STATE-OWNED COMPANIES AND THEIR USE AS INSTRUMENTS OF SCIENTIFIC AND TECHNOLOGICAL POLICY. THE BRAZILIAN CASE.

by Enrique Saravia[1]

1. The political-economic elements associated with the technology question

The technological development seen throughout the world over time has led to a generalized conviction that any country that does not have its own technology; or that does not establish and consolidate a mature relationship in terms of the transfer of technology, is condemned to political and economic dependence.

The creation, innovation and development of technologies require, in turn, a determined volume of resources, which in countries such as those in Latin America, is only within reach of the public sector, either directly with or supporting the national private sector. A large transnational company makes its technological effort in its country of origin, and the technology is thus already incorporated in the original investment.

Technology was not considered an important political question until the end of the sixties. The technical assistance programs run both by the United States government, such as the Alliance for Progress, and by international organizations, made no reference to science and technology as important factors in terms of development. Only at the Punta del Este conference, in 1967, were science and technology specifically considered as important factors for development, although this issue has been debated intensively since then, and most of the problems involved appear to include the following:

- the role of transnational companies in the transfer, development and application of technology;

- the responsibility of the receiving countries in terms of developing mechanisms to absorb the technology transferred;

- the provision of institutional mechanisms to improve the flow of technology between the producing countries and those that use it;

- the desire of the receiving countries to produce their own technologies to give them a certain degree of autonomy in decision-making in the flow of technology.

There are five main protagonists in all these problems: the transnational companies, the governments of the countries supplying the technology, the

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governments of the receiving countries, the universities of these countries and the companies based in them. The problematic is complex, as these actors have opposing interests. The tactical alliances between two or more of these countries generally depend on circumstances and the actual problem being discussed and dealt with.

The most significant reason for the growing importance of the problems associated with technology is the development of specific strategies by the transnational companies in a highly dynamic market. In terms of Latin America, its economic history is highlighted by the strategic modifications of actions related to foreign capital, largely due to the originating country's needs. In a swift summary of this issue, one can see that from the time of the Industrial Revolution to the 1929/30 crisis, foreign investment was concentrated in the areas of construction and exploration of public services, particularly railways, ports, electricity and telephony. After an indecisive phase; during which foreign capital migrated from these types of activities, came a period of intensive direct investment in industrial infrastructure. The decentralization that began in the U.S and Europe was one of the causes that led to this situation. The other was the incentive that most Latin American countries used to attract capital destined to finance their economic development plans. In the mid seventies, it was already clear that technology was the most profitable business and the one that bestowed more economic power. On the other hand, trade and exploration are not subject to the same political and social risks as those of public services and wholly-owned subsidiaries, such as those with direct contact with the general public, labor relations, problems with contamination of the environment, etc. The countries dealing with these sorts of problems are those that use technology and not those that produce and transfer it.

This currently includes the more developed countries or those that have emerged recently as economic powers, and that have earmarked the most resources for R&D activities, as shown in Table 1 below. The result of this effort is shown in Table 2.

Table 1. *National spending on research and development (R&D) in the selected countries in relation to their gross domestic product (GDP), per capita and per researcher, in the most recent years such data is available.*

Country	**Year**	**Spending on research and development (R&D)** (Current US$ in millions in terms of PPC (1))	**Spending on research and development in relation to gross domestic product (GDP)** (%)	**Spending on research and development (R&D) per capita** (Current US$ in terms of PPC per inhabitant)	**Spending on research and development (R&D) per researcher (in terms of full time worked)** (Current US$ in terms of PPP per researcher)
Germany	2007	69,334.4	2.53	842.9	242,427.97
Argentina	2007	2,657.2	0.51	67.0	68,694.45
Australia	2006	14,867.5	2.01	714.2	170,363.07

Brazil (2)	2007	20,430.2	1.11	107.9	228,502.90
Canada (3)	2007	23,970.0	1.89	713.8	169,940.43
China	2006	86,758.2	1.42	66.0	70,895.02
Singapore	2006	4,782.5	2.31	1.086.6	191,043.81
South Korea	2006	35,885.8	3.22	743.0	179,437.80
Spain	2006	15,595.7	1.20	353.9	134,679.84
United States (3)	2007	368,799.0	2.68	1.220.8	233,343.27
France (2)	2007	43,359.6	2.08	682.1	196,599.40
Italy	2006	19,383.8	1.14	328.9	219,200.70
Japan	2006	138,782.1	3.39	1.086.3	195,552.83
Mexico	2005	5,919.0	0.46	57.0	122,290.45
Portugal	2007	2,754.3	1.18	259.6	98,416.30
United Kingdom	2006	35,590.8	1.78	587.4	193,919.02
Russia	2007	25,119.9	1.12	176.6	53,551.86

Sources: Organization for Economic Co-operation and Development, Main Science and Technology Indicators 2008/2 e Brazil: the Federal government's Integrated Administration of the Financial System (Siafi). Special data extraction made by the Federal Data Processing Service (Serpro); Industrial Research of Technological Innovation (Pintec) of the Brazilian Institute of Geography and Statistics (IBGE)

Prepared by: Prepared by: General Coordination of Indicators – The Brazilian Ministry of Science and Technology.

Notes: 1) PPP – Purchasing power parity. 2) Refers to 2006. 3) Refers to 2005.

Table 2. *Filing of patents for inventions in national offices in relation to gross domestic product (GDP) - 2004*

Countries	**GDP PPP US$ billion**	**Filing of patents**				**Filing of patents per billion of current US$ at PPP to GDP**			
		Total	**Residents**	**Non residents**	**Filing Office country(4)**	**Total**	**Residents**	**Non residents**	**Filing Office country(4)**
South Korea	1.005	140.115	105.027	13.428	21.660	139,38	104,48	13,36	21,55
Japan	3.788	423.081	362.342	20.766	39.973	111,70	95,66	5,48	10,55
Singapore	118	8.585	509	2.362	5.714	72,63	4,31	19,98	48,34
Israel (3)	170	10.258	1.329	4.569	4.360	60,22	7,80	26,82	25,59
Australia	632	30.206	8.555	4.855	16.796	47,79	13,54	7,68	26,58
Canada(3)	1.003	37.227	3.929	7.512	25.786	37,12	3,92	7,49	25,71
United States	11.679	356.943	185.008	135.196	36.739	30,56	15,84	11,58	3,15
Germany	2.360	59.234	48.329	9.455	1.450	25,10	20,48	4,01	0,61
Chile(2)	135	3.120	241	2.879		23,11	1,79	21,33	

Russia	1.407	30.190	22.944	1.958	5.288	21,46	16,31	1,39	3,76
China	7.127	130.384	65.586	32.109	32.689	18,30	9,20	4,51	4,59
United Kingdom	1.881	29.954	18.816	9.407	1.731	15,92	10,00	5,00	0,92
Brazil (INPI)	**1.483**	**21.742**	**10.879**	**10.863**		**14,66**	**7,34**	**7,33**	
Argentina(1)	484	6.457	899	5.558		13,34	1,86	11,48	
Mexico	1.046	13.198	531	2.010	10.657	12,62	0,51	1,92	10,19
Brazil (WIPO)	1.483	18.692	3.892	2.356	12.444	12,61	2,62	1,59	8,39
France	1.838	17.290	14.230	3.060		9,41	7,74	1,67	0,00
Italy(2)	1.610	9.273	7.877	1.396		5,76	4,89	0,87	
Spain	1.091	3.184	2.864	236	84	2,92	2,63	0,22	0,08

Sources: for the filing of patents: The World Intellectual Property Organization (WIPO), except in the case of Brazil, as data was also used from the National Institute on Intellectual Property (NIIP); for gross domestic product (GDP) in terms of purchasing power parity (PPP): World development indicators. 2003 and the World Bank atlas; on CD-ROM. World Bank.

Prepared by: General Coordination of Indicators – The Brazilian Ministry of Science and Technology.

Notes: 1) refers to 1999; 2) refers to 2000

Apparently, in the current situation Latin American economies are in, the State will be in a decisive position to confront and coordinate technological efforts. In general terms, the private national companies have little installed capacity, and do not have sufficient resources to cope with the necessary tasks of scientific and technological research. If these entities decide to carry out these tasks, they will only be able to make any significant advancement with the political and financial support of their respective governments (even if only partial in nature). However, it is important to note that there have been some cases of technological research and development being made by private companies in Latin American countries. Nevertheless, even when combined, these do not account for a significant slice of the pie in the area of industrial technology, and these companies have engaged in this type of activity largely thanks to the policies of industrialization and the stimulation of exports adopted by the governments of their countries.

When considering transnational companies, they normally bring technology built into their investment. In general, they do not carry out R&D activities in the countries receiving these investments. If, as in some cases, they do perform them, the patents are not filed in the receiving country, and thus from the point of view of the exclusive rights and remuneration associated with this technology, there is little benefit for the receiving country.

2. The public policies of science and technology in Brazil

The basic presupposition for any efficient efforts being made in the area of science and technology is the existence of an associated governmental policy or, at the minimum, a clear government alignment in this sense[2].

Brazil has offered various important initiatives in this sense. As such, among the main objectives of the I PBDCT (the First Basic Plan for Scientific and Technological Development), which was in effect between 1973 and 1974, was to strengthen the capacity of national public and private companies to absorb and create technology.

The main objective of the far more ambitious II PBDCT (1975-79) was to update technology in various sectors, strengthen project engineering and the activities of consulting and consolidating the system of industrial ownership.

The main objective of the III PBDCT (1980-1985) was to reduce the country's dependence on science and technology. According to Barbieri and Delazaro (1993), this is understood within a policy framework of import substitution, which was necessary to act simultaneously in controlling the flow of technology from abroad, as well as to promote technological development in companies and government research institutions.

The policies attempted by the Brazilian government from this time on have not had either the strength or the coherence of the PBDCTs. It is true to say that the external conditions – particularly the technological variables and their socio-structural consequences, have changed substantially. It is also true that economic policies have increasingly modified the role attributed to the State in terms of economic and social development.

A movement to free up the control of foreign technology actually began in the mid eighties. The contracts related to the projects approved by the PDTI (Program for the Development of Industrial Technology) and PSI (Integral Sectorial Program), both created by Executive-Law 2,433/88, were awarded without any prior consultation. Within the scope of the National Institute of Intellectual Property (INPI), restrictions were eliminated and not every clause in the contracts was examined for companies or sectors with high technological capacities. The measures adopted from 1990 heralded a new era characterized by a wider liberalization of the economy, including the aspects concerning the transfer of technology (cf. Barbieri and Delazaro 1993).

[2] The area of science and technology (S&T), according to the internationally-accepted manuals, includes the activities of "experimental research and development - R&D" and "correlated scientific and technical activities – CS&TA".

Among other effects, the new vision of trading technology led to a considerable increase in overseas remittances (transfers) associated with these contracts, as is shown in Table 3 below:

Table 3. *Brazil: Overseas transfers associated with contracts including the transfer of technology and related services/activities. 1992-2002 (in '000 current US$)*

Year	Total	Type of contract				
		Provision of technical assistance service	**Provision of technology**	**Brands: license to use / termination**	**Patents: exploration permit / termination**	**Franchises**
1992	160,484	126,352	31,250	2	2,880	...
1993	227,419	146,018	41,660	44	39,697	...
1994	373,222	244,096	48,266	1,756	79,104	...
1995	652,014	286,217	222,164	5,013	138,620	...
1996	960,564	368,749	378,154	13,237	200,424	...
1997	1,454,260	760,971	512,545	14,060	166,684	...
1998	1,756,327	1,017,959	540,113	12,529	182,747	2,979
1999	1,553,354	931,790	482,266	37,939	97,083	4,276
2000	1,802,231	1,045,747	619,476	31,160	94,436	11,412
2001	1,704,521	1,085,642	505,126	28,134	75,069	10,550
2002	1,581,915	1,005,203	485,439	22,163	59,102	10,008
2003	2,127,019	1,557,625	453,737	26,680	75,076	13,901
2004	2,263,299	1,671,469	469,975	41,552	64,475	15,828

Source: The Central Bank of Brazil / Economic Department (DEPEC) / Balance of Payments Division (DIBAP).

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Other important instruments introduced to monitor the development of science and technology policies in Brazil were: the White Book of Science, Technology and Innovation (BRASIL MCT: 2002), which indicates the country's need to build an autonomous model for technological development; and the Law of Technological Innovation – LIT N° 10,973 of 02.12.2004, which established measures to stimulate innovation and scientific and technological research in the production sector, with the aim of increasing capacity, achieving technological autonomy and improving industrial development in the country. Decree 68868 of 2009 establishes the Research, Development and Innovation Support Program for Information and Communication Technology (ProTIC).

3. The science & technology policy as a public policy

The policy in question is a public policy, that is to say, a series of programs of actions taken by the governmental authorities to consider and resolve problems included in the scope of the agenda of public power.

All public policy includes a certain degree of institutionalization. Existing bodies and entities, or those created for this purpose, are encumbered with the tasks of providing guidance and, possibly even implementing, financing, supervising and evaluating the activities designed to implement a public policy.

In the specific case of scientific technology policy, Brazil has various organizations with total or partial power to draw up, implement and evaluate this policy.

As such, as well as the Ministry of Science and Technology, we can cite the National Institute on Industrial Property – INPI, the Financing Company for Studies and Projects – FINEP, the BNDES, the IPEA, and universities. etc., as well as the funds managed by ministries such as the National de Scientific and Technology Development Fund – FNDCT and the Fund for Technological Development in the Telecommunications Sector – Funttel.

However, the aim of this paper is to describe and analyze the role of state-owned companies in the implementation of scientific technology policy. We aim to show how they act to comply with these objectives in accordance with their own business interests, in order to efficiently resolve the production problems affecting them.

4. The institutionalization of public policies

Institutions play a decisive role in all public policy, with the result that they make or determine the main decisions taken. Their structures, workforce, and organizational culture are all elements that help define the policy. The institutions stamp their specific modus operandi on the actions taken. Elmore states that: “as practically all public policies are implemented by large public organizations, only by understanding how these entities work can we see how the policies are modeled during the process of implementation” (Elmore 1978: page 187).

Ham & Hill (1988: 130) affirm that “the complex and often conflicting trends in the study of these organizations should be mentioned; due to the enormous importance that the complex bureaucracies have in the process of public policy making. To understand the part the organizations play, it is necessary to understand their structure and internal behavior. But even this understanding will prove deficient if the organizations are not considered in terms of their wider social structure”.

Selznick reminds us that: “all the formal organizations are molded by tangential forces, and their structures rationally ordered with pre-established targets. All formal organizations – unions, political parties, the army, companies, etc. – try to mobilize human and technical resources as a means of achieving their goals. However, the individuals within the system tend to resist being treated as the means to a specific end. They interact as human beings, bringing their own and specific problems and purposes; but even more importantly, the organization is immersed in an institutional matrix and is, therefore, subject to pressures from its own context, to which a general adjustment should be made. As a result, the organization can largely be seen as an adaptive social structure facing problems that arise simply because it exists as such an organization in an institutional environment, independent to its objectives (economic, military, political) which led to its existence in the first place" (Cf. Selznick 1949:123).

The previous affirmations help to explain why state-owned entities do not act as passive instruments in the policy of science and technology. They follow the general lines established by the government, but adapt to their own interests and institutional necessities.

It is possible to say that public policies are the product of a combination of various ingredients, the amount of each which depends on the historical backdrop. In Brazil, all existed when the policy analyzed was drawn up as well as during the process of implementation by the state-owned entities. The abovementioned ingredients are: 1) the ideology of those with power; 2) the ideas and capacity of the bureaucracy to articulate; 3) "l'air du temps": the prevailing discourse and values in the national and international scenarios; 4) the electorate and electoral processes; 5) the international influences and pressures channeled through foreign governments, the public and private financial institutions and other social conglomerates, such as churches, non-governmental organizations, etc.; and 6) local pressure groups (economic interests, means of communication, intellectuals and other opinion formers).

Prior to the drawing up of the PBDCTs, the state-owned entities generally imported technology and there were no obstacles in terms of acquiring technology incorporated in financing contracts. Very few state-owned entities had their own programs for technological development. There were two behavioral paradigms related to the selection of technology and that were adopted when industrial projects were prepared. The first option was to select the technology before finalizing the financing. The second was to check the existing possibilities of external financing and any prerequisites or restrictions that would have to be adhered to before purchasing the technology. The second option was obviously the one normally chosen, as it was easier and there was often external pressure to do so.

Beginning in the 1950s and more obviously in the 1960s, various state-owned entities began institutional and organic creative work in the area of technology and development. We go on to analyze the cases of Petrobras, Eletrobras, the Telebras group, and the specific example of EMBRAPA, a company set up with the main objective of researching agriculture and livestock.

5. Leopoldo A. Miguez de Mello Research and Development Center – CENPES (Petrobrás)

The State-Owned Oil Company PETROBRAS is the largest Brazilian corporation and one of the biggest oil firms in the world. The main objective of CENPES, its research center, is to meet the technological demands that drive Petrobras in order to consolidate and expand the firm in the world energy scene.

The embryo of CENPES was the former Center for Oil Research and Product Improvement – CENAP, set up by Petrobrás in 1955 to qualify specialized human resources and technological research.

Industrial research activities during the initial period were carried out in a laboratory located in Rio de Janeiro, in accordance with the new directives of national policy associated with import substitution and the installation of refineries in Brazil. In 1963, the Petrobrás Board decided to create a Research Center exclusively for research and development activities, which led to the gradual substitution of foreign technicians by Brazilian professionals.

In 1968, the research carried out by Cenpes helped in the first discovery of offshore oil in the Guaricema field in Sergipe. The first underwater well was drilled in the Campos Basin in the State of Rio de Janeiro in the same year.

Cenpes was renamed Cenap in 1973 and, similar to the former, began operating in the adaptation of imported technologies for local geological and environmental conditions, the national market and raw materials. This expansion led to the transfer of the Center to a larger area provided by the Federal University of Rio de Janeiro (UFRJ), at Cidade Universitária on Ilha do Fundão, where it is currently located.

Installed in its new main office, in 1975 Cenpes was once again renamed the *Leopoldo Américo Miguez de Mello Center of Research and Development*. In the following year, basic engineering activities, which until then had been spread out throughout the company, were integrated in Cenpes, thus complementing the areas of research and development. In 1992 – and once again in 2002 – Cenpes consolidated its position as the largest research Center in Latin America. In1992, Petrobrás earmarked 1% of its gross revenue for Cenpes.

In 2004 a project was approved to enhance the Cenpes in an area of 183,000 square meters also located in Rio de Janeiro. In 2006 Petrobras celebrated Brazil's sustainable oil and gas production self-sufficiency after the P-34 and P-50 platforms went online. The platforms were designed by the Cenpes and incorporate important technological innovations. The company also announced the development of an innovative refining process that uses a part of vegetable oil to produce conventional diesel fuel. In 2007 Petrobras publicized the discovery of major oil and gas concentrations in the pre-salt sections. The new frontier may increase the country's oil and gas reserves by 50% and, in order for this field to be commercially viable, a lot is being invested in technology. Another fact announced was that the first bioethanol (lignocellulose ethanol) pilot plant in Brazil that uses the enzymatic route went online.

With more than 2,000 employees distributed in an area of 122,000 square meters, Cenpes had 30 pilot units and 137 laboratories working for various different bodies within the company. The technologies developed by Cenpes resulted in the filing of 950 international and 500 national patents, as well as considerable number of registered brands. In 2007 alone, in Brazil, 22 patents were granted and requests submitted for 59 more. Abroad, 129 requests were submitted and 29 granted.

Approximately 500 new research and development projects are underway, and this figure is expected to increase significantly when its installations are expanded by 183,000 m^2.

The Research Center is being enhanced to satisfactorily respond to the expansion in Petrobras' activities. The construction work will increase the Research Center's area by 183,000 square meters. Full delivery is expected for early 2010. With the enhancement project, the Cenpes will have 227 research labs, in 23 lab buildings – nine in the new part, which will add to the 14 in the current building.

Petrobras' current strategy in terms of technology development is based on four priorities at Cenpes: increasing technological capacity for deep and ultra deep water production; increasing the recovery of oil from wells; new refining technologies suited to the production of oil products from the oil available in the country, as well as the characteristics of end consumers; and technologies associated with new and alternative sources of energy.

6. Electricity Research Center – CEPEL (Eletrobras)

CEPEL was created in 1974 as a non-profit company linked to the Eletrobras system and with ties to the Ministry of Mines and Energy, to oversee the changes taking place in the national energy sector and develop a scientific and research infrastructure in Brazil. According to the statute published in the federal government's Official Register (Dario Oficial) on January 21, 1974, Cepel's main objective is to "provide an infrastructure for scientific research, with the aim of stimulating the national development of advanced technology in the field of equipment and electrical systems ".

Up to 1974, when the Center was set up by the Ministry of Mines and Energy and companies from the energy sector, research in Brazil had been restricted to the work carried out by electro-technical institutes linked to universities, such as those in São Paulo, Rio de Janeiro and Itajubá (MG), as well as study centers and small laboratories run by some energy concessionaires. In this case, the main objective was to solve the problems of maintaining metering equipment and instruments.

The search for more technological autonomy in the electricity sector only really materialized at the end of the 1960s. The considerable expansion of installed energy capacity required a type of technology that, in certain cases, was still only at experimental stages in industrialized countries. The use of energetic sources located in regions increasingly distant from the major consumer centers, the complexity of operating and controlling the energy transmission networks – which experimented with an increasingly interconnected system – and the need to transmit and distribute large amounts of energy to highly concentrated urban or industrialized zones, led to more interest from both the concessionaires and equipment manufacturers to find their own alternative technologies.

After agreements were made with the Federal University of Rio de Janeiro, the Center was installed on campus at UFRJ on Ilha do Fundão, where CNEN's Nuclear Engineering Institute (IEN) already operated, and where the facilities for Petrobras' Research Center were being built (CENPES).

Eletrobras delegated the task of setting up a research center to Furnas, which got in contact with the l'Hydro-Quebec Research Institute - IREQ. The Canadian institution was one of the most advanced in the world of energy research and had played a fundamental role in the pioneering experience of the Hydro-Quebec plant, which transmitted 750 kV.

The First National Development Plan (I PND), which outlined on the government's directives in the period between 1972 and 1974, gave rise to the policy for science and technology defined in the PED (Strategic Development Program), drawn up by the Costa e Silva government for the period between 1968 and 1970).

The creation of CEPEL was, therefore, the result of the merging of two government strategies: on the one hand was the attempt to try and reduce the burden of payments made in royalties and for patents in the country's balance of payments and, on the other hand, was the need for a technology research center for electricity companies, given their growing needs in this area. The expansion of national generating capacity was based on the construction of large hydroelectric plants, which led to the building of the bi-national Itaipu dam, which highlighted the main technological challenge faced in the sector: the transmission of large blocks of energy over long distances.

The government of President Sarney set up a ministry in 1985 specifically designed to draw up national science and technology policies – the Ministry of Science and Technology (MCT). The new ministry prepared the First Science and Technology Plan (1 PND), the targets of which were to reintegrate Brazilian universities in discussions about the main national problems, and recover and update the capacity of scientific laboratories to stimulate the demand for national technology.

The specific scientific and technological development in the energy sector was still based on the directives of the National de Energy Plan - prepared by Eletrobras for the Ministry of Mines and Energy.

Cepel is currently recognized as a Center of excellence in the Brazilian energy sector, and is the largest energy research center in the Southern Hemisphere

Cepel carries out testing, diagnostics and performs technological services utilizing more than 30 laboratories, some of which have no equal in either Brazil or Latin America. Cepel also has the backing of an Office for the Certification of Products and Services (ECPS), licensed by INMETRO for electrical products requiring certification, and that has technological display areas for visitors interested in new technologies.

Its computer programs – the result of research – provide solutions for the problems associated with generation, transmission, distribution, and consumption of energy, together with training, simulations and technological services.

With the technological support of government programs such as: PRODEEM, Luz no Campo, PROCEL and CRESESB - CEPEL helps to reduce regional inequalities, combat the wasting of energy and losses, improve the efficiency of the system and develop new alternative energy sources.

CEPEL’s main office at Cidade Universitária (UFRJ) directs and coordinates the Research Center and more than 20 laboratories with multiple specializations from corrosion to isolating fluids, and dielectric testing to the electronic metering of energy. There is also the laboratory for superconductivity, using leading edge technology, and laboratories working on the conservation of energy, lighting and refrigeration. The Laboratory Simulating the Electronic Power Network/Grid (TNA) in real time is the largest in Latin America, and uses a hybrid analogue and digital simulator.

The laboratories provide support for research as well as trials, tests, audits, expert reports, diagnostics for industries, equipment manufacturers, energy concessionaires and large consumers.

Thematic laboratories were more recently implemented, specializing in the supervision and control of operating electrical systems, technical-economic analysis of power systems, the quality of energy and intelligent systems.

Technology demonstration centers are also located at the Fundão, with a Solar Efficient House, the Exhibition of Efficient Technologies, both housed in the Center for Efficient Technology – CATE. The Solar house is part of the CRESESB program – the Sergio de Salvo Brito Reference Center for Solar and Wind Energy, with the aim of spreading the use of renewable energy throughout the country.

Designed to provide technological services and to train engineers in the energy sector, the Center of Transmission Technology and Reactive Compensation Equipment – CETEC, offers specialized courses and has developed a series of computer programs for its clients.

One of CEPEL's largest laboratories: the "George Zabludovski Laboratory", is found in Nova Iguaçu, in the State of Rio de Janeiro, alongside the Adrianópolis substation run by Furnas, where testing is carried out of such magnitude that the timing has to be coordinated with Furnas to avoid periods of peak demand in the Grande Rio region. These laboratories meet the requirement to test equipment for electrical systems at the maximum tension levels in use in the country, of 765 kV in alternating current (AC) and 600 kV in continuous current (CC). These laboratories are administratively subordinate to ALAB – Area of Laboratory Knowledge, and are divided between the High-Tension Unit and the High-Power Unit, all of which work to a quality system implemented in accordance with ISSO GUIDE 17,025. The laboratories: CA1 – Calibration AP1 – High Current and AP4 – Activation and Safety are part of the Brazilian Calibration Network or the Brazilian Network of Laboratories approved by INMETRO.

The George Zabludovski Laboratory is based in the Product Certification Office, ECPS, licensed by INMETRO and the Center for Diagnostics of Electrical Equipment and Installations, both with the respective objectives of providing certification services for electrical equipment in explosive atmospheres; switched low-tension equipment, plugs, electrical sockets, fuses, wires and cables; and the degree of protection of covers, casings and insulation; monitoring and diagnosing electrical installations and equipment, including transmission lines, gas insulated substations, power or current transformers, lightening conductors, among others.

The founding partners - ELETROBRÁS and its subsidiaries: CHESF. ELETRONORTE, ELETROSUL and FURNAS - contribute with the funding to maintain CEPEL and provide guidance for the work carried out at the Research Center.

The partners are Brazilian electricity companies –state owned and private- and oil company Petrobrás.

7. The Center for Research and Development – CPqD (Telebras)

The CPqD was created as the technological branch for the Telebras System at the time when Brazilian telecommunications was a state monopoly. When the system was privatized in 1998, it became a private foundation. The General Telecommunications Law of 1997 recognized its importance for Brazilian society, and set aside funding for technological development in the Brazilian telecommunications sector. As a result, the Fund for Technological Development in Telecommunications (FUNTTEL) was created, which provided some funding for the research and development projects carried out by the CPqD supported by the State through the Ministry of Communications.

Given this new situation, the CPqD had to comply with the directives of a Board of Control– made up of representatives from civil society, the academic and scientific community, industry and operators, the National Bank of Economic and Social Development, FINEP and the Ministries of Communications and Science and Technology – and structured a business area led by other sectors in the economy. It simultaneously maintained its characteristics as an independent and impartial entity to award product compliance certifications, as well as reports and technical expert analysis on various themes linked to its specialty.

In 2000, CPqD started to play a stronger role in the international competitive market, creating CPqD USA, a private company with 100% Brazilian capital, based in the Silicon Valley (USA), with independent operational structure from the Brazilian one.

The CPqD comprises of three companies: PADTEC, TROPICO and CLEARTECH

PADTEC

Padtec is a company set up to develop and industrialize optical communications equipment, and is the only company in the country to manufacture High Density Wavelength Division Multiplexing systems, as well as producing optical amplifiers, type converters, O/E converters, optical commutation systems and CWDM (Coarse Wavelength Division Multiplexing) systems. Created by CPqD in 1999, Banco Pactual's Flynet Investment Fund bought into the company in 2002. The Flynet Fund was incorporated by Idéiasnet S/A in December 2004, thus becoming a partner in the company.

The company's exports accounted for 10% of its total revenue in 2004, and Padtec exported to Saudi Arabia, Argentina, Colombia, Malaysia, Mexico, Paraguay, the U.S., Canada and Germany. The continuity of technological development of Padtec' products has been ensured by its cooperation with the CPqD as well as through its internal product development activities.

TRÓPICO

In 1999, CPqD and Promon Group, in a joint-venture, created Trópico S.A. - a company Later, Cisco joined this partnership.

Trópico Sistemas de Telecomunicações S.A. is a joint venture between the CPqD, Promon and Cisco Systems, focused on the development, manufacture and distribution of modern telecommunications equipment. The company was restructured in 2003, and the development team was transferred to the CPqD, and the funding was provided from FUNTTEL resources.

Maintaining its capacity for technological development, the company still offers new products to the market based on multi-service networks, or NGN (Next Generation Networks), providing operators more productivity in the use of their telecommunications networks, new services, as well as complying with the new requirements established in their concession contracts.

The reduction in costs with the restructuring and new contracts led to an increase of approximately 17% in the company's revenue. Of particular note were the Vectura Softswitch (VSS) products in 2004 – a differentiated platform for multimedia connections to NGN networks – and Vectura Signaling Server (VSI) – a control platform for signaling and integrated application services for telecommunications networks. The first of these already deals with real traffic, with the first VoIP Telephony Network. The second, also working in the operator's network, will allow for a wide range of advanced applications.

Trópico technology already reached approximately eight million terminals. It already holds 20% of the digital plant installed in Brazil, and extended its presence in the Latin America and United States markets.

CLEARTECH

Created in 2000 to provide clearing services in the Latin American market, ClearTech has signed contracts with the main telecommunication service operators in the country. It has a production infrastructure capable of processing more than three billion call detail records - CDRs/month, and is currently one of the largest clearing houses in the world in terms of the number of CDRs dealt with.

The company has complete autonomy in the processes of maintaining and developing its systems/applications. The company expanded the services it provided to its customer base in 2004, mainly by means of increasing the volumes processed and offering new services. As well as the CPqD, EDS Word Corporation and DBA Engenharia de Sistemas also have stakes in the company.

8. The Brazilian Agricultural Research Corporation – EMBRAPA

The Empresa Brasileira de Pesquisa Agropecuária (The Brazilian Agricultural Research Corporation) – Embrapa, linked to the Ministry of Agriculture, Livestock and Supplies, was created on April 26, 1973. Its mission is to find feasible solutions for the sustainable development of rural space, with a focus on agribusiness, by means of generating, adapting and transferring knowledge and technologies for the benefit of diverse segments in Brazilian society, and at the same time, conserving natural resources and the environment and diminishing external dependence on technologies, basic products and genetic materials.

Embrapa operates using 38 Research Centers, three Service Centers and 13 Central Divisions, and is present in almost all states in Brazil, and in varying ecological conditions. To become one of the largest research institutions in the southern hemisphere, the company has invested heavily in training its personnel, and currently has 8,275 employees, of whom 2,113 are researchers, 25%with a Masters degree and 74% with a Ph.D. Embrapa coordinates the National Agricultural Research System, which includes most public and private entities involved in agricultural research in the country.

The technology generated by SNPA has changed the face of Brazilian agriculture. A series of technologies to incorporate open pastureland in the productive system led to the region accounting for 40% (46) of Brazilian production of grains, and become one of the largest agricultural frontiers in the world. Soya was adapted to the Brazilian conditions and the country is currently the second-largest producer in the world. The supply of beef and pork has multiplied by three; and chicken ten times. Milk production has increased from 7.9 billion liters in 1975 to 21 billion liters in 2002, and Brazil's production of vegetables went up from 9 million tons from an area of 700,000 hectares in 1980 to 15.7 million tons from an area of 806,800 hectares in 2002. In addition, specific research programs have managed to organize technologies and production systems to increase family-based agricultural efficiency and incorporate small producers in agribusiness, thus guaranteeing an improvement in their income and well being.

From the very beginning, Embrapa has generated and recommended more than nine thousand technologies for Brazilian agriculture, reduced production costs and helped Brazil to increase the offer of food.

In the area of international cooperation, the company has made 275 technical cooperation agreements with 56 countries and 155 research institutions, mainly involving joint research. To help in these efforts, Embrapa now has a presence in the U.S. and France, with the support of the World Bank, in the form of laboratories for the development of research in state-of-the-art technology. These laboratories include the physical bases of the U.S. Department of Agriculture in Washington and Agrópolis at Montpellier University, France, giving researchers access to the highest level technology in areas such as natural resources, biotechnology, information technology and precision agriculture.

9. Conclusions

The centers studied in this paper were all created between the end of the 1960s and the beginning of the 1970s, but most of their development was seen during the period when the second PND was in effect, and had a direct connection with industrial policy implemented during the period, which prioritized the raw material and capital goods sectors, as well as the expansion of economic infrastructure. In this context, significant investment was made in the oil, telecommunications and energy sectors. As a result, the state-owned companies were advised to use their purchasing power to increase the index of nationalization of acquired goods and services, thus strengthening their ties with local industry.

The main objective of increased technological autonomy in each of the companies studied was conditional on the specific company's economic and political characteristics, as well as the technology in the sector it operated in.

Both CENPES and CPqD adopted models for the development of research that involved an increased and significant participation by industries and universities. PETROBRÁS sought qualified personnel at the universities, trained them and fed them through to other industries. As a result, this created a strong link between the company and the fledgling industrial sector, which desperately needed more specialized personnel to meet the rising demand. TELEBRÁS, in a similar way to PETROBRÁS, made ties with universities and industries, although all the work developed was centralized at the CPqD. As far as CEPEL was concerned, it concentrated its efforts on qualifying its work force. Various exchange programs were implemented with educational and research institutions in Brazil and, more often, abroad, clearly demonstrating the center's concern with excellence in the qualification of its technicians. This strong link with these entities allowed CEPEL to significantly increase its technological capacity and grow its body of highly-qualified technicians (Cf. Erber and Amaral s.d.)

At the beginning of the 1990s, the three research centers were restructured to adapt them to the new prevailing technological and industrial paradigm.

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