified by the supplier (such as the middle of the night).
PEAK LOAD	The maximum electricity demand in a stated period of time. It may be the maximum instantaneous load or the maximum average load within a designated period of time.
PHOTOVOLTAIC	The direct conversion of sunlight to electrical energy through the effects of solar radiation on semiconductor materials.
PUMPED STORAGE PLANT	A hydroelectric power plant that generates electrical energy to meet peak load by using water pumped into a storage reservoir during off-peak periods.
RENEWABLE RESOURCE	A power source that is continuously or cyclically renewed by nature. A resource that uses solar, wind, hydro, geothermal, biomass, or similar sources of energy.
RESERVE CAPACITY	Generating capacity used to meet unanticipated demands for power or to generate power in the event normal generating resources are not available.
RESERVOIR STORAGE	The volume of water in a reservoir at a given time.
STORAGE RESERVOIRS	Reservoirs that have space for retaining water from springtime snow melts. Retained water is released as necessary for multiple uses — power production, fish passage, irrigation, and navigation.
THERMAL POWER PLANT	A facility that uses heat to power an electric generator. The heat may be supplied by burning coal, oil, natural gas, biomass or other fuel; by nuclear fission; or by solar or geothermal sources.
TRANSMISSION GRID	An interconnected system of transmission lines and associated equipment for the transfer of electrical energy in bulk between points of supply and points of demand.
TURBINE	Machinery that converts kinetic energy of a moving fluid, such as falling water, to mechanical power, which is then converted to electrical power by an attached generator.
WATT	Basic unit of electrical power.

Appendix B: Storage hydro power scheme



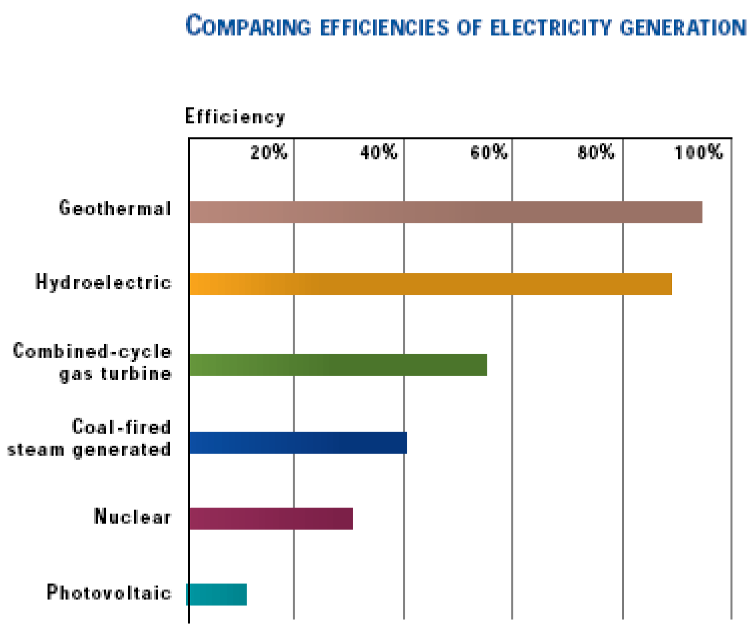
Appendix C: Main Agents in the Brazilian Electricity Sector

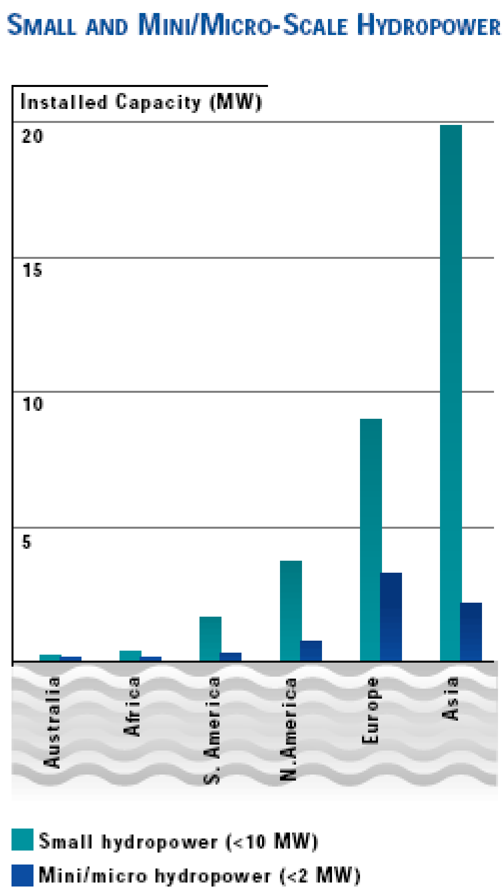


ANEEL:	Agência Nacional de Energia Elétrica- National Agency of Electric Power
CNPE:	Comitê Coordenador do Planejamento da Expansão Coordinator Committee of Expansion Planning.
MME:	Ministério de Minas e Energia- Ministry of Mines and Energy
ONS:	Operadora Nacional do Sistema- National Operator of the System
CCPE:	Comitê Coordenador do Planejamento da Expansão Coordinator Committee of Expansion Planning
ANP:	Agência Nacional do Petróleo_ National Agency of Petroleum

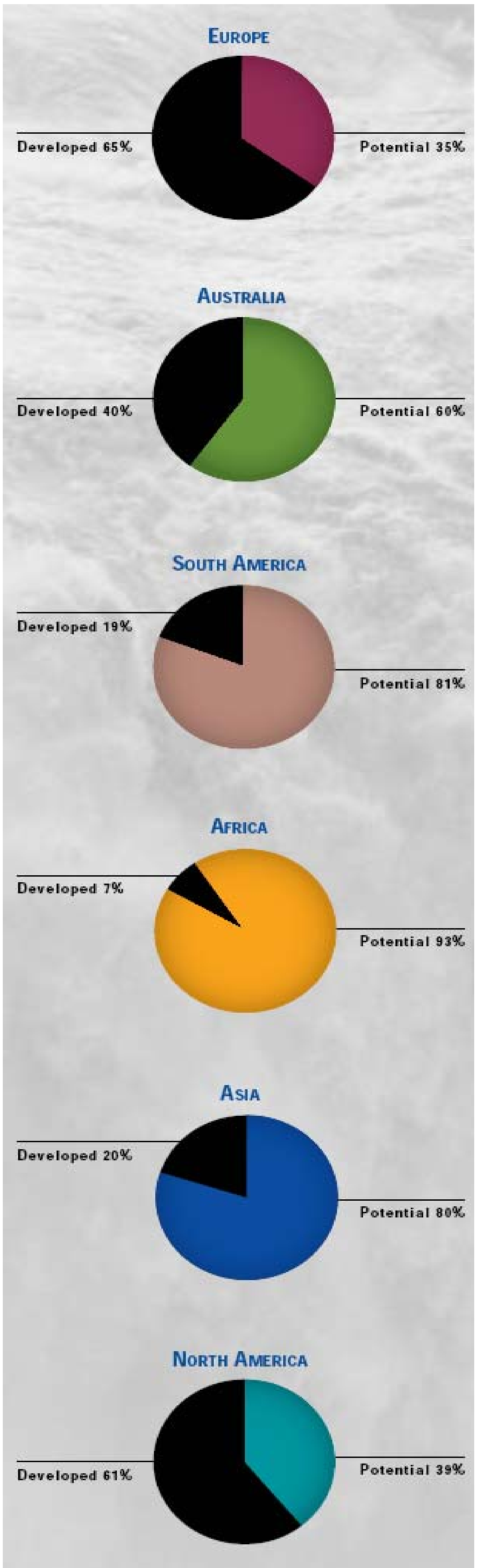
APINE:	Associação Brasileira dos Produtores Independentes de Energia Elétrica- Brazilian Association of Independent Power Producers and Energy
ABRACEEL:	Associação Brasileira dos agents - Brazilian Association of Retailers of Power Energy
MAE:	Mercado Atacadista de Energia Elétrica- Wholesale Market of Power Energy.
DE:	Decentralized Energy

Appendix D: Hydroelectric Related Charts





Appendix E: Developed and Potential Sources of hydro Energy in the World



Appendix F: Location of Small Hydro Power Plants in Brazil

Appendix G: Electricity Supply in Brazil