Innovation in energy sector – A comparative study in Brazil and Portugal

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Abstract
The energy sector is a strategic vector for the competitiveness of countries. It is consensual that this sector has played a crucial role in the context of the global economy. The prices of oil, as well as the prices in other sources of energy have affected the economies of several countries, in the last decades, assuming a key factor in its economic growth and development.
We considered important to understand how this sector can be important in countries with different stages of development and how companies from this sector lead with different threats and opportunities and develop innovation strategies to assure competitive advantages. The current study analyzes innovation in energy sector, studying the largest companies from Brazil and Portugal, focusing on different dimensions, such as investment in R&D, R&D activities and cooperation for innovation.
Through a case study methodology, the study point out some differences and similarities from this two countries with different stages of development (Brazil and Portugal), considering the dimensions of innovation studied.
Key words: Energy sector, innovation activities, R&D, cooperation for innovation.

1. The importance of energy sector

Energy sector has a central role in the three dimensions of sustainable development: the social dimension (fight against poverty), the economic dimension (security of supply) and the environmental dimension (environmental protection). This sector is determinant not only for developed countries but also for developing countries.
Sustainable growth is one of the priorities within the Europe 2020 Strategy of the European Union, through which it aims to promote an economy that is not only more competitive but also more efficient in terms of resource use, ie more environmentally friendly. The European Union (EU), as the rest of the world, is faced with major challenges as regards energy and the environment, these include: ever-increasing global demand for energy, volatile prices, rising emissions of the greenhouse gases responsible for climate change, and unstable oil and gas supplies, with reserves concentrated in just a few countries. So it is required efforts in order to prevent the worldwide energy situation from getting even worse. The development of new energy technologies can play a decisive role and help EU's to achieve the goals of reducing energy consumption and greenhouse gas emissions by 20% until 2020 and increasing by 20% the share of renewable sources in Europe's energy mix (European Commission, 2002; European Commission, 2006).

2. Literature review

The majority of innovation studies differentiate innovation from invention. “Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice" (Fagerberg, 2005). Innovation is a process that includes invention, commercialization and diffusion with a multidimensional and nonlinear track. Innovation has been an important issue in several studies in economics, management, technology, sociology, with different interpretations (Arrow, 1962; Pavitt, 1984; Cohen and Lewin 1989; Urban, 2009). Joseph Schumpeter (1934) gave an essential contribution defining economic innovation as: 1) the introduction of a new good with which consumers are not yet familiar; 2) the introduction of a

new method of production;3) the opening of a new market; 4) the conquest of a new source of supply of raw materials or half-manufactured goods; 5) the carrying out of the new organization of any industry.

R&D is one of the most used inputs to study innovation occurrence (Cohen and Klepper, 1991, 1992; Unger, 2005).

Several authors recognised that R&D facilitates the firm improvement in terms of efficiency (Cohen and Levinthal, 1989; Lucas, 1993; Hewitt and Wield, 1992; Mody, 1993; and Audretsch, 1995). They believe that R&D generates not only new information, but also develop the firm's capability to incorporate and exploit the existing information. Consequently, the productivity effect of knowledge may depend on the firm's own investment in R&D or worker training.

Some studies confirm this relationship between R&D and productivity. For example, Griffith et al. (2004) use a panel of industries across 12 OECD countries and find evidence that R&D investments increase technology transfer by improving firms' absorptive capacity and conclude that industries in countries that lag behind the productivity frontier can catch-up particularly fast if they invest heavily in R&D. Also Klette (1996) finds some evidences, in Norwegian manufacturing plants that confirms this that R&D investments in the past have higher productivity growth. Finally, Griliches (1979 and 1986) concludes that R&D contributes considerably to productivity growth, and that privately financed R&D expenditures have a larger effect on private productivity and profitability than federally financed R&D.

According to Tether (2002:949), "Innovation cooperation means active participation in joint R&D and other technological innovation projects with other organizations. It does not necessarily imply that both partners derive immediate commercial benefits from the venture. Pure contracting out work, where there is no active participation is not regarded as co-operation."

Cooperative activities for innovation, as well as strategic technological alliances, became important issues of many theoretical and empirical studies in the 1980s and 1990s. After the mid-1980s, several studies paid particular attention to cooperation in innovation, including strategic technology alliances (Doz and Hamel, 1997), collaborative activities for R&D (Fusfeld and Haklisch, 1985) and innovation networks (Freeman, 1991; Beimans, 1992).

Also several studies point out the positive economic impact of cooperation on the competitiveness of firms (Powell et al., 1999; Hagedoorn et al., 2000; Cassiman and Veugelers, 2002), on performance and knowledge spillover and on success in the development of new products (Miotti and Sachwald, 2003; Sivadas and Dwyer, 2000).

Cooperation for innovation must assure absorptive capacity in order to firms benefits from external spillovers and increase the profitability of R&D cooperation (Cohen and Levinthal, 1990; Cassiman and Veugelers, 2002). Cooperation activities also contribute to increase firm's capability and their ability to benefit from future cooperative R&D projects (Mark and Graversen, 2004).

4. Research methodology and data collection

In this paper we focus on the topic of innovation in energy sector and analyse possible motivations related with the investment and development on R&D and collaborative partnership for innovation in the two largest Brazilian and Portuguese companies.

The empirical research applies the case study methodology. According with Yin (1994) "how" or "why" questions have better explanatory power in case studies since "such questions deal with operational links needing to be traced over time, rather than mere frequencies or incidence" (1994, p. 6). Yin (1994) defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the limits between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (Yin, 1994, p. 13).

This exploratory study adopted an iterative process of data collection in conducting two cases built on the results of a semi-structured interviews applied to key-informers from Portuguese and Brazilian energy sector – Petrobas and Galp Energia. This methodology is applied to study innovation in organizations (Bjelland and Wood, 2008; Lakhani, 2008; Di Gangi and Wasko, 2009).The interviews were applied to key-informers during the 1st trimester of 2013. The research questions explored are: (1) Why Brazilian and Portuguese energy sector companies invest in R&D? (2) How Brazilian and Portuguese energy sector companies develop R&D activities? (3) How and why Brazilian and Portuguese energy sector companies develop cooperation for innovation? (4) What are similarities and differences in R&D investment, R&D activities and cooperation for innovation process between Brazilian and Portuguese energy

sector companies? Besides semi-structured interviews, documental data was collected in companies websites, journals and other documents.

5. Discussion of the two cases

The two cases considered are Petrobas and Galp Energia.

Petrobras is a Brazilian and transnational capital intensive, which works seamlessly in exploration and production, refining, marketing and transportation of oil and gas, petrochemicals, distribution of oil, electricity, biofuels and other renewable energy. It is a public traded corporation with 80,492 employees, 1,420 of which are devoted exclusively to R&D and 314 for basic engineering projects. Among researchers, 23% have a doctorate and 42% of master's degrees. The company operates on all continents, has commercial, operational or technological forecasting in 27 countries (other than Brazil).

Founded in 1953 with the objective of performing the activities of the oil industry, in Brazil began operations in 1954 with the refineries Mataripe (BA) and Cubatao (SP). With an initial production of 2,700 barrels, equivalent at that time to 1.7% of national consumption.

An activity that marked the history of the company was the R&D and development of new technologies. The beginning of this process occurred in 1957, with the creation of CENAP (Improvement and Research Center of Petroleum), replaced in 1966 by CENPES (Center for Research and Development Leopoldo Américo Miguez de Mello), now meet the technological demands of the company.

In early 1985 has PROCAP, the Training Program Deepwater Technology in partnership with STO ((Science, Technological Institucions), to improve the company's technical competence in the production of oil and gas in water depths up to 1000 meters. The PROCAP 1000 marked the beginning of exploration in the Offshore segment, from 1986 to 1991, the program has undertaken 109 projects interdisciplinary. During this period 80% of the projects were aimed at extending the existing technology and 20% for technological innovation.

In 1993 it created the PROCAP 2000, extending the technological effort to explore the depth of 2000 meters between 1993 to 1999 in partnership with STI. In the second phase of the program, 20 projects were developed in the network, with a budget of about US$ 750 million. In addition to expanding the limits of operation, the program also sought to reduce production costs. For that 80% of projects were focused on innovations and 20% for customizations.

In 2000, was instituted PROCAP 3000, also in partnership with STI, whose initial budget was US$ 130 million for the period 2000 to 2006, involving 350 employees and 21 network projects of strategic importance to the scenario of water ultra. As a result of the cumulative action of CENPES, its network of innovation, the three versions of PROCAP and other technology programs of the company, have completed the first ultradeep drilling as early as 2005, with a well of 6,915 meters in the Santos Basin, 200 km from Rio de Janeiro. A year later, the company's value exceeded US$ 100 billion and Brazil won self-sufficiency in oil and gas with the entry into operation of the P-34 and P-50.

The share capital of the company is now controlled by the Federal Government (48%), followed by foreign shareholders (32%) and non-governmental Brazilian shareholders (20%), and its business units are currently structured in six major areas: financial, Gas and Energy, Exploration and Production, Supply, and International Services.

Galp Energia was established on 22 April 1999 with the name of GALP - Petróleos e Gás de Portugal, SGPS, S.A, as the result of the merging between Gas de Portugal (portuguese company for the natural gas import, transport and distribution activities) and Petrogal (portuguese state owned oil company). Nowadays, Galp Energia includes a group of companies. With internationalization, Galp Energia has evolved from a domestic company to an Iberian company in an initial phase, and an international company in a second phase. Today Galp Energia, has similar presence in Portugal and Spain, is located in the "upstream" and "downstream" in Africa, in the "upstream" of Latin America, particularly in and Brazil, and in "upstream" in Asia (East Timor).

Galp Energy is the company that leads the ranking of national exports. It exports to 55 countries but the most important markets are USA, Mexico, the Netherlands and Britain.

In 2012, Galp Energy presented a turnover of 18,507 million euros, representing an increase of 10% compared to 2011. Had earnings before interest and taxes (EBIT RCA) of 585 million euros, 48% more than in 2011and a net profit RCA of 360 million euros, ie 43% more than in 2011. The company's market value is € 9,752 million

The current human resources of Galp Energia comprise over 7,000 employees, in 13 countries in 4 continents. These numbers reflect the business expansion, particularly in the Iberian

Peninsula and businesses in Africa and Brazil. Currently over 40% of Galp Energia employees work outside Portugal and the company has a markedly Iberian business identity. Almost 90% of directly created job opportunities refer to this geographical area.
Galp Energia has more than 40 exploration and production projects, in four continents and its goal is to produce more than 300kboepd in 2020. With two refineries the company has a capacity to process 330 thousands crude barrels per day.
In terms of innovation and technology Galp Energia has developed a set of collaborative relationships with SCT (Scientific and Technological System) entities in order to develop activities of creation and use of knowledge that differentiate and create value for business strategies. Consequently the company has built a strategy for R&D and innovation supported on cooperation with these entities, creating a flexible network of partnerships that allows to share important skills. The three main foundations of the strategy for R&D and innovation are:
1- Closer linkages with the SCT and with customers;
2- Development of differentiation in the markets where the company is present, supported in the creation of new services in order to answer needs and expectations of the customers;
3- Active participation in the development of sectoral policies, which strengthen the future development of the energy sector.

6. Analysis of the cases

In the following section we analyze the two cases of energy companies according with three main dimensions in order to answer to the questions of the study.

(1) Why Brazilian and Portuguese energy sector companies invest in R&D?

The alignment of strategic and technological enterprise for the next 10 years resulted in the prioritization of some actions, such as the acceleration of technological development, the expansion of national capacity and performance in the network involving the internal structure of R&D and technology partners abroad. Specifically, the company's technological guidelines are grouped into three key axes: Expanding the Boundaries; Diversification and Value Addition of Products, and Sustainability. In turn, these axles address the strategic issues for the company that should guide the R&D internal and external, both integrated and coordinated by CENPES and, more directly, by Petrobras Technological System.
Among the strategic goals of Petrobras, presented in the Business Plan 2012 to 2016 stand out the programs listed below which provide investments of US$ 236.5 billion:

- Program for Increasing Operational Efficiency (Proef) Operating Units and the Campos Basin in Rio de Janeiro: seeks to increase the reliability of delivery of oil production through interventions and maintenance platforms and subsea systems, improving levels of operational efficiency and preserving the integrity of production systems
- Optimization Program Operating Costs (Procop): aims to increase cash generation on the horizon of 2012-2016 PNG, increase the productivity of their activities from internal and external benchmarks and strengthen the management model focused on efficiency costs
- Content Management Program-Local Prominp Petrobras: aims to make the most of the competitive capacity of domestic industry of goods and services to meet the demands of PNG 2012-2016 with adequate time and cost to market best practices.
- Program Divestitures (PRODESIN): aims to raise funds to finance the 2012-2016 PNG and optimization of the portfolio of assets of Petrobras.
- Program Optimization of Logistics Infrastructure (Infralog): aims to plan, monitor and manage projects and actions in an innovative way to meet the needs of the company's logistics infrastructure by 2020. The analysis of integrated logistics solutions enable the exploitation of synergies and cost reductions in all businesses of the Petrobras System, contributing to capital discipline.

Galp Energia has developed a great effort in order to ensure its competitiveness and sustainable growth. The investment in R&D in different fields of company´s operation allowed the company to get a higher efficiency in its operations, namely in refining and in the marketing of oil products and natural gas, as well as in the exploration potential of concessions.
The company's growth potential is also a reflection of its efforts in terms of qualify and develop human capital, as well as in a continuous-improvement policies in what regards health, safety, the environment and sustainability. These efforts allow the company to be prepared to the technological and innovation challenges, through the allocation of resources to research and development projects and to a multiplicity of advanced training programmes.

This investment in R&D and the development of the several research projects are determinant for the achievement of the targets that will provide the sustainable growth of Galp Energia in short, medium and long run:

- The development until 2010 a production capacity of 300 kboepd;
- The insurance additional resources that will allow the company to reach and sustain a production level of 400 kboepd;
- The operation of refining base in accordance with the highest standards of safety, efficiency and reliability;
- The development of the trading of crude and oil products;
- The achievement of a minimum 15% share in the Iberian market for oil products;
- The achievement of sustained growth in the African market for oil products, aiming to sell, in the long term, a material volume of those products;
- The development of a minimum capacity for the trading and supply of natural gas and liquefied natural gas (LNG) consistent with our equity natural gas stakes and with the dimension of the market where we operate;
- The grow of sales activities in the Iberian market for natural gas in order to keep, at the very least, the current market share;
- The participation in the market for biofuels through a vertically-integrated approach;
- The promotion of energy efficiency solutions and the insurance of the sustainability of company operations;
- The development of Galp Energia's corporate centre, in terms of skills and responsibilities, considering the geographical dispersion of company activities;
- The promotion of policies for innovation, sustainability, health, safety and the environment, permanently meeting, in anticipation, the needs of our different operations;
- The strengthens of an advanced training programme of human resources that will provide company with the human capital required to answer the challenges to come.

Finally it is important to refer that the market for liquefied petroleum gas (LPG) contracted in 2011 was affected not only of the adverse economic conditions but also of higher average air temperatures. However, Galp Energia maintained its market share after it increased efforts in innovation and sales.

Finding 1: Brazilian and Portuguese energy sector companies invest in R&D in order to obtain a better performance in terms of reduction of costs, of higher efficiency, of an increase of sales and profit, and naturally, of an improvement in terms of sustainability, and safety. These factors allow assure the important market share and a sustainable growth of both companies.

(2) How Brazilian and Portuguese energy sector companies develop R&D activities?

Petrobras invested R$ 2.2 billion in research and development (R&D) in 2012. The management of these resources is coordinated by CENPES, the largest research complex in the Southern Hemisphere and private use of Petrobras. From these resources £ 586 million were invested in universities and institutions of national science and technology for the realization of projects of R&D, qualification of technicians and researchers, and the expansion of laboratory infrastructure. The partnership with suppliers, especially in projects related to the pre-salt, which led to the installation of R&D centers and laboratories in the Technological Park of Rio, including the actors: LabOceano - Laboratório de Tecnologia Oceânica; NUTRE - Núcleo Tecnológico de Recuperação de Ecossistemas; Neo; CEGN - Centro de Excelência em Gás Natural; Instituto Global para Tecnologias Verdes e Emprego – GIGTec; LAMCE – Laboratório de Métodos Computacionais em Engenharia Schlumberger; Baker Hughes; FMC Technologies; Halliburton; Tenaris Confab; BG; EMC²; Siemens; General Electrics; V&M; Georadar.

Here are some innovative actions and results recently achieved by Petrobras:

1. Discovery Microfossil kind of knowledge that contributed to more accurate positioning of reservoirs at different depths in the pre-salt basins of Santos, Campos and Espírito Santo.
2. Completed lab tests for the injection of CO2 as fluid oil recovery. 3rd. Completion of initial testing technology that will maximize the drainage of tanks and minimize the amount of wells in the pre-salt.
3. Completed basic design of floating liquefied natural gas shipped to the utilization of natural gas pre-salt Santos Basin.

4. Applied new way to anchor that meets specific pre-salt.
5. Developed equipment for emergency repair during operation of pipelines transporting liquid without interrupting the flow.
6. New formulation for diesel Podium, with reduced sulfur content from 200 to 50 parts per million (ppm) and incorporation of 5% biodiesel.
7. Developed catalyst for use in production of high density polyethylene material having high mechanical performance.
8. Creating a core experimental Bahia to test separation technologies, CO2 capture and storage, which may contribute to future projects of the pre-salt Santos Basin to prevent emissions to the atmosphere.
9. Completion of new geological model of the Brazilian Atlantic Continental Margin, which will yield more accurate estimates of the risks inherent in exploration offshore sedimentary basins.
10. Update model for the geological evolution Parnaíba Basin, which enables you to enhance the analysis of the factors affecting the presence of accumulations of oil and gas in that area.
11. Completion of three-dimensional seismic velocity model for the discovery of Jupiter in the pre-salt Santos Basin.
12. Applying the latest technology in simulators and analyzes developed in Petrobraswhich assisted in the drilling of the first horizontal well in the pre-salt.
13. Installation of the first intelligent completion systems in the pre-salt, which will increase production.
14. Start of operation of subsea multiphase pump more hélico-axial currently operating in the world, developed by Petrobras and Framo Engineering, which increased by about six thousand barrels per day of liquids production in Barracuda Field.
15. Start of operation of subsea system injection of seawater developed by Petrobras and Framo Engineering, which currently injects 500 m3 per day in Albacora Field, in the Campos Basin.
16. Preparation of Basic Design and Technical Documentation for bidding platforms P-74, P-75, P-76 and P-77 oil fields of the Assignment Agreement.
17. 5% increase in gasoline production of Gabriel Passos Refinery (Regap) by using the new additive iso-zoom.
18. Start of operation of the first unit of industrial hydrodesulfurization of cracked naphtha technology with Petrobras in Capuava Refinery, which allows to produce gasoline with a sulfur content of up to 50 ppm, according to the specifications of the ANP for 2014.

As technology projects and expansion of production capacity of Petrobras that will be developed in the coming years, stand out: Blue Whale Project; Project Baúna and Piracaba; Project Roncador Module III; Sapinhoá Pilot Project; Lula NE Pilot Project; Papa-Terra project; Park Whale Project; Project Roncador Module IV; North Sapinhoá Project; and Project Lula - Iracema South.

Investment in Galp Energia, 2012 was € 940 million, with about 70% of the total allocated to the Exploration & Production. The Refining & Marketing business, which by the end of 2011 was the major focus of investment in 2012 represented only about 20% of the total. Investment in Exploration & Production totaled € 653 million (more € 354 million than in 2011) which was mainly allocated to development activities of block BM-S-11 in Brazil, which accounted for € 306 million. About 40% of the investment in the segment allocated to exploration activities, highlighting the investment in Mozambique which totaled about € 79 million. The investment in the business segments Refining & Marketing and Gas & Power totaled € 284 million, € 412 million less than the previous year. This decrease was due to completion of investment in refinery conversion project

Investment in Research and Development is understood as strategic and across the entire value chain of Galp Energia, with particular focus on activities involving higher technology. Thus, Galp Energia decided to develop cooperation with the national scientific system in order to establish a network of advanced skills in the field of exploration and production (E&P). In this field investment in R&D is essential to overcome the technological challenges of the E&P activity in various parts of the world where Galp Energia operates. Also with regard to refining, while the only Portuguese refiner, Galp Energia considers investment in R&D as a strategic value creation, differentiation in product and process innovation. Regarding the capture and sequestration, Galp Energia participates in COMET, a project that aims to identify an infrastructure of transport and storage of CO2, covering the area of the western Mediterranean.

In the field of E&P, Galp Energia is also developing some projects, such as the project modelling and characterization of fractured reservoirs and the seismic imaging project in reservoirs beneath canopies of evaporites.
In the field of refinig, as part of the PhD Program in the business (EngIQ) some R&D projects are being developed: 1) Lonic liquids for extracting mercaptans; 2) Optimization of Parex unit; 3) Development catalyst hidrodesmetalização; 4) Oligomerization of Olefins C5 - C8.; 5) Improved Alkylation; 6) Technology for NMR characterization of crude oils and some current procedural; 7) Ginseng project..
In the field of capture and sequestration, Galp Energia is also developing several projects of R&D. The most importante is COMET, an integrated infrastructure for the transport and storage of CO2. This project aims to identify a CO2 transport and storage infrastructure on the Mediterranean coast. This infrastructure will cover the West Mediterranean area, in particular the Iberian Peninsula and Morocco, and will identify locations with the capacity to store CO2 in geological formations
Moreover, Galp Energia develops several new products and services related with energy and sustainable mobility. Some of these projects are the project Smart Galp, the energetically Efficient Flett project, a sustainable campus network, the PT Galp Innovation Challenge and the electric car project.
Also some projects related with the improvement of energy efficiency, we being developed, highlighting the programme Galp 20-20-20, the largest scholarship programme for applied research in energy efficiency (with the participation of IST, UA- Universidade de Aveiro and FEUP- Faculdade de Engenharia da Universidade do Porto), the creation of two R&D projects (industrial PhD) in partnership with UA and the programme that promotes energy efficiency in Palácio de Belém, in partnership with EDP and LNEG (national lab of engineering ang geology).
Finally, in terms of mobility, Galp Energia is developing several projects, such as, R&D fuel project for development and verification of innovative and eco-efficient fuels, as well as fuel quality control. Is also developing cooperation in project 3Gforce in partnership with the Institute of Mechanical Engineering of IST. Another project, Living Lab Galp Toyota was created in partnership with Toyota and IST and finally in what concern biofuels, Galp Energia created R&D consortiums with ISA (Instituto Superior de Agronomia), Instituto Politécnico de Portalegre (IPP) and VICORT and Domingos Reynolds Sousa companies to develop processes of harvest, extraction, production and refining of jatropha oil to biodiesel.

Finding 2: Brazilian and Portuguese energy sector companies develop R&D activities through the development of several projects research in different fields, such as exploration and production (E&P), refining/capture and sequestration, through the development of programme of advance training and shared investigation, through the development of new products and services.

(3) How and why Brazilian and Portuguese energy sector companies develop cooperation for innovation?

To strengthen technological skills to face the internal and necessary developments, a comprehensive system of partnerships developed by Petrobras over the years, including the participation of national and foreign universities, technology companies, suppliers, engineering companies, research centers and other oil companies, in which the CENPES, under the supervision of Petrobras, plays the role of coordinator of technological efforts. Currently, we have a total of 7 regional centers, 3 in Rio de Janeiro, one in Bahia,one in Sergipe, one with the Holy Spirit and one in Rio Grande do Norte, and 50 thematic networks.
Petrobras is a Brazilian company that invests more in R&D, and in the period 2006 to 2010, its total investment in R&D got to the total of US$ 1.2 billion, placing the company among the eight largest investors in the industry worldwide energy in that area, and specifically in 2010, the company invested R$ 1.8 billion in R&D (PETROBRAS, 2010).
About the company's total expenditure on R&D, infrastructure projects and considering, there is a total of US$ 2.6 billion in the period from 2008 to 2010, about five times the average for the period 2001 to 2003. Of the total of these expenditures, 44% resulted solely from internal R&D, 29% of partnerships with national ICTs, 8% of ICT and partnerships with overseas companies and 19% of partnerships with national companies (PETROBRAS, 2010).
The history of the company's investments in R&D over the last seven years is due in part to the enactment of Resolution No. 33/2005 which regulates the investment of at least 1% of gross revenue in R&D for companies successful in bidding rounds of ANP, being 50% of the funds

invested in internal R&D and 50% invested in projects and programs developed in partnership with ICTs previously accredited in ANP (PETROBRAS, 2010).
Another important point of the innovation performance of the company was the realization of 705 projects of R&D from 2006 to 2010, with prior authorization from the ANP, representing about 99% of total investment during the same period, when considered all oil dealers that operate in Brazil and are subject to mandatory investment in R&D. In result, the investment of Petrobras, in partnership with ICT, grew nearly tenfold from 2004 to 2010, reaching US$ 300 million in 2010.
The investment in new knowledge is determinant to creating a culture of sustainable innovation. This type of culture can represent an important source of differentiation, essential in a competitive market. So, the development of R&D and innovation strategy is crucial for Galp Energia. For this purpose the company created several linkages and cooperative relations with SCT in a permanent network that share skills and knowledge.
Some of the more significant collaborative partnership for innovation develop by Galp Energia are:

1- The creating of a digital platform of relationship with Scientific and Technological System. In 2010 the number of registered scientists, technologic entrepreneurs, partners and suppliers quadrupled an achievement (480 members). Additionally, the interaction between the members of this network and the adoption of this channel to present innovative proposals to Galp Energia increased significantly.
2- The development of 20-20-20 programme aims to promote the participation of MsC students with 30 studies in the area of rational energy systems and behaviours applicable in industry and buildings. This programme started at 2007 and already involved the participation of 53 entities, state-owned or private.
3- The promotion of open innovation. Galp Energia Challenge is one of the open innovation channels either STS. The aim of this programme is to challenge university community and technology-based companies for the presentation of proposals of technological solutions to solved existing problems in the company.
4- Also the main R&D projects already presented are developed in partnership with several universities and other entities (COMET project, ENGIQ programme of training and PhD-refining, R&D projects related with energy efficiency and mobility).

Finding 3: Brazilian and Portuguese energy sector companies develop several collaborative partnerships with universities, institutes, researcher centres and national and multinational companies. This collaborative partnership allows both companies to shared skills and knowledge essential for an innovation culture, as well as, to the development of a differentiation strategy.

(4) What are similarities and differences in R&D investment, R&D activities and cooperation for innovation between Brazilian and Portuguese energy sector companies?

In order to analyse possible similarities and differences concerning the several aspects analysed during our study it was developed comparative analysis. Table 2 presents the summary results of this analysis.

Table 2- Comparative analysis between Petrobas and Galp Energia

	Petrobas	Galp Energia	Similiarities	Differences
Companies characteristics	Public company	Private company		√
	Transnacional company	Transnacional company	√	
	Intensive capital	Intensive capital	√	
	Leader in Bovespa	Leader in PSI20	√	
	Integrated corporate strategy for growth, profitability and environmental responsibility	Corporate strategy of sustainable value creation, development and expansion of activities and corporate responsibility in economic, environmental and social dimension as a catalyst for innovation and how to improve the satisfaction of their stakeholders.	√	
R&D and innovation	Large investments in R&D	Large investments in R&D	√	
	Reasons of the investment: • expansion of national capacity; • cost optimization; • adding value; • product diversification and sustainability; • improved levels of operational efficiency	Reasons of the investment: • increase competetiveness; • get higher efficiency in its operations; • increase production; • guaranty highest standards of safety an quality.	√	
	Several developments in innovation and development of several R&D projects in E&P, refining, capture and sequestration	Several developments in innovation and development of several R&D projects in E&P, refining, capture and sequestration	√	
	In order to strengthen technological competencies the company develop various partnerships with universities, research centers, technological conpanies, suppliers and competitors	In order to strengthen technological competencies the company develop various partnerships with universities, research centers, technological conpanies, suppliers and competitors	√	

Finding 4: Brazilian and Portuguese energy companies revealed more similarities than differences concerning the subject proposed by this study.

Conclusions

The present study analyzes innovation in energy sector, studying the largest energy companies from Brazil and Portugal. Our findings based on these two cases, that are representative of the energy sector studied, allow understanding why and how these firms invest and develop R&D activities, as well as why and how they cooperate to undertake these activities.

Confirming the theoretical framework of our study, the empirical study suggests the important role of R&D concerning the improvement of efficiency, increase production, guaranty highest standards of safety an quality and the important achievements in terms of firms competitiveness. These developments are possible through cooperation between several stakeholders and sharing resources, such as natural resources, skills, competencies, knowledge or technology, technological.

The study also confirms the importance of the energy sector and the cooperation between the developing countries and developed countries, since problems related with limited access to energy sources, the very widespread use of traditional biomass and dependence on imported energy sources constitute a significant obstacle to social and economic development**.**

Finally the comparative analysis between the companies studied, considering its characteristics and aspects related with the form and reasons to develop innovation, suggests that these companies have essentially similarities, enlarging a great effort in terms of R&D development and cooperation for innovation, being, not only competitors but manly partners in several projects, sharing the same vision, mission and objective and implementing the same type of strategies.

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