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MANAGING INNOVATION IN OIL AND GAS COMPANIES

A proposed framework for the management of innovation at Ecopetrol S.A.

Master´s Thesis
in International Business
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1 INTRODUCTION

Nowadays it is very common to open a book or a journal in any kind of business management and find information about how relevant innovation is for companies which want to grow, to be competitive, and in other words, not to die in the dynamic and changing markets. As a result it may not be longer on doubt that innovation is an unavoidable imperative in any industry and for any kind of company.

In effect, results from a recent study made with more than 800 companies around the world, show that companies believe that enhancing innovative ability is today the most important lever to increase profitability and growth (Arthur D Little 2005). However, what innovation means is much more than coming up with new ideas, it is more about storming resources and people than just storming brains, and about understanding what drives change and how to make it happen (Gailly 2011).

As a result, managing innovation can be considered inherently risky and difficult. In fact, innovation can enhance competitiveness, but it involves a different set of management knowledge and skills from those of everyday business operation (Tidd, Bessant & Pavitt 2005). As expressed by Gailly (2011) it requires the development of innovation management capabilities, which involves significant human and technical challenges adjusted to specific characteristics and context.

Besides being a challenging process, what makes it valuable is that if managing innovation was simple and easy, everybody would do it and there would be no room left for competitive differentiation. Under this context, executives have to figure out how to get an innovation effort with a high probability of succeeding (Loewe & Chen 2007) without having a unique and magic formula for introducing and developing innovation within organizations. In fact, as some authors and surveys have suggested (Arthur D Little 2005; Tidd et al 2005; Lawson & Samson 2001), every individual case may require the strengthening of different capabilities which will give it a competitive advantage in every specific industry.

Based on this, what seems to work in a company in the way as it manages innovation, may not work the same in another, even with similar characteristics between the companies. Therefore, executives of many companies, no matter the industry they belong to, constantly exhibit a great interest in knowing how to manage effectively innovation across the organization, according to its external and internal conditions, and in order to get competitiveness and market differentiation.

In this way, although different models have been proposed about innovation management, it seems not to exist a magic formula to manage innovation in a company, which makes difficult and challenging the generation of value through innovation (Tidd et al 2005). Consequently, it requires an internal analysis of the company´s conditions and capabilities as well as those of the sector in which the company is, in order to iden-

tify which elements must be considered to the management of innovation, and how they should be arranged in order to create value for the organization while taking advantage of the current capabilities and values of the company in the market.

1.1 Background to the study

By far innovation has constituted a critical source of competitive advantage, although this advantage is not easily to be obtained. There are various meanings about innovation, but in a general and simple way it can be understood as the mechanism by which organizations produce new products, processes and systems which are required for an adaptation to dynamic markets, technologies and forms of competition (Dougherty & Hardy 1996; D'Aveni 1994; Utterback 1994).

Different literature has focused on studying innovation´s outcomes and nature, and due to this innovation can be classified in different types and given in new or existing products, services, business models, and markets, as well as process and management innovation (Tidd et al 2005; Schumpeter 1994; Damanpour 1988; Utterback & Abernathy 1975). However, innovation in practice has evolved during the last years, and the traditional view in which it was a role of just R&D departments as a matter of coming up with new products and services, has become obsolete. The landscape of innovation has shifted significantly thanks to the availability and an easier access to information and knowledge, as well as to the growing use of alliances and partnerships.

Normally, innovation is messy, involves false starts, recycling between stages and jumps out of the normal sequence (Tidd 2006). Due to this, innovation requires a wise administration in order to extract the value that it represents while dealing with complexity and risks.

According to Tidd et al (2005), innovation management is about learning to find the most appropriate solution to the problem of consistently managing this process, and doing so in the ways best suited to the particular circumstances in which the organization finds itself. The authors also point out that there is unlikely to be the "one best way" to manage innovation, because industries differ in technological and market opportunities, and instead of finding the magic formula, it is better to explore which are the links between structure, processes and culture of an organization, the opportunity for and characteristics of technological innovation, and the competitive and market environment in which the firm operates.

An interesting perspective on innovation management has been given by Lawson and Samson (2001) who proposed that innovation management can be viewed as a form of organizational capability. According to the authors, companies can execute innovation process in an effective way which leads to innovation in new products, services, and

processes. As a result, superior business performance can be exhibited. Under this innovation capabilities´ perspective, companies should invest more in innovation capabilities as the primary engine for wealth creation, rather than in the possession of physical assets. As an interesting contribution the authors proposed, under dynamic capabilities literature, seven elements that constitute innovation capabilities. These are: vision and strategy, harnessing the competence base, organizational intelligence, creativity and idea management, organizational structures and systems, culture and climate, and management of technology. (Lawson & Samson 2001)

Similarly, Christensen (2001) argues that there are three classes of factors that affect what an organization can and cannot do. Those are its resources, its processes, and its values. Consequently, when asking what sorts of innovations their organizations are and are not likely to be able to implement successfully, managers can learn a lot about capabilities by sorting their answers into these three categories.

Nevertheless, in general it seems no to exist a unique accepted comprehensive and systematic framework which allow managers toward successful innovation. Some have suggested (Arthur D Little 2005; Tidd et al 2005; Lawson and Samson 2001) that innovation management may be sector or industry specific and the firm-level differences given by their competitive environment, strategy, task complexity and management style, influence the innovation process across firms.

Under this perspective, successful innovation may involve core elements and processes regardless of the industry or firm. For example, fundamental differences between industries with regard to innovation investments and efficiency were found in a study developed by the consulting firm Arthur D. Little in 2005 in more than 800 companies around the world. The results, which were obtained by analyzing the levels of investments in R&D (as a percentage of the sales) against the levels of sales generated by products launched in the last 5 years, are shown in the next figure.

The oil and gas industry, particularly, faces greater and more exacting technical challenges, which makes innovation more important for their success and sustainability, especially when the demand for global energy continues to grow to be double in the first half of this century due to the improvement of living standards and population growth (Shell innovation 2011). Thus, in order to survive and supply the future energy demand, companies must strengthen their capabilities and adopt innovation (as soon as possible) as a core element into their strategy, and throughout innovation be able to achieve the goals they set.

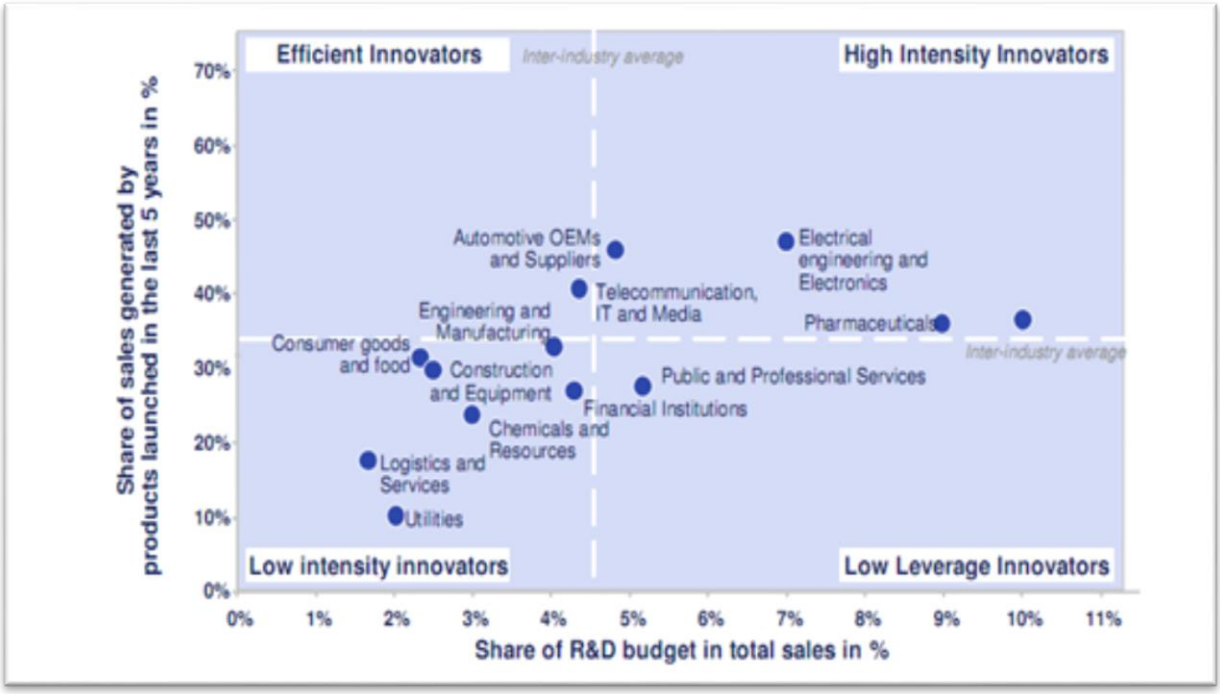

Figure 1 Industry differences in innovation

Source: Arthur D Little (2005)

Given the fact that the oil and gas industry exhibits specific characteristics that other industries do not, innovation in here may be also sector-specific. Actually, around 90% of the world´s oil reserves are entrusted to state-owned companies and more than half of the largest companies in the oil and gas industry belong totally or in some proportion to the state (see Appendix 1). In this way, National Oil Companies (NOCs), which were originally created as political instruments face new demands in the today´s competitive world, and the world still knows little about them and their perspectives. Many of them are internationalizing and developing new oil reserves overseas as well as investing in international refining and retail activities, and in general they are evolving and looking for an elusive balance between their national and commercial mission (Marcel 2006).

The oil and gas as an industry moves in cycles, and currently enormous amounts of innovation, technology and investments are being given (Oil innovations pump… 2007). Companies in this sector mainly face two big challenges, one associated to innovation in procedures and technologies for exploration, extraction, production and commercialization of the product, and other related to the investment in alternative fuels, in order to satisfy the future energy demand which seems to be shaped not by natural limits but by social choice (Dicken 2011).

In fact, recently the BP, throughout its Statistical Review of World Energy (which documents trends in the production and use of energy since 1956), generated the Energy Outlook 2030 (see Appendix 2), which presents estimations around the increment in the

future energy consumption associated to two powerful driving forces: population and the income growth. The inform states that in the next 20 years, although the population growth is trending down, the income growth is trending up, and due to the relationship between income and energy consumption found in the past years, more people with more income will mean that the production and consumption of energy will rise, and industrialization, urbanization and motorization continue to be the forms that shape the modern energy economy. Perhaps what is more relevant for the oil and gas industries to be extracted from the report is that for the first time in the next two decades non-fossil fuels will be major sources of supply growth (The contribution of fossil fuels to primary energy growth is projected to fall from 83% (1990-2010) to 64% (2010-2030) meanwhile the contribution of renewables to energy growth increases from 5% (1990-2010) to 18% (2010-2030)). (British Petroleum 2011)

Innovation has been and will continue to be required in the oil and gas industry in order to face the continuous challenges. However, how oil and gas companies are organizing internally their potential resources, processes and values to make effectively that innovation happen, is not widely known. Thus, companies that don't have a history of innovation have made it primarily an R&D issue, or are struggling to make their innovation efforts pay off (Loewe & Chen 2007). As pointed out by Greg Lewin, President of Shell Global Solutions International BV, innovation is an ancient art, but managing innovation is still in its early stages of development, it can be considered a relatively young management technique which has received much less attention than any other aspect of innovation such as creativity, entrepreneurship or venturing (Verloop 2004).

This phenomenon occurs around the world, although one could find a little bit more references about how to manage innovation in the oil and gas industry in developed countries than in developing nations, where it is highly difficult to find an integral guidance for companies to approach innovation according to the sector and internal conditions of the company given the external environment. In fact, research about innovation in Latin America, has found that innovation processes in the region tend to be informal, the majority of innovations are adaptive and incremental, and radical and breakthrough innovations are limited. This phenomenon is due to the fact that in the region the technological change is exogenous and that the few which is endogenous rarely comes from R&D activities or basic research (Arocena & Sutz, 2002; Jaramillo, Lugones & Salazar 2000, Durán, Ibañez, Salazar & Vargas 1998). Additionally, there is a minimum integration between the enterprises with National Innovation Systems, which make the innovation processes in Latin America weaker than those in developed countries (Malaver & Vargas 2004).

Colombia is not the exception to this phenomenon, innovation outcomes are still poor to give the nation a competitive advantage (OCyT 2012; Malaver & Vargas 2007;

Malaver & Vargas 2004). According to Naranjo and Calderón (2010) Colombia exhibits remarkable technological lags in its efforts against developed countries, and even compared to nations of similar development (technological efforts made by Colombian economy are lower 50% to those made by the average Latin American countries, and investments in R&D by the business sector is quite low). Furthermore, the innovation processes in the country are still informal because they are not planned and do not follow a strategic technology and innovation management. (Naranjo & Calderón 2010)

Thus, there is a need for identifying the way as companies in the oil and gas industry can manage innovation to support the company´s objectives and generate sustainable value. It means how companies identify the main elements which relates to the management of innovation in their companies, and particularly how they approach and structure them to support innovation efforts and leverage the goals achievement.

It seems no to exist enough evidence about how companies are structuring innovation and turning it into a reality within their organizations (especially in economies which may incorporate very little innovation) (Verloop 2004). Thus, due to the great relevance this sector has and will continue to play around the world as well as the need it exhibits to innovate, the author has found it important to identify and analyze how the oil and gas companies can manage innovation effectively and which are those elements to be considered and structured into a framework for innovation management. If there would be more clarity about the different elements interrelated into the management of innovation in an oil and gas industry, particularly in a developing country where the oil and gas companies contribute greatly in the national economy and where innovation process in the region tend to be informal, it would be easier for other companies in similar conditions to approach innovation and learn from other´s experiences in the sector, especially when companies share similar external conditions. With this knowledge, a company´s innovation efforts were better focused on the generation of value for the company, so then, generation of value for the nation.

As a result, the present study seeks for identifying the main elements, their interrelations and structure, required for managing effectively innovation in oil and gas companies. To do this, the author focuses its research in the analysis of the most important and biggest company in a developing country. This, throughout a holistic single case study, looks for structuring a framework for managing innovation in a company in the oil and gas industry, called Ecopetrol S.A., from Colombia, a developing nation in South America.

1.2 Research questions and sub questions

According to what has been exposed in the last section, this research considers the relevance and importance of making innovation results a reality inside companies through the definition and implementation of an innovation framework for the management of it; in fact it covers innovation management in both the theoretical and practical setting. Designing a framework for managing innovation in Ecopetrol S.A. requires asking specific questions for which the research provides answers. The research question and sub questions derived from it enable the categorization and analysis of the research findings.

Thus, in this study the research question is formulated from the basis of both the case study´s requirement towards a structuring of its innovation system and the theoretical aspects towards innovation management in the oil and gas industry, as follows:

Research question: *How to manage innovation in the oil and gas industry?*

By answering the research question the main structures for managing innovation are presented, which provide the desired benefits for the target organization. As stated by Clough and Nutbrown (2002) for clarifying a research question ones can use the Russian doll principle, it means taking the research idea and breaking down the research questions from the original statement until the very essence of the question can be expressed, in a similar way as the Russian doll is open into different pieces to reveal finally a tiny doll at the center. Thus, the research question of the present study is approached through the next sub questions:

1. *What kind of innovations do the oil and gas companies make?*
2. *What are the principal elements on which companies focus to manage innovation?*

All of the sub questions provide useful information for the main problem. The first sub question addresses the direction on which oil and gas companies focus their innovation efforts. The second sub question allows the identification of the main elements involved at managing innovation within a company in the oil and gas industry and the relationship between the identified elements and how they are normally organized for managing innovation effectively. Thus, by giving answer to the sub questions, it is possible to build a framework for the management of innovation at Ecopetrol S.A. in order to improve the way as the company actually manages it.

Based on the given context, the present research principally seeks for identifying and analyzing the main elements for managing innovation that should be considered and structured within a company in the oil and gas industry. Thus, a company in the oil and gas industry in Colombia is analyzed, based on the needs for each organization to find its own particular answers to the general puzzle of innovation management.

By the end of the research a proposed framework for managing innovation at the case company is constructed, based on the theoretical background, research´s findings,

and in the company´s innovation environment and conditions. This research uses an inductive approach in which the author collects data and develops a framework as a result of the data analysis. Thus, primary qualitative data is collected from the single case company, with the use of non-standardized interviews, according to the differentiation given by Healey (1991) and Healey and Rawlinson (1993). It covers semi-structured and in-depth (unstructured) interviews used to gather data, which are normally analyzed qualitatively (Saunders, Lewis & Thornhill 2007).

This chapter has considered the main aspects associated to the problem which is the focus of the study. Consequently, the next chapters cover the concepts in innovation and innovation management, as well as some issues in innovation in the oil and gas industry. They also show the interaction between these factors and how companies in the oil and gas industry organize and structure innovation to turn it into a reality with the aim of achieving their goals, satisfying the current energy demand and preparing for future dynamic changes.

In these chapters literature about innovation management and about innovation in companies in the sector is identified and reviewed for the construction of the scientific background. In the context of the research, due to the fact that the case study company can be considered in the group of low or medium innovators (in terms of efficiency of innovation), it is recommended to benchmark it against the most innovative companies in the same industry (Arthur D Little 2010). This is why the author attempts to find the way as other Latin American companies in the oil and gas industries manage innovation, due to the sharing of similar characteristics with the case study company (state ownership, geographical location, position in the 50 largest oil and gas companies in the world). However, literature and research in these companies is limited which does not contribute enough to the regional industry analysis that has been planned initially.

The final chapters cover the methodology, data collection, analysis and results from the research.

Across the study the author manages to contribute to the analysis of the innovation management topic applied in a commodity sector: the oil and gas industry, from which there was not found extensive applied scientific literature. Thus, this work provides remarkable insight into an unexplored field that has not been largely studied, and contributes to a replicable knowledge of how innovation should be managed in an oil and gas company in a developing country.

2 MANAGING INNOVATION

Innovation is not exclusive of high-tech environment, in contrast, it occurs in all sectors of economy activity and it must be seen and adopted as a mindset, and not as a one-time event. As noted by Goyal and Pitt (2007), for succeeding at innovating, the principles of innovation management should be incorporated as a part of the day to day activities for each employee in any level of the company. As a consequence, only by embracing an integrated innovation framework companies are able to compete and be successful in a global economy.

In this chapter the key definitions underpinning the phenomenon of innovation, innovation management, and how companies start its innovative path are reviewed.

2.1 Understanding innovation and how it works

Nowadays, innovation is associated with corporate success and it is considered as extremely important and needed for business survival, up to a point that none company could maintain its market share or profits over a long period of time without being innovative. According to Naughton (2004), the increased importance of innovation is attributed to the advances in technology, the change in customer needs, shorter product life cycles, and global competition.

Innovation has been studied from multiple perspectives at different levels of analysis by scholars from a variety of academic disciplines (Damanpour & Schneider 2008). One of the most representative and initial contributions to innovation literature is that built by Joseph Schumpeter as early as 1934, with the publication of the Theory of Economic Development. He saw innovation as an involving process of "creative destruction", where economic development was driven by innovation with new technologies replacing existing ones. Thus, for Schumpeter, innovation was the introduction of something new or with improved quality, i.e. a product, service, production method, market, raw materials, or an industry or firm.

Later on Zaltman, Duncan and Holbek (1997) defined innovation as

> *any idea, practice, or material artefact perceived to be new by the relevant unit of adoption (Zaltman et al. 1997)*

In 1985, Peter Drucker gave a broader concept on innovation, considering it as the process of equipping in new, improved capabilities or increased utility. He also emphasized a focus on market orientation. In particular, Tushman and Nadler (1986) defined

innovation as a creative process whereby new products, services, or production processes are developed for a business unit (Huang, Chou & Lee 2010).

Later on, in 1991, Damanpour defined innovation as

> *the generation, development, and adoption of novel ideas on the part of the firm (Damanpour 1991)*

and in a similar way, the UK Department of Trade and Industry's (DTI 1998) defined innovation as the successful exploitation of new ideas. Similarly, the Oslo Manual defines innovation as

> *the implementation of a new or significant improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations (European- Comission 2005, 46)*

Despite the relevant importance of innovation in the current world, it has been difficult to structure an academic consensus about innovation`s definition, scope, characteristics and proper operationalization (Garcia & Calantone 2002). In general, researchers have defined innovation as the development and/or use of new ideas or behaviors, which may be associated to a product, service, technology, system, or practice (Kissi, Dainty, & Liu 2012; Walker 2008; Damanpour & Wischnevsky 2006; Zaltman et al. 1997; Amabile 1988). Under this context and for the purposes of this study the author chooses the definition given by Katz (2006) since it covers clear and basic elements at innovating which are mentioned frequently in the innovation literature:

> *the successful generation, development and implementation of new and novel ideas, WHICH introduce new products, processes and/or strategies to a company OR enhances current products, processes and/or strategies LEADING TO commercial success and possible market leadership AND creating value for stakeholders, driving economic growth and improving standards of living.(Katz 2006, 6)*

In general, innovation evokes "newness" as its main characteristic, which is defined by Blythe (1999) as

> *the degree to which a given product is outside the observer's experience. (Blythe 1999)*

According to Johannessen, Olsen & Lumpkin (2001) it is possible to identify three newness dimensions: what is new, how new, and new to whom, which in turn can be divided into three levels: new to the company, new to the market, and new to the industry. Under the context of this research the three given dimensions and levels of newness can be present in the oil and gas industry as it is shown later on.

Early models describe innovation as the interaction of a set of complex processes, a linear sequence of functional activities. According to Doyle and Bridgewater (1988), innovation depends on factors such as the firm´s marketing ability, firm´s strategy, resources, networks and processes, as well as firm´s culture and leadership.

Innovation is different within firms. Smaller or younger firms are more flexible, less bureaucratic, and generally exhibit internal conditions which encourage innovativeness (e.g., Lewin & Massini 2003; Penrose 1959; Schumpeter 1942). In young firms, innovation is fluid and dynamic (Utterback & Abernathy 1975), whereas in larger, long-established firms, innovation is affected unconstructively by considerable bureaucratization. These characteristics influence greatly the way as innovation is designed within the companies. For the purpose of this study, the focus is on long-established firms in which there are more available resources for investing in innovation although at the same time high levels of bureaucratization are present, due to the many organizational layers and rigid procedures, which in turn impact innovation process and outcomes.

The nature of companies (services, manufacturers) also impacts their approach to innovation. It has its basis on the fact that service companies are more likely to follow a continuous change approach to innovation wile manufacturing companies tend more to introduce innovations periodically rather than continuously. Service companies´ main orientation to innovation are organizational changes whereas for manufacturers are new products and processes changes. However, it does not mean that innovation patterns are totally different; indeed neither of the sectors exhibits a single pattern of innovation (Tether, Mina, Consoli & Gagliardi 2005).

Due to the fact that innovation implies the exploitation of new ideas, it is often confused with invention. However, innovation and invention are not the same; the former should not be equated to invention, and the former not necessarily lead on to innovation. As Freeman (1982,7) noted, an invention represents an idea of a new or improved service, product, process or system, while innovation is manifested only with the commercial transaction that involves the new service, product, process or system associated with the invention. In other words, invention is the generation of newness or novelty, and innovation is the value that is derived from that novelty.

The quantity of inventions normally exceeds considerably that of innovations. Hamel (2006) states that

> *Innovation in whatever form follows a power law: For every truly radical idea that delivers a big dollop of competitive advantage, there will be dozens of other ideas that prove to be less valuable (Hamel 2006)*

Given the gap between invention and innovation, considerable knowledge, capabilities, resources and supportive structure is required to enhance the innovation process. When this is not effectively identified, the funneling paradigm studied by Berth (1993) happens (see Figure 2), in which the number of the original ideas is significantly lower than the number of successfully commercialized ideas.

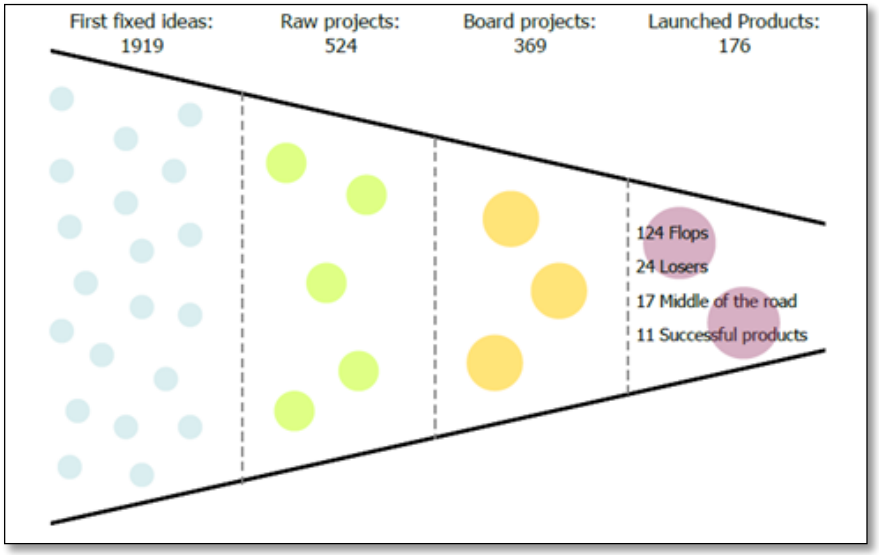

Figure 2 The innovation funneling paradigm

Source: Essmannn (2009; 25)

Unquestionably innovation is important for contemporary companies and business development. Although many papers have been written around the topic, there is not still a precise recipe for successful innovation (Becheikh, Landry & Amara 2006). Researchers have tested the effect of innovation-related variables (Souitaris 1999; Wolf 1994), but the results differ and innovation phenomenon is still poorly understood (Coombs, Narandren, & Richards 1996).

Innovation is highly affected by the interaction of different aspects (internal and external). Regarding the literature review in innovation done by Tippu (2011) some studies have focused on the factors that affect innovation results. Some of those aspects are: the organizational structure, the organizational culture, human resources, technology, legal environment, communication flow, competition, and costs. External factors also play an important role in innovation, in special regulation, clients, and manufacturers (Blayse & Manley 2004).

In a similar trend, according to Van der Panne, Van der Beers & Kleinknecht (2003) there is a positive impact of the next aspects in successful innovation:

- The firm's culture susceptible to innovation and able to recognize the nature of innovation efforts;
- The previous firm`s experience with innovation projects;
- The multidisciplinary character of the R&D team (technological and marketing skills);
- An articulated innovation strategy and a management style that matches the strategy;
- Compatibility of projects with the company's core competences
- Product quality and price relative to those of substitutes;
- Adequate timing of market introduction.

Given the fact that innovation does not capture value if the successful exploitation of ideas does not occur, it is necessary to consider the elements that influence an innovation system in more detail. However, before identifying those common elements present in the literature that integrate the innovation structure in a company, it is important to check how innovation has evolved and the different typologies involved at innovating.

2.1.1 Innovation models - evolution

Over the last 30 years our understanding of innovation, its sources and the nature of the required skills, has been transformed. Nowadays, diversity is the key. There is no unique model of innovation, therefore, there is no single model of managerial and work force skills required for innovation (Tether et al. 2005).

According to Burgelman (1996), since World War II, innovation has been the rule and the remedy for all business problems. Since the last century numerous models of innovation have emerged.

Technological innovation was initially associated with studies of innovation processes. Some of the best known, among others are: The process-based model of innovation or technological innovation audit model (Chiesa, Coughlan & Voss 1996), the pentathlon model (Goffin & Pfeiffer 1999), the TEMAGUIDE model (COTEC 1998), and the process of innovation management model (Tidd & Bessant 2009; Tidd et al. 2005).

One of the most representative researchers in innovation management has been Roy Rothwell. He made available a useful historical perspective on innovation management, in which he suggested that our perception of the innovation process has evolved from simple linear models, to increasingly complex interactive models. Rothwell`s five generations of innovation models are (Rothwell 1992):

- First generation: Technology push

- Second generation: Market pull
- Third generation: Coupling of R&D and marketing
- Fourth generation: Integrated business processes
- Fifth generation: System integration and networking

In particular, the 'fifth-generation innovation' proposed by Rothwell (1992), understands innovation as a multi-actor process, involving high levels of integration at both intra- and inter-firm levels, and facilitated by IT-based networking. In fact, as shown in the Figure 3, in this generation, innovation is highly dependent on cross-functional integration within the firm, coupled with close inter-relations with suppliers, customers, commercial partners, and other sources of technology, such as universities or research institutes (Tidd 2006).

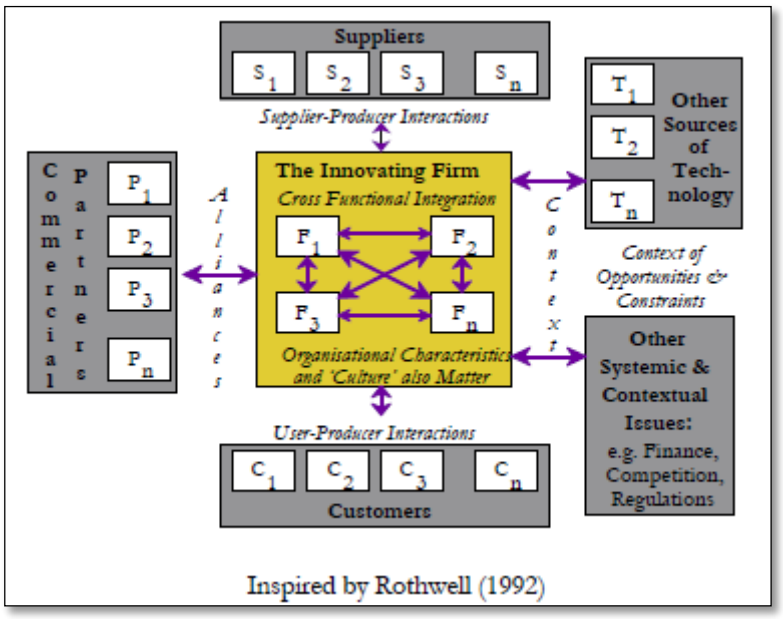

Figure 3 The 5th generation "systemic integration" model of innovation

Source: Tether et al. (2005; 77)

Similarly to the innovation models and their evolution, Kondratiev in his book The Major Economic Cycles (1925) suggested 5 different waves of innovation, although Freeman and Perez nowadays talk about a '6th wave' emerging which is linked to growing social movements, as it is shown in the next figure (Seebode, Jeanrenaud & Bessant 2012).

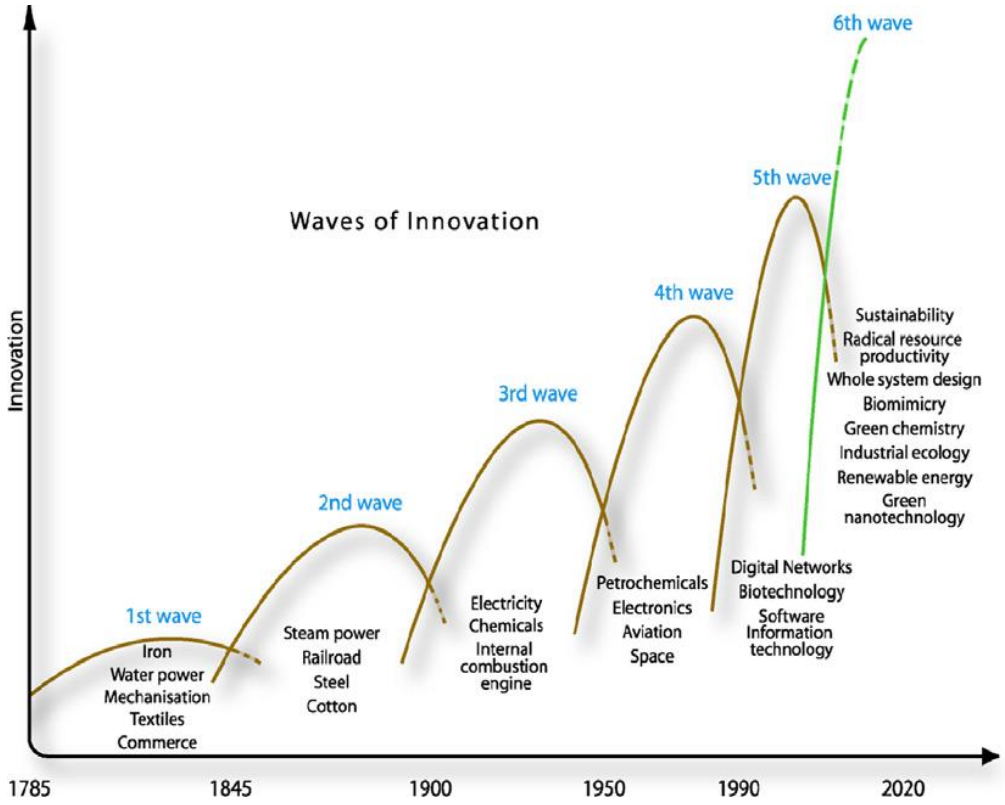

Figure 4 Sustainability as a 6th 'long wave'
Source: Seebode et al. (2012; 196)

Paralelly, Niosi (1999) provides a concise description of 4 successive generations of innovation, focused mainly in R&D function. The first generation brought the corporate R&D laboratory. The second generation adapted project management methods to R&D. The third generation brought internal collaboration between different functions in the organization. Finally, the fourth generation adds routines designed to make more flexible the conduct of the R&D function through the incorporation of the knowledge of users and competitors.

Independently of the historical overview, one could conclude that in every wave or generation, organizations tend to follow a set of best practices, which evolve over time in the way as the external contexts change and require different approaches to innovation management. However, although innovation has evolved in its understanding and practice, it is important to highlight that current business do not act always in the same way as that proposed in the last generations or waves (i.e. the majority of firms still go alone for innovation, especially when developing new products and processes new to the firm). Instead of this, companies seem to adopt a more context-based approach, which is called by Ortt and van der Duin (2008) "contextual innovation". Thus, being consistently innovative demands a complex arrangement of the right ingredients, and the process is more than the application of the same formula in another organization.

The most successful innovative companies succeed by carefully selecting the right approach within a given context (Griffin 1997). Indeed, Brown and Eisenhardt (1997) have shown that firms may adopt broadly different approaches to innovation, even when they develop similar innovations. Furthermore, some research shows that even within a single company, different approaches to innovation may be adopted (Ortt & van der Duin 2008; Van den Elst, Tol & Smits 2006; Verloop 2006).

2.1.2 Innovation typologies

Researches on innovation have focused on the study of different innovation types on the assumption that they differ from each other in attributes and in their adoption processes (Light 1998; Kimberly & Evanisko 1981; Daft 1978). Thus, many typologies have been proposed.

From the perspective of the interaction with markets, innovation can rise mainly from the existence of any of the next two scenarios. On the one hand, when ideas for new products or processes rise from inside the company and find their way to the marketplace it is known as a "technology-push innovation". Meanwhile, where the necessity identified in the market becomes the origin of something new which seeks for satisfying the identified need, it is known as a "need-pull or market-pull innovation". Interactions happen all the time; the push can dominate a period and the pull a next one, but always interaction between both is fundamental for successful innovation (Tidd 2006). An emerging view suggests that to be innovative, a firm needs complementary market-pull and technology-push strategies. Normally firms that operate with this balanced focus tend to perform better than other firms which focus only on either technology-push or market-pull.

Porter (2007) identifies six variations of innovation: technology invention (focused on the creation of new technologies), systems solutions, product improvements, process improvements, new business models, and market extension. The Oslo Manual extends its definition to four different types of innovation: product or service, process, marketing methods, and organizational methods.

In the Table 2, suggested by Trott (2005), it is possible to see that innovation can occur in different dimensions (product, process, organizational, management, production, commercial/marketing, and service innovation). These dimensions are not mutually exclusive, they work in conjunction, which means that one type of innovation may lead on to another type (Neely & Hii 1998)

Table 1 A typology of innovations
Source: Trott (2005; 17)

Type of innovation	*Example*
Product innovation	The development of a new or improved product
Process innovation	The development of a new manufacturing process such as Pilkington's float glass process
Organisational innovation	A new venture division; a new internal communication system; introduction of a new accounting procedure
Management innovation	TQM (total quality management) systems; BPR (business process re-engineering); introduction of SAPR3*
Production innovation	Quality circles; just-in-time (JIT) manufacturing system; new production planning software, e.g. MRP II; new inspection system
Commercial/marketing innovation	New financing arrangements; new sales approach, e.g. direct marketing
Service innovation	Internet-based financial services

SAP is a German software firm and R3 is an Enterprise Resource Planning (ERP) product.

The previous given classifications can be simplified into three basic types: in terms of products (product innovation), processes (process, organizational, management, production, commercial/marketing, and service innovation), and strategy (business concept/model innovation) (van Zyl 2006; Baker 2002; Stjernholm 2000; Hamel & Hamel 1996; Prahalad 1994).

Research has offered a close link between product and process innovations (e.g. Freel 2003; Michie & Sheehan 2003; Lager & Hörte 2002; Sternberg and Arndt 2001; Gopalakrishnan, Bierly & Kessler 1999; Papadakis & Bourantas 1998), as well as has shown that product and process innovations follow different processes and do not necessarily have the same determinants.

Innovation can also happen in each of the firm´s core: in the technical, and in the administrative core. Concerning technical and administrative innovations, the dual-core theory establishes that while the former pertain to products, services and process technologies, the latter involve organizational structure and administrative processes (Damanpour & Evan 1984; Kimberly & Evanisko 1981; Daft 1978). Furthermore, technical and administrative innovations follow different processes since the former normally tend to follow a bottom-up process, while the latter follow a top-down process.

As mentioned earlier, categories and dimensions that have been used to describe innovation and its dynamics are vast (Cooper 1998; Gopalakrishnan & Damanpour 1992; Utterback 1986). Another mean for categorizing innovation is to place it on a scale ranging between the extremes: incremental and radical (Plessis 2007; van Zyl 2006; Baker 2002; Cooper 1998; Neely & Hii 1998; Hamel 1996). This division has to be mainly with the newness of the initiative, as follows:

Incremental innovations: The majority of the innovations given in a firm are of this type. They can be considered as either line extensions or modifications of existing products or services (Dosi 1998). These innovations tend to be market-pull innovations because the vast of ideas come from the marketplace as a result of a closely alignment with consumer's needs. In general, incremental innovations are likely to improve existing internal competencies by offering the opportunity to build on existing know-how.

Radical innovations: They can be both: new to the world and new to the firm. When new to the world, it is also a breakthrough, while in new to the firm it might not. Due to the fact that these innovations are more likely to originate from scientists, they can be normally technology-push innovations (Dosi 1998). This type of innovations requires different management practices. Radical innovations are risky, they tend to ignore the consumer needs, but still, they are needed for the long-term success of a firm, because they can change existing market structures. In addition, radical innovations are likely to open up opportunities to develop incremental innovations. For radical innovations, the invention phase used to exhibit a degree of extreme newness or novelty, which carries out ambiguity, uncertainty, and complexity (Katz 2006).

Managing innovation differs between both types of innovation. Managing for radical innovation, where uncertainty is high, requires different approaches from those used to manage incremental innovation. However, organizations need to have, as well as develop, a balance between incremental and radical innovation; the former help at improving the current conditions, while the latter anticipates the future. Plessis (2007) states that companies, with mixed portfolios (radical and incremental innovations), are more successful than those which focus just on one type of innovation.

From a broader perspective, Huang et al. (2010) compares innovation typology as follows: sustaining vs. disruptive innovation, closed vs. open innovation, and creative vs. imitative innovation.

Sustaining and disruptive innovation: According to Baker (2002), the given categorization of radical and incremental innovation cannot distinguish between newness and impact that an initiative has. This impact may go from small improvements through to a fundamental transformation of an industry, and even of a market and economy. In this way, Christensen (1997) introduced another dimension for innovation; he differentiated between sustaining and disruptive initiatives. While the former improve established products, process and/or strategy, the latter bring different products, process and/or strategy to the marketplace.

Particularly, disruptive innovation establishes a new market for new products or services which may be simpler, more convenient, and cheaper than those which are currently available in the market (Christensen, Baumann, Ruggles & Sadtler 2006; Christensen & Overdorf 2000; Bower & Christensen 1995). At the beginning, these products or services may not satisfy existing needs of the mainstream customers. However, with-

in the time the company can catch the next wave to potentially disruptive technologies and experience the chance to prevail over obstacles when technologies or market change.

Open and closed innovation: Chesbrough (2006) defines open innovation as

> *the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. (Chesbrough 2006, 1)*

In closed innovation, firms do not cooperate or exchange knowledge with externals while in open innovation they do. Nowadays it is more frequent that firms realize they are unable to have all the competencies required to develop innovation in-house. This pushes them to open up their R&D process and engage with other firms. Thus, regarding the importance of collaboration in the exploration of creative individuals, innovation communities and other collaborative initiatives, the concept of open innovation has increased its popularity within the academia and among managers and business practitioners (Ollila & Elmquist 2011; Morgan & Finnegan 2008; Chesbrough & Appleyard 2007). In fact, according to the last study done by Bain & Company (Rigby & Bilodeau 2013), companies expect a change in the use of open innovation in about 50% more.

One of the factors which support this phenomenon has to be with the increment in the expenditure on outside suppliers, from 20% to nearly 70% of total corporate expenses (Porter 2007). In this way, supply chain is nowadays considered a major strategic asset, although many companies still treat their suppliers as mere "vendors". However, what the best companies do is, based on a segmentation of suppliers (strategic or commodity supplier), to define special attention for the co-generation of innovation streams. As a result, collaborative innovation, which is critical for the value creation, is derived from the interaction between firms and their suppliers, throughout effective strategies, architectures, and models for creativity. These companies are aware that differentials in thinking constitute the primary source of innovation; they see their business not as isolated ones, but as a part of an interconnected value chain or network in which creation of value is strategically aligned and managed.

Open innovation support companies to remain competitive in changing environments since it increases adaptability and impact the generation of products and services better adjusted to the market needs. Companies doing open innovation also increase creativity and the access to knowledge, as well as achieve quicker and cheaper innovation cycles.

Although open innovation is actually highly implemented it is necessary to consider that too much openness may be dangerous and could lead to a loss of core competence (Enkel, Gassmann & Chesbrough 2009). It also brings new managerial challenges which need to be addressed (Ollila & Elmquist 2011). One form to mitigate the associ-

ated risks is to clearly identify the real need to outsource in the firm`s innovation process. It is possible to achieve if firms identify and understand the skills, capabilities and knowledge that make them unique in the business. Another important aspect to take into account is to ensure intellectual property rights and use appropriate protection strategies, such as the use of knowledge brokers, in order to minimize knowledge leak risks.

Imitative and creative innovation: Innovation may be generated internally, or from imitation or adoptation of other firms` innovations (Huang et al. 2010; Walker 2008; Damanpour & Wischnevsky 2006; Cavusgil 2004; Knight & Cavusgil 2004; Lewin & Massini 2003; Massini, Lewin & Greve 2003; Nelson & Winter 1982; Daft 1978; Kimberly & Evanisko 1981; Sandberg 1999). Imitative innovation relates to competent mimic followers which refer innovation as new to the firm rather than new to the world (Hegarty & Hoffman 1990). Levitt (1966) suggests that being a fast follower is a more reliable strategy than being a first mover or creative innovator. However, it depends on every individual case and industry.

There are three main characteristics of imitative innovation: First, the outcome is the same existing products and services in the markets, which means that the speed to market must be high in order to avoid lost opportunity (Högselius 2003; Sandberg 1999; Levitt 1966). Second, technological capabilities of imitative firms should be solid and R&D intensive (Schewe 1996). Third, intellectual property (IP) management is a great challenge.

Innovations in products, services, program or technologies, which are developed inside the organization (creative innovation), normally are for the firm´s own use or for sale to other firms. When these innovations are offered or sold to other firm, the process of innovation for the adopting organization varies from that used by the generating firm. In the first case, the innovation process in the generating firm implies the stages of idea generation, project definition, design, development, marketing and commercialization (Cooper & Kleinchmidt 1990; Baker & McTavish 1976; Rothwell & Robertson 1973). In the second case, the innovation process for the adopting firm considers awareness of innovation, attitude formation, evaluation, decision to adopt, trial implementation and sustained implementation (Damanpour & Gopalakrishnan 1998; Zaltman et al. 1997; Rogers 1983)

The next table shows the differences between the recently mentioned types of innovation (Huang et al. 2010):

Table 2 Innovation typology and their classification standards

Source: Huang et al. (2010; 955)

Innovation typology	Classification standard
Sustaining v. Disruptive	Better quality or the additional functionality of a product or service vs a simpler, more convenient, and less expensive product or service (Christensen *et al.*, 2006)
Closed v. Open	Only an Internal source vs Merging of internal and external sources (Chesbrough, 2006)
Creative v. Imitative	New to the market vs New to an individual firm (Sadowski and Sadowski-Rasters, 2006)

Zahra and Covin (1994) identified three major sources of innovation: imitative, acquisitive and incubative. The imitative source relates the firm's disposition to copy innovations which have been introduced previously by other organizations. The acquisitive source is associated with the firm's disposition to acquire innovations, developed by other organizations, through purchase, licensing, acquisition, or merger. Finally, the incubative source has to be with the firm´s disposition to generate its own innovations through internal development, i.e., R&D, which supports the introduction of new goods and methods as well as the opening of new markets and the way as serving those markets effectively (Knight & Cavusgil 2004; Nelson and Winter 1982; Schumpeter 1934).

The type of source and kind of innovation a company chooses to focus on must be considered carefully, firstly, because the emphasis a firm may put on one source or innovation type can represent less managerial time and attention from another source (Hitt, Hoskisson, Johnson & Moesel 1996), and secondly, because it impacts the definition of the capabilities and skills a firm must have to adopt innovations successfully in the marketplace (Zahra & Covin 1994).

Having an understanding about what is innovation, how it works and the way as it has evolved within the time, the next section covers a description of the most common elements that, based on a literature review, commonly integrate a system for managing innovation.

2.2 Innovation management

In the business environment it continues to be quite common to hear question such as 'Why are some organizations more innovative than others?' and 'What organizational structures and management processes facilitate or inhibit innovation?' These kinds of questions have been, and are, approached by scholars in different ways.

As it was explained previously, innovation can be perceived as an outcome or a process. Researches who have perceived innovation as an output have tried to determine the contextual, structural as well as process conditions under which firms should innovate (Van de Ven, Angle & Poole 1989; Dean 1987). On the other side, researches who have understood innovation as a process have attempted to identify how it emerges,

develops and becomes a part of routine activities in a firm. Both researches do agree that certain approaches and perspectives are just useful for specific contextual conditions (Abrahamson 1991; Damanpour 1991; Meyer & Goes 1988; Poole & Van de Ven 1989). However, according to Wolfe (1994), no matter the perspective, results in innovation research are inconsistent, and today we continue to be far from the suggesting answers to the mentioned questions raised above.

Innovation may not only change an organization, it may also redefine an industry by influencing the generation of new ideas. However, an accepted and systematic framework which guides managers toward successful innovation has not been defined yet in the same way for every industry or firm. Additionally, various patterns of innovation may co-exist in different kinds of firms at the same period of time (Tether et al. 2005). Due to this, various scholars have oriented their research to the management of innovation and have suggested that innovation management may be sector or industry specific, if not firm specific (Vaccaro, Jansen, Van Den Bosh & Volberda 2012; Birkinshaw, Hamel & Mol 2008; Hamel, 2006, 2007; Birkinshaw & Mol 2006; Mol & Birkinshaw 2006). Even so, differences at firm-level such as competitive environment, strategy, task complexity, and management style, mean that the relevance of each innovation process may differ across firms.

Although the challenge for innovation in companies is the same, the approach to it differs significantly. Some firms develop more effective routines than other companies, and although innovation remains as a risky process, their well-developed ability to manage the innovation process makes them an imitative model to follow by others (Bessant 2005; Dodgson 2000; Gundling 2000; Kanter 1997; Baden-Fuller & Pitt 1996).

According to Christiansen (2000), specific innovation management systems (idea generation methods, project management methods) have a deep impact on innovation results and innovative ideas. Normally, innovation management takes for granted that ideas can be generated easily and managed like a production process. However, it has been considered by Meissner and Sprenger (2010) as a positivistic and somehow dehumanized view of innovation management, especially when considering that idea generation is not a simple process to be managed in a company to guarantee the generation of innovative ideas.

In general, innovation processes describe the performed activities at each stage of the development of an innovation. Thus, innovation management can be seen as the governance and organization of these innovation processes (Ortt & van der Duin 2008). In a similar vein, according to Christensen (2002), management of innovation relates to the strategic and organizational context for the individual innovation processes in order to generate successful product and process innovations whereas economizing on time and resources.

Innovation management relates to a set of tools for the innovation. When a company decides to innovate, it is highly recommended that the firm dedicates time to define the way as innovation is going to be managed. It implies the definition of an innovation management model. The most common elements in the literature, among others, refer to the firm`s innovation process, the organizational structure, the resources for innovation, the innovation policy and objectives, and the measurement and control methods. The organizational structure should contemplate both, the structure for innovation project development, and the innovation process management. The innovation policy and objectives, aligned with the innovation strategy, should contemplate the foundations and the main directions for the firm to follow at innovating. Both, strategy and organizational structure are important aspects of an organization's internal environment, and they have an impact on innovation management practices. In fact, strategy defines how important is innovation to the company throughout the definition of whether a firm is an imitator, follower or leader, while the structure of an organization, either functional or divisional, determines the way innovation practices are organized (Ortt & van der Duin 2008).

Having the innovation strategy and policy defined, the company must allow resources for innovating. Some studies have tried to explain how resource allocation strategies influence performance outcomes of innovation project portfolios (Klingebiel & Rammer 2013). This activity contemplates the prioritization of innovation projects and the construction of the innovation project portfolio. Finally, the way as the innovation system is going to be measured and controlled, has to be defined, in order to determine the firm`s innovation performance.

Different frameworks for managing innovation have been created. However, they relate in the same or different words to basic elements, as those mentioned above. Basically, when defining the elements of an innovation model for a firm, it must consider at least that:

- Organizations should focus innovation based on the industry they belong to, their position in the value chain, and the competitive environment.
- All those projects which seek for developing new business models or radical innovations, should be separated from the other firm`s activities.
- The innovation objectives established by firms under the innovation strategy, must be ambitious and grounded in sustained business intelligence
- Organizations should determine an integrated innovation process which covers excellent upstream and downstream development
- New service and products performance should be measured and aligned with firm`s employee incentive system, avoiding oversimplification of the measurement metrics.

- Product and technology development should be separated, and companies should define a clear portfolio management system.
- A corporate culture of innovation must be promoted, and it must be assured that staff has the right innovation capabilities.

Moreover, when managing innovation firms face two challenges linked to organizational learning. First, they have to guarantee that they have routines ready for process and which support the firm´s strategy and organizational context. Second, those routines must be adapted to produce firm advantages through experimentation and consolidation processes. It constitutes continuous learning, which has been called by Senge (1990) "adaptive learning" and by Argyris and Schon (1978), the "single loop learning" (Bessant 2005). Throughout this learning, companies can constantly modify the sophisticated routines that they have created in order to retain competitive edge (Graham & Shuldiner 2001; Baden-Fuller & Stopford 1995).

However, when organizations face situations different to the traditional ones, those routines may be ineffective or inappropriate. It happens because those situations do not occur every day, they are essentially discontinuous. Then firms are often enabled to deal with that new context in an effective way. In this way, new entrants are commonly who can exploit the opportunities of developing disruptive innovations while existing incumbents do badly (Foster & Kaplan 2002; Christensen 1997; Tushman & Anderson 1987). This phenomenon is stronger for well-positioned firms which have strong processes developed under steady-state conditions that at the same time act as a set of barriers to identify external signals and respond effectively to innovation treats.

The mentioned situation requires the development of new behaviors and approaches to organizing and managing innovation in a more suitable way to the dynamic environment. It means to develop alternative routines for discontinuous innovation which can exist with those created for stable environment. It implies that firms must also act different with their networks, because in steady-state conditions strong relationships with regular parties are necessary, but with discontinuous innovation, what evidence has suggested, is that organizations need to exploit much weaker ties across different parties with the aim of acquiring new ideas and different sources of knowledge and expertise (Bessant 2005).

As mentioned previously, different literature on innovation management expose different frameworks which analyze the technical innovation audit (Chiesa et al. 1996), the new product development process (Clark & Fujimoto 1991), R&D management and technology acquisition process (Roussel, Kamal & Erickson 1991), and implementation of production innovations (Voss 1988). For the purpose of this research, and based on a wide review of the literature, the author compiles the elements explained in the next sub-numerals, as those factors that should be taken into consideration when defining and building an innovation framework.

2.2.1 Innovation strategy

With the aim of reducing the risk of diverting key resources and damaging the firm´s focus, innovation activities must be driven by the strategy and by what is essential for the business. The linkages between innovation strategy and the business goals are the provision of leadership to make innovation happens by adopting and implementing a strong vision for innovation, an enduring commitment to innovation, and a clear provision of resources (Cooper, Edgett & Kleinschmidt 2004). Interestingly, over the long-term innovations may change the goals of organizations, due to that new markets or business can be found and exploited, so then the organization can be re-oriented.

The next figure shows how product and services relate with markets and customers in the strategy definition.

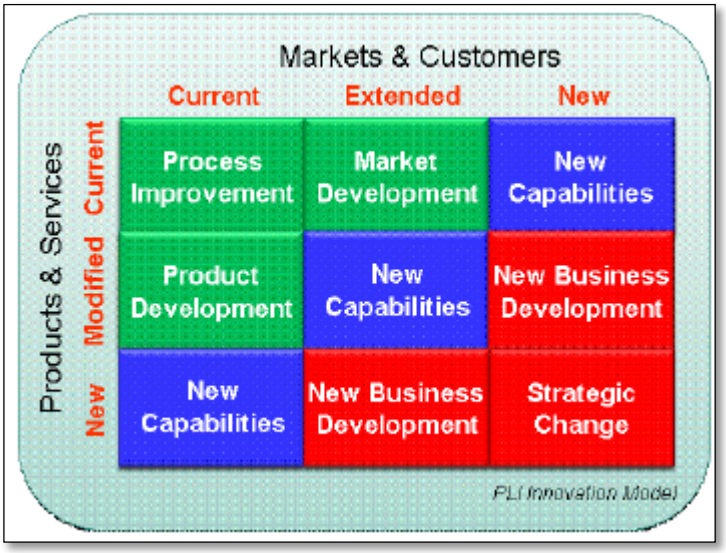

Figure 5 Innovation typology and their classification standards

Source: An integrated approach to managing innovation (2012)

From this it is possible to extract that there may be three types of innovation strategies:

Firms which operate in the green area: They can innovate with existing resources and skills because normally new ideas tend to focus on expanding the current range of products and services.

Companies operating in blue area: They must address a crisis, therefore new capabilities and resources are normally required.

Organizations in the red area: They operate with higher risk because either in markets or with products and services they are trying with something totally new to the business. Therefore, these organizations need the acquisition of new resources, capabili-

ties, ideas and management. In general, these strategies are called diversification strategies.

The integration of innovation into the business strategy depends on the business' appetite for risk and its risk profile. In the Figure 6, it is possible to see that the more traditional the business strategy is, the more number of ideas are generated and the less the risk profile is involved. Conversely, the more challenging and innovative the business strategy is, the less the number of ideas generated and the more the risks involved.

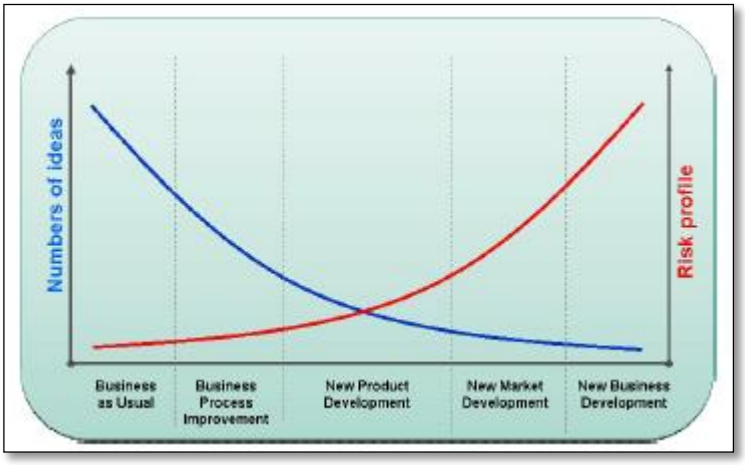

Figure 6 Innovation typology and their classification standards

Source: An integrated approach to managing innovation (2012)

Companies create value when innovating depending on the business strategy. Figure 7 shows, according to Arthur D´Little (2008) the main three sources of value creation in innovation.

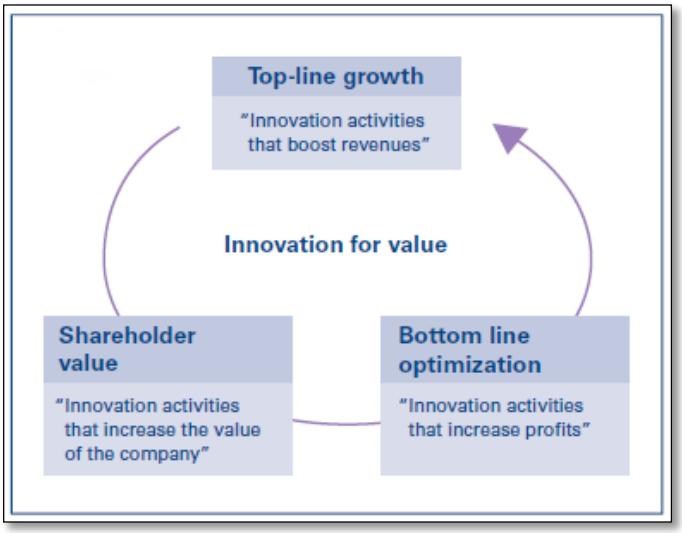

Figure 7 Innovation for value

Source: Arthur D Little (2008; 4)

When implementing top-line growth it comes normally from organic growth, growth by acquisition, radical innovation, and business model innovation. In the case of bottom-line optimization, organization design and culture are key levers, since there is a continuous focus on cost optimization, and in maximizing the efficiency of R&D outputs while reducing time to market, quality problems and associated costs. Finally, when aiming for enhanced shareholder value, the net present value of all future cash flows increases as well as the value of non-operating assets.

Once the kind of value that a firm aims to create is selected and recognized, the way as innovation is managed in the context, where the company operates, play a relevant role in innovation successful.

Managers make different decisions in different contexts. Those decisions are done in two levels: one strategic, and one operational. Firstly, decisions made before and innovation process is started are done at a strategic level (i.e. whether to innovate in-house or externally, whether to innovate or to sell a business unit). Secondly, decisions at operational level have a direct influence on the innovation process definition and execution (i.e. whether the activities should be scheduled in parallel or in a linear sequence, how flexible should be the process) (Ortt & van der Duin 2008). Overall the activities that are planned must be consistent with the firm´s strategy, which in turn means that managers have to take conscious decisions about innovation goals (Sundbo 1997).

Dougherty and Cohen (1995) found that the behavior of senior managers tends to be influential in the innovation strategy. People acting as chief executives who are willing to innovate and make it happens, commonly have a clear vision of the future operation and direction of organizational change and creativity (Shin and McClomb 1998). Meanwhile, those working as senior managers are responsible for sharing a vision for innovation, being supportive and adopting an attitude tolerant to change as well as defending innovation within the organization. Interestingly, managerial tolerance to change is what helps in creating the right environment for developing innovation (Damanpour 1991).

Having into account that in the strategy domain there are no simple recipes for success, a capacity to learn from experience and analysis is extremely important. Thus, three main ingredients in innovation strategy can be pointed out from Bessant (2005): The firm´s position (in terms of its products, processes, technologies and national innovation system), technological paths, and the organizational processes followed by the company to integrate strategic learning within the whole organization and its stakeholders. Besides these elements, innovation depends heavily on having a supporting organizational context where creative ideas can come out and be successfully implemented.

The firm`s vision drives “quality of innovation”, whereas company support drives “quantity of innovation” (McAdam & McClelland 2002). Thus, innovation strategy, aligned with business strategy, must create the conditions in which a company can learn

and start operating with shared problem identification and solving, and with the ability to capture and accumulate learning about technology and about management of the innovation process. Thus, innovation strategy must focus mainly on building and maintaining organizational conditions, essential for innovating, which involve working with structures, work organization arrangements, training and development, reward and recognition systems and communication arrangements (Bessant 2005).

Finally, any transition towards an innovation strategy will take some years because of the resources and energy which are necessary before this transformation is produced (Hope Hailey 2001). To move on this direction, Sawhney, Wolcott and Arroniz (2006), all of them researchers of the Kellogg School of Management, developed a tool in order to develop a successful innovation strategy, which is called "the innovation radar".

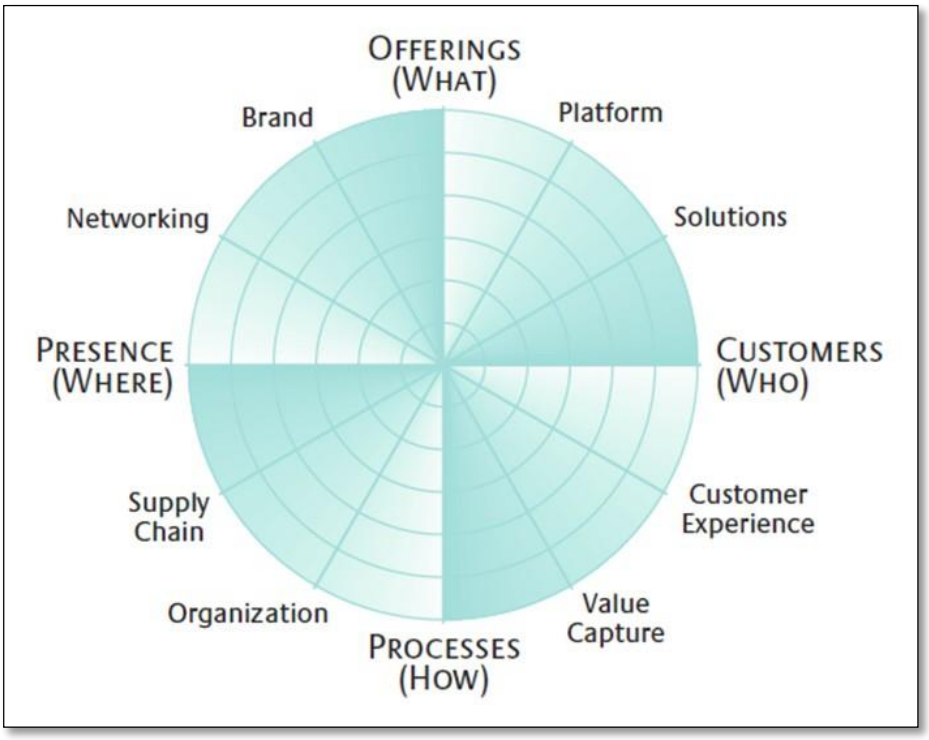

Figure 8 The innovation radar

Source: Sawhney et al. (2006; 77)

This radar provides a 360 degree of the current innovation focus and strategic position of any company by covering innovation in four major business dimensions: Offerings a company creates (WHAT), customers it serves (WHO), processes it employs (HOW), and points of presence it uses to take its offerings to market (WHERE). From those dimensions, the radar allows organizations to innovate in 12 areas: Offerings, platform, solutions, customers, customer experience, value capture, processes, organization, supply chain, presence, networking and brand. By using this radar, any company can measure its innovation performance with an unrestricted view, and define how its

current innovation strategy can face its competitors. With this in mind, the company can identify opportunities and prioritize on which dimensions it should focus its innovation efforts.

2.2.2 Innovation process

Once innovation has been integrated at a strategic level, the next step has to be with the definition of an integrated innovation process. Inside any innovation process there is a chain of common and numerous internal complex processes which work for helping the organization to respond to change. According to Van de Ven (1986), a process innovation is

> *the development and implementation of new ideas by people who use to engage in transactions with others within a corporative context (Van de Ven 1986, 591)*

In fact, innovation process has to be with the practices, procedures, activities, etc. that transform ideas into products, services, processes, business models, etc. This process requires time, resources, capabilities, knowledge, and structure to be executed (Essmann 2009; Essmannn & Preez 2009).

The innovation process is complex and integrates different events and activities that may occur sequentially or in parallel. Innovation processes may differ to some degree within different firms. The basic stages of any innovation process are easy to sketch but tricky to implement (Want innovation?... 2001). Then, it is critical to have an efficient process capable of managing innovation´s ambiguity present in any context (Globe, Levy & Schwartz 1973; Adams, Bessant & Phelps 2006).

According to Loewe and Dominiquini (2006), a good innovation process exhibits the next characteristics:

- Allowed divergence and exploration at the start in order to avoid a re-hash of ideas which has been generated before.
- It contains a big platform where individual ideas can be synthesized to their further development, considering also larger opportunities at hand.
- Experiments for testing critical assumptions and refine business model are allowed.
- Promising ideas are not killed prematurely because evaluation criteria can be adjusted within the process in order to reflect the real state of development of the innovation

Although discussion about the need for innovation exists, it is less clear how the process must be managed. In general, innovation research suggests a well-established framework which can be considered as a best practice innovation. It contains routines created by firms in order to search, select and implement stages of innovation process. (Tidd & Bessant 2009). However, different degrees of novelty require different solutions to the search, selection, and implementation.

Various authors have approached the innovation process and its stages. For example, Luecke (2003) points out that the stages of innovation process may include creative idea generation, assessment of the idea, and development and commercialization. Dodgson, Gann and Salter (2005) suggested the TPD approach for understanding the process of innovation: Think (generation and feed of ideas), Play (encouragement of designers and engineers to engage in problem solving and to make design choices), Do (rapid prototyping, market assessment, and implementation of new ideas). The TPD approaches innovation process as a fluid boundary among various stages of it. Moreover, according to Kanter (1988), who postulated that innovation is a set of behaviors carried out by individuals within an organization, the tasks of the innovation process include idea generation, coalition building, idea realization, and diffusion of the innovation.

In order to achieve efficiency, organizations should establish formal processes for innovating and make use of tools and techniques that may facilitate innovative endeavors. It is common to find approaches to innovation process in the literature such as the Cooper Stage-Gate-Model (see Cooper 1998), the Funnel Model (e.g. Terwiesch & Ulrich, 2009), or the Open Innovation Process Model (Chesbrough, 2003).

The stage-gate model is by far one of the most known and employed model for managing innovation processes (Kurkkio 2011; Cooper 1990). It exists at least since 1957, and within the time many of the principal world companies have used some version of this process. This model contains a series of stages and activities which range from idea to launch. Between each stage, there is a gate where go/kill decisions are made on whether the organization should continue investing on the innovation project or not. Some variations of the model have been done, but in general these models variations begin with an ideation stage called discovery and end with product launch, as shown in the Figure 9. The stage-gate model variations typically have between 4 and 8 stages.

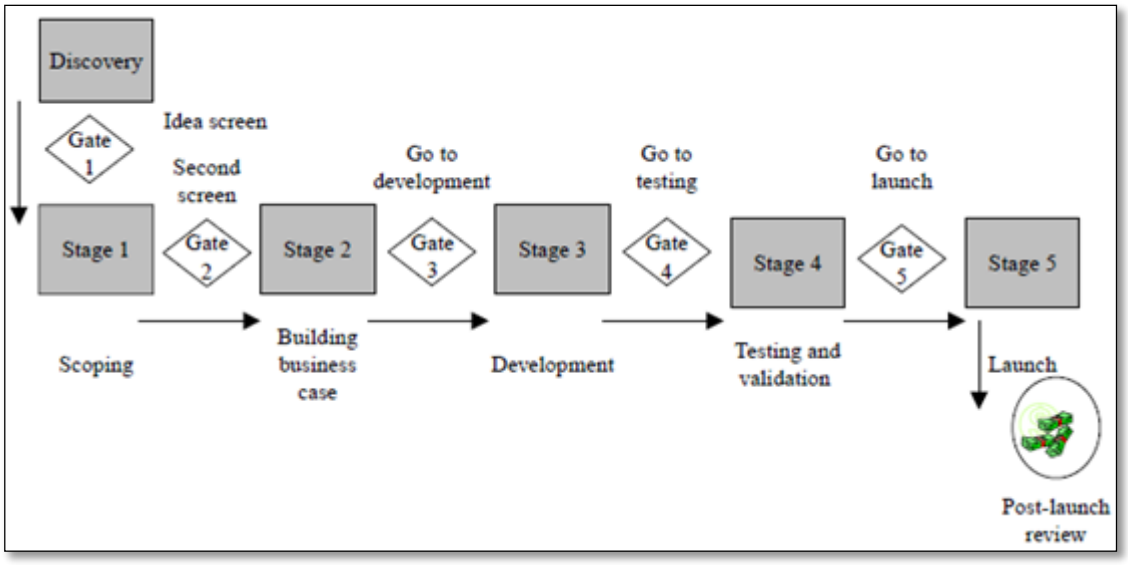

Figure 9 An overview of a typical stage-gate system for major new product developments

Source: Cooper (2008; 216)

Although the stage-gate model is perhaps the most familiar, there are other methodologies for innovation project management such as Phased Development, Product and Cycle-time Excellence and Total Design (Jenkins, Forbes, Durrani & Banerjee 1997). What is common in these methodologies is that the process is divided into structured stages which by turn have milestones as control quality checkpoints where stop/go decisions regarding the continuity of the project have to be made.

Regarding the funnel model, the next approaches can be identified in the literature (Arthur D Little 2008):

The "single funnel" concept: It is recommended in sectors where innovation is primarily driven by idea management (i.e. consumer goods)

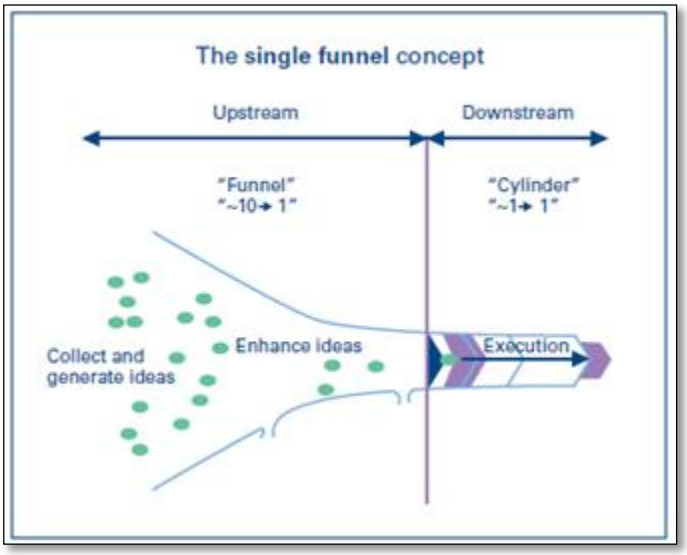

Figure 10 The single funnel concept

Source: Arthur D Little (2008; 8)

The "double funnel" concept: It is useful where innovation is mostly research driven and downstream innovation has large technical uncertainties (i.e. pharma, oil and gas exploration).

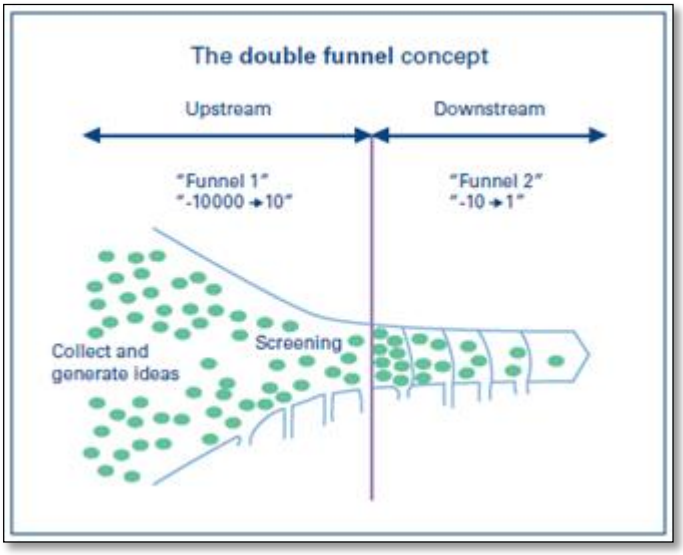

Figure 11 The double funnel concept

Source: Arthur D Little (2008; 8)

The "mixed funnel" concept: It is recommended where innovation requires analytical thinking across several life cycles (e.g. automotive, telecom equipment, manufactured goods, medical technologies, or software companies).

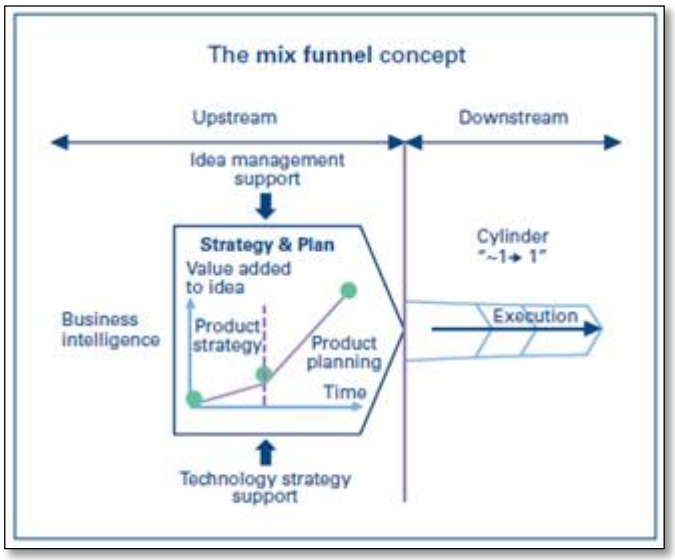

Figure 12 The mix funnel concept

Source: Arthur D Little (2008; 9)

The next table shows the comparison between the three innovation funnels:

Table 3 Comparison between innovation funnels

Source: Arthur D Little (2010; 8)

Idea-driven innovation engine	***Research-driven innovation engine***	***Analysis-driven innovation engine***
Innovation engine is fed and driven by a large number of ideas	Innovation engine is fed by a huge number of ideas generated from research	Innovation engine is fed and driven by an analytical top-down approach
One idea corresponds (more or less) to one product or service	One idea corresponds (more or less) to promising components/targets in a future product/site	Selecting which products to take to market follows a throughout analysis of the market, competitors, and internal capabilities
Product/project portfolio management is about picking the winners - non-promising projects are discontinued	Product/project portfolio management is picking the winners among the huge mass of promising ideas/targets – non-promising ideas/targets are discontinued	Product strategy and product life cycle plan determine which projects to execute
Initiated downstream development projects are seldom stopped	A majority of projects in downstream development will be stopped before launch	Ideas are fragments of a complete product or service
Most suitable for industries that are largely driven by idea management, e.g.: - Fast-moving consumer goods - Services - Telecom operators - Chemicals	Most suitable for industries that are largely research driven, e.g.: - Pharmaceuticals - Oil and gas exploration	Initiated downstream development projects are seldom stopped Most suitable for industries that are mainly strategy and analysis driven, e.g.: - Automotive and manufactured goods - Telecom equipment - Software, MedTech, etc

Regarding the open innovation model, as explained before, a firm commercializes its own ideas as well as innovations from other companies, with the purpose of taking its in-house ideas to market by deploying pathways outside its current businesses. Figure 13 shows the different models when comparing closed and open innovation, as ex-

plained by Chesbrough (2003). Contrastingly, in the latter model, the barrier between the firm and its external environment is porous so then collaboration is allowed and innovations move easier between the two.

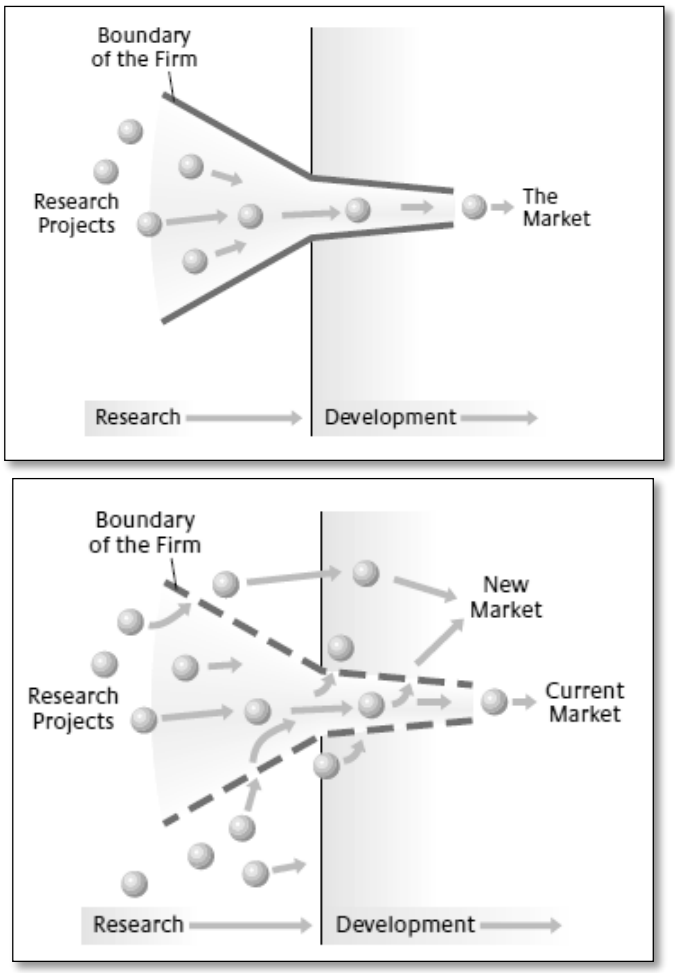

Figure 13 Closed and open innovation
Source: Chesbrough (2003)

Besides the explained models, many others are present in the literature. For example, an interesting framework for innovation process is that given by Kanter (1988). In this model she highlighted idea generation as the first task in the process of innovation. Kanter suggested that linkages with users, structural integration across fields to create cross-disciplinary contacts, broader definitions of jobs, incentive structures, organizational complexity, etc., facilitate idea generation into a company. Furthermore, there are some factors which have impact on the way as innovation process are developed: focus on high value opportunities, high involvement of top management, development of innovation as a core skill, availability of tools to support the process, and reward system for people for sharing ideas and knowledge.

The second sequential task identified by Kanter (1988) in the innovation process is the coalition building, which has to be with the sale of the concept of a project to poten-

tial allies. Consequently, once the idea has been generated and accepted by the top management, the next step suggested by Kanter is the idea realization, in other words, the conversion of the idea into a working proposition throughput the structure of innovation teams. Finally, according to Kanter´s model, diffusion can be considered as the last stage in the innovation process. Thus, the final result of the innovation process is transferred to those who can exploit the innovation. This final stage is intensive and involves people, activities, patterns, and structure to change (Manral 2011).

Another interesting view of the innovation process is that given by Duncan (1976) and Rogers (1983), who suggested that innovation process contains two main subprocesses: initiation and implementation. The initiation stage is related with the activities related to problem perception, information gathering, attitude formation and evaluation, and resource development leading to the decision to adopt. Meanwhile, the implementation stage is integrated by the events and actions associated with modifications in the innovation and the firm, the initial use of the innovation and the continued use of the innovation until it becomes a routine feature of the company (Damanpour & Gopalakrishnan 1998).

More recently, according to Bessant (2005) the majority of firms have a core renewal process in innovation which involves a series of linked activities which are influenced by the headings of innovation strategy, the innovative organization and the innovation linkages. These activities are:

Searching: It has to be with the internal and external scan of the environment for threats and opportunities for change.

Selecting: It is related with the selection of which of the signals respond to the business strategy, according to what the company can best develop.

Implementing: It has to be with the translation of the potential of idea into something new, and the launch of it in the internal and/or external market.

Learning: It is associated with the opportunity to learn that firms have, which is processed through the mentioned steps so they can build their knowledge base and can improve the way as the business is managed.

In a similar vein, TEMAGUIDE (contraction of the words Technology Management GUIDE), which exists since 1998, is the result of a research conducted by some European organizations (COTEC, SOCINTEC, CENTRIM, IRIM, and the Reseach and development unit of Manchester Business School) (Alvano & Hidalgo 2012). It explains the innovation process through five phases: Scan, Focus, Resource, Implement, and Learn. In the first phase the firm seeks for signals about changes in the context that can affect its future. Then, the second phase focus on generating ideas in order to have a set of alternative solutions that help to solve the identified need. Consequently, the next phase is based on the development of skills and competences required by chosen innovation projects. Therefore, the fourth phase is related to the innovation project, having

as outcome a new (or renewed) product or service. Finally, the last phase helps companies to analyze each project through every phase, check the differences between objectives and results, and achieve knowledge and improvement opportunities.

These five elements of the innovation process model proposed by TEMAGUIDE, can be supported by techniques and tools, such as those shown in the Figure 14 (COTEC 1998):

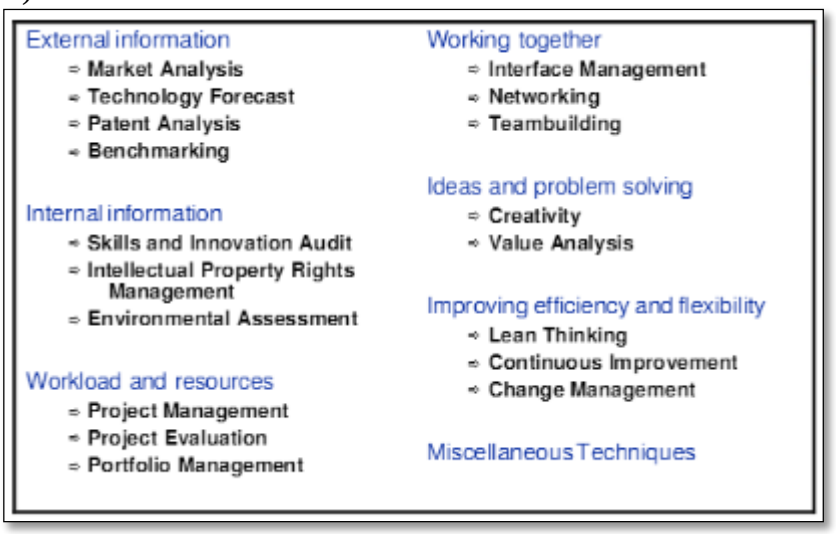

Figure 14 Technology management tools and their application potential
Source: COTEC (1998; 6)

In order to study the innovation management process in the case study company, the author takes into account the elements identified by TEMAGUIDE since the model suggested represents an interactive cycle, rather than just stages. It is also selected because it includes a learning stage, which closes and improves the cycle in the innovation process and therefore offers the firm opportunities to do it better the next time. Furthermore, several tools and techniques compiled by TEMAGUIDE can support the analysis and definition of the suggested innovating routines that people can carry out in the company.

Before moving to the explanation of the next element identified in the innovation framework (technology management), key aspects, such as creativity, the fuzzy front end (FFE) stage, the innovation universal success curve, and the innovation adoption stage, will be taken into consideration due to their relevance throughout the innovation process execution.

Creativity is commonly associated with ideas, which can come from different parts of the firm. In relation with the innovation strategy explained in the last section, in the case of the green area, ideas come mainly from inside the company, while in the blue area, ideas come from external entities, and in the red area ideas come principally via third parties.

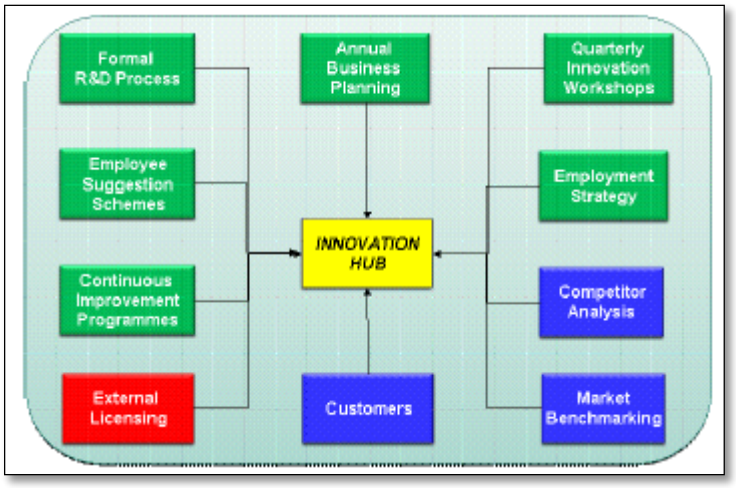

Figure 15 Innovation typology and their classification standards

Source: An integrated approach to managing innovation (2012)

Different ideas and innovations are to make a difference; they must represent tangible value in the short and long time for the organization, must be consistent with the business strategy and the current situation, must be supported by all stakeholders, and must be feasible. In this sense, creativity and innovation share characteristics which sometimes tend to overlap (Angle 1989). While creativity is the generation of novel and useful ideas, especially at the individual level (Amabile, Conti, Coon, Lazenby & Herron 1996), innovation, according to what has been mentioned previously in this document, can be conceived as the process by which these ideas are captured, filtered, funded, developed, modified, clarified, and eventually commercialized and/or implemented. Indeed, organizations in order to remain relevant and to compete in pursuit of its mission, must pay attention to the frequently generation of creative ideas and to the use of its innovation process to realize the potential value of those ideas.

Amabile´s et al. (1996) suggested that anyone of normal capability can be creative since creativity is not something related to the intelligence quotient level. Creativity is influenced by the work environment and is integrated by three components: individual expertise, individual creative-thinking skills, and individual tasks motivation (Amabile et al. 1996). Similarly, King and Anderson (1995) explored innovation in working groups finding that factors, such as leadership style (collaborative and democratic), cohesiveness between team members, group longevity (short life), and group structure (heterogeneity), have a direct influence on the promotion of innovation in a group environment.

There are many methods for developing ideas, such as the classic brainstorming or the use of checklist of ideas for combining ideas, developed by Osborn (1963), and working changes to problems developed by Evans and Lindsay (1999) by turning negatives into positives and changing the focus of the problem. Interestingly, brainstorming is the most preferred method used by companies (McAdam & McClelland 2002; Kelley

& Storey 1998), and commonly people who have an idea are not the ones who can turn it into a business. This is why the innovation project team definition is very important within the innovation process execution.

The experience has proved that unleashing creativity and inventive potential in organizations normally leads to an explosion of innovative ideas (Albury 2005). Nevertheless what becomes critical is how to select the ideas for further development. Some guidance can be provided initially by the overall firm´s goals and objectives. Nevertheless selection criteria are needed which rest on the judgment of senior managers and professionals, and on the need for innovation and resources availability. Selection criteria must not be too tough, neither too lax, since the former would discourage innovators and inhibit radical innovation, and the latter will consume more resources by failed innovations (Albury 2005).

The next figure shows the ”universal success curve” analyzed by Stevens and Burley (1997). It was developed based on tracking of the commercialization of patents, the venture capitalist’s experience, and the project literature. Astonishingly, the success rates were similar in the three cases. In this way the curve shows that the chances of commercial success for substantially new products averages 1 in 300 at the idea submission stage, 1 in 125 at the small project stage, 1 in 9 at the early stage development stage, 1 in 4 at the major development stage, and 1 in 1, 7 at the commercial launch stage (Stevens & Burley 1997).

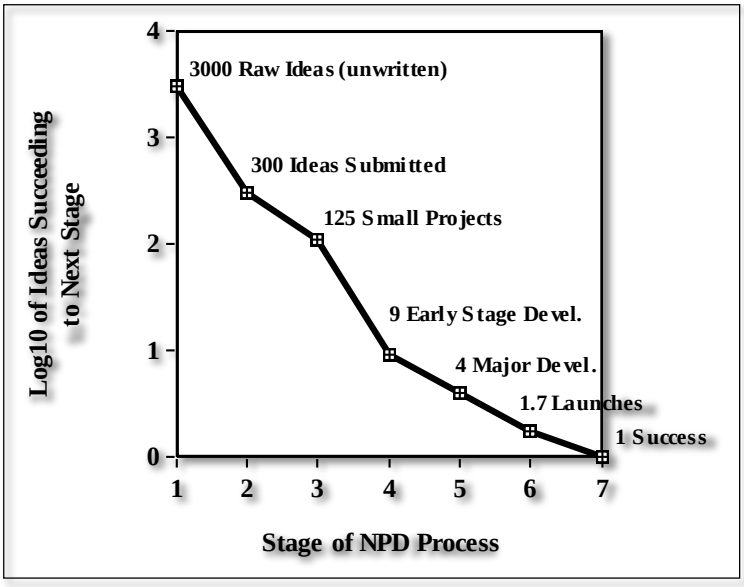

Figure 16 “Universal” industrial success curve for substantially new products, with success rates from launch unchanged over the last 40 years (at 60%)
Source: Stevens and Burley (1997)

Besides the different, but similar, innovation models mentioned in this section, in the past decade relevant importance has been given to the fuzzy front-end (FFE) stage of

innovation because some consider that it is the root of success for innovative firms, especially when developing discontinuous innovations (de Brentani & Reid 2012; Björk & Magnusson 2009; Chang, Chen & Wey 2007; Seidel 2007; Cooper & Kleinschmidt 1987; Koen, Ajamian, Bukart, Clamen, Davidson, D'Amore, Elkins, Herald, Incorvia, Johnson, Karol, Seibert, Slavejkov & Wagner 2001). This stage begins when a company shares a new idea, and ends when the company takes the decision to either launch a formal development project or, alternatively, decides not to do so (Kim & Wilemon 2002). Several scholars consider the FFE as a sequential process consisting of different sub-phases (Cooper 2008; Griffith-Hemans & Grover 2006; Khurana & Rosenthal 1998). However, it is considered as the most difficult stage to manage in the innovation process due to the high level of uncertainty that it involves related to the potential market and the underlying technology (Kurkkio 2011; Chang et al. 2007; Verworn 2006; Montoya-Weiss & O'Driscoll 2000)

Similar to the relevant importance of the FFE stage, the protection of innovation is also important after the development stage, and before the product commercialization in the market. For radical innovations, patents, copyrights, and trademarks can be useful for protecting the innovations so competitors cannot easily copy the new idea (Tipu 2011; Frame & White 2004)

Finally, innovation adoption plays a significant role in innovation performance. In general, compatibility, relative advantage, and complexity of the innovation have the most consistent significant impact on the adoption of the innovation in the market (Tornatzky & Klein 1982). Different characteristics affect the diffusion of innovation in markets, such as relative advantage (degree to which an innovation is perceived to be better than other product), compatibility (degree to which an innovation is perceived to be consistent with existing values, experience and needs of potential adopters), complexity (degree to which an innovation is perceived to be difficult to understand or use), trialability (degree to which an innovation can be experimented on a limited basis), and observability (degree to which the results of an innovation are visible to others) (Tidd 2006).

2.2.3 Technology management

Technology has a great impact on organizational learning since technical systems within a company define the way as knowledge flows and is accessed by employees and third parties. How able is a firm to develop innovation depends on its scientific and technological capabilities as well as its technological management capability (White & Burton, 2007).

Since the 1970s, technology management has been associated with different disciplines such as R&D management, innovation management (Hollen, van den Bosh & Volberda 2013), engineering management, and strategic management. In fact, the US National Research Council defined it as follows:

> *Management of technology links engineering, science and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization. (Wu, Yu & Wu 2012, 165)*

Complementary, Cetindamar, Phaal and Probert (2009) argued that technology management is a kind of dynamic capability, which can be seen as the combination of resources and processes which can be developed, deployed and protected for managing technology. According to Pavitt (2002), technology management processes cover three main activities: generating scientific and technological knowledge, transforming knowledge into working artifacts, and matching artifacts with user requirements.

Similar to the innovation process structures, Gregory, Probert & Cowell (1996) identified five stages for technology management: identification, selection, acquisition, exploitation, and protection.

Technology management indicates the innovative attitude towards innovation. It includes the definition of the infrastructure for innovation: the platform or application (include tools) that supports the innovation core processes. It also considers technical personnel and committing funds for new technological development. (Dasgupta & Gupta 2009) In order to be useful for innovation this infrastructure must exhibit three basic characteristics: It has to be available anywhere, quick and easy to use, and it has to facilitate effectively cross functional learning as a core attribute (An integrated approach…).

Technology tools (intranet, databases, an electronic suggestion scheme, etc.) and non-technology tools (brainstorming, research collaboration, a management system controlling the whole innovation process, etc.) enable an organization to harness and apply knowledge while increasing the opportunities for innovation. However, firms must be aware that excess of standardization and automation, as a result of the use of information technology, may stifle innovation (Gordon & Tarafdar 2007). Then, the right technological competency which can promote innovation is required across organizations that build their innovation programs.

According to Pavitt (1984), there are four different types of industry which have their own patterns of innovation and define the orientation of technology management in the company:

Science-based industries (electronics, pharmaceuticals): need core of degree-level science and engineering skills. Due to this there is a strong work between companies and universities or with their own R&D laboratories.

Scale-intensive industries: They rely on economies of scale, focus on harnessing scientific managers, increasing cross-functional integration skills, specialists, engineering, and trained and willing workforce.

Specialist suppliers engage in cooperation with other actors in the network: They require skills of interactive learning as well as expertise for the development of client-specific solutions.

Supplier-dominated industries where the majority of innovations come from outside the organization: They require people trained with entrepreneurial skills for analyzing market trends, as well as able to implement and use new technologies.

Information intensive firms: They are commonly present in the service sector, where in-house software or systems development is the principal source of technology. Innovation is based on technical and communication skills to develop software and acquire technology from outside.

However, having a technological leadership does not mean better economic benefits. As noted by Teece (1998), the benefits of investing in technology depend on the company`s capacity to transform technological advantage into commercially viable products services or processes, as well on the capacity of the firm to defend its advantage against imitators (i.e. the strength of patent protection). Thus, according to Tidd (2006) factors such as secrecy, accumulated tacit knowledge, lead times and after sales service, the learning curve, complementary assets, product complexity, standards, pioneering radical new products, and strength of patent protection influence the firm`s capacity to benefit commercially from its technology.

2.2.4 People and innovation culture

The set of values and beliefs shared by people within an organization is known as organizational culture (Dasgupta & Gupta 2009). It contains the behaviors, norms, values, philosophy, and feelings that characterize the organization (Martins & Terblanche 2003). Corporate culture plays an important role within any innovation management system since it impacts the decisions an organization has to take with the aim of establishing successful innovation capabilities. These decisions in turn impact corporate culture, too.

The management system directs and drives innovation within an organization. When managers allocate resources and challenge employees` thinking, innovative behaviors and performance is improved in the business place (Shalley and Gilson 2004; Scott &

Bruce 1994). In fact, some studies have found a direct relation between innovation support and the generation and implementation of ideas (De Jong & Den Hartog 2007; Brand 1998; Oldham & Cummings 1996) as well as between freedom and autonomy, and innovative behavior (Krause 2004; Oldham & Cummings 1996).

What characterizes the most innovative people (Steve Jobs, Jeff Bezos, etc) has to be with the way as they interpret and analyze the world in which they live. In fact, five "discovery skills" have been defined to distinguish true innovators from the rest of us (Dyer, Gregersen & Christensen 2009):

DOING: Aspects related with:

- Questioning: innovators are all the time questioning the status quo and considering new options
- Observing: innovators detect small details which suggest new ways of doing things.
- Experimenting: innovators try new experiences and experiment constantly the world
- Networking: innovators interact with individuals from diverse backgrounds, and throughout it they can gain radically different perspectives.

THINKING: Together the four mentioned elements help innovators to generate new insights and learn.

In order to get innovative people within the company, managers have to check continuously inside their companies and ask whether anybody is being asked about their ideas, if the staff knows about the need for ideas and innovation, and whether the people are rewarded for their ideas and contributions (An integrated approach…). In fact, research has shown that one of the most important factors when developing innovation culture has to be with the ability and commitment of leaders and teams, in special with the leadership and commitment from the top management teams. Thus, when innovating leaders need to change their organization – its approval processes, its reward systems, its innovation language and its expectations about the rate of change. It does not mean that a company has just to focus on innovation without taking care of operational excellence and the multiplier effect of each on the other (Davidson 2011). Additionally agents of innovation as well as varied, interconnected and autonomous innovation teams are necessary across the company (Camelo-Ordaz, Fernández-Alles & Martínez-Fierro 2006). These champions assist project managers with the implementation and tracking of ideas, innovation and changes.

According to Porter (2007), leadership is essential for innovation because all innovation creates change which is disruptive and causes conflict that triggers control reactions. There are three sources of change: sustaining change that improves the existing business, disruptive change that needs to be developed outside the core business, and externally sourced change that can be spun into the business (Davidson 2011). Then, a

leader or innovation champion is vital for overcoming the resistance to change. This champion must have the ability to create trust, focus on win-win approaches with all parties and work for a greater company position.

Under this view leaders influence innovation while reducing uncertainty and complexity associated with it throughout communicating a shared vision, giving enough autonomy, and supporting change (Vaccaro et al. 2012; Dasgupta & Gupta 2009; De Jong & Hartog 2007; Elenkov, Judge & Wright 2005). In special, middle managers play an important role in innovation due to their experience and closeness to the staff and project managers. They are able to create a trusted atmosphere and provide a safe psychological work place for team members to explore and generate solutions like innovation champions (Kelley and Hyunsuk 2010; Huy 2001).

Another reason for which leadership has been identified as a critical individual influence on innovation (Nam & Tatum 1997; Sarros, Cooper & Santora 2008) is that leaders can define and build a workplace environment which encourage and support creativity and innovation. A climate for innovation must be free of discrimination or recrimination for people when they propose new ideas for the organization and they result in failure or negative outcomes (Kissi et al. 2012; Gumusluoglu & Ilsev 2009; Kissi, Payne, Luke, Dainty & Liu 2009 ; Amabile et al. 1996). Those companies that invest in their people, and understand the value of the ideas they have, ensure that elements such as facilities, equipment, time and resources help to foster ideas and innovations.

There are many ways in which people in the organization can do things in a different manner and be encouraged to voice their ideas. Then, it is a key responsibility for managers to 'audit' the organization in terms of how friendly it is towards being innovative. In fact they must encourage employees to share knowledge by acquiring, creating, and transferring it (Nonaka & Takeuchi 1995; Quinn 1985).

Situational and psychological factors impact innovation within companies. Amabile et al. (1996) and Ekvall (1996) found that the perceived work environment makes a difference to the level of innovation in firms, in the way as it can promote creativity and innovative behaviors (Mathisen & Einarsen 2004). In fact, companies can create working environments where innovations are encouraged or hampered (Tidd et al. 2005; Dougherty & Cohen 1995). It means that organizations need to be able to manage both: an environment where people are free to explore creative possibilities, as well as a system with enough control to manage innovation in an effective way.

In this way, participation and communication is well valued in effective innovation systems. A culture that encourages participation and involvement in decision making throughout open communication channels, enhances knowledge sharing, therefore promotes innovation (Dasgupta & Gupta 2009; Rezgui 2007). As it was pointed out by Steve Jobs when talking about the distinctive innovative ability at Apple, innovation is

more than having good processes which make you more efficient, it comes from cross-functional communication and cooperation within employees (Fliaster & Spiess 2007).

There has been considerable empirical work on organizational climates which support innovation process. One of the findings is that the level of centralization and formalization in a company has shown to have a negative impact on organizational innovation because rigidity in rules and procedures is perceived as an obstacle for seeking new sources of information (Vyakarnam and Adams 2001; Damanpour 1991; Burns & Stalker 1961). Furthermore, factors that promote organizational learning, such as organizational characteristics such as job rotation, interdivisional teams, and delegation of responsibility, also promote innovation (Lundvall & Nielsen 2007).

According to McLean (2005), in the literature appear factors related to organizational culture that support or impede creativity and innovation. On the support side, these factors have been identified as organizational encouragement, supervisory encouragement, work group encouragement, freedom/autonomy, and resources. On the impediments side, just control has been identified as decreasing organizational creativity and innovation.

Organizational architecture optimized for business growth is fundamental to deliver innovative solutions on a sustainable basis. Thus, companies have many possibilities when choosing the way as organizing for innovation, which can be developed individually or simultaneously, as follows (Kaplan & Winby 2007):

- Ambidextrous organizations
- Venture boards
- Innovation councils
- Cross group solutions teams
- Thought leader resource networks
- Open innovation networks
- Innovation communities of practice
- Shared services organizations

Different forms of organizing the firm for innovation can be identified. It seems that each company search for the manner that suits the best according to its needs and strategy. For example, in Cisco Systems innovation is driven by a Board (teams that usually address a market with annual potential of $1 billion plus) or a Business Council (addresses a $10 billion plus annual opportunity within three to five years). Decision-making is delegated in the board and the council, so they can make decisions on behalf of their organization. Thus, due to the fact that speed is critical for the business (but not at the cost of quality), a new business idea may take as little as 45 days to be presented and approved by the Cisco Board of Directors (Davidson 2011). Complementary, Cisco`s project innovation portfolio is mixed, it manages closed and open innovation, sustaining and disruptive innovation development. Currently they have roughly 30 busi-

nesses adjacent to their traditional networking business, and most of them belong to growth activities. Additionally, Cisco motivates innovation stars in different ways. Innovators can participate in decision making via the boards or councils. There is also a wide range of bonuses within a group (an innovator may receive three times more what other employees receive) and the company has developed a common innovation language, and shares the same vision, strategy and its execution.

In this way, the manner as managers introduce innovations into the company, and allocate the resources for their production or adoption, has a direct impact in the innovation outcomes, since it impacts two factors: innovation´s rate and speed. The former is related with the extent of firm´s innovativeness, i.e., the number of innovations adopted, or developed, by the firm in a period of time. The latter has to be with the timing of innovation, i.e., the time a firm takes to adopt an innovation after its first introduction elsewhere. While the rate reflects the magnitude of innovation, the speed reflects the organization´s responsiveness and the ability to adopt or generate an innovation faster than firm´s competitors within the industry (Lengnick-Hall, 1992). According to Kessler and Chakrabarti (1996), speed used to be more appropriate in dynamic environments that are highly competitive and with low regularity restrictiveness. On the other hand, Evans (1991) suggests that innovation rate shows to be more useful under environments with high levels of complexity and continuous environmental transformations.

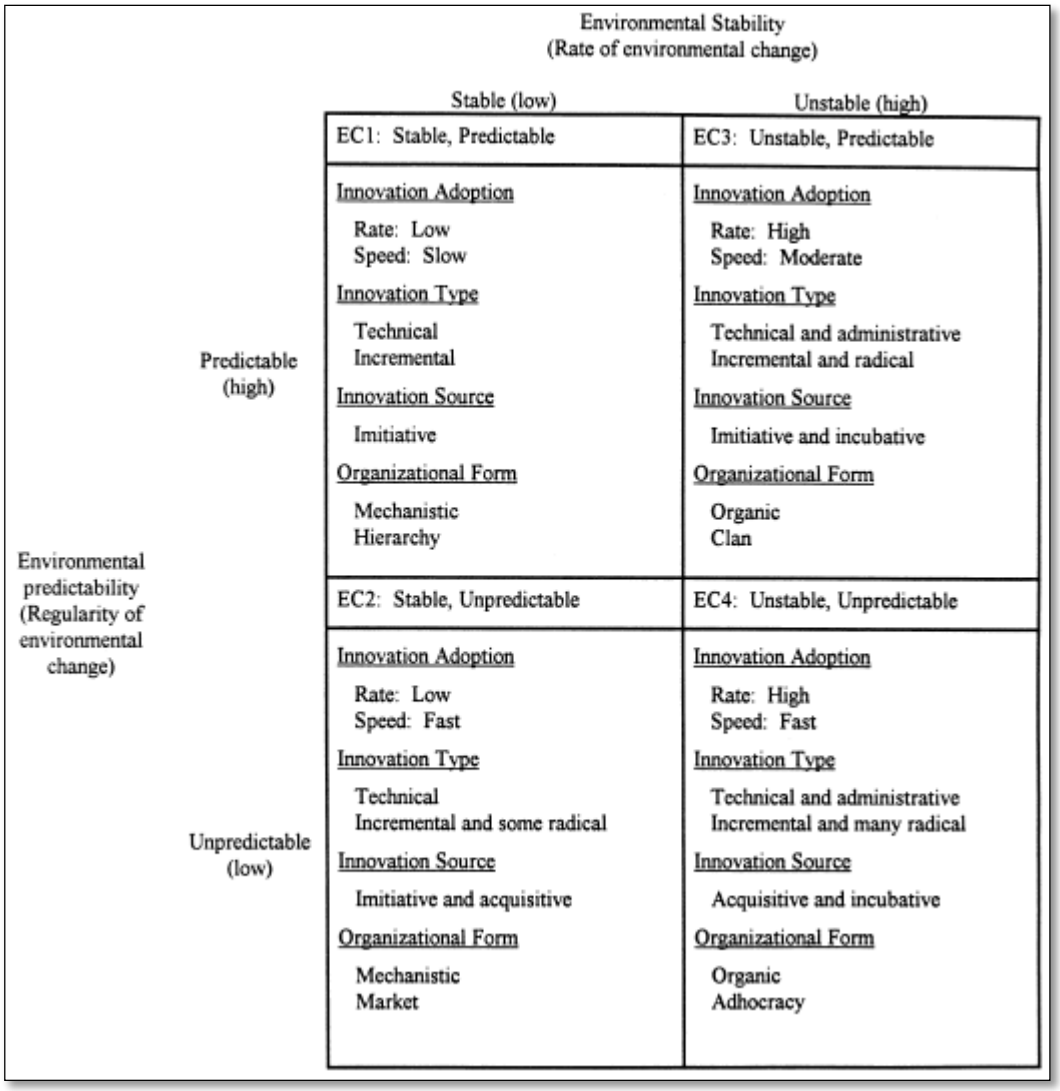

Figure 17 Innovation adoption features of organization`s that effectively innovate in four environmental conditions (EC)

Source: Damanpour and Gopalakrishnan (1998; 12)

Damanpour and Gopalakrishnan (1998) sketched out the basic characteristics of innovative organizations and the rate, speed, types and sources of their innovations, everything under four sets of environmental conditions, which by turn are considered as a driving force for organizational innovation (Tornatzky & Fleischer 1990). It can be seen in Figure 17.

Past research has suggested a relation between the condition in the environment (stable and unstable) and the organizational structure (mechanistic and organic), and the impact on firm`s innovation. Thus, organizations inside a stable environment that used to have mechanistic structures are supposed to be non-innovative, whereas firms inside an unstable environment that used to have organic structures are supposed to be innovative (Damanpour, 1991; Nicholson, Rees & Brooks-Rooney 1990; Daft 1982; Burns and

Stalker 1961). However, this approach is not adequate to explain how companies implement and develop different types of innovation.

In a similar way, the dual-core theory, which has been exposed previously, also refers to the organizational structures that make possible innovation. According to the theory, a mechanistic structure is required when firms highly develop administrative innovations, because it facilitates the top-down process which is involved in this type of innovations. On the other hand, an organic structure is required when organizations focus mainly on technical innovation, because it makes easier the bottom-up process involved in this kind of innovation. In this sense the dual-core theory suggests that organizational structure must be defined depending upon the type of innovation to be adopted (Daft 1982).

2.2.5 Knowledge management

Due to the constant and increasing hostile market environment, innovation plays a relevant role in business performance since it represents a means of survival. A systemic and effective management approach based on knowledge and learning directs competitive advantage. Then, the key to improvement and innovation is focused on the ability to absorb and integrate new knowledge with the existing one, which is known as organizational learning. The higher this ability is, the higher is the level of the firm`s competitiveness, innovativeness and product introduction success (Yeung 1999).

Continuous organizational learning improves the efficiency and effectiveness of firm`s innovation (Mullen & Lyles 1993). Then, companies that desire to deliver value through innovation and be in a better position to face the rapid changes must provide adequate time for people to learn and create knowledge, and exchange ideas, thoughts and experiences (Egbu 2006; Nonaka 1994).

The external turbulence in markets has made science to focus attention on the resources and organizational capabilities as a critical source of competitiveness. Since the end of the last century the concept of knowledge has received special attention as the most strategically significant resource for the firm (e.g. McAdam 1999; Blackler 1995; Nonaka 1991) and it has been affirmed that it plays a critical role in the innovation process (Hull, Coombs & Peltu 2000). However, several authors have underlined that is not the firm`s knowledge what is its competitive advantage, but the ability to apply that knowledge effectively to create new one. In order to this, differentiation across companies has been based on the firms` ability to integrate efficiently their innovation management practices with their knowledge management practices.

Oil and gas industry has taken advantage of knowledge management since it has impacted operations efficiency and effectiveness when experiencing rapid changes and

throughout the advance of technology, extension of offshore drilling, acquisitions, growing reliance on foreign oil sources, and focus on environmental issues (Leavitt 2002).

Knowledge linkages can allow firms to develop stable relationship networks and collaborations based on trust which make easier the access to national and international markets (Bell & Giuliani 2007; Lin 2006; Bell & Albu 1999). In fact, in industries with a high tendency for internationalization, such as the oil and gas industry, knowledge management systems play a key role in the sustainability of firms. It allows companies to acquire technological capabilities to face the challenges imposed by the market and to carry out innovations (Wang & Miao 2006; Figueiredo 2003; Bell & Albu 1999).

Many definitions can be identified around knowledge management. For example, Gorelick and Monsou (2006) define knowledge management as a system which promotes collaborative environment for creating new knowledge, capturing and sharing existing knowledge, and allows a firm to apply what it knows in its goals achievement. Meanwhile Beckman (1999) defines it as the formalization of and access to experience, knowledge, and expertise that create new capabilities, enable superior performance, encourage innovation, and enhance customer value. On the other hand, the definition of knowledge management by an important oil company, Chevron´s (now Chevron Texaco) refers to the processes, tools, and behaviors which offer the right content to the right people at the right time and in the right context. In this way, people can make decisions, harness business options and promote innovative opportunities (Leavitt 2002).

Rather than a precise definition, what is relevant is that effective knowledge management has been identified in the literature as one aspect which improves innovation and performance (Darroch & McNaughton 2002). Knowledge management impacts innovation especially in the idea generation, the management of information flows, and the management of implicit and explicit knowledge (Adams et al. 2006). An innovation process needs specific and broad-based knowledge and competency which can be obtained within the organization or externally by collaborative developments or acquisitions from other sources (Essmannn & Preez 2009).

Knowledge management has to be with the achievement and communication of ideas and information that underlie innovation. Indeed, innovation is hard to achieve without a sound knowledge base. According to Davis (1998) and Nonaka (1991) knowledge management covers the management of both, explicit and implicit knowledge held by a firm, as well as the processes of collecting and using information. (Adams et al. 2006) Implicit or tacit knowledge is difficult to manage since it is in the minds of the knower an is also embedded in the firm`s culture, structure and processes. Due to this, a company, in order to support a climate of creativity and learning, needs to manage its intellectual capital which is integrated by its structure, culture and processes (Soderquist, Das-

gupta & Gupta 2009; Chanaron & Motwani 1997; Amabile et al. 1996; Carnegie & Butlin 1993).

Interestingly Plessis (2007) figures out the influence of knowledge management on innovation process, since knowledge management:

Supports a firm´s innovation model by creating tools, platforms and processes for creation, sharing and leverage of tacit knowledge in the firm. It is done in many forms, such as communities of practice, knowledge transfer across organizational and inter-organizational boundaries, share of knowledge with experts through collaboration.

Assists companies, throughout the use of platforms and processes, in converting tacit knowledge to explicit one. It is done for example with the use of discussion databases, online collaboration communities of practices, and electronic capture of knowledge.

Facilitates collaboration in the innovation process and provides accessibility to external knowledge which may be required for the internal innovation process.

Ensures the flow of knowledge used in the innovation process by the creation of a knowledge sharing culture and throughout the use of collaboration forums which make easier internal and external collaboration. It provides a knowledge-driven culture within which innovations can be incubated since creativity and learning through mistakes is encouraged and valued.

Supports the maximum benefit in the use of knowledge as a resource in the innovation process. It provides platforms, tools and processes to ensure the integration of the corporate knowledge base for people in order to know what knowledge is available, where it is and what is missing in it.

Assists the organization in identifying the gaps in knowledge in order to build (acquire or create) systematically the knowledge base in these areas. It represents a steady growth of the knowledge base through gathering and capturing of explicit and tacit knowledge, which in turn feeds the innovation process through the creation of a wider knowledge base available.

Supports the firm in building the competencies required in the innovation process since staff members can access and develop a wider frame of knowledge which help them to improve their innovation skills` quality.

Specifically in the oil and gas industry, as mentioned above, communities of practice impact growth and customer satisfaction since oil and gas companies join organizations across all industries in their purpose for finding ways to improve their performance. Thus, these communities create a channel for knowledge that crosses different boundaries and helps in the creation and standardization of practices since members collaborate and help each others in their desire and need to share problems, experiences, etc.

Interestingly Leavitt (2002) highlights different examples of different benefits from knowledge management in the oil and gas industry, such as:

Halliburton Energy Services use communities of practice to create and transfer knowledge and experience of people worldwide in the purpose of meeting the needs of their clients.

Schlumberger created the InTouch system which centralizes the knowledge and allow people to access easily to information. Throughout this system the company has reduced the use of resources (money, time, etc.)

Shell structured global communities of practice with which it transfers best practices and shares stories "from the edge" (successful stories in innovation). From them the company achieved interesting improvements in its processes.

Chevron has focused its efforts in building a learning organization and it has meant increments in productivity and employee safety as well as the reduction in operating costs.

In general, the oil and gas industry can be seen as a good example in knowledge management, and nowadays those companies which have succeed in its application are able to address pertinent challenges (acquisitions, globalization issues, reducing downtime, etc.). Furthermore, open innovation is being applied in leading companies in the oil and gas sector. On the one hand Statoil opened the website called innovate.statoil, a portal with challenges in the company in which the firm reaches out to external contribution. On the other hand, Shell launched a marketing campaign, Inside Energy, which seemed to be aimed at consumers as well as business partners and which couples with their GameChanger program for external innovation contribution.

Last but not least, another relevant aspect associated with innovation and knowledge management is related to human capital. According to Hansen, Nohria & Tierney (1999) and similarly to Sveiby (1997), companies adopt two main approaches to knowledge management: a codification strategy and a personalization strategy. The former is focused on information technology resources while the latter is centered on human resources. Based on Gloet and Terziovski`s (2004) study, knowledge management contributes to innovation performance when soft human resources management and hard information technologies practices are implemented. In parallel, in the study of Donate and Guadamillas (2011) human resources, leadership and cultural values are highlighted as enablers of knowledge management. Based on this, the role of managers is found critical in developing knowledge management initiative for innovation while considering that human resources have to be pushed in the right use of the tools and participation in knowledge management initiatives.

2.2.6 Innovation measurement

Due to the fact that innovation impacts somehow business performance, it is necessary to measure this impact in order to know about the current standing in innovativeness and the necessity of continuous improvement. Without innovation measurement, there is not clear room for constant improvement.

The frequency at measuring innovation depends on how critical are the innovations for the whole business performance since its measurement is strongly linked to the firm´s innovation platform in the way as it must give managers real time information about the progress of innovations. Moreover, the nature of the innovation measures relates with the innovation process stage. During the first stage of an innovation process, when ideas are being generated, measures are commonly quantitative and inexpensive (i.e. the number of ideas produced within a period of time) (Chiesa et al. 1996; Lee, Son & Lee 1996) or the extent to which firms use different tools and techniques (Thompson 2003; Cebon & Newton 1999; Chiesa et al. 1996; Loch, Stein & Terwiesch 1996; Szakonyi 1994; Rochford 1991). Throughout the process evolves, measures become qualitative and consume more resources, such as time and money (i.e. patent data).

In the literature, different innovation measures are reported with the same importance for both academics and practitioners. However, measurement of innovation is hard to achieve, and within the time it has focused mainly on the measurement of innovation inputs and outputs in terms of expenditure in R&D activities and information technology (Becally 2007; Adams et al. 2006; Neely & Hii 1998), speed to market, and numbers of new products (Sumita 2008; Adams et al. 2006; Cordero 1990).

Within the time, these indicators have been shown to have many shortcomings. For example, R&D expenditures measures just one fraction of the total input to the innovation process. In fact, rather than R&D, there are more crucial inputs for the innovation process and many companies that innovate lack of this function. Similarly, patent counts, which are mainly related with research inputs, reflects the propensity to patent rather than the current firm innovations. Furthermore, measuring the number of innovations does not consider that innovations are context-specific and the impact of the innovation sample may differ between the units, which gives raise to the issue of selectivity which offers a segmented view of the real innovation performance (Neely & Hii 1998).

Cooper (1999) states that the process structure, the use of stage gates, and the key performance indicators (KPI´s), are a first priority in order to develop effectively an innovation process. KPI´s are a set of indicators that allow having a signal about the innovation process performance; they are vital for the decision process when applying the stage-gate model (Cordero, 1990).

Some researchers have focused their studies in identifying innovation measures. On the one hand Fortuin and Omta (2009) identify some of these measures as follows:

- Business unit satisfaction score
- Projects delivered on time
- Average man-hour costs
- Employee work satisfaction score.
- R&D/BU employee transfer rate.
- Number of man-hours spent on R&D projects versus the indirect hours (e.g. training, study).
- Number of inventive ideas proposed.
- Number of process improvements

On the other hand, Wu et al. 2012, relate five indexes when measuring innovation: technology index (master and control of a technology given a time), patent index (reflection of owning technologies with proprietary intellectual rights), industrial standard index (establishment of standards in the industry), scientific research index (quantity and quality of a firm's scientific research projects and papers), and market index (promotion of business diversification and the mastering of multiple technologies).

Based on a wide body of literature, Adams et al. (2006) suggest a synthesized framework for innovation management, integrated by seven categories: inputs, knowledge management, innovation strategy, organization and culture, portfolio management, project management, and commercialization. Each category relates with defined measurement areas, as follows:

Inputs management: It is related with the resources used at innovating. One of the most common measures has to be with R&D, expressed as a ratio between expenditure (e.g. Parthasarthy & Hammond 2002) or numbers employed in R&D roles (Kivimäki, Lansisalmi, Elovainio, Heikkila, Lindstrom, Harisalo, Sipila & Puolimatka 2000) and some expression of output. Nevertheless, this does not seem to be a very useful measure for small and medium-sized enterprises (SMEs), which may not have formal R&D activities (Kleinknecht 1987), or, indeed, for service industries, which tend to have low R&D intensity (Hipp & Grupp 2005).

Another measure used is the expenditure in the innovation activities, expressed in total expenditure, expenditure expressed as a proportion of sales or revenues, and expenditure by item (organizational department, patent, innovation or scientist) (Oliver, Dewberry & Dostaler 1999; Geisler 1995).

In a similar vein, facilities or physical resources are measured from buildings to computer equipment. Furthermore, the use of formal systems and tools in support of innovation constitutes a important input to the innovation process (Cooper et al. 2004; Bessant & Francis 1997).

Regarding people, some measures are associated with the number of persons committed to innovation activities, and some qualitative characteristics such as their skills, experience and education.

Knowledge management: It is not easy to measure knowledge within a firm since it is mostly intangible and present throughout all innovation activities. However, there are many attempts for measuring the number of ideas generated under a period of time, while others check for the use of different generative tools and techniques. When firms are aware about the importance of knowledge within it, they can also measure the knowledge repository to measure the accumulation of knowledge across the company. Furthermore absorptive capacity (firm`s ability to absorb and put to use new knowledge) is also measured, although it is not easy to identify which is the right level of it (Cohen & Levinthal 1990). Tangible knowledge is measured by counting the patents brought into the company, although lastly the validity of patent statistics has been questioned since their use and value is not the same for every organization. Finally tacit knowledge is very difficult and complex to measure, however some approaches have been done, from which that of Sveiby (1997) is one of the most used since it takes the difference of the firm`s market value between its net book value as an indicator of the value to an organization of intangible knowledge assets.

Innovation strategy: This normally describes a firm´s innovation posture regarding its competitive environment. In the literature is possible to identify two types of measures of innovation strategy: measurement of the existence of an innovation strategy within the firm, and, in case that the company has an innovation strategy, measurement of the effectiveness of it, in terms of alignment of structures, systems, innovation goals and strategic objectives. In general, measures on this topic focus on the relationship between strategy and performance. Firms that have an innovation strategy and implement it have results (flexibility, capital management, resources allocation, tolerance to internal conflict, etc) which differ from those that do not.

Organization culture and structure: It is related with the way as people are grouped and the innovative climate within which they work. One of the measures in this aspect, which has resulted to be robust, is the Team Climate Inventory (TCI) (Anderson & West 1998, 1996) and the KEYS instrument for assessing the work environment for creativity (Amabile et al. 1996).

The TCI contains four main aspects:

- Participative safety (how do team members are allowed to, and feel about, proposing new ideas)
- Support for innovation
- Vision (how clear is the company strategy and goals)
- Task orientation

A fifth aspect was introduced by Kivimäki, Kuk, Elovainio, Thomson, Kalliomäki-Levanto & Heikkilä (1997): interaction frequency, which relates to the interaction (frequency) within the project team.

Portfolio management: Successful innovative firms tend to use formalized tools in all projects included in a portfolio. Measures focus on project portfolio balance in terms of quantity related to project duration, risks and project sizes. Another measure seeks for defining the formalization level in the company´s processes that evaluation of projects represents (Farrukh, Phaal, Probert, Gregory & Wright 2000; Cebon & Newton 1999; Chiesa et al. 1996; Miller & Friesen 1982).

Project management: This element is associated with the process that converts inputs into a marketable innovation. Measures on project management that focus on efficiency mainly compare budget and resources consumed across the project. Other measures stress on speed in terms of performance against schedule and duration of the process. In a similar vein, the use of structured and specific tools and process is measured. There are also some metrics related to risks management (Bowers & Khorakian 2013) which achieve in successful innovation projects.

Commercialization: It refers to the implementation of the innovation by taking it to the market, which is vital for the survival and growth of the firm. In here, market dynamics are more important than technological capabilities (Calantone & di Benedetto 1988; Globe et al. 1973).

Little work has been done in the analysis of measures of innovation commercialization Hultink, Hart, Robben & Griffin (2000) perhaps because it is considered as responsibility of other disciplines as marketing. Some of the measures consider the rates of adoption and diffusion of innovations over time across markets (Van Den Bulte 2000; Kessler & Chakrabarti 1996).

Lastly, another measure commonly used has to be with the existence of a Chief Innovation Officer, Director of ideas, or Innovation Leader, who is responsible for managing the innovation process within a firm, especially in large organizations. This is an indicator of an integrated innovation approach and of whether the company is really innovative and is immersed in an innovation culture.

Due to the debate that traditional measures have had, new direct and simple indicators, identified in the study done by Becheikh et al. (2006), have been developed: innovation count, and firm-based surveys. The former has to be with the collection of information on innovations from a variety of sources such as new product/process announcements, specialized journals, databases, etc. The latter relates to the surveys and/or interviews done with different organizations.

Finally and based on the literature review made by Neely and Hii (1998), there is no unique best way to measure the innovation performance because a particular set of indicators may not work in another organization. Then, what is suggested is that every company draws a practical framework and installs a wide range of measures to be used when required.

After identifying and describing briefly the main common elements in the literature of innovation systems, the next section emphasizes on the construction of innovative companies and the aspects to consider in the path to the innovation, while highlighting the relationship between innovation and competitiveness.

2.3 Building innovative firms

Aligned with what has been explained in the last section, the first element when building innovative firms has to be with the clear and precise definition of the firm´s innovation strategy. For the implementation of the strategy some aspects must be guaranteed: a flexible structure, the empowerment of employees, the interaction between the business units within the firm, and a control system. Furthermore, managers have the responsibility of establishing an organizational culture of innovation support and encouraging the proper development of R&D activities (Becheikh et al. 2006).

Thus, before anything, managers have to be aware that the key challenge when building innovative organizations is related with the efforts to innovate, to harness technological advances, competitor`s failures, opportunities in the industry and the investment in knowledge processes and knowledge workers. (Carneiro 2000)

2.3.1 The path for innovation

Porter (2007) states that when a company decides to innovate, it should focus on:

1. Thinking of innovation strategically
2. Identifying business units where different innovations will have an impact
3. Identifying and selecting innovation champions
4. Designing an innovation program, ensuring the participation of the required people
5. Addressing strategy, leadership and relationships, legal and contractual elements, organizational design, performance processes, and econometrics. Apply the best practices in each aspect.
6. Launching innovation pilot projects
7. Measuring performance, adjust, expand and proliferate

According to the author, by following these directions a company may be more successful at innovation which is highly recognized as a trigger for the achievement of the company´s goals.

A few, and commonly the same, firms are in people`s head when talking about examples of successful innovation. In this case, Google and Apple are in that group and

their contrasting experiences are interesting in order to recognize that the way as each firm innovates differs from each other. These companies are considered by far one of the most innovative companies in the world. Both companies have created interesting new products and services that have changed markets. It seems that both firms have a defined innovation capability which helps them to innovate. In fact, they do have it. However, what is real is that although both companies are very innovative, their approaches to innovation are from different perspectives, and the methodologies and concepts to achieve their innovation goals differ significantly.

On the one hand, Apple tends to innovate in small, centralized teams directed by the top down to specific goals, placing big bets on a few innovations within a time. On the other hand Google encourages decentralized and distributed innovation based on what people need or desire. What this example demonstrates is that there are several different approaches to innovation success, and that the culture expectations and the leadership commitment to innovation play a very important role in achieving innovation within the firm.

As Google and Apple did, when innovating, firms make active decisions (consciously or unconsciously) about how innovation must be done within the company, specifically about what is expected and what is permissible for every element. Some firms settle into a selected innovation model with no need to take many strategic decisions about how to define all the elements, because they are already given, somehow. However, these decisions, impact how successful the firm´s innovation initiatives are, how pervasive is innovation within the firm, the range of ideas and how they are sponsored and converted into new products and services. In this way, some of the main options that may be present at building an innovation model or program, which are not an "either-or" proposition, are shown in the next figure (OVO 2008):

Figure 18 Decisions at building an innovation model

Decisions related with strategy and structure

Open vs. Closed Innovation: What some experts recommend is that when initiating it is better to develop and straight internal skills and management process in order to produce and evaluate ideas before opening the door to collaborative or open innovation. As soon as the internal capabilities are mature and repeatable, it is easier to administrate ideas from third parties.

Few people working on innovation vs. a broadly participative model: The number of persons participating in innovation can vary and depends on the types of ideas that the firm desires to generate. Briefly three elements must be considered: Disruptions levels the company wants to achieved, the firm´s relevance of the level of engagement and participation across the employees, and the difficulty level when selling an idea within the firm.

In general, participation encourages employees to produce more ideas and feel more involved and engaged. Nevertheless, rarely a participative model based on large groups of people produce disruptive innovations; they commonly are good for incremental innovation. The principal reason behind this trend is that people usually cannot remove their preconceived notions about the business, and it is difficult for them to think about the business in a very different way. However, ideas generation techniques, such as brainstorming, open suggestion boxes, and idea campaigns may help to produce some breakthrough and game-changing innovations as well.

In this way, when a company´s main purpose is to generate more disruptive ideas, or is to focus on less participation and engagement, then a smaller team seems to be more effective. As a result, many companies, which are aware of the limits and impact of their culture and infrastructure, establish and encourage small teams and give them the authorization to think out of the box, like disrupters. However, in this case, the whole organization may believe it was not considered any more for thinking, so the firm may act slower to adopt and implement the innovation team ideas. In addition, having small teams does not mean that they capture and recognize all the market opportunities, they may be also subject to strong biases, and ignore some options.

Having small or large innovation teams is not an either/or proposition. The majority of firms builds and implements a mixed innovation portfolio, composed by both incremental ideas, to improve current services and products, and disruptive ideas to establish an added value in the long term. That is the reason why smart companies have well defined idea campaigns and broad participation, as well as smaller innovation teams that work on specific issues.

It is recommended that when building the innovation program, firms start with ideas campaigns, due to their easiness for involving and engaging employees. Nevertheless, if

disruptive ideas are desired, a small team can be defined and trained, in order to focus on the generation of more disruptive ideas.

Suggestive vs. directed: Many companies use suggestion boxes for collecting initiatives. With the use of this methodology anyone in the company can submit any idea in any topic. Although firms benefit from the multiple ideas posted by many people across the firm, the costs involved in the development and maintenance of this technique are high, especially when collecting and managing multiple and different ideas, which were born from employees´ different opinions. Due to the lack of structure in the idea submission, the evaluation of ideas is a very difficult task, and the emphasis on context and importance of the idea continues to be in its submitter. As a result, many companies turn to idea campaigns, where idea submitters are oriented to propose ideas for solving a specific issue, to ensure that submitted ideas are aligned with the organization goals and strategy.

Consequently, a broad participation is gained with a determined orientation which is important for the business. This technique is known as a directed ideation, and usually involves the production of fewer ideas than those produced with the use of suggestion boxes. However, the produced ideas with the directed ideation, due to their alignment with business needs, have greater likelihood of helping in the solution of a problem or challenge, and many of them are likely to be selected and implemented for the business value creation.

Developing both, a suggestion box and directed ideation (through idea campaigns), organizations may benefit from aligned and not aligned ideas. In order to reduce the difficulty level when analyzing ideas submitted in a suggestion box, people must be asked to supply as much information as possible in order to provide a clear context, and communicate the challenge or need which they think the idea addresses, as well as its potential benefit.

Decisions related with operation and scope of innovative teams

Incremental vs. disruptive: Although many firms want to be on the top position in the market, many of them are not ready for it because they still lack the ability to innovate consistently, and the tolerance for change and risk that radical or disruptive innovation involves. As a result, many firms initiate their innovation program focusing on incremental innovations despite they would wish to start an innovation initiative to produce radical innovations that take them to the place they want to be. The reason behind this is that radical innovations, as explained previously, imply many risks, and companies need first to gain the skills and credibility required to move on to disruptive innovation.

Once again, the expectations of the management team, and the firm´s culture and challenges from competitors, market and customers play a relevant role in the decision of focusing on incremental or disruptive innovation. What the management team ex-

pects and is willing to tolerate impacts significantly on the incremental/disruptive innovation spectrum. If this team is not willing to take risks and is comfortable in how the things are, incremental innovation will be the approach. By contrast, if the team wants to change and disrupt the market, it will focus on radical innovation development. However, it is not easy to move from incremental to radical innovations, since people initially are allowed to apply simple techniques to solve small problems; just when those issues are addressed, or simply classified as issues which can be solved eventually, turning on to disruptive innovation and asking people to focus on radical ideas may be possible.

Thus, when starting at innovation, firms are highly recommended to focus initially on incremental innovation until they mature the abilities and culture for focusing on disruptive ideas. Once the disruptive team is ready, truly disruptive ideas can be generated.

Centralized vs. Decentralized: Innovation can happen in any place (individual´s mind, business unit, business partner, etc) and innovation programs can be run in one or several of these locations. On the one hand, the implementation of a centralized methodology means the creation of a common approach to innovation as well as its application. It represents a benefit for the organization since there is a well-known and unique process, tools, methods, language, evaluation criteria and tools within the organization. Additionally, a centralized approach create value because many tasks within an innovation program, such as management of trends, idea facilitation, sponsorship, managing third parties in collaborative innovation, and innovation training, are more effectively accomplished in a centralized role. Finally, working with a central team increases the generation of disruptive ideas since the team is able to work on longer time horizons without the pressure of being measured based on results and quarterly reporting.

On the other hand, organizations must analyze and define what roles and task must be centralized and which should be distributed and decentralized. Thus, ideas coming from everyone in the company should be worked as close to customer and the idea submitter as possible. Nevertheless, this is not always possible due to the impact of the ideas on other processes. Due to this, the idea needs to be considered in a central team. Consequently, although innovation activities may happen in a distributed way, the use of one process, one language, and one set of tools and methods, is required; in this way ideas can be easily transmitted.

Product/Service/Operations/Business Model: One interesting question when building an innovation program has to be with the kind of ideas that the company is expecting to be generated. Firms used to be very willing to innovate around what it considers its strengths, becoming a reluctant in some other attributes. It is mainly because teams that deliver the products or services are experts at what is built and delivered, but have less understanding about what the clients and channels need or want. Normally, in many

cases the opportunity for dramatic innovation in a firm has to be with something around the periphery of the firm´s core activities. Then, organizations should focus on developing skills on what they know well (product, service), but it must consider also different approaches, such as business model innovations. In this sense, it is not good to shut the door to ideas which are not related to products or services from the start because a barrier for ideas can be generated.

In general, product innovation is important to maintain market share, process innovation to have competitive prices and management innovation to keep a flexible and durable organization (Heunks 1998).

Decisions related with the structure and process of innovation

Recognition and Compensation: The way as people are going to be recognized and rewarded is fundamental since it may shape the innovation model, and therefore will impact the way as innovation team works, the innovation culture, and the ability of the teams to share ideas and collaborate.

Different approaches are valid. For example, a firm can structure the innovation program as a contest where the best idea receives the best prize (cash or physical goods), or a softer, but important, recognition can be provided to active innovators (more time to innovate, peer recognition, new titles). These are just two of many approaches which work well for reward and recognition across organizations.

However, what is relevant from the way as a firm rewards or recognizes employees, is that it can impact the amount of collaboration and evaluation of ideas in the innovation program. Too much emphasis on individual rewards has two main consequences. Firstly, collaboration can be negatively affected because people focus on the size of the prize that they can obtain. Then, the incentive for personal reward is bigger than the incentive for collaboration. Secondly, people may focus just on producing ideas, no matter their quality and added value, because at the end they are just pursuing the final prize.

Research has identified that most really innovative people like, over cash prizes, rewards and recognition in the way of peer recognition and more time to work closely on innovation. In order to this, firms must balance the methods they choose to reward and recognize people with the aim of encouraging the right behaviors and incentivizing people to participate actively in the innovation process.

Commonly, what the best innovation recognition and reward programs include are both measures for submitting ideas but also for active participation within the program, along with peer recognition.

Wisdom of crowds versus defined criteria and "experts": When evaluated ideas, for defining their cost, impact and opportunity to success, many methods can be used. James Surowiecki (2004) wrote about a concept called "wisdom of the crowds", a social

networking phenomenon. He identified four characteristics of a crowd which impact an evaluation and decision making process: diversity of opinion, independence of every peer member, decentralization, and aggregation. Nevertheless, some concerns have been identified around this method. On the one hand, different firms in the same industry interact with the same crowds, and then there is not much option for products or services that really differentiate in the market. On the other hand, most innovation based on wisdom of crowds input will be incremental at best.

Another way as companies evaluate submitted ideas is by defining evaluation criteria, success factors, and specific roles. Evaluation teams are integrated by people from different areas of the company and when evaluating they look for the best option for the business and not for a specific line of business or function. These teams are more suitable to consider game changing and disruptive ideas and evaluate them under the market conditions and firm´s internal capabilities.

When defining the internal evaluation process, firms must include both wisdom of crowds as well as evaluation criteria and use of experts, although the latter also cannot consider many opportunities of the market when the company enjoys a status quo context.

All the elements defined previously are not hard trade-offs or mutually exclusive choices. However they represent a guide in the path to innovation. Therefore it is important to consider and define them when building an innovation program with the aim of not to avoid the identification of vast innovation options which can enrich the process.

The next section goes deeper into the innovation capabilities concept and their interrelation with innovation success within the firm.

2.3.2 Building and developing innovation capabilities

Innovation is a critical source of competitive advantage although this is not easily obtained. Literature has studied innovation based mainly on its outcomes and nature. However, many studies suggest that one of the key factors of innovation success is firm resources and capabilities (e.g., Van der Panne et al. 2003; Christensen & Overdorf 2000; Teece 1986). The allocation of resources for innovation and management practices is directly associated with the type of innovation that firms carry out.

Since Penrose (1959), resource allocation and its association with the existence of firms has been a central topic for researchers. Penrose contributed especially to what is known as the “resource-based view” theory of the firm (Darroch 2005) that considers firms as heterogeneous in resources (which in turn are difficult to accumulate and imitate). In general, the resource based view theory of the firm considers advantages as

'sticky' and 'path dependent' while claims that the competitive advantage of a firm comes from strategies which harness current firm-based assets.

However, the ideas of Penrose were more or less ignored until the development of the "core competences" perspective on the firm, carried out by Prahalad and Hamel (1990), who distinguished between the short-run and long-run competitiveness of firms and suggested that firms need to focus on collective learning in the organization throughout the development of core competencies.

Over time scholars have recognized that to keep leadership and obtain competitive advantage, a list of assets is not enough, especially when acting across changing environmental conditions. In this way, capabilities take importance as business processes require to adapt, integrate and configure assets in advantageous forms which suit the requirements of the external environment (Teece, Pisano & Shuen 1997).

In recent years different scholars have tried to develop a general framework which focuses on the development of "dynamic capabilities". Thus, for Teece et al (1997):

> *The competitive advantage of firms lies with its managerial and organizational processes, shaped by its (specific) asset position, and the paths available to it. (Teece et al. 1997, 518)*

Static (or operational) and dynamic capabilities differ in that the former reflects the firm´s ability to carry out existing activities, whereas the latter reflects the firm´s ability to integrate, learn and adapt by reconfiguring internal and external competences to address changing environments. Although working with static capabilities may be productive and efficient since the business life is ensured (Winter 2003; Prahalad & Hamel 1990), when environment changes they do not offer the firm the potential to adapt and respond to the new context and circumstances (Gebauer 2009; Teece 2007)

Capabilities can be distinguished based on the type of knowledge they contain (Verona 1999). While functional capabilities allow a firm to develop its technical knowledge (Pisano 1997; Amit & Schoemaker 1993; Prahalad & Hamel 1990), integrative capabilities allow firms to absorb knowledge from external sources and blend the different technical competencies developed in different business units (Pisano 1997; Kogut & Zander 1992; Cohen & Levinthal 1990; Grant 1996; Henderson & Clark 1990).

Capabilities can be also classified into assimilative, adaptive, generative and strategic (Dantas & Bell 2006). On the one hand assimilative capabilities make emphasis on operational elements across each capability dimension, while adaptive capabilities focus on design, adaptation and absorptive efforts. On the other hand, generative capabilities are based on formal R&D activities for the development of new products and processes,

whereas strategic capabilities provide companies with a competitive advantage in relation to competitors based on advanced R&D driving the technological frontier.

Various researchers have approached the capabilities topic. According to Atoche (2007), capabilities exhibit three lifecycle stages (founding, development and maturity stage) which in turn have six branches that are present when external factors have strong effects on the development of capabilities. Under pressure the reaction of firms can be retirement, retrenchment (reduction), renewal (reinforce a capability), replication (implement in other business unit), redeployment (apply it within the firm), and recombination (combine two or more capabilities to create a new one).

Fuchs, Mifflin, Miller & Whitney (2000) developed the concept of higher-order integration capabilities. These kind of capabilities represent the firm`s ability to mold and manage multiple capabilities. In order to this, innovation capability is considered as a capability of this type, and firms which possess it, have the ability to successfully stimulate innovation throughout the integration of firm`s key capabilities and resources.

According to Annique (2000), an innovation capability relates to the firm´s ability to combine different kind of resources, in special employees´ specific knowledge, for creating new resources which allow organizations to achieve and sustain competitive advantage. This process is impacted by communication across the company, which facilitates knowledge mobilization, and by overlapping knowledge, which in turn facilitates the creation process.

Similarly, Kim (1997) defined innovation capability as the ability to produce new and useful knowledge based on previous knowledge, while Burgelman, Maidique & Wheelwright (2004) defined it as the set of firm´s attributes that make easier, as well as support, the innovation strategies. Innovation capabilities reflect the ability to integrate newstream and mainstream capabilities. While the newstream enables the creation of new products and services, the mainstream focuses on diminishing costs and improving quality.

From any perspective, innovation capability is considered as an ability to frame and manage diverse organizational capabilities and resources that successfully promotes innovation activities. In general, the stronger the firm`s innovation capability, the more effective their innovation performance (Lawson & Samson 2001).

Loewe and Dominiquini (2006) identified four keys to a systemic innovation capability as shown in the next figure.

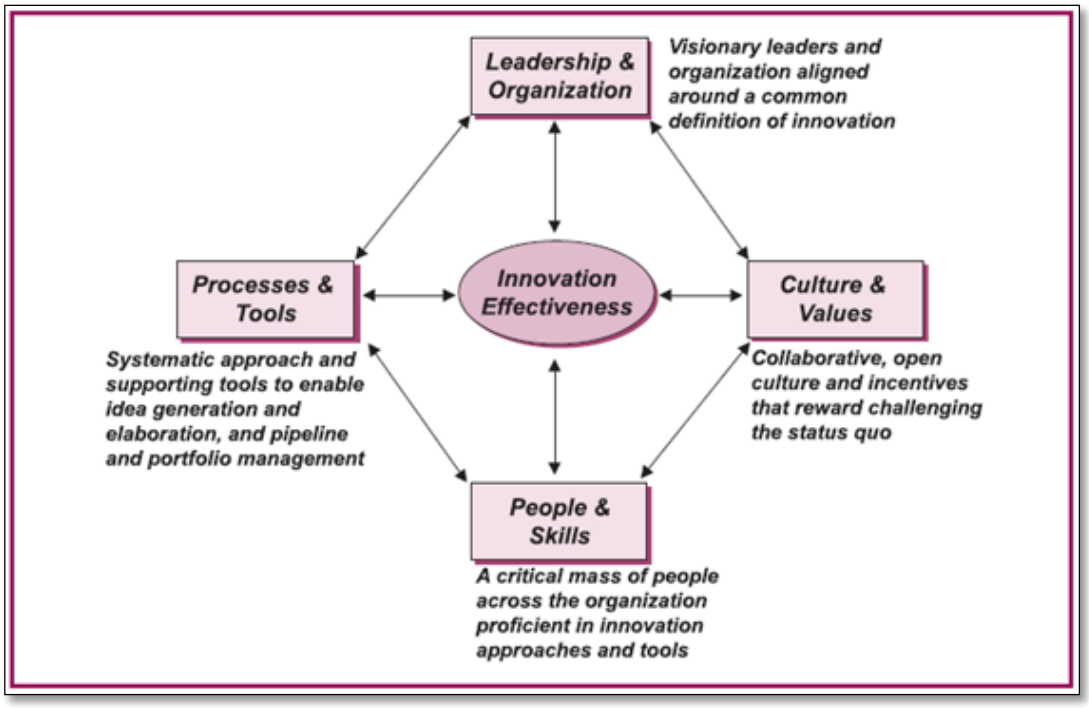

Figure 19 Four keys to a systemic innovation capability
Source: Loewe and Dominiquini (2006; 25)

According to the mentioned authors, leaders have the mission of continuously reinforce and demonstrate, through their actions, the importance of innovation. Furthermore, organizations must focus on building an environment where creativity can be encouraged and also collected by a well-established and suitable process. Finally, what firms cannot forget is that continuing innovation is a result of an internal culture of innovation, which cannot be expected to be transformed overnight since it is the consequence of the initial creation of a safe zone for innovators, where mistakes and failures are accepted as a necessary part of innovation.

When managing innovation, some capabilities tend to be generic, such as the need to learn to manage projects, and some are more specific to the needs of particular groups of firms, e.g. learning to manage relationships in networks. Behind these specific capabilities is where sustained behavior can happen, but it requires unlearning of old behaviors and considerable efforts in changing those considerations previously given. In many firms, it is just achieved when a crisis emerge or with the intervention of external change and facilitators. (Bessant, Caffyn & Gilbert 1996)

Innovation studies at firm-level have identified the accumulation of technological capabilities as a critical factor in order to create innovation capabilities (Dutrénit 2004; Figueiredo 2001; Kim 1997; Bell & Pavitt 1992). Technology capabilities are those abilities used to make use of technological knowledge with the purpose of assimilating, using, adapting, and changing current technologies, or the capacity to absorb new technologies and turn them on new knowledge. According to Morrison, Pietrobelli & Rabel-

lotti (2008), technological capabilities are the technical, managerial or organizational skills with which organizations use equipment and information of technology to accomplish any process of technological change. These capabilities are developed within the time and accumulated through its past experience. They are acquired, assimilated, adapted and modified based on the generation and transfer of knowledge (Atoche 2007). In developing countries the process starts when firms select and buy or adapt technologies from developed countries. With this, firms create production processes, and then absorb the transferred technology while diffusing it across the firm. Finally firms develop an innovative way of doing things by their own and are able to compete with technology in markets of developed countries.

Lawson and Samson (2001) proposed that innovation management can be viewed as a form of organizational capability from which firms can carry out effective innovation processes. Throughout these processes, companies can lead to innovation in products, services, and processes in order to get superior business performance results. Based on the dynamic capabilities and innovation management literature, the referred authors propose an "innovation capability" construct with seven elements such as: vision and strategy, harnessing the competence base, organizational intelligence, creativity and idea management, organizational structures and systems, culture and climate, and management of technology. The model, which is shown in the next Figure, is based on the assumption that the firm is focused on innovation and innovation outputs as their primary competitive strategy. The model is considered in this research since although currently not all the companies focus their strategies in innovation outputs, those successful companies around the world do focus their strategy mainly in identifying and creating new sustainable opportunities in the market.

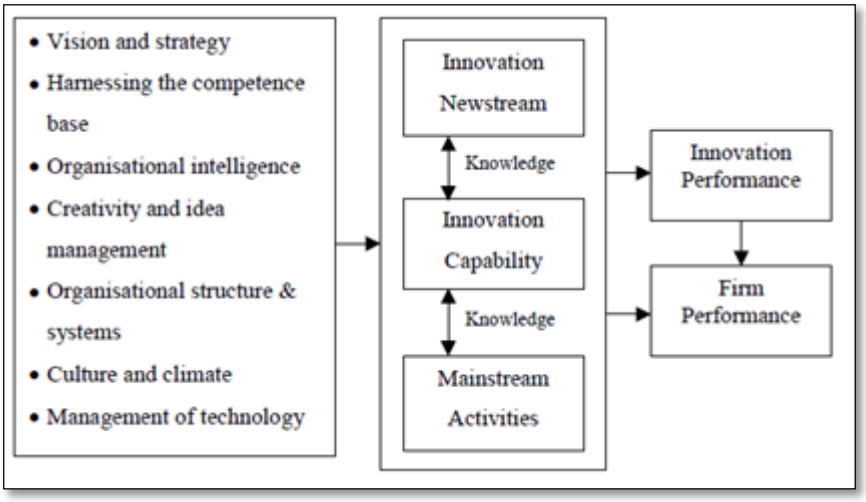

Figure 20 A model of innovation capability
Source: Lawson and Samson (2001; 388)

The elements that integrate the model are proposed to exist, to some degree, within innovative organizations. They also reflect that innovation capability is composed of reinforcing practices and processes within the firm, which are mechanisms for encouraging, measuring and supporting innovation. (Lawson & Samson 2001)

Vision and strategy: As explained before, the firm`s strategy defines how the resources, products, processes and systems of a company have to be adopted to deal with the changing environment conditions. Effective innovation management depends heavily on the clear articulation of a firm´s common vision and the firm´s innovation strategy. It implies the decisions that the organization makes about what businesses and functions must be developed and in which markets, and how innovation support the performance in those markets. Without a strategy for innovation, efforts can be dispersed and lost, since it directs organizational attention.

Harnessing the competence base: The way as resources for innovation are distributed within the firm, is critical for innovation success. Thus, variables such as resource management, accessibility to funding channels, innovation teams and innovation champions are relevant for the construction of innovation capabilities as well as basic for the exploitation of the competence base within the firm.

Organizational intelligence: It is referred directly with learning from customers and about competitors throughout the use of some techniques, such as environment scanning, technological forecasting and competitive analysis (Saleh & Wang 1993). According to Glynn (1996, 1088), organizational intelligence is the ability to process, interpret, encode, manipulate and access information with the purpose of improving the firm`s adaptability to the environment in which it works. Intelligent organizations tend to use knowledge and ideas to diminish the risks and ambiguity that innovation implies, since this information is used to identify new possibilities for investigation and to remove those options which do not represent a profitable result. In order to this, firms are able to produce, communicate and act based on updated information about their environment.

Creativity and idea management: Creativity can be considered as the process of generating ideas. On the one hand, it can operate along a continuum when multiple ideas from employees result in significant continuous improvement. On the other hand, it may be a radical idea when just one or a few ideas result in options which transform the strategy or create new business or markets. Furthermore, creativity can be knowledge-driven since it defines how to apply new knowledge, and it can also be vision-driven since it establishes the new knowledge a firm needs in order to achieve its goal. Finally creativity must be encouraged at all levels within the firm and in every shape it can be present.

Organizational structures and systems: All the elements of an innovation system depend on the firm´s structure and its resulting processes which must be oriented to a fa-

vorable environment. In general, as business grow more layers are added to the structure, then, organizational structure becomes more bureaucratic and mechanistic which can difficult the flow and implementation of new ideas. In contrast, in order to eliminate those barriers that separate functions across the company, firms create permeable business boundaries and foster organic structures which support the potential for the born of more innovative ideas. (Ashkenas 1998; Maira & Thomas 1998) Furthermore, they use their rewards systems as a strong motivator of behavior and successful innovative activity.

Culture and climate: Tolerance of ambiguity, empowered employees, creative time, and communication represent relevant elements underlying the firm`s culture and climate for innovation success. The establishment of high-difficulty stretch goals within a company may support the formalization of an innovative culture across the firm.

Management of technology: Nowadays, technology management is vital for companies since there is a re-orientation to external networks and the leverage of corporate knowledge across the firm. Indeed, some companies are more focused on the technology management rather than in R&D per se (Fusfeld 1995). Moreover, the effectiveness of the relationship between technological strategy and business strategy has been proved to be a determinant of R&D performance (Roberts 1995).

In general, for building innovation capabilities within the firm, at least there must be an identifiable organizational group responsible for innovation, free communication flow and innovation strategy aligned throughout the organization, an innovation system coupled with innovation resources and networks, a learning oriented focus on managing innovation projects, the right identification and nurture of innovation skills and talent, appropriate metrics for measuring the progress of innovation projects and the innovation program, and finally, an organizational environment with a culture and leaders that recognize the importance of the innovation system and the construction of innovation capabilities. (O´Connor 2008)

Similarly to the framework proposed by Lawson and Samson detailed before, Essmann and Preez (2009) propose an interesting structure for building and developing innovation capabilities. This structure contains three dimensions: innovation capability construct, organizational construct, and capability maturity.

The first dimension describes organizational innovation capability focused on the innovation capabilities areas which contain:

- Innovation process
- Knowledge and competency
- Organizational support

Throughout the second dimension, the fundamental aspects of a firm are addressed; they include:

- Strategy and objectives

- Function and processes
- Organization and management
- Data and information
- Customers and suppliers

Related to the third dimension, there are 5 levels for innovation capability maturity, as is shown in the next figure.

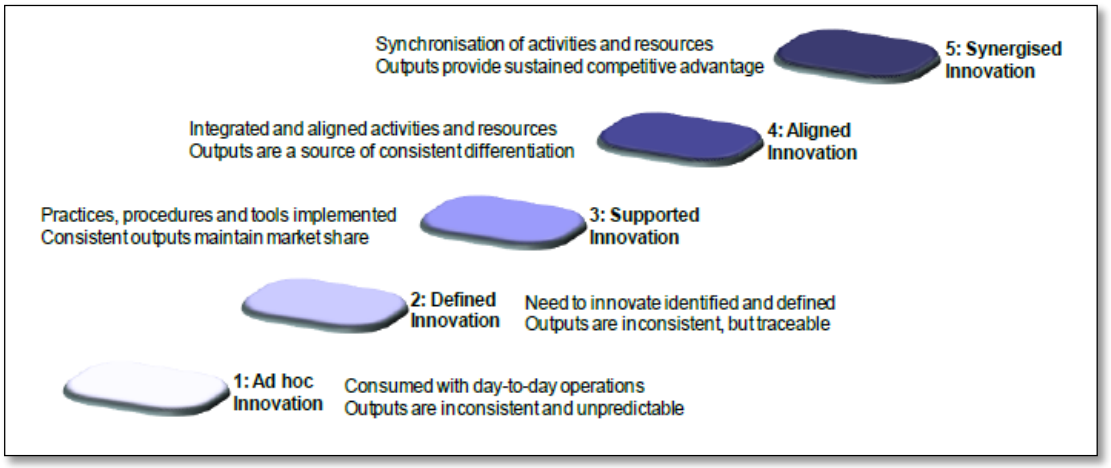

Figure 21 Innovation capability maturity levels

Source: Essmannn (2009; 140)

The different steps to get innovation maturity are integrated in the next Figure, where each organization creates the innovation path according to its strategic intentions and its different clusters of firm capabilities (Atoche 2007).

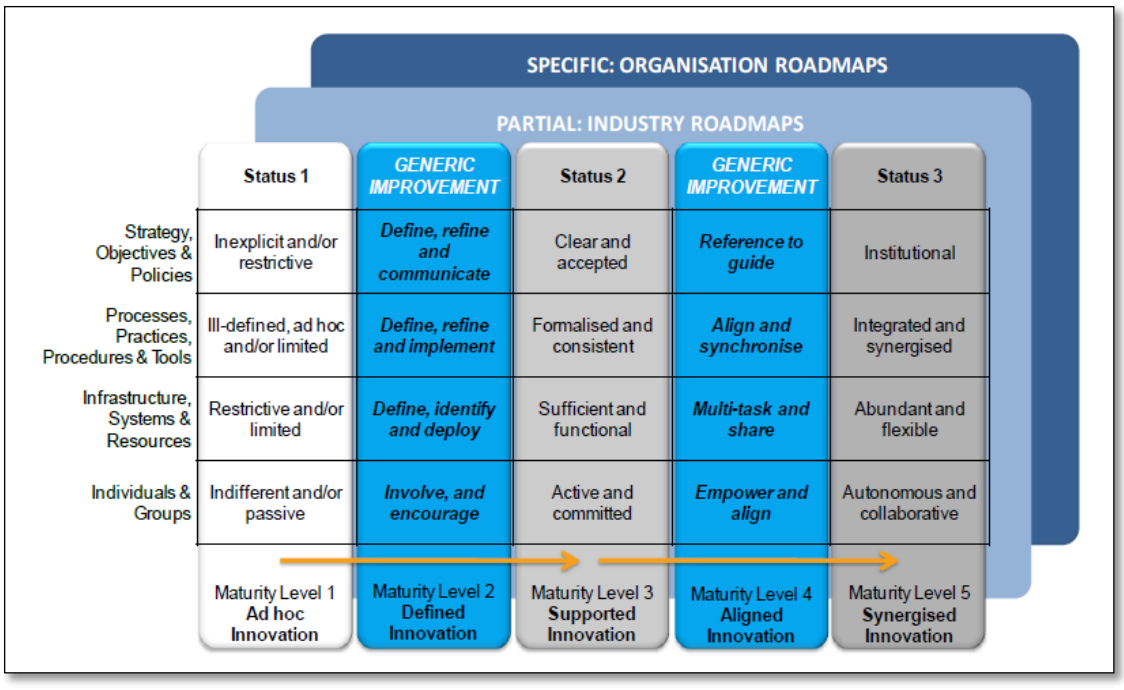

Figure 22 Capability requirement improvement framework
Source: Essmannn (2009; 162)

In the work of Essmann and Preez (2009) they integrate three dimensions: Capability maturity, innovation capability construct, and organizational construct, from which the authors identified 42 innovation capability requirements, valued as critical and essential to organizational innovation capability. The model proposed by these authors describes the "what" of innovation capability but not the "how" since every organization fulfills those requirements in a specific way which cannot be imitated exactly by other company.

Due to the fact that skills and knowledge are not directly observable when developing innovation capabilities, measuring them is quite difficult. There are a variety of factors that contribute to innovation capability which can be internal or external to the firm. On the one hand, internal factors, such as entrepreneur and workforce, help in building a stock of knowledge and skills into the firm. Within the time the firm capabilities are strengthened through internal learning and due to this there are major investments in R&D and minor adaptations to products and processes. For measuring internal sources in innovation capabilities, firms tend to analyze R&D expenditure and scientists and engineers involved in innovation activities. (Romijn & Albaladejo 2000)

On the other hand, when firms interact with third parties such as suppliers, customers, public institutions and industry associations, they can gain something that is not easily provide by themselves (i.e. information about technologies and markets). In this way organizations can develop what is called "learning by interacting", since there is a mobilization of external resources for technological learning (Lundvall 1988). Radical innovations are linked by Lundvall (1992) and Maillat, Quévit and Senn (1993) to proximity between the network partners since closeness increases trust and personal relations. Both factors are required to manage high uncertainty and risks associated with radical innovations.

Although an evaluation about the firm´s innovation capabilities is not part of the scope of this research, for the purpose of this study many of the innovation capabilities proposed by Lawson and Samson (2001) and by Essmann and Preez (2009) are considered for the structure and definition of the innovation system structure of the company case study, since they support and leverage the innovation model as a whole.

To finalize the chapter, the next section briefly reviews the relationship between innovation and competitiveness, analyzing the impact that the former may have on the latter based on large innovation performance studies done by a well-known worldwide consulting firm.

2.3.3 Innovation and competitiveness

We live in a world where everything changes quickly (markets, competitors, products, services, laws, society, etc) so innovation and continuous organizational learning have become major sources of competitive advantage (Barbara & Alberto Ivo 2009; Aramburu, Saenz & Rivera 2006; Nonaka, Toyama & Byosière 2003; Wang & Ahmed 2003; Stock, Greis & Fischer 2002; OEDC 1997; Brown & Eisenhardt 1995; Rosenthal 1992; Nonaka 1991). Under this context innovation is not a strategy, it is a requirement (Moore 2005) and actually represents one of the most representative factors that underlie countries' international competitiveness, productivity, output and employment performance (Wu et al. 2012; Madrid-Guijarro, Garcia & Van Auken 2009; Becheikh et al. 2006; Galia & Legros 2004; Tourigny & Le 2004; Storey 2000; Michie 1998; Asheim & Isaksen 1997)

In order to stay ahead in the modern global marketplace, companies have to search for new strategies with the purpose of improving their competitiveness. The ability to change and adapt is vital for survival (Trott 2005). According to Freel (2000), the importance of innovation for economic development is intensified by the increment in global competition, reduction in product lifecycles, improved technological capabilities of firms, and rapid change in consumer needs and demands.

Innovations are nowadays some of the major sources for the long-term sustainability of competitive advantage of firms (Wang & Miao 2006; Figueiredo 2003; Bell & Albu 1999). Based on this, it is undeniably that all organizations face the challenge of innovation, since their survival and growth depend greatly on their ability to renew what they offer to markets and the way in which it is offered (Tidd et al. 2005). Within the time and throughout a trial-and-error process firms learn to organize and manage innovation in a continuous basis. Thus, firm-specific routines give rise to structures, policies and procedures which are embedded into the firm and define the innovation approach (Pavitt 2002; Nelson & Winter 1982).

Innovation influences business performance. It happens because the generation of new products or processes makes a firm more competitive in relation to its rivals, and the process of innovation changes the internal capabilities of the organization making it more flexible and adaptable to market pressure (Neely & Hii 1998).

A study made by the well-known worldwide consulting firm, Arthur D´Little, in 2010, shows that the most innovative global companies achieve up to twice as many sales, as much as double the EBIT and take half the time to break even when introducing new products and services. The study gave a score to participating companies, which ranked their innovation excellence compared with their industry peers. The score was built taking into account: new business innovation, innovation strategy, how firms measure innovation, and how they manage their innovation processes.

The mentioned study managed to identify the top companies in each industry by analyzing sales and EBIT companies achieved from the introduction of new products, the time they required to get the product to market and to break even on the initiative. With this information, it was possible to identify that the majority of firms participating have significant room to improve their innovation efforts compared with the best in the industry. (Arthur D Little 2010)

Similarly a previous study called the global innovation excellence survey in 2005, developed by the same consulting firm, identified that top quality innovators have 2.5 times higher sales or new products and get 10 times higher returns on their innovation investments than other firms in the same industry (Arthur D Little 2008). Additionally, it was identified that the common factors that give the best firms at innovation are their successful management of their product and service portfolios, their strong idea management, and the use of systematic tools to create business intelligence and client`s insights.

The most innovative companies do not see the future into the same conditions they currently have. They are aware they are not going to sell the same set of products and services with the same success. Due to this they are willing to engage into radical innovations. In the study, top companies exhibit high willingness to work with an open approach to innovation (open up business intelligence and idea development to third parties), which in average is 19% more than the average company (Arthur D Little 2010).

Based on the mentioned study, the figure 23 shows how companies across different industries have as a primary strategic value of innovation activities the top-line growth (boost revenues), or the bottom-line optimization (increase profits) (Arthur D Little 2010). The oil and gas industry can be interpreted as the Energy & Utilities industry, therefore, the top-line growth is the main goal of innovation (75%).

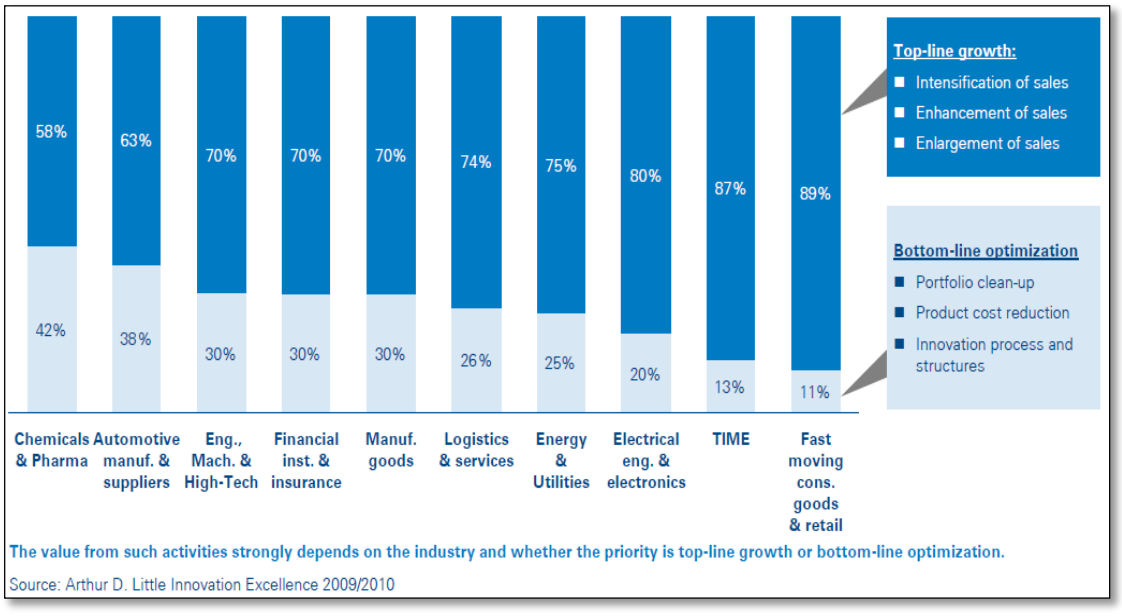

Figure 23 Primary strategic value of innovation activities
Source: Arthur D Little (2010; 6)

When analyzing innovation performance, what experts recommend is that depending on the level of innovation that a company has developed, which is selected based on its strategy, the company should be compared with the top innovators in the industry when the company is a medium innovator and with the best in the world at innovation when the company is already one of the top innovators in the industry.

According to Arthur D Little (2010), there are different context in which companies operate, such as:

Sectors where innovation is driven by idea management. Fast-moving consumer goods companies and telecom operators normally belong to these sectors. Here, firms generate a large number of ideas and implement the best ones normally within the next 5 years.

Sectors where innovation is research driven (with large technical uncertainties and high downstream costs). Pharmaceuticals and oil and gas companies are typical where this approach is most common. Here, a huge number of ideas are generated from research over a long time of up to ten years. Particularly in this kind of sectors once innovation projects are being developed, they can be stopped before their launch.

Sectors where innovation needs an analysis-driven approach. These commonly include companies in the automotive, manufactured goods, telecom equipment and software industries. Here, the decisions about products to take to market come from a market analysis, and the process may take up to 5 years.

Although there is a strong tendency for a company`s innovation approach in each sector, within a same sector the three different approaches are present across the firms. This is due to the different company`s objectives, scope and time horizon of product portfolio, competitive environment and the firm`s value chain position. What is important then is to choose the right innovation engine in order not to waste time or resources. Interestingly, one of the key findings of the study is that companies trying to replicate the success of the most innovative firms and which follow the same innovation engine can speed up their progress. The Figure 24 shows how firm`s approach differs in each sector analyzed in the study done by Arthur D Little (2010). Specifically for the oil and gas industry, which is included into energy and utilities sector, firm`s innovation engine is 44% analysis-driven, 32% idea-driven, and 24% research-driven.

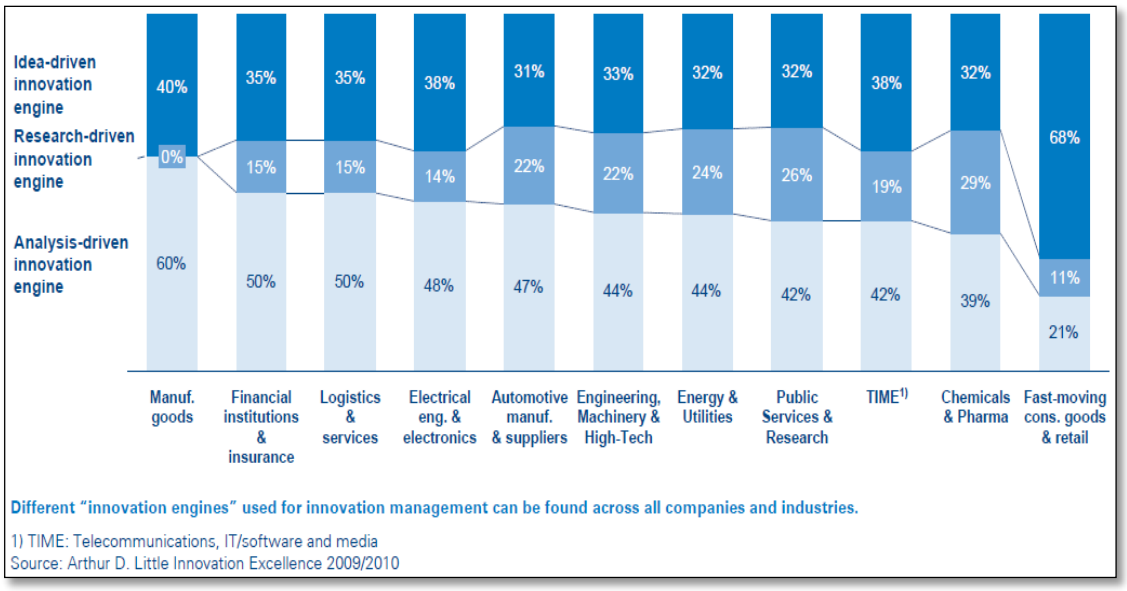

Figure 24 Innovation engine per industry cluster
Source: Arthur D Little (2010; 10)

Companies which succeed at establishing new business normally separate these projects from the organization and processes (Arthur D Little 2010). Indeed, they can set up a new organization with new process for the specific purpose. This is then highly recommended to separate new business development in another unit where common processes do not impede the flow of innovation.

Finally, innovation efforts and adoption of new procedures and technologies may increase competitiveness (Goel & Rich 1997) due to that knowledge workers can perceive and deal with what target market accepts or expects as value, which boosts incremental and radical innovation that can be used by companies as their knowledge-based competitive edge, so they are able to defend themselves against their competitors.

Having built the literature review in innovation management and its main elements and relationships, the next chapter covers the main facts in the oil and gas industry in order to have a clear context about the surrounding environment of the company case study.

3 THE OIL AND GAS INDUSTRY

Over the time, natural resources have been an important source of wealth. Decades ago it was said that the world was running out of hydrocarbons. Actually, this is not completely true since advances in exploration technology have increased the number of proven reserves of oil compared with those of three decades ago, and technology advances have made it possible to unlock more oil from old fields (Watkins 2006). In fact, an energy consultant, Cambridge Energy Research Associates, estimated that the total base of recoverable resources of conventional oil totaled about 4.8 trillion barrels, which is likely to grow (Oil Innovations Pump… 2007). It evidences how new technologies in the industry can tap into more resources, and how oil companies are doing both: seeking out new sources of fossil oil in extremely distant places and using new technology to extend the lives of old oil fields. As pointed out by Lawrence Goldstein, who is an energy analyst at the Energy Policy Research Foundation:

> *Ironically, most of the oil we will discover is from oil we have already found… what has been missing is the technology and the threshold price that will lead to a revolution in lifting that oil. (Oil Innovations Pump… 2007)*

What companies are using is called secondary and tertiary oil recovery methods throughout which firms inject all sorts of exotic gases and liquids into oil fields, such as water, soap, natural gas, carbon, dioxide, etc. Thus, innovation, technology and investments are being unleashed in the oil and gas industry. (Guntis 2008; Oil Innovations Pump… 2007).

In the Appendix 1 it is possible to check the world´s largest oil and gas companies (based on the number of proved oil reserves). Companies located in the top ten places tend to remain year after year in these positions, and due to this national oil companies from middle-east countries (except from Venezuela) continue to be the largest oil and gas firms in the world. For example, the company Saudi Aramco has achieved the top spot in the rankings for consecutive 23 years

Interestingly during the last years natural gas' contribution to reserves and production growth continues to gain traction. Actually Russia has the world´s largest natural gas reserves (around 25% of the world total) followed by Iran (with 15% of the world total), however geology and simple market forces make it difficult for commercializing. Nowadays, due to the rise of liquefied natural gas technology, gas is turning into a fungible commodity since gas is identical to every other cubic meter, no matter who produces it (Vaitheeswaran 2005).

The market for oil continues to grow, although some argue that this phenomenon is going to stop sooner. For example, China`s demand for oil has grown significantly and continues to go up. Nevertheless, the country has focused its efforts on finding alternatives to hydrocarbon fuels. In this way China is leader in producing electric vehicles and hydrogen powered automotive technologies, not because it is concerned for the environment but by their desire of stopping dependence on Persian Gulf oil (Vaitheeswaran 2005).

Thus, in order to supply new and current demands, oil companies have to go after reserves harder to reach. For the achievement of this purpose, companies have been supported by the increased oil prices. Otherwise it would not be economical viable for companies because the more mature a field is, the more expensive it is to extract the oil from it due to the technology and logistics that are required. Higher prices coupled with sophisticated technology make searches for new oil more affordable and open up opportunities to develop supplies.

Due to this, over the time researchers have analyzed the relationship between oil price and innovation in the oil and gas industry and have suggested a relationship between these two variables. In fact, many years ago, in 1932 John Hicks (1932) introduced the theory of induced innovation according to which changes in relative factor prices lead to innovations. Later on, David Popp (2002) found a positive correlation between energy prices and innovation. With this evidence in mind we could suppose that innovation is nowadays much more important considering the high prices that oil has exhibited and continues to do.

Consequently, when prices are high or more expensive, the agents of the economy can adopt or develop new technologies which tend to be more efficient in the use of energy, or use non-exhaustible sources of energy (Zuleta 2008). One common example is that of the multi-year oil crisis prompted by the 1973 OPEC embargo (Ikenberry 1986). At that moment the international oil price increased suddenly and remained at high levels for almost a decade. As a result of this phenomenon energy efficiency improved and industrialized countries incremented the use of nuclear power (Cheon & Urpelainen 2012; Geller et al. 2006). Due to this, one could imagine that new and alternative ways of energy are emerging in the world, in order to improve efficiency and reduce the use of conventional energy sources.

Oil companies can be privately controlled international oil companies (IOCs) or national oil and gas companies (NOCs). The latter are major forces in the industry since they own much of the world`s oil and gas infrastructure, produce most of the crude in the planet and control the majority of the world`s oil reserves. However, although NOCs companies tend to compete globally they also have to act locally as agents of their governments by serving the needs of people in their country. In some cases some NOCs have become the focus of political ambitions and center of debates. Thus, NOCs´ strate-

gy responds to their unique combinations of competitive and political pressures. (Fletcher 2009)

Within the oil and gas industry there are also three levels or categories which can be distinguished in which the key players are positioned (Keogh, Jack, Bower & Crabtree 1998) as follows:

Operators: In this group are companies such as BP, Shell, Elf, Exxon, which license the oil and gas rights to acreage as well as take direct legal responsibility for exploiting them. On the one hand, some operators have integrated downstream activities and retail their petroleum products and petrochemicals. On the other hand, others subcontract the exploration and production functions.

Contractors: Large firms such as Schlumberger, Baker Huges, Halliburton and AMEC are examples of contractors. These companies arrange and provide services to the operators, such as drilling and production services, construction, maintenance, logistics, and general oil field support.

Suppliers: In this category there are the suppliers of basic items (i.e. nuts, bolts, papers, etc…) and the suppliers of highly specialized products and services which have to invest in high levels of innovation due to the dynamics of the industry. In general suppliers have to deal with contractors, and in some cases directly with the operators.

The next section covers the general stage of innovation across the companies in the oil and gas industry in order to context the study and to know what is surrounding the industry in innovation matters.

3.1 General stage of innovation in the oil and gas industry

Although the world has more proven reserves of oil today than it did three decades ago, many of the remaining supplies of oil and gas in the world are located in places which are hard to reach, such as under deep oceans or in the frozen Arctic. Indeed, companies such as Petrobras, which have growth significantly in the past decade, have concentrated investments in offshore exploration and oil fields (Brazil girds… 2009).

Oil and gas companies manage to extract around 50% of the physical deposit at a given site. Within the time, and due to technological improvements, this percentage increases. (Welfens 2011)

Actually, the energy sector covers the oil and gas industry, therefore any trend in the oil and gas companies impacts the energy sector, and vice versa. Particularly in the energy sector some future scenarios are contemplated in order to define company`s strategies in the market (Fundación de la innovación BANKINTER 2006):

The first scenario has to be with the continuity of the current energy conditions, in which the world will continue to depend on fossil fuels, subordinating any

environmental interest to a second plane which makes difficult the path to the sustainability.

In a second outlook there is a shift towards energy efficiency, where the protagonists are the renewable energies derived from an oil and gas rising. Under this scenario, there is higher concern about environment, so then investments in clean and efficient technologies will be increased. Thus, training and research in renewable energies will play a fundamental role.

In a third panorama there will be many technological advances related to energy supply. Under this prospect, China would lead the expansion in electric vehicles and new technologies in the transport sector, while USA would lead innovation in biofuels due to advances in biotechnology (United States and China… 2011). This scenario is thought to happen in a long-term, where the technological change impacts the sector and moves the fossil fuels to another stage, ensuring the energy supply for the world.

All the possible scenarios, coupled with the current conditions of the oil and gas industry mean new opportunities for companies and for business creation. Thus, the challenge for the oil and gas companies can be seen in two big fields:

First, there is a need for the development of better technologies for oil exploration and production, pushing back the oil peak further and further (Vaitheeswaran 2005) and using them to help companies to operate in new and challenging environments, and also to squeeze more from existing resources. Regarding to this point, according to Enos (1962), there is a time lag of about 11 years between invention and innovation. Additionally Furtado (1997) found that differences in the degree of appropiability between upstream and downstream of the oil and gas industry had a great impact on effect of R&D promotion.

Second, there is an interesting opportunity in alternative fuels due to an increasing change in energy consumption, according to the estimation by 2030 made by the BP (British Petroleum 2011), when for the first time non-fossil fuels will be major sources of supply growth. (See Appendix 2)

Different challenges in energy consumption in different industries such as in the automotive, construction and electricity generation push oil and gas companies to think different. In the same vein it forces them to orient their strategies in order to align their realities with the changes of the environment.

With a high level of certainty, in the future there will be greater demand for more and different kinds of energy sources. Due to this, oil and gas companies will face higher capital costs to satisfy new energy demands, which in turn could create a shift in the industry operating models. Information technology will support companies in this transition.

In the oil and gas industry, especially in the petroleum refining industry, the technology has experienced major changes, although outcomes of the process are the same

(gasoline, kerosene, etc.) (Zunsheng 1994). Technological progress in an industry uses to depend on radical innovation and the incremental improvements that are done during the diffusion and implementation of that innovation. Thus, technological investors gain not from the original investment but from the operating improvements from using and upgrading technologies.

The industries, in which oil and gas companies operate, leave their mark on innovation. On the one hand, exploration is risky by nature, then innovation processes are also more risky and geared more towards new innovations. On the other hand, exploitation values more efficiency and optimization, then incremental innovations are more affordable. (Ortt & van der Duin 2008)

Grant (2003) analyzed the strategic planning in the 10 biggest oil companies in the world and found that these companies create their strategies without the use of strategic planning systems, and furthermore, that there was limited use of new tools and little evidence that the systems of strategic planning were conducive to strategic innovation. Additionally, in order to solve operational problems and for developing new production systems, oil and gas companies have organized themselves as agglomerations, due to their geographical closeness. These concentrations are mostly located close to the oil beds and are integrated by a large supply network of oilfield operators and different worldwide suppliers (Globerman, Shapiro & Vining 2005; Agrawal & Cockburn 2003; Markusen 1986). These companies supply complex technological goods and services, and equipment that are often classified as cutting-edge technologies. Because of this, these firms find it interesting to undertake coalitions and partnerships among themselves in order to absorb knowledge and technology from others, as well as to build innovative technological capabilities (dos Santos & Tavares 2010).

According to Welfens (2011), given the relative oil prices and the new technologies, oil reserves will meet world demand for about four more decades. However, due to the expected technological advance in exploration and in the use of energy, this forecast could increase over time. Although natural gas can be perceived as a substitute for oil, it is used mainly for electricity generation and heating, while oil continues to supply energy in the majority of industrial activities.

Investments in innovation have not been done mainly by the oil and gas companies. Although the technological advances in the industry have been significant, during the last decade the expenditure in R&D in the oil and gas industry was remarkably little (Crooks 2008). Oil and gas companies preferred to share technology rather than develop it by themselves. For example, Royal Dutch Shell, which is one of the most innovative companies in the industry, in 2006-2007 was the 104th place in a global ranking developed by the Britain´s Department for Business and Enterprise of companies by R&D spending (Crooks 2008). Thus, technology was in the hands of service companies which are now far ahead in terms of numbers of new patents granted. The risks associated to

innovation were shared across the companies, for example Bright Water was an initiative of BR, Chevron, Mobil and Texaco. Thus, companies did not generally control much distinctive technologies that only they could offer.

Nevertheless, over the time the oil and gas industry has transitioned from stability to turbulence (Grant 2003). Thus, due to the dynamic of the market and the oil prices, companies are more aware of the importance of technology and investing in R&D. Due to this, companies are competing for the next breakthrough, although like in the history of Microsoft vs. IBM, the next big step forward in the industry can be done by anyone, even from outside the ranks of today´s industry leaders.

An interesting example from the oil and gas industry is that of Shell. Due to this, and in order to have clear vision about what other companies in the sector have done, a review about the path that Shell has gone is presented as follows.

Shell´s experience at innovation

Some companies, like Shell (located in the top 10 of largest oil and gas companies in the world, see Appendix 1[1]), are incorporating every day more innovation as an integral part of the way the company does business. Shell Global Solutions, Shell Hydrogen and GameChanger can be considered as interesting examples about how an oil and gas company responds in an innovative way to the challenge of doing business in an environment that is continuously changing (Verloop 2004). It is an interesting example of what a company has developed to support its innovation system and relate innovation to the strategy.

The firm is involved in both upstream (exploration and exploitation of oil and gas) and downstream (refining oil) activities. The company´s mission is to provide energy, no matter its kind (solar, wind, hydrogen, etc.) and due to this there is focus on both incremental and radical innovations. The former enhance the competitive position in (Verloop 2006), whereas the latter may create new value chains, are funded at corporate level and completed in collaboration with partners.

Shell has approached its goal through a new central organization called Projects and Technology (P&T) which integrates both upstream and downstream R&D. The group develops differentiating technologies with application within a 2 to 20 years time horizon, which includes the development of game-changing technologies which may help new future businesses. The difference of P&T with Global Solutions is that the latter is

[1] Petroleum Intelligence Weekly's annual ranking of the world's 50 largest oil companies is a benchmark survey recognized industry-wide and the leading source of comparative corporate performance assessments. The rankings are based on six operational criteria that allow the comparison of private sector and state-owned oil companies. (PIW 2010)

focused on projects with less than a 2 year time horizon. P&T is supported by six pillars: R&D, technology solutions and deployment, project execution, well engineering, technical IT and engineering. It ensures the development of solutions that are fully integrated along its entire value chain. In especial, the integration of technology solutions and deployment, and the execution group guarantees standardization of design and equipment in order to apply the best practices to the group. The former is responsible for applications engineering while the latter is responsible for supplying everything (i.e. drilling and production platforms, refining and petrochemical plants, and pipelines and LNG tankers). (Kulkarni 2011)

Actually the firm has made important technologies advances and continues to focus on different game-changing technologies that will allow it to achieve its goals. The firm goes further than other in the industry, for example it has achieved interesting advances in well development and actually is focused on analyzing common geologic heritage between South America and Western Africa through high-resolution gravity and magnetic data for a better understanding of the basins and their hydrocarbon reservoirs. (Kulkarni 2011)

The company has implemented two important strategic activities within the company: scenario planning (Ramirez, Roodhart & Manders 2011; Ramirez, van der Heijden & Selsky 2008; van der Heijden 2005; Schwartz 1997; Schoemaker & van der Heijden 1992) and GameChanger. For developing strategic activities actually the company operates with the concept of domains (i.e. bio-fuel domain), which can be seen as linkages between different potential desired company futures to Shell. Domains reveal the areas that Shell needs to explore and develop in order to achieve the different strategic possibilities identified in the scenario planning. They contain small set of flexible strategic propositions and the innovation projects (i.e. the ethanol project and algae project into the bio-fuel domain) which have been selected to test and develop those propositions. The process to accept a project for a domain is very strict and the outcomes of it may be incorporated into an existing business unit or activity, or become a new operation with the entire domain. (Ramírez et al. 2011)

In general domains can work at different levels where technologists, scenarists and strategists meet, so then it can integrate efforts more effectively. Furthermore, they are consistent with the new technology implementation, which can take years and usually goes from laboratories to small prototypes and then to small-scale pilot plants and finally to full commercial facilities. New business models go through the same process before making big bets.

GameChanger is a process for developing innovation projects based mainly on new and emerging technology; it is with a focus on radical innovation. This is highly used across the company and seeks for converting ideas into projects and eventually, for those successful projects, into ventures (Verloop 2006; Välikangas & Merlyn 2003; van

Dijk & van den Ende 2002). In fact, from 1998 to 2007 around 2.150 ideas were submitted from which 200 had been successful products, services or processes (Ramírez et al. 2011).

In the GameChanger of Shell, ideas are received from anyone and initially assessed by peers in order to define if those ideas are worth further investigation; if so, the idea is transformed into an innovation project which in turn is then reassessed in the way as it can fit Shell´s needs and processes. Finally those ideas that became into projects and that are successfully investigated may be transferred into an existing business unit of Shell or converted into an external business. During the various stages of the process, different teams are appointed to operate with the aim of ensuring the purpose of each stage. It is in concordance with the idea that the inventor needs to leave the team in stage two since this stage requires analytical perseverance and sound business sense, which are not the most representative characteristics of the inventor (Verloop 2006). For the case of incremental innovation the entire project is carried out by a multi-disciplinary team composed by technical and commercial people.

During the last years GameChanger´s essence has evolved to a new stage Game-Changer 2, in which strategy and innovation interact. Additionally, this new stage recognizes fuzziness (elements of ambiguity or ignorance) to exist alongside the progress of innovation, which in the first stage was identified as being present just at the beginning of the innovation process and due to this the purpose was to eliminate it as soon as possible early in the process. With this change between the two stages, ignorance as well as knowledge are openly recognized and harnessed across the different phases of the innovation projects. With this, one of the purposes of GameChanger2 is to discover what the firm does not know that can help at innovation (Ramírez et al. 2011; Ravetz 1987)

Many benefits have been identified with the implementation of the GameChanger 2, especially due to the domain concept. First, although the proportion of ideas surviving the first gate was reduced there was an increase in graduating project quantity and the overall portfolio scores also increased. Second, it has led to more focused development and the earlier selection of winners. Finally, there has been an increment in the number of external ideas because of the company has focused its external efforts and selected the right innovation partners. In this case, when external collaboration is given, the company supervises strictly the project in order to ensure that innovations fit into the system and keep the integration between upstream and downstream activities (Ortt & van der Duin 2008). In general, the impact has been two-fold: projects which should have died later are detected and stopped earlier, and the adoption rate for those projects that manage to go until the end has improved significantly.

Collaboration is one of the keys at innovations systems in Shell. The company is aware of the opportunities in the industry and develops alliances with universities and

technology companies, even outside the oilfield realm. For example, it keeps relations with the Massachusetts Institute of Technology and with Hewlett-Packard for developing an extremely high-resolution seismic data acquisition system that will be a significant leap forward in seismic data quality. (Kulkarni 2011)

The way as Shell learnt and then guaranteed that the development of domains would not be conditioned, was carried out by executing two steps. First, a broader set of stakeholders were convened in order to ensure that linkages between units and processes required for innovation successful were in place. Different perspectives from this team were articulated and used to evaluate new initiatives and check the effectiveness of innovation in relation to strategic intent. Second, new domains rose during the Game-Changer from world-class experts who helped in the development of "Shell technology futures" which refer to the potential technologies than may become commercial in any short future time. Furthermore, it contained the pathways that were assessed in relation to the sets of global (20 years) and long-term energy (50 years) scenarios available (Roodhart & McCormick 2007).

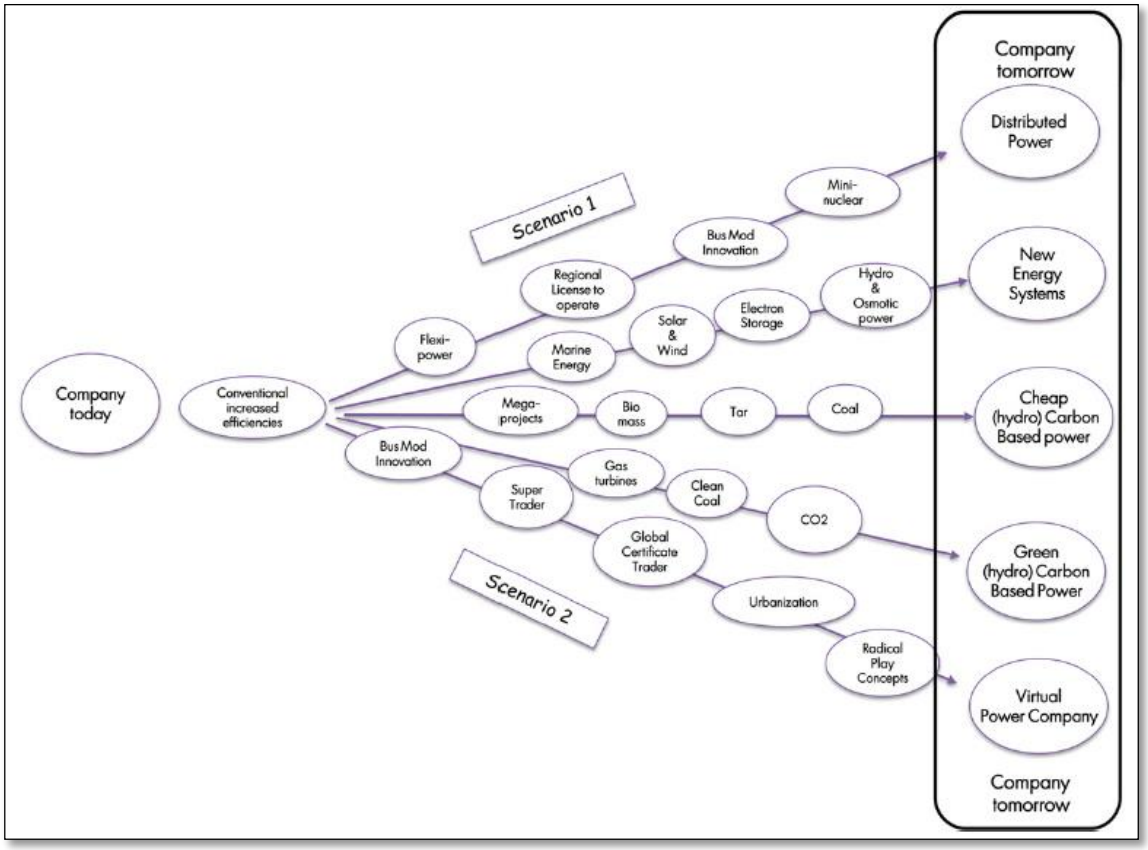

Figure 25 Domains between the company`s potential futures and its present
Source: Ramirez et al. (2011; 259)

In Shell domains are transformed throughout the enrollment and migration of new projects into the domain and by strengthening links with other domains. Thus, domains

can be transferred as a single entity into a Shell business unit, or can remain as a strategic innovation initiative. This prevents the innovation at the company from stable routines, department or process, so then it helps the firm to develop productive connections between fuzziness and knowledge (Ramírez et al. 2011; Ravetz 1987).

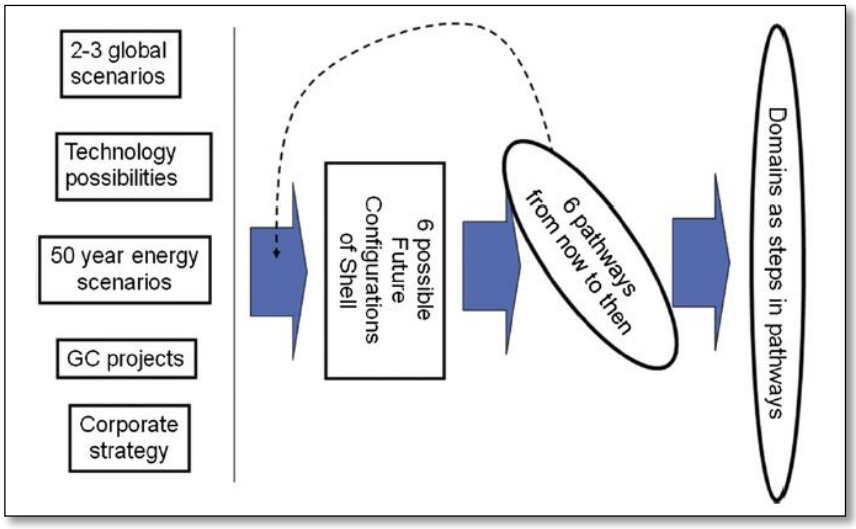

Figure 26 A domains recipe

Source: Ramirez et al. (2011; 259)

Based on the study of Ramirez et al. (2011), domains imply some managerial attributes, such as further engagement of senior management, selection of projects based on strategic criteria, projects more connected to the business, clear broad vision which can be converted into action, growth of business value, learning via domain`s projects, improvement of the link between technologies, scenarios and strategies, and regular revision of the domain`s existence and goals.

Based on all the efforts the company makes, the technology portfolio is focused on the development of core technologies. The path to achieve it relies on fast development and great orientation to replication. Thus, the company seeks for leveraging the technology developed in one area of the world for adoption in another part of the world. In similar way the firm looks for taking advantage of its global scale to achieve cost efficiencies in equipment sourcing and procurement as well as implementing standardized operations worldwide (Kulkarni 2011).

The author considers important the experience that Shell has constructed around building and executing innovation within the company. This example works as motivation as well as a demonstration that being innovative is possible, especially when it implies the right definition (throughout trial and error) of what leverages the innovation process across the firm and the creation and development of innovation capabilities within the organization, in a sector such as the oil and gas industry.

To conclude the chapter, the next section continues to identify innovation in the oil and gas industry, but specifically in the most representative companies in Latin America. Unfortunately information about innovation in these companies is not easily available and is not published, then data about innovation programs or models across the firms is difficult to access. Due to this, the next section covers slightly how these companies are oriented and how this orientation defines the way to innovate.

3.2 Innovation in the largest Latin American oil and gas companies

According to Liu and White (1997), in developing economies innovation is driven by the synergy between investment in absorptive capacities, such as R&D and people, and investments in sources of new knowledge, such as foreign technology.

Unfortunately the findings obtained by Sutz (1998) in a study regarding innovation in Latin America done more than a decade ago, where innovation investment, performance and outcome were significantly low, still continue to exist in a similar trend. Actually innovation processes in the region tend to be informal, the majority of innovations are adaptive and incremental, and radical and breakthrough innovations are limited. This phenomenon is due to the fact that in the region the technological change is exogenous and that the few which is endogenous rarely comes from R&D activities or basic research (Arocena & Sutz, 2002; Jaramillo, Lugones & Salazar 2000, Durán, Ibañez, Salazar & Vargas 1998).

Moreover, there is a minimum integration between the enterprises with National Innovation Systems, which make the innovation processes in Latin America weaker than those in developed countries (Malaver & Vargas 2004). In order to this, companies have developed technological capabilities and innovations that have allowed them to compete successfully in the regional markets although these have also limited their international competitiveness. The majority of companies import the technology (machinery and equipment), and although there is a lack in the incorporation and adaptation of this technology, it has not been an impediment for them to learn and achieve technological development. (Malaver & Vargas 2004) It has been possible because of companies have had to face technical problems and adaptation of the acquired technologies, satisfy customer needs and leverage business opportunities. This phenomenon is also present in the oil and gas companies, in which innovation does not appear like in companies in the sector in developed countries.

Although organizational learning and technological advance have boosted innovations (the majority of them of low complexity and scope), the innovation capabilities continue to be limited. Consequently, it is difficult for companies to move on higher complex technological capabilities throughout more systematic and frequent projects,

based on R&D, and with higher results in terms of innovation degree, complexity and scope (Malaver & Vargas 2007).

Some international references, such as the OECD (Organization for Economic Co-operation and Development) have defined the use of The Frascati Manual and The Oslo Manual, and for developing countries The Bogota Manual. Under the premises of these manuals, countries are able to measure their development and technological innovation. Thus, different studies of innovation in Latin America have showed that the related indexes have improved over the time. However, a great advance is still required in technological capabilities and the relationship between innovation and competitiveness. Since innovation in the region is still informal, sizing the phenomenon represents a big challenge.

In Latin America, the most representative oil and gas companies are NOCs, so then they are influenced somehow by the policies defined by the government for companies in the public sector. Innovation in the public sector has been done mainly incrementally, brought by public service professionals to improve performance and the lives of service users. Borins (2001) found that half of all innovations in the public sector are not originated at the top of organizations; they normally come from staff and professionals in every level of the organization (including users and customers), in particular from those new employees during their first months in the company before they are acculturated.

The risks of innovating in the public sector are intensified due to the existence of two factors: risks are exposed earlier to higher levels of public scrutiny, and risks to individual and community quality of life are more significant. It reinforces risk aversion at innovating in the public sector. (Albury 2005)

In general innovation in the public sector is characterized by a need for strengthening the knowledge base by identifying, when evaluating different innovation attempts, "what worked" and did not, and by analyzing the relative cost-benefits of different innovations in the same area of public service.

Albury (2005) identified some barriers or inhibitors to innovation, such as short term budgets and planning horizons, poor skills in active risk or change management, few rewards or incentives to innovation or adopt innovations, technologies available but constraining cultural or organizational arrangements, over-reliance on current high performer as sources of innovation, reluctance to close down failing programs or organizations, culture of risk aversion, and delivery pressures and administrative problems.

Actually in the Western Hemisphere, the most influential national oil companies (NOCs) are PEMEX, PDVSA and Petroleo Brasileiro SA (Petrobras). (Fletcher 2009) The first two mentioned companies are among the five largest suppliers of crude to US, while the latter has exhibited an interesting evolution and expansion due mainly to the discoveries off shore in Brazil.

PEMEX is the most important company in Mexico and therefore the biggest source of income of the country. It is the single producer of crude, natural gas, and petroleum products in the country, and the third exporter of crude to the US (Canada and Saudi Arabia are the first and second exporters, respectively)

PDVSA is the largest employer in Venezuela and represents a third of the country`s GDP and 80% of the Venezuela´s exports earnings. The country has the largest proved oil reserve in South America, followed by Brazil.

Petroleo Brasileiro SA (Petrobras) is a clear example of the evolution that a company has to do in order to be innovative, by investing in people development, and in networks. The company has developed an important reputation on deep-water exploration as well as has achieved good expertise into the Gulf of Mexico and foreign waters through its international operations. Although the Brazilian market is not closed for foreign oil and gas companies, Petrobras is the dominant player in the country and still has around the 95% of crude production in Brazil. (Fletcher 2009) The company has gone partially public and it is perceived as a good and profitable partner for US service companies and IOCs. Moreover, Petrobras has a major position in the production and market of ethanol, and due to the Brazilian market size, it is developing oil supplies for this market rather than for export.

In the oil and gas industry the knowledge networks of large, technology-using oil companies play key roles in innovation systems. Petrobras has been able to move forward an innovative company, in part thanks to the great influence that knowledge networks (with suppliers, research centers, universities) have had on the capabilities development (assimilative, adaptive, generative, strategic), and due to this learning networks have been transformed in innovation networks. These linkages have given the company new forms of collaboration with suppliers and universities for joint innovation and specialized and complementary R&D activities. Additionally, this knowledge construction have involved Petrobras into the definition of specifications and technical problems, and into the solution of problems during joint R&D activities (Dantas & Bell 2006)

Differently from other oil and gas companies, Petrobras has developed R&D and knowledge bases in both core and non-core technologies. It has converted the company in a key actor in driving technological changes at the international technological frontier in ultra-deep water technologies. It has been possible because the company has procedures to evaluate internal capabilities and complementary of other organizations. As a result, the firm can identify its in-house capabilities as strategic assets, which are attractive to other oil and gas companies, as well as recognize that some capabilities required for innovating inside the company are located outside its organizational boundaries (Dantas & Bell 2006).

Lastly, the search for oil and natural gas has resulted in great technologies advancements in exploration, development and production activities within the industry. Thus,

as a consequence of the evolution of Petrobras, Brazil has emerged within the last 30 years as a center of excellence for deep and ultra-deep water oil and gas exploration and production. Due to the integration of oilfield operators and integrated suppliers of off-shore equipment and services, nowadays to explore and produce oil and gas in deep and ultra-deep waters (more than 1.000 meters of water depth) is part of the reality of the firms (dos Santos & Tavares 2010).

According to Naranjo and Calderón (2010) Colombia exhibits remarkable technological lags in its efforts against developed countries, and even compared to nations of similar development (technological efforts made by Colombian economy are lower 50% to those made by the average Latin American countries, and investments in R&D by the business sector is quite low). Particularly, investments in R&D activities (0,19% from the country`s GNP) as well as in S&T (science and technology) activities (0,5% from the country`s GNP) are significantly low when compared with those made in other economies (OCyT 2012). This, coupled with a low participation of the private sector, a weak relationship university-enterprise, and the reduced number of researchers in the country, explains the nation`s lower capability to generate innovations.

In the country, the innovation processes are still informal because they are not planned and do not follow a strategic technology and innovation management (Naranjo & Calderón 2010). Some of the weaker practices are related to the selection and negotiation of technologies, which is relevant to incorporate new technologies. However some companies have taken advantage of their productive and commercial capabilities to get technological learning and respond to problems such as technical, technological adaptation and customers' requirements, although some international opportunities had been lost due to the low technological companies' profile.

Some innovation inhibitors have been identified in the country, which reflect the reality of various companies in the nation. Some of them are (Barrera 2011):

- Lack of support by leaders
- High resources investment associated with innovation
- Fear of failing and loss of money
- History and experience about how to operate the business
- Changes in business models, clients, competition, suppliers and environment
- Lack of innovation culture
- Lack of time due to daily work duties
- Short-term thinking
- Informal and non-structured processes
- Lack of incentives to people to innovate
- Working independently by departments without linking with other areas
- Too many, and rigid, processes and norms
- Employees are not involved into the innovation process

- Old business models applied to organizations that require to adapt to the new environmental conditions

In general, although Colombia has been working in the formulation of a public policy which supports innovation efforts, it has not been possible to change the fact that companies work independently in their technological developments to solve their specific problems, and that the academy continues centered on doing science without interacting with the industry.

To conclude, according to particular studies, innovation in Latin America exhibits weak linkages and limited knowledge flow, informal systems, firms are not the central loci of R&D efforts (Melo 2001) and, the region`s national innovation systems are open as well as heterogeneous. Additionally, in Colombia innovation remains informal, no matter the sector, and outcomes from it are still poor to give the nation a competitive advantage (OCyT 2012; Malaver & Vargas 2007; Malaver & Vargas 2004).

4 METHODOLOGY

This section seeks for detailing how the author went about giving answer to the research question and sub questions. Furthermore, it includes a description of the choice of the method in the light of the questions and how the data was planned to be analyzed. For further understanding, the chapter is divided into three main parts: research design, data collection and data analysis, as follows.

4.1 Research approach

According to Robson (2002), a case study can be defined as:

> *A strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence. (Robson 2002, 178)*

Similarly, Yin (2003) claims that a case study:

> *is a research design that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. (Yin 2003, 40)*

In addition, the author distinguished between four case study strategies based upon two discrete dimensions: single case vs. multiple case; holistic case vs. embedded case. This research followed a single case strategy due to the fact that it provided the author with an opportunity to observe and analyze a phenomenon in the case company that no one has analyzed before. Thus, the author carried out the research during the year 2012 and the first semester of 2013, in a company called Ecopetrol S.A which belongs to the oil and gas industry from a developing country, Colombia. The use of a single case study was also influenced by the author´s own professional affiliation and the manifested interest made by the company for the analysis of the phenomenon. Complementary, it constituted a holistic case study, because the research was concerned with the single organization as a whole.

Qualitative data was collected based on non-standardized interviews one-to-one and the collection of information about the company taken form its website, and the documents and procedures the company provided to the author for the analysis. The use of interviews was considered the most effective way of meeting the author´s research objectives because they were particularly useful for getting the perceptions and thoughts

behind the participant´s experience. Moreover, throughout the use of non-standardized interviews it was possible to have direct interaction with the people involved in the definition and establishment of policies and an action frame within the company in matters of innovation, and also with those who have some direct implication in the design and structuring of an innovation model for Ecopetrol S.A., nowadays.

The next section goes deeper about how specifically the data was collected for the research and how the analysis was carried out.

4.2 Data collection

This research used an inductive approach throughout the author collected data and developed a framework as a result of the data analysis. Primary qualitative data was collected from the single case company, Ecopetrol S.A., with the use of non-standardized interviews, according to the differentiation given by Healey (1991) and Healey and Rawlinson (1993). It covered semi-structured and in-depth (unstructured) interviews used to gather data, which are normally analyzed qualitatively (Saunders et al 2007).

In total 11 one-to-one interviews were developed, from which just one was not done face-to-face due to a person´s geographical work location. This interview was done using Microsoft Lynk, a program to chat which is installed across the employees´ computers. As much as possible, the author succeed to make face-to-face interviews in order to capture the non-verbal message that could exist because from the 11 interviews, the author managed to make 10 in person.

The sample for the interview was selected based on people´s hierarchical position, experience, professional roles and responsibilities, direct relation with the innovation process and with the different elements that could integrate a common innovation framework. At first, an analysis of all the different areas of the company was done in order to identify those that could be more involved into an innovation framework definition and implementation. The next list include the total of areas analyzed in the company:

- Internal audit department
- Vice Presidency of strategy and growth
- Legal Vice Presidency
- Disciplinary control office
- Vice Presidency of human resources
- Strategic supply chain department
- Corporative financial Vice Presidency
- Vice Presidency of HSE and operative sustainability
- Executive Vice Presidency of exploration and production

- Executive Vice Presidency of downstream
- Vice Presidency of transportation
- Vice Presidency of innovation and technology
- Direction of shared services center

As a result of the exercise and based on the roles, scope and responsibility of each area, from the 13 analyzed areas, 7 were identified as those which had a higher and more direct interaction with an innovation framework definition and implementation. They were:

- Vice Presidency of strategy and growth
- Vice Presidency of human resources
- Strategic supply chain department
- Executive Vice Presidency of exploration and production
- Executive Vice Presidency of downstream
- Vice Presidency of transportation
- Vice Presidency of innovation and technology

These areas play a relevant role across any innovation process and due to this people from these sections were identified to be interviewed. The identification and selection of people in there was possible due to a deeper analysis on the internal composition of each area. From it, 15 positions were identified as relevant for the study. People from this sample had different years of experience in the company, and although were more men than women the researcher found this aspect interesting since it was possible to have different perspectives from each one´s professional experience in Ecopetrol S.A. as well as in other companies. Neither positions nor names are mentioned in the study due to confidentiality about personal information offered to the respondents.

Based on the literature review and due to there was not found any well-known or recognized interview done previously for another similar study which could match the interest of this research, an interview design was required. Thus, the researcher identified the main aspects which need to be analyzed, and based on this formulated open questions sequentially. A couple of reviews were necessary for selecting the final list of questions which was presented to be reviewed and approved by a person in the company who supported the development of the research (the company`s innovation leader). This person suggested some adjustments and finally approved the interview design (see Appendix 3), which in average took 1 hour to be totally answered, which was considered enough time including the explanation of the research and additional questions that the participant could have.

Having the interview ready, the researcher contacted the identified people and asked them for their collaboration at answering the interview. In every contact a description of the purpose and intention of the study was described as well as the reasons for which he/she had been chosen, and for those who kindly accepted to take part of the study an

appointment was scheduled in their workplace, a place where they feel most comfortable. From the 15 people contacted, 11 persons agreed to answer the interview (73% of the identified sample). Due to multiple occupations, the remaining 4 could not attend the different spaces the researcher created to make the interview.

Due the nature of the interviews (in-depth interviews), questions were made using a natural, but formal, style in order to make the respondent feel comfortable about the question and be able to answer it by heart. Sometimes the interview format became a list of things to be discovered because once the interview had started the respondent could jump from one subject to another and the wording and sequence of the "questions" depended on the "answers" the respondent gave.

Respondents´ and research´s mother tongue is Spanish, therefore, the interviews were developed and recorded in Spanish and following the recommendations established in the literature for this matter. Written notes were also taken in parallel for supporting the recollection of information. In fact the estimated time every interview took was 1 hour plus or minus 10 minutes, which depended of the person`s knowledge and confidence on the topics.

Once every interview was done, the audio-recorder was subsequently transcribed taken care of the actual words, expressions and examples used by the respondents in the interview. These transcriptions were done in Spanish in order not to lose what people could try to say when using expressions or idioms which may not have any English translation. This activity was time consuming but extremely necessary in order to avoid a build-up of the recordings and associated transcription work.

After the transcription, a process of data cleaning (Saunders et al 2007) was done. It consisted in making sure that the transcription was accurate by correcting any transcription errors, which was possible by sending the transcriptions to the respondents for final checking.

Complementary, secondary documentary data was also collected based mainly on the information given by the company directly to the researcher. This information was mainly in electronic format (pdf, word, excel, ppt, project, etc…) downloaded from the company`s website, and internal published documents and procedures.

4.3 Data analysis

Due to the fact that this research followed an inductive approach, and in order to determine the content of the collected information, the process of qualitative analysis involved the development of data categories (coding) with the aim of comprehend and manage data, integrate related data drawn from different transcripts and notes, identify key themes or patterns form them for further exploration, develop and/or test theories

based on these apparent patterns or relationships, and draw and verify conclusions (Dey 1993; Miles and Huberman 1994).

In this section, qualitative analysis is explained. It was made based on the literature review, the interview data analysis and the analysis of other kind of information such as strategy documents, procedures and news compiled from sources such as the company´s website and intranet.

After collecting the data, the first step the author followed was to familiarize herself with the qualitative data by reading through the responses many times. Then, based on the literature review, a list of the main themes in the data was prepared and from it were identified 22 initial categories relevant to the research question, as follows in the next table:

Table 4 Original categories and identification codes for data analysis

CATEGORY	***IDENTIFICATION CODE***
1. Innovation meaning understanding	InnUnd
2. Innovation perception in the company	InnPer
3. Innovation strategy definition	InnStra
4. Innovation road map existence and clarity	InnRmap
5. Orientation of an innovation management framework	InnFram
6. Clarity of the existence of elements of an innovation management framework	InnEle
7. Understanding and orientation regarding leadership and innovation management	InnLead
8. Understanding and orientation regarding organizational structure and innovation management	InnStr
9. Understanding and orientation regarding innovation process structure and innovation management	InnPro
10. Understanding and orientation regarding communication and innovation management	InnCom
11. Understanding and orientation regarding culture and motivation structure and innovation management	InnCul
12. Innovation tools and techniques use and diffusion across organization	InnTool
13. Ideas and opportunities searching	InnIdea
14. Innovation focus and type	InnFoc
15. Open innovation knowledge and understanding	InnOpund
16. Open innovation opportunities	InnOpen

17. Innovation decision process existence and effectiveness in the company	InnDec
18. Ensuring the generation of innovation value	InnVal
19. Knowledge management and innovation management	InnKnow
20. Technology management and innovation management	InnTech
21. Resources for managing innovation	InnRes
22. Innovation measurement	InnMea

In this way, data was classified according to the preliminary categories. After it, a glossary of categories was built in order to have more clear understanding about what should be included in each category. However, as the author was going deeper into all the data and building the glossary or code book, it was necessary after the first classification exercise to reduce some categories from 22 to 20 and read throughout the responses and information while reclassifying it again.

During a third formal review of all the data, a new organization of categories was required to reduce them to a manageable number for the analysis. Finally, as a result of this exercise, nine categories were selected and defined as follows:

1. Innovation management framework (InnFram): This category refers to two aspects:

    a. The existence, clarity and structure of a framework for managing innovation in Ecopetrol S.A. (InnFram). It also includes the elements of an innovation framework (InnEle).

    b. The existence and clarity of an innovation road map (InnRmap). This is about how innovation will take the organization forward. It seeks for identifying the path the company has established to innovate and the way as it has been structured and given out to people. It also concerns how the road map leverages the company goals achievement within the time.

2. Innovation strategy (InnStra): This category refers to two aspects:

    a. The existence and definition of an innovation strategy in Ecopetrol S.A., and how this strategy is identified and known by the employees (InnStra). It also includes the level of definition of the innovation strategy and the identification of what needs to be complemented or re oriented.

b. The focus and type of innovation, in other words how the company should balance the different kinds of innovation it may have (product, process, services, business models, incremental, radical, etc) (InnFoc).

3. Innovation process (InnPro): This category includes:

   a. The existence of an innovation process (formal or informal) within the company, the way as it is structured and implemented, and how it leverages and support innovation value generation (InnPro). It also refers to the identification of the project management framework and how it relates to the innovation process, as well as to the identification of improvement opportunities. Furthermore, it relates to the relation between standardization and innovations process, since the company is hardly focused on standardizing their processes (InnSta).

   b. The existence and effectiveness of innovation decision process in the company. It refers the way as decisions regarding innovations are taken in the company: Who take decisions, who approve them, in which scenarios are they taken, how often it happens, what kind of decisions are taken (InnDec).

   c. Current organizational structure and how it leverages innovation (InnStr). It also includes proposed organizational structures to foster innovation. The way as companies arrange their people and business areas impacts the way as innovation is managed.

   d. Innovation tools and techniques, their use and diffusion across organization (InnTool). This relates to the different tools or techniques of innovation that people know and/or practice in the company. It looks to identify how common they are across the company and how they can be used to develop and enable the innovation process.

   e. Ideas and opportunities searching (InnIdea). This is referred to the identification of sources from where Ecopetrol S.A. can get new ideas or business opportunities. The sources may be internal or external to the organization. It is important to know if the employees identify the possible sources of ideas in order to consider them as a valuable input for the innovation process.

   f. The way as the company could ensure the generation and value obtaining from the different efforts done in innovation (InnVal). It has to be with how to choose and implement innovation options whilst building and capturing value from the intellectual effort involved. Additionally, it refers to how to adopt and diffuse innovations internally and externally to the organization.

4. Technology management and innovation management (InnTech): This category relates the relationship between technology and innovation management, and the role that the former plays in order to leverage innovation. The way as technology is managed impacts innovation results and generation value.

5. People and innovative culture (InnCul): This category consists of:

    a. People´s understanding about innovation (InnUnd). The way as innovation is understood impacts the way as innovation is managed in companies and especially how people feel they are a part of an innovation system. Based on the experience of the author, in Colombia there is commonly a partial understanding about innovation, and since innovation is a new and hot topic these days, everyone talks about innovation, although just a few really have a clear understanding about it.

    b. The way as people perceive innovation within Ecopetrol S.A. and how innovative they think the company is (InnPer). This perception can be the result of a general feeling or based on facts; sometimes it can also be obtained by benchmark of Ecopetrol S.A. with other company they know and identify as an innovative one.

    c. The role that leadership plays in order to leverage innovation (InnLead). It also tends to identify the orientation that leaders should exhibit to encourage innovation.

    d. The role that corporate communication plays in order to leverage innovation (InnCom). It also refers to the identification of improvement opportunities in the way as communication currently is done.

    e. How people perceive their innovative culture, and the way it leverages innovation (InnCul). It also looks for identifying the way as incentives impacts motivation, and how this may support a culture of innovation.

6. Knowledge management and innovation management (InnKnow): This category is about the relationship between knowledge and innovation management, and the role that the former plays in order to leverage innovation. Knowledge management is highly important since the ability to generate it may be less significant than the ability to trade and use it effectively.

7. Innovation measurement (InnMea): This category refers to the metrics the company can use to measure its efforts in innovation and the obtained results. Measuring innovation is not an easy task: although there are different approaches for doing it, there also pros and contras for using any approach in particular. The way as a company should measure its innovation capabilities must be based on the characteristics and nature of the company, as well as on the evolution it exhibits on the path to innovate.

8. Open innovation (InnOpen): This category is related to the general knowledge and understanding that employees have about open innovation and the perception and possibilities people see for Ecopetrol S.A. to practice it (InnOpund / InnOpen). It also includes the identification of the opportunities the company has in order to improve its performance at practicing open innovation.

9. Resources for managing innovation (InnRes): This category is about any kind of resource required to innovate (money, people, time, incentives, etc…). It looks for identifying the availability and conditions of these resources in Ecopetrol S.A., as well as the opportunities to improve their distribution.

Having validated the final categories selection, data was again classified and organized to be analyzed. During the whole exercise, it means each time the information was read and reorganized, different notes were taken which were used later to complete the analysis.

The classification of the information was done in parallel in two kind of files: some in a word processing or text editing program (Microsoft Word) and one in a data sheet. The former contained all the transcribed interviews and the documents and procedures of the company related with the topic, and the later was built as a result of the classification of the data into the defined categories.

Based on the classification of all the information, the selections were extracted per category and grouped together into the data sheet. Then, a summary was written down for each selection, and later they were summarized for each category.

Having this ready, an analysis of possible relationships and interactions within categories and between them, was done. They were built on a matrix (2x2) in which the categories were listed in column “a” as well as in row “b” to be compared. As a result, and based on the literature review, three kind of relationships were identified between the different categories, as follows:

Relation of content: The aspect in the column “a” contains the aspect in the row “b”.

Relation of impact in the definition: The aspect in the column “a” impacts the definition of the aspect in the row “b”

Relation of impact in results: The aspect in the column “a” impacts the result of the aspect in the row “b”

The identified relationships between categories are shown in the next chapter of this document.

As the author continued working with and thinking about the data, comments, questions and even some plausible answers began to emerge. They moved the author to analyze the information from another perspective, it is by analyzing the answers given by people who worked in areas with similar operation nature. As mentioned before, respondents belonged to different areas of the company, which, for the purpose of the analysis was classified into 3 main groups of people:

Group of operations support: It includes people who work on areas of support of operations, e.g. supply chain, human resources, innovation and technology, etc.

Group of strategist: It is integrated by people who work on areas where the strategy is defined.

Group of core operations: It includes people who work directly in the operations of the business core.

Having this classification of people, categories were analyzed within each group, and then between each group. To do this, a summary of answers was done for each category in each group, and interesting findings were found across the respondents´ groups. These findings are shown in the next chapter of this document.

Furthermore, after analyzing every selected category, the main and most common answers given by the respondents were extracted, and with this information a figure composed by 9 blocks of 3 by 3 spaces was built in order to represent those common answers and respondent´s perceptions. The figure is shown in the next chapter of this document.

Finally, based on the different perspectives given to the analysis of the information previously explained, the author managed to answer the research question and build a framework to manage innovation in the case study company.

4.4 Trustworthiness of the study

In order to ensure credibility and trustworthiness in the study, according to Butterfield, Borgen, Amundson, Maglio (2005) the next aspects were taken in order to build confidence in the study and its findings:

Triangulation in the data collection: interviews, internal documents of the company, and external information about the company and the industry were the three primary sources of data. Throughout them the verification of information from one source to another was easier. Documents and external information associated with innovation management in the case company and the industry was hardly obtained and checked with the aim of ensuring they were consistent with the information obtained from the interviewed. Moreover, the interviews were developed by different people in different positions of different areas across the company, which gave the research varies perspectives over the same topic based on each one`s experience and knowledge.

Interview fidelity: the data collection from the selected sample was done by applying the interview protocol. Furthermore, the study captured different perspectives beyond that provided by people working directly in the area which is responsible for the definition and implementation of innovation policies in the company. In fact, the sample inte-

grated people from other areas in which their main function was not directly related with innovation definition. This was done in order to achieve interview reliability.

Theoretical validity: with the purpose of achieving it, the discussion of the case study findings made reference to previous research in order to express theoretical agreement and convergence.

During the interviews, the informants were asked to make additional comments on innovation management in the company or in another company which they admired, especially regarding the structure of an innovation framework and limitations, if exist, to the implementation of it. Systematic notes were also taken during the interviews. Full interview transcripts were completed as soon as possible after the interview, and as stated before, sent to each interviewed for the final check in order to eliminate some of the bias concerned with interview-based research (Miles and Huberman 1994).

5 CASE COMPANY – ECOPETROL S.A.: AN INTEGRATED APPROACH TO THE MANAGEMENT OF INNOVATION

Ecopetrol S.A. is by far the largest and primary petroleum company in Colombia. The company was created in 1951 and due to its continual growth, it actually takes part in the Fortune Global 500, where it is ranked 303 (Global 500... 2012). The most significant changes which have helped the company to succeed, have happened in this century. In 2003 the company changed its organic structure and in 2007 became mixed stockholding corporation since it sold shares in the Colombian market. One year after that, Ecopetrol S.A. announced the listing of its American Depositary Shares (ADSs) on the New York Stock Exchange (NYSE), and again in 2011 the company offered a new round of stocks which allowed the company to get sufficient cash to meet its investment plan in order to increase oil production to remain an oil exporter.

Actually the company is the fourth more important oil and gas companies in Latin America (with PDVSA, Petrobras and PEMEX) and is ranked within the 40 biggest oil companies in the world. It currently has operations in different places such as Brazil, Peru and United States (Gulf of Mexico). In Colombia, the company is responsible for more than 60% of the national production, and is owner of the biggest and most important refinery in the country as well as the majority red of oil and gas lines. Nowadays, the company is increasing its participation in the biofuels sector.

Since 2009, Ecopetrol S.A. is the hub of a business group that operates mainly in Colombia and extends to other countries. By the end of 2011 the business group was integrated as shown in the next figure (Reporte integrado… 2011).

Recently, in June, 2012, Cenit Transporte y Logística de Hidrocarburos S.A.S. (the most recent in the business group), was created with the aim of distributing and managing the pipeline network, and terminals for storage of crude and oil derivatives.

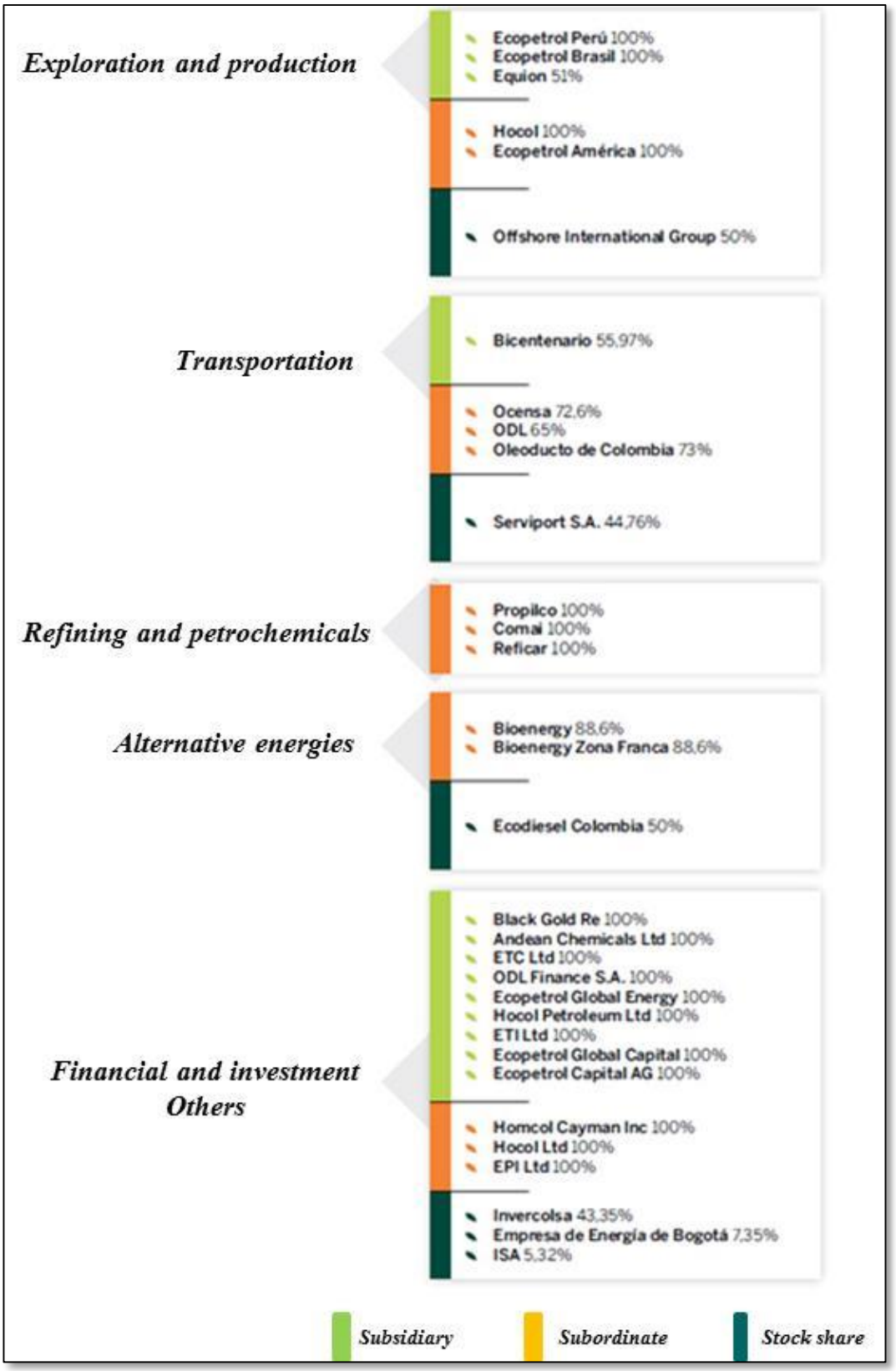

Figure 27 Ecopetrol S.A. business group

Source: Reporte integrado… (2011; 3)

5.1 Ecopetrol`s strategic frame

The company has defined a strategic frame which is shown in the next figure. There are three strategic guidelines which orient the company`s behavior and goals: profitable growth, organizational consolidation, and corporate responsibility.

Figure 28 Ecopetrol S.A. strategic framework 2011−2020

Source: Ecopetrol´s website (2012)

The company´s current mission is based on finding and converting energy sources into value for its customers and shareholders while ensuring people´s integrity, process safety and environmental care. It also seeks for contributing to the welfare of those areas where the company operates. To do this it counts with staff that strives for excellence, the company`s overall development and the construction of long-term relationships with the stakeholders. (Ecopetrol´s website)

Ecopetrol S.A. has also structured a great vision for the future of the company. The company, as part of the business group focused on oil, gas, refining, petrochemicals and fuels, looks for being one of the top 30 companies in the oil industry, known for its in-

ternational positioning, innovation and commitment to sustainable development (Ecopetrol´s website).

5.1.1 Profitable growth guideline

Ecopetrol S.A. has built a ”MEGA” (which in Spanish is: Meta Grande y Ambiciosa) which means ”a big and ambitious goal”. It contains the main strategic goals that the company wants to achieve by 2020 in this orientation. The next table shows those established goals:

Table 5 MEGA for Ecopetrol S.A.
Source: Ecopetrol´s website (2012)

		2020
Upstream	Equivalent production (MBOED)	1300 MBOED with profitability (ROCE) of 20%
	1P Reserves addition 1P 2008 – 2020 (MMboe) (New, revaluations & purchases)	2008 – 2020 6.000
Downstream	ROCE Downstream (%)	15%
	ROCE Refining (%)	11%
	Petrochemicals production (Mtons/Yr)	2700 with profitability (ROCE) of 13% to 15%
	Biofuels production (Mtons/yr)	450
	Gas sales (GBTUD)	1.000 (Local and international sales including royalties)
	Transportation ROCE (%)	10% - 12%
	Distribution (Wholesale distribution)	8%

The company has defined different strategic focus to be developed in order to get a competitive advantage and achieve the established goals, as follows:

Upstream - exploration and production:

- Competitive advantage in heavy crude oil
- Increasing the recovery factor throughout two main programs:
  - Development of Infill drilling, and
  - Incorporation of technologies in secundary and tertiary recovery
- Exploring hydrocarbon in proven and frontier basins
- Developing unconventional hydrocarbons
- Growing up in the business of gas, integrated to downstream
- Offshore exploration

Downstream - refining:

- Focusing on markets with the aim of:
    - Being recognized for the production of clean fuels
    - Capitalizing and developing local, regional and international market opportunities
    - Being the best option for supplying feedstock for the petrochemical business
- Sustainable and profitable growth, with the aim of:
    - Converting heavy crude oil in a competitive advantage of the company, maximizing its value chain
    - Managing effectively projects
    - Managing environmental conditions in order to support a sustainable future operation and project development
- Maximization of refining margin for:
    - Optimizing an integrated management in the supply chain
    - Capturing opportunities to provide raw materials, inputs and technologies that add value
    - Managing the alignment between the regulatory and competitive business development
- Linking partners or third, depending on the project`s maturity

Downstream - petrochemicals:

- Maximizing the petrochemical margin, throughout:
    - Optimizing the supply chain integrated management
    - Ensuring availability and logistics of competitive raw materials
    - Maximizing the use and reliability of the current
- Consolidation in the market in the most cost-effective way, with the aim of:
    - Ensuring a profitable local and regional market participation
    - Defining the viability of business expansion and its sustainability with strategic alliances
    - Giving continuity to business opportunities in strategic alliances to take advantage of local and regional markets

Downstream – biofuels:

- Profitable consolidation in the local markets, throughout:
    - Ensuring the timely execution of Bioenergy[2] and the excellence of Ecodiesel`s[3] operation
    - Potentiating the percentage of mixtures

[2] Subsidiary of Ecopetrol business group

[3] Subsidiary of Ecopetrol business group

  - Diversifying supply sources of conventional raw material (cane and palm)
- Competitiveness in biofuels value chain, throughout:
  - Ensuring the implementation of best practices, technologies and capable human talent
  - Monitoring and developing new and more efficient processes and new raw materials
- Developing growth opportunities in the national market; analysis and consolidation of current projects, and, according to governmental policies, development of new projects with an industrial emphasis.

Gas:

- Strengthening the gas local market as well as developing the regional market, over:
  - Consolidating the leadership in the local market
  - Exporting to regional markets
- Finding gas resources and developing them in an economical and viable way, throughout:
  - Finding conventional and unconventional resources
  - Developing on time and competitively the current as well as new resources
  - Evaluating the regasification as an option of local supply
- Managing the regulatory, across:
  - Managing stable and clear rules in order to ensure future production and its commercialization
  - Managing regulation and policies for exploration and production of unconventional gas

Transportation and Logistics:

- Commercial and service orientation
- Investment diversifications
- Benefits center consolidation

5.1.2 Organizational consolidation guideline

The MEGA for this guideline by 2015 is shown in the table 6, as follows:

Table 6 Ecopetrol S.A. organizational consolidation by 2015
Source: Ecopetrol´s website (2012)

		* Accident frequency index with loss of time 0,40

<table>
<tr><td rowspan="3">Operational Excellence</td><td>EHS</td><td>* Relative index of spills 7,01
* Total frequency index of recordable cases 1,30
* Process safety frequency index 0,13</td></tr>
<tr><td>Costs</td><td>* Producing 6,01 US$/Barrel by 2015
* Refining 6,22 US$/Barrel by 2015
* Transporting 7,51 $/BKM by 2015</td></tr>
<tr><td>Energy</td><td>* 1% of reduction in energy intensity
* 7% increasing the efficiency in energy transformation</td></tr>
<tr><td rowspan="2">Human Talent</td><td>Human talent availability (2015)</td><td>* Opportunity: 95% sized employees group cover
* Quality: 80% of leaders and critical positions with key technical competences in approved level</td></tr>
<tr><td>Work environment index (2015)</td><td>* 90 points achieved in the study done under Great Place to Work methodology</td></tr>
<tr><td>Project Management</td><td></td><td>* Ranking in the 1st quintile in IPA scale by 2015</td></tr>
<tr><td>Shared Services Center</td><td></td><td>
<table>
<tr><th></th><th>2009-2011</th><th>2012-2014</th><th>2015…</th></tr>
<tr><td>Customers portfolio</td><td>Ecopetrol S.A. and holding group</td><td>Ecopetrol S.A. and 100% of holding group</td><td>Sector oil and gas</td></tr>
<tr><td>Services portfolio</td><td>38 services</td><td>11 services chain</td><td>55 services</td></tr>
<tr><td>Costs optimization</td><td>5% of the total cost</td><td>5% of the unit costs</td><td>Profitability as a benefit center</td></tr>
<tr><td>Customer satisfaction</td><td>90%</td><td>92%</td><td>92%</td></tr>
</table>
Benefits generation: 5% savings on cost of sales (procurement and contracting plan)</td></tr>
<tr><td>Supply chain management</td><td></td><td>Achieving “Advantage Level” based on SCOR (Supply Chain of Reference), which means:
* Supply chain risk reliability, from 53% (current) up to 94%
* Supply chain costs, from US$15 up to US$13
* Supply chain velocity, from 33 days up to 12 days
* Inventory days, from 215 days up to 133 days</td></tr>
<tr><td>Innovation and technology</td><td>Technological advantages in:</td><td>* Adding value to the integral chain of heavy and extra heavy crude oil throughout technology, knowledge and innovation.
* Ranking in the 1st quartile in information management</td></tr>
</table>

This guideline is integrated by:

- Operational excellence: It is focused on:
    - Strengthening process security
    - Reinforcing an environmentally responsible operation
    - Managing the occupational risks
    - Optimizing costs
    - Protecting people
    - Having an adequate capability for acting when emergencies
    - Having a greater energetic efficiency
- Human talent: It seeks for ensuring the talent, the work climate, and culture, focusing mainly on:
    - Translating the business strategy into human talent tactics which support business growth
    - Having strategies and conditions to attract and retain the best human talent
    - Strengthening culture and leadership towards operational excellence and high performance
    - Ensuring productive labor relationships
- Project management: the goal is to be in first quartile of IPA (Independent Project Analysis Inc.) scale when measuring cost, time, and return on investments, throughout:
    - Building rightly project teams
    - Being disciplined in the implementation of the maturity model for projects
    - Applying practices which increase project value
- Shared Services Center: the focus is on services and clients portfolio, cost optimization, generation of benefits, and customers satisfaction.
- Supply chain: the main goal is to be part of the 25% of the best companies in the world featured by its chain reliability.
- Finances: the strategic focus in order to achieve financial ability, are:
    - Support of operations decisions throughout financial analysis by segment
    - Growth throughout capital discipline and costs efficiency throughout the whole chain
    - Required liquidity to support growth and operations
- Innovation and technology: It looks for adding value to the integrated chain of heavy and extra heavy crude oil throughout technology, knowledge and innovation, ensuring the required technology for the achievement of goals.

5.1.3 Corporate responsibility guideline

The MEGA for this guideline by 2015 is shown in the table 7, as follows:

Table 7 Ecopetrol S.A. corporate responsibility guideline
Source: Ecopetrol´s website (2012)

Stakeholders relationship	Trust and reputation	Reputation Institute >70% "Strong" / Merco – First Position
	Support behaviors stakeholders	Level of compliance with commitments in CSR > 90%
	Business sustainability	Login to Dow Jones Sustaintability Index (already achieved by 2011) Bronze 2015 / Silver 2020
Environmental management	Eco efficiency	% reduction of relative dumping: 8%
		% reduction of relative solid waste generation: 12%
	Climate change	% reduction of relative greenhouse gas emissions: 7%
		Number of diversified energetic sources: 4
	Bio diversity	Number of protected habitats: 2

All the three guidelines mentioned above are developed within a scheme of corporate governance (based on governability, transparence, and control), and under the implementation of a process management model.

In order to achieve the company`s goals, the firm has planned to do investments for around $80.000 million USD, from which around 87% is estimated to be invested in exploration (25%) and production (62%) operations, 8% for refining and 7% for transportation. Furthermore, around 90% of the investments are thought to be done in Colombia.

5.2 Company`s organizational structure and innovation management

The next figure shows the company`s organizational structure by the end of 2012, which has had a couple of changes during the last years.

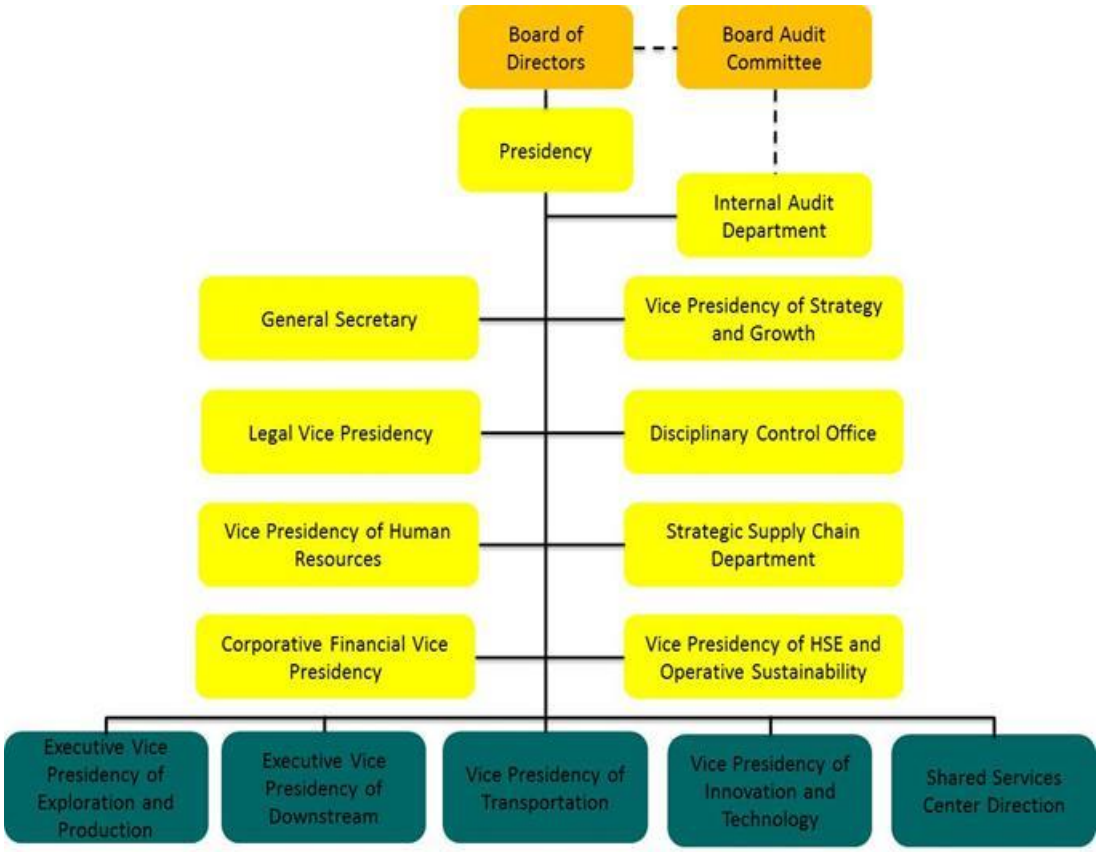

Figure 29 Ecopetrol S.A. organizational chart
Source: Ecopetrol´s website (2013)

Aware of the importance of innovation in the world and in the industry, in 2012, the company created the Vice Presidency of Innovation and Technology which is actually working on the formalization of its internal structure. Its function is to support the company to mark out the route and to add value to the business chain by managing innovation, technology, knowledge and development of competitive advantages. This new Vice Presidency is integrated by three areas: the Colombian Petroleum Institute, the Information Technology Division, and the Strategic Direction in Innovation, Technology and Knowledge.

Before the new Vice Presidency was created, innovation had been managed by the Colombian Petroleum Institute (ICP for the Spanish- works) with a remarkable focus on scientific research. Actually, the ICP supports technological projects in the company and its structure stands as one of the more modern and complete in Latin America.

The ICP still looks for researching, developing and transferring strategic technologies which allow the company to maximize the added value of the operation as well as the optimal growth of the hydrocarbon sector, within a framework of sustainable development.

The institute offers specialized technical services for the oil and gas industry through its 24 laboratories and 29 pilot plants. It also has 9 technological areas which include

five research lines applied to the value chain (exploration, production, refining and petrochemicals, transportation, and supply and marketing). The institute has developed agreements with different universities in order to carry out research and development programs on industry-related topics. Due to this the company has become stronger in the patent process and actually it has received 47 patents for different process and products used in the operation, from which 40 still are still valid. The majority of them have been designed for refining and transportation. Remarkably, 2012 has been an interesting year for it since 12 patents have been granted to the company (three in Mexico, two in Russia, and seven in Colombia). Due to this Ecopetrol S.A. is the company that has most patent applications in the country and which has received the most patents in the country, making it a national leader in the IP mechanism.

Although patent applications are a valuable resource for the analysis of innovative activity (Gardner & Joutz 1996) since they are a better proxy than R&D expenditures, their use, as an exclusive unit of measurement, is not enough since not all inventions result in patents and they also vary in their economic impact. In Ecopetrol S.A., measuring innovation by the patent process is very common, although patents do not reflect totally what innovation is and makes for the company.

The ICP has a technical information center, which seeks for offering technical-scientific information solutions to research projects and technical services of laboratories. It has around 130.000 publications (books collections, journals, subscriptions, etc.). Moreover, there is a semiannual magazine called “Ciencia, technologìa y futuro” (in English it means science, technology and future), edited and published by the company since 1995, which is specialized in spreading the achievements of scientific research and the technological developments of Ecopetrol S.A., as well as other research from other oil and gas and energy institutions. In a similar vein, there is another semiannual magazine called Ecopetrol &nnova which allows the disclosure of the innovation produced by the institute.

To provide support and technological support to the different areas of Ecopetrol S.A., the Institute works organizationally through research units, specialized disciplines, and Technical Services and Laboratories, in addition to coordination of Technology and Knowledge Management.

- Research unit: Conducts applied research to solve problems which are particular to the Colombian reality (Colombian subsoil and their operations).
- Specialized disciplines: Responsible for the development, adaptation or specific technological product innovation for businesses of Ecopetrol S.A.
- Technical Services and Laboratories: Offers very highly specialized services in the oil industry under international standards and with a world class infrastructure.

- Technology and Knowledge Management: Responsible for the development, review and validation of policies, guidelines and strategies for technology and knowledge management for the company.

Actually the main programs, in which the ICP works in order to develop technological solutions for Ecopetrol S.A., are:

- Basin analysis for reducing uncertainties: It contains projects in chronology of deformation in basins, modeling offshore areas, and prediction of reservoirs.
- Increased productivity in Ecopetrol S.A. fields - Focus on heavy crude oil: It includes projects in maximizing reservoir contacts, strengths development in the exploitation of offshore fields, and integrated damage assessment training.
- Increased recovery factor by applying technologies and enhanced secondary recovery: It covers projects in secondary recovery, enhanced recovery, and heavy crude oil recovery.
- Schemes refining and petrochemical high conversion: It includes projects in raw charge scheme, diesel production increase, compliance fuel quality, bottom of the barrel conversion, petrochemicals and lubricants bases, supply chain, and technical specialized support.
- Hydrocarbon transportation improvement: It covers projects in heavy crude oil transportation, alternatives to reduce losses, and new transport schemes - process sustainability.
- Energy: It includes projects in energy diversification, unconventional hydrocarbons, and biofuels.
- Geophysics: It focuses on seismic reflection (experiment seismic 3C3D, imaging subsalt, technology support).
- Technology support areas: It works on projects in advanced process control for Ecopetrol S.A., management of alarms, assets integrity assurance, new materials, and reduction of environmental risks for Ecopetrol S.A.

As part of the knowledge management, the company has an “innovation and technology school” and a methodology for making internships in other areas of the company. Some of these programs are still under construction, although are considered interesting initiatives for improving the company`s performance in innovation and technology.

There is a frame for managing the technology in Ecopetrol S.A., which leverages the company`s strategic framework. The unit of knowledge and technology management is responsible for the implementation and control of this framework, which is shown in the Figure 30. The core of it is creativity, which is surrounded by competitive intelligence, technology strategy structure, technology incorporation, transfer and assurance of knowledge and technology, and monitoring and evaluation of technological innovation management.

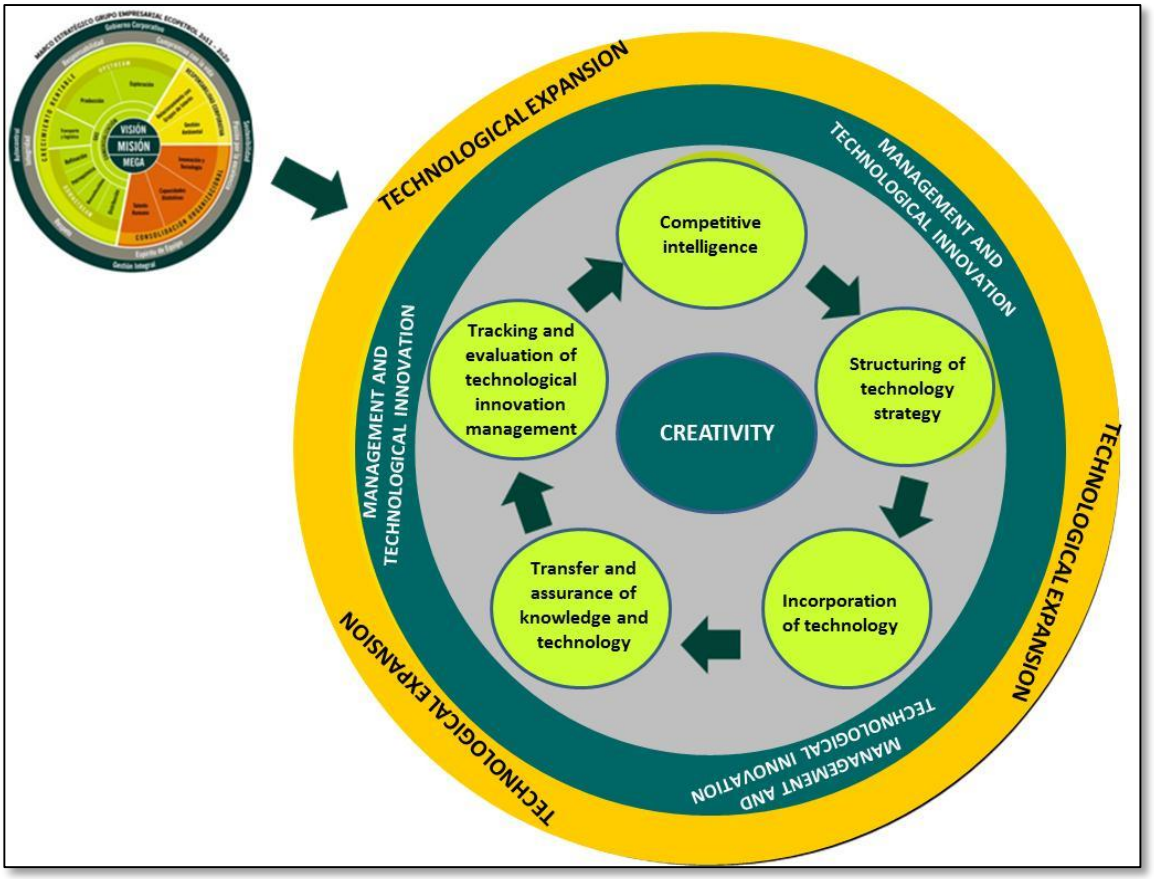

Figure 30 Ecopetrol S.A. technology management framework

Source: Ecopetrol´s website (2012)

The management of technology in Ecopetrol S.A. has been defined as the discipline responsible for planning, developing, applying or implementing knowledge, capabilities and technological practices. It is meant as a strategy for the management of process in acquisition, creation, development, transfer, protection and use of technology which must be coherent with the business plans.

Taken advantage of the experience in technological innovation that the ICP has gained, and similarly to the way as the knowledge management program was implemented in the company, Ecopetrol S.A. plans to develop and test an innovation model in different areas in 2013 in order to gain confidence and adjust what is needed in that model, so then it can be launched in 2014 for the whole organization and in 2015 for the business group (includes all the subsidiaries). The results of this research will work as the basis of the design of the innovation model for Ecopetrol S.A. In this way, this research, which is developed based on a rigorous analysis that has not been done before in the company, will support the structuration of the innovation model throughout the purposed innovation framework, as a result of this work.

5.3 Structuring the innovation system at Ecopetrol S.A.

In the last years, Ecopetrol S.A. has been aware of the importance and relevance of the innovation for the company`s goals achievement. In this sense, the role that innovation actually plays and how it is structured and managed is something that currently the company is reevaluating. As a consequence of this process, a new Vice-presidency was defined and implemented in the company in 2012, which is called the Vice-presidency of innovation and technology. This Vice-presidency is still under construction since the teams are not completed, yet.

However, despite the efforts, for the majority of employees innovation continues to be something which is merely associated to technological innovation and invention, furthermore, a work that just a few can do. This is in part due to two reasons: the lack of a company´s innovation management framework, which is known and lived by people across the company, and the consolidated existence of the ICP, which has worked for many years focused purely on R&D (which is also a relevant part of innovation management, but not everything).

Due to this, innovation efforts are not articulated within the company and people do not feel part of it. In this way, the company has a lot of opportunities to improve the way as it manages innovation in order to make synergies which allow the firm to create value throughout innovation across the company. However, to do this, the company needs to structure and implement a framework for the management of innovation; this framework must consider different elements which cannot exist independently and need to be aligned to the company´s strategy.

In this section a framework for managing innovation in Ecopetrol S.A. is presented and described. It is built based on the analysis of the collected information following the methodology explained previously in the chapter 4 of this document.

Initially, the different elements are presented as well as the identified relationships among them. Based on this, in the third part of the section, the framework is introduced as a purposed approach for the management of innovation. In this way, and based on the analysis of the information, the author suggests how the framework should be developed and implemented into the company.

5.3.1 Identifying the main elements

As explained in Chapter 4 of this document, the obtained information for analysis finally was classified into the next 9 categories:

- Innovation management framework
- Innovation strategy

- Innovation process
- Technology management and innovation management
- People and innovative culture
- Knowledge management and innovation management
- Innovation measurement
- Open innovation
- Resources for managing innovation

The identified categories, except from the innovation management framework category, can represent the elements that integrate the framework for managing innovation in Ecopetrol S.A. These categories were identified based on the literature review and on the collected information. As explained before, a description of each element of the innovation framework is presented here.

Innovation management framework: Based on the suggestion made by some authors that the management of innovation may be sector or industry specific, if not firm specific (Vaccaro, Jansen, Van Den Bosh & Volberda 2012; Birkinshaw, Hamel & Mol 2008; Hamel, 2006, 2007; Birkinshaw & Mol 2006; Mol & Birkinshaw 2006), an innovation framework for this case study is the set of interrelated elements which allow the case company to manage innovation effectively. In this sense, the innovation framework for Ecopetrol S.A. is the approach to manage innovation within the company, it is the strategic and organizational context for the innovation process to generate value for the company.

Innovation strategy: It links with business goals and determines what is really essential for the business and can be leveraged by innovation. The innovation strategy avoids the risk of diverting key resources and damaging the firm´s focus at investing on initiatives which are not aligned with corporate strategy. In general, companies are able to create value by innovating depending mainly on the business strategy. Furthermore, innovation strategy focus mainly on building and maintaining organizational conditions, essential for innovating, which involve working with structures, work organization arrangements, training and development, reward and recognition systems and communication arrangements (Bessant 2005).

Innovation process: It is a chain of common and numerous internal complex processes, which transform ideas into products, services, processes, business models, etc. As a process it requires the allocation of resources, knowledge generation, capabilities building, and a structure to be executed (Essmann 2009; Essmannn & Preez 2009). In general, the innovation process contains routines created by firms in order to search, select and implement stages of innovation process (Tidd & Bessant 2009).

Technology management and innovation management: Technology management leverages innovation in a firm. According to Cetindamar et al. (2009) it can be seen as a kind of dynamic capability, which can be seen as the combination of resources and pro-

cesses that can be developed, deployed and protected for managing technology. Technology management processes cover three main activities: generating scientific and technological knowledge, transforming knowledge into working artifacts, and matching artifacts with user requirements (Pavitt 2002).

Furthermore, technology management indicates the innovative attitude towards innovation. It includes the definition of the infrastructure for innovation: the platform or application (include tools) that supports the innovation core processes. It also considers technical personnel and committing funds for new technological development. (Dasgupta & Gupta 2009)

People and innovative culture: People is perhaps, one of the most important and common elements of any innovation framework. It is because people´s behavior finally defines the way as an organization performs. By following the definition given by Dasgupta and Gupta (2009) about organizational culture, innovative culture can be defined as the set of values and beliefs shared by people about innovation within an organization. It has to be with aspects such as values, behaviors, climate, resources, processes, and success (Rao & Chuán 2012), as well as with innovative mission and vision statements, democratic communication, safe spaces, flexibility, collaboration, boundary spanning, incentives, and leadership (Dombrowski, Kim, Desouza, Braganza, Papagari, Baloh & Jha 2007).

As it is explained later, people and innovative culture is one of the most important elements on which Ecopetrol S.A. has to focus in order to develop and execute an innovation framework. Without focusing on a cultural transformation it will be highly difficult to achieve the expected results.

Knowledge management and innovation management: Knowledge management has to be with the achievement and communication of ideas and information that underlie innovation. Indeed, innovation is hard to achieve without a sound knowledge base. Since the end of the last century the concept of knowledge has received special attention as the most strategically significant resource for the firm (e.g. McAdam 1999; Blackler 1995; Nonaka 1991) and it has been affirmed that it plays a critical role in the innovation process (Hull, Coombs & Peltu 2000). However, several authors have underlined that is not the firm`s knowledge what is its competitive advantage, but the ability to apply that knowledge effectively to create new one. Thus, organizational learning, which has to be with the ability to absorb and integrate new knowledge with the existing one, is vital for improving company´s performance and innovating. According to Yeung (1999), the higher this ability is, the higher is the level of the firm`s competitiveness, innovativeness and product introduction success.

As it is explained later, Ecopetrol S.A. has developed and implemented and excellent knowledge management framework, however and despite the different international awards the company has achieved in this matter, people do not feel they ensure

knowledge completely. It is because creation and generation of knowledge is given in the company, but it still lacks the ability of applying that knowledge effectively to create new one.

Innovation measurement: It allows the company to assess its innovation status and the impact it is having on the company´s results. Innovation measurement is necessary in a company since innovation impacts business performance and companies should know their current standing in innovativeness and the need for continuous improvement. The nature of the innovation measures relates with the innovation process stage. Based on the literature review made by Neely and Hii (1998), there is no unique best way to measure the innovation performance because a particular set of indicators may not work in another organization. Then, what is suggested is that every company draws a practical framework and installs a wide range of measures to be used when required. Above all, innovation measurement must allow the company to identify whether it is generating value through innovation, or not.

Open innovation: According to Henry Chesbrough (2006), open innovation is the use of internal and external knowledge to leverage internal innovation. He also highlights that throughout open innovation it is possible to expand markets for the external use of innovation. Collaborative innovation, which is critical for the value creation, is derived from the interaction between firms and their stakeholders, throughout effective strategies, architectures, and models for creativity. Open innovation support companies to remain competitive in changing environments since it increases adaptability and impact the generation of products and services better adjusted to the market needs. Companies doing open innovation also increase creativity and the access to knowledge, as well as achieve quicker and cheaper innovation cycles. Although open innovation is important for companies´ competitiveness, it also implies some risks which need to be considered before implementing it.

As it is explained later, Ecopetrol S.A. has opportunities to develop open innovation since the company outsources many core activities and depends greatly on some stakeholders such as clients, suppliers, shareholders, and communities to develop its operations.

Resources for managing innovation: It is the set of means required to support innovation, such as money, space, trained people, time, incentives and recognition, among others. Resources to innovate must be defined and allocated for the company in order to achieve the innovation objectives. Innovation always should generate value, due to this it is necessary to know what resources to allocate and how to distribute them across the company and the innovation process. To do this companies have to balance what they want to achieve and what they are willing to invest to get it. In fact, both excess and lack of available resources can inhibit innovation (Baldaia 2013). The reason behind this is because when companies have abundant resources, they have a conservative cul-

ture where creativity is taboo, and when they lack resources, cost compression inhibits innovative perspectives.

The next figure, which is composed by 9 blocks of 3 by 3 spaces, shows the main and most common answers given by the respondents after analyzing every selected category. In the center of the figure there is the innovation management framework category, which is surrounded by the other eight categories which at the same time are represented in the external blocks. Different colors allow to identify each category which is also surrounded by the main and most common answers that the interviewed gave regarding every aspect.

Intellectual property and benefits must be considered when doing it	Few people are well aware of open innovation concept	People consider it as a big and challenging opportunity	Rewards do not have to be just in money but in other kinds	Must be more to facilitate innovation rather than to implement it	Ecopetrol needs more spaces and platforms to share ideas	The path to innovation in Ecopetrol	The north that shape the innovation activities	Must have 2 approaches: 1 for now and 1 for the future
The ICP has applied open innovation to solve technical challenges	***Open Innovation***	It must have a clear focus since it may not apply to everything	People´s efforts in innovation must be rewarded	***Resources***	The most commonly appointed are money and trained people	Ecopetrol should innovate in what it is expert	***Innovation Strategy***	Focus on Ecopetrol´s strategic framework
It is necessary to strengthen universities and suppliers relationships	It should be implemented when the innovation is more mature	The selection of allies is critical in the first company in the country	Infrastructure and work environments are highly needed	Resources´ availability and delivery are critical for innovation	Time is a valuable resource that people do not use to have	Unknown by the majority of employees	Focus that the company must have to reach the top	Clarity on current company´s position and goals
Firstly to measure participation, then financial impact	People´s innovation efforts must be measured in their BSC´s	It could be through the valuation of organizational competences	**Open Innovation**	**Resources**	**Innovation Strategy**	Process for managing organizational consolidation initiatives	The most of people do not know any innovation process	There is a maturity model for projects development
Value generation must be always measured	***Measurement***	It could be through the valuation of a solution given to a problem	**Measurement**	***Innovation management framework***	**Innovation Process**	Initiatives from diverse nature must be processed differently	***Innovation Process***	Innovation must generate competitive advantages for Ecopetrol
People give few ideas about how to measure innovation	Metrics must be in line with the company´s innovation level	The ICP has measured its impacts through a baseline	**Knowledge management**	**Culture and people**	**Technology management**	For many, organizational structure to innovate is not important	The process must be robust, flexible, agile, practical and effective	There must be always clarity about what the innovation seeks
Organizational learning must be achieved by rotating people roles	Ecopetrol is leader in it and has received many awards for it	Knowledge models exist, but people do not use them enough	Partial understanding of innovation scope and meaning	Leaders are essential to transform the culture to innovate	Different perceptions about the innovation´s company level	External and internal technologies must be clearly defined	Information technologies use must be strengthened	Methods are ok, but still there is a need for more application
People agree knowledge should leverage innovation	***Knowledge management***	People still work isolated and need to share more knowledge	Awards for recognizing excellence have lost their essence	***Culture and people***	Innovation must be in people´s natural behavior	Many technologies have not been totally appropriated	***Technology management***	Technologies are not the all-in-one solution for everything
It is highly related with culture and people management	Innovation efforts and results must be always documented	It is needed to strengthen a knowledge-innovation relationship	Lack of people with competences and expertise to innovate	Culture is the most critical element commonly appointed	Most of employees do not feel they are innovative	Ecopetrol is moving to license technologies in the market	Ecopetrol cannot just acquire and adopt all the technologies	Ecopetrol needs to associate with specialized companies

Figure 31 Most common answers per category given by respondents

An analysis of the information was also prepared according to the nature of the respondent. It is, every respondent was classified into one of three possible groups of people regarding his/her functions in the company. The three groups, as described in Chapter 4 of this document, were:

Group of operations support: It includes people who work on areas of support of operations, e.g. supply chain, human resources, innovation and technology, etc.

Group of strategist: It is integrated by people who work on areas where the strategy is defined.

Group of core operations: It includes people who work directly in the operations of the business core.

Based on this respondent´s classification, the next table shows the main position that each group exhibited on each category.

Table 8 Main perceptions about each category by group of respondents

CATEGORY: Innovation management framework		
Core operations	***Operations support***	***Strategists***
People in this group demand a lot for value generation from innovation efforts. They require that innovation leverage Ecopetrol´s growth for the company to be recognized as an innovative one in the market. Throughout this it may have more allies and get more contracts to operate. Briefly, they need that innovation helps the company to generate competitive advantage in the industry.	People in this group are less aggressive with their perception about innovation in the company. They indicate that innovation is a topic which is under construction. They also stress that despite the efforts what the company has done in innovation matters, there is still a long path to be walked, especially when talking about human resources and innovative culture in the company.	People in this group give more relevance to business process management than to innovation. It is based on the fact that the company is doing valuable efforts on aligning the organization's business processes with the wants and needs of clients. Although for them it is clear that innovation leverage this business process management, it is still not clear neither defined how innovation does it (or can do it) in the company.
CATEGORY: Innovation strategy		
Core operations	***Operations support***	***Strategists***
People in this group define the innovation strategy to be focused on supporting the organizational strategy throughout the achievement of the MEGA and new products development.	People in this group define the innovation strategy as something which is currently under construction and that is leveraging the company goals.	In this group there are different positions on the issue. Some say that innovation is just possible in process, while others affirm that innovation must be focused on leveraging the competitive advantages that Ecopetrol S.A. wants to build.
CATEGORY: Innovation process - Generalities		
Core operations	***Operations support***	***Strategists***
People in this group say that innovation process must be robust, agile and flexible, as well as must have clear and defined responsibilities. Additionally they do not associate the project maturation model	People in this group associate the project maturation model to the process throughout which an idea can be developed. They highlight that depending on the business initiative nature and complexity, the	People in this group clearly focus firstly on standardizing, then improving, and finally on innovating. They also highlight the process of organizational consolidation initiatives.

to innovation process.	model may vary.	
CATEGORY: Innovation process – Organizational structure		
Core operations	***Operations support***	***Strategists***
People from the three groups share the same perception. They think that organizational structure is independent of the company´s need for innovation. In this way, organizational structures can be important but not vital for innovation. They also support an organizational structure in which there is a unit or department responsible for the innovation management, supported by a network of employees across the organization.		
CATEGORY: Innovation process – Idea generation		
Core operations	***Operations support***	***Strategists***
People in this group identify process development, benchmarking, and listening to the customers as sources for ideas and identification of opportunities.	People in this group make especial emphasis on benchmarking and the achievement of the MEGA, as sources for ideas and identification of opportunities.	People in this group highlight process development and benchmarking as sources for ideas and identification of opportunities.
CATEGORY: Technology management and innovation management		
Core operations	***Operations support***	***Strategists***
People in this group consider that the company has done important advances in in technology management. However, there is still a need for greater appropriation of technology within the organization.	People in this group think that the company needs to make a deeper identification of the technologies it requires, in order to have no single technology as the end, but as the means.	People in this group consider that the company needs to appropriate more the existing technologies, while having a better use of them, especially of information technologies.
CATEGORY: People and innovative culture – Human resources capabilities		
Core operations	***Operations support***	***Strategists***
People in this group are aggressive in their perception about human capabilities since they claim that Ecopetrol S.A. does not have enough people with the required expertise and specialized knowledge in the industry.	People in this group, contrary to the perception of people in core operations, consider that Ecopetrol S.A. has valuable human resources, although they still need to be trained in innovation matters.	People in this group consider that people working in core operations still lack of expertise and specialized knowledge, while people in support operations need to be trained more in innovation issues.
CATEGORY: People and innovative culture – Cultural change		
Core operations	***Operations support***	***Strategists***
People in this group are aware that the company needs a cultural change, although there is not clarity	People in this group highlight the next elements as vital to work with in the cultural transformation:	People in this group consider that the main focus in innovation must be to look for something that feels

about how to achieve it. They talk independently about workers´ adaptation, motivators, change management, and challenge the status quo for a constant learning.	organizational learning, fear of failure, teamwork, incentives, change management, and leadership.	natural for people but that exhibits order across the organization. They also highlight incentives and motivators as relevant in the cultural change.
CATEGORY: People and innovative culture - Leadership		
Core operations	***Operations support***	***Strategists***
People in this group think that leaders must be an example for their employees and must motivate them. To do this, leaders need to be motivated and trained in order to get more experience in innovation management and also in the industry.	In general, people in this group think that leadership is important for a cultural change. They also claim that resources are as important as leadership, especially time and training.	For people in this group, leaders are the engine of innovation as well as the responsible for moving people to an innovative culture.
CATEGORY: Knowledge management and innovation management		
Core operations	***Operations support***	***Strategists***
People from the three groups share the same perception. They think that the company has perfect models for knowledge management. However they claim that these models need to be more appropriated, in special in the way as how to attract and spread knowledge from people around the world, and how this knowledge can leverage innovation.		
CATEGORY: Innovation measurement		
Core operations	***Operations support***	***Strategists***
People in this group consider that in order to measure innovation value the company needs to structure measurable and controllable work schedules. Additionally, they claim that every innovation must represent an added value for the company, but innovation should not be as something obligatory for people, therefore it should not be included in the employee individual measure of performance.	People in this group make emphasis on the timely resource allocation in order to comply with the value promise. They also highlight how important is to measure the benefits created by innovation, which in any case should impact the P&L of the company. They also suggest many ways in which innovation could be measured, and highlight that innovation should be included in the employee individual measure of performance.	People in this group make emphasis on the initiatives focus. They claim that the company cannot innovate in everything, so then there is a need to prioritize in what initiatives are decided to be implemented. This prioritization must be based on the added value that the initiative exhibit.
CATEGORY: Open innovation		
Core operations	***Operations support***	***Strategists***
People in this group high-	Similarly to people in the	People in this group make

light the value that open innovation can bring to the company. They also recommend to strengthen relationships with third parties such as universities and private companies (suppliers, customers, etc)	core operations, people in this group highlight the value that open innovation can bring to the company. However, they also make especial emphasis on the risks in the selection of allies and management of them. It is because due to the nature of the company many expectations can be created for stakeholders, which cannot be supplied totally by Ecopetrol S.A.. Additionally, the company can be easily judged by third legal parties if considering all the restrictions it has since it still belongs to the Government and is the biggest company in the country.	emphasis on the clear focus and purpose that must be hold when doing open innovation since it may not suit for every situation. Therefore, it is necessary to clearly define when and how to apply it.
CATEGORY: Resources for managing innovation		
Core operations	***Operations support***	***Strategists***
People in this group make emphasis on the importance of the allocation of resources for innovation, such as time, money and trained people.	People in this group gives importance to time, money and people, as well as to infrastructure, incentives and recognition for innovative people.	Contrary to people in the other two groups, strategists indicate that Ecopetrol S.A. currently has limitation in resources (austerity) and due to this people should do more with the same resources they actually have.

Based on the whole analysis of the information, the results for each element in the innovation management for Ecopetrol S.A. are presented as follows:

Innovation management framework: Ecopetrol S.A. has decided to have just one management and control system which in fact has an element called innovation and improvement. Therefore, what the company needs to develop is a model which takes part into that management and control system, as pointed out by a respondent:

> *The success of it is that we make it as part of the management and control system of Ecopetrol S.A. If we are unable to include it in the natural way in which we manage in Ecopetrol S.A., it is a waste of time.*
> *In the long time, innovation, which is a huge topic into an organization, should be modeled into each process developed by the company in a way that each process exhibits elements of innovation.*

There is a common perception that the framework to manage innovation must help the company to build competitive advantage. It also must be simple, original, natural, practical and creative, based on the best industry practices as well as focused on the company needs. Furthermore, some people highlight that the framework should not convert into making summits or getting awards, perhaps as some issues have become into the company. Additionally, the framework cannot be neither a responsibility of a few nor a topic of specific areas.

> *In Ecopetrol S.A. there is a message which was designed for employees to associate their contribution with the nature and goals of the company. This message is "We are energy for the future". In the same vein as this message has impacted people`s performance and sense of belonging, innovation should be in people´s language and influence employees at feeling it as part of their daily work.*

When talking about the different elements which should be part of an innovation framework, people identify different elements, some of them in common such as people and innovative culture, but in general there is not a shared clarity of the aspects which should be considered in a framework to innovate. It clearly reflects that in general people may do not know any innovation framework for Ecopetrol S.A., and if they have heard about it they do not have it completely internalized. It also reflects the great importance people give to the human factor as a key element when talking about innovation.

Among others, the different elements which were mentioned by the respondents are listed here: competent human talent, culture, leadership, staff development, motivation and staff recognition, communication and dissemination to understand where is the company and where it is going, clear roles and responsibilities, ability to forgive and capitalize on mistakes, finances, long-term visions, clarity about the current stage of the company and its capabilities, monitoring the environment, strategic road map in innovation, innovation strategy, alignment between technology and innovation throughout the organization, conducive environment to innovation (work spaces, infrastructure), awareness and outreach on what is meant by innovation in the organization, processes, management of information technology, tools to integrate the organization throughout a culture of innovation, metrics, structure that allow the measurement of the innovation effectiveness and the value generation assurance, organizational structure, and challenges and ideas management.

The framework for managing innovation should include current procedures and methodologies which people use in the company to improve process, products and ser-

vices, as well as to manage projects. However, after checking the current procedures and methodologies in topics related to innovation management, just a couple of official documents were found related to the management of initiatives for improving processes, products or services in some areas of the company. In general there is a lack of procedures which define and integrate innovation strategy and innovation procedures and methodologies to be applied similarly across the company. Only one document about the management of initiatives of organizational consolidation was found to be applied across the company, as well as the project management model which is also implemented across the company. Nevertheless those documents are not properly linked and the former only focus on the management of initiatives of organizational consolidation which is just one of the three focus of the company´s strategic framework.

The company has a history surrounded by the creation and implementation of different models which are always accompanied by the filling out of multiple formats, which have hindered the real purpose of the models in generating value. Thus, instead of helping people to work better, formats are perceived by many as something which is tedious and inhibits people´s willingness to work better. In this way, the framework for innovation management should avoid as much as possible excessive documentation and of formats across the process.

In general, Ecopetrol S.A. has achieved different awards for the models and management systems it has developed and implemented. However, what people feel is that even thought that recognition is highly important for the company´s public shares and market reputation, the company still needs to make people live those models and extract value from them. As a respondent pointed out:

> *This company wins many awards, many!!! And it wins awards because its concepts are clear, they are greatly structured and create phenomenal models. Ecopetrol S.A. shows any model and it hits! But the applicability of the model and its results applied to concrete things that one can show… there is where it begins to fail!!! You have to dig a lot to catch it. It is not common that I can follow it up and say oh! it is clear that the management model says this and here the team absorbed it and did followed the steps, and here is the result. It's a little more difficult. We have good models, here we have toys, and so our role is to play them in a clear and intentional way.*

Although there is an innovation road map defined by the Vice-presidency of innovation and technology for Ecopetrol S.A., it is not common and well-known among the members of the organization. Additionally this map has not been constructed based on analysis of facts about how the organization works in innovation matters and what is

needed to leverage the company´s goals. In this context, it is not clear for the majority of employees how innovation leverages generation value and the goals achievement process. Additionally it is not completely clear where the industry is moving to in innovation and technology matters, and where the company wants to go in this topic.

In this sense, a communication strategy is highly needed in order to tell and explain people what is innovation for Ecopetrol S.A., why it is important, and what place the company needs to get in this matter. In innovation it is always important to tell people what is going to happen, make things happen, and then tell again people about the results of it. In this way, the innovation framework must contemplate the communication plan which allows attracting people and keeping them motivated to what is happening in innovation in the company.

Despite the different efforts many areas make to innovate in the company, people do not feel Ecopetrol S.A. is an innovative company, therefore employees do not conceive themselves as innovators. It happens in part because of the isolated efforts made in innovation, the lack of government in this matter, and the misconception about innovation meaning and scope. Although people say that innovation is highly important for the company to achieve its MEGA, there is not yet a clear link between how innovation can leverage the achievement of the company´s goals. In general the company is very clear in what they want to achieve and where it wants to stay in the industry and in the world, but it is not clear how innovation is supporting that vision and purpose.

Based on this, the company, throughout the Vice-presidency of innovation and technology, designed and launched an ideation process in 2012, which was implemented in the ICP. During 2013 the process has been implemented in some other areas of the company and in 2014 it is expected to be applied by the whole company. Ecopetrol S.A. decided to implement this process partially in order to test it and learn from its implementation. Although the ideation process allow people to better focus their efforts in innovation in some areas, the company still lacks of an integrated innovation process linked with other crucial elements into an innovation management framework.

By 2015 Ecopetrol S.A. plans to involve into the ideation process other companies which belong to the business group. However, and perhaps it deserves a deeper research after this study, it is not as easy as though since companies are very different in nature and behaviors, and it is necessary to understand that most of them have been acquired by Ecopetrol S.A. so then it is needed to comprehend how innovation is managed in mergers and acquisitions in order to know how to approach those companies.

> *We have to be the preferred partner of all, we have to be said: I want to work with you, and not the upturned: please work with us. That's when people have to say, if it is an issue of unconventional hydrocarbons, let us work with Ecopetrol S.A., because they have the knowledge, their op-*

> *erations model is excellent, and their response times are the best. Then, of course, innovation is driving us surely to outweigh our income, but we also win because we get more options to generate new business and enhance our corporate image. It also has a very important value!!!*

Finally, Ecopetrol S.A. is aware of the importance of innovation in the company, but there is not clarity about how to develop it and make it as a representative part of the company. What is highly clear is that innovation must create value for the company, otherwise it would be a waste of time to expend resources in something which in the long term do not offer benefits for the company. To do this, there is a need to develop, implement, communicate, control and measure and innovation management framework which suits the best for the company and its characteristics. This framework must be supported by the top management, who must understand and broadcast the importance of innovation and what is the degree of involvement expected from the employees in this issue.

Innovation strategy: The position of state company that Ecopetrol S.A. had during the most of its existence, gave it some privileges among other companies such as the management of the oil resources of the country. Thus, in the last years the company had not felt the need to innovate since it kept a dominant position in the local market. However, due to the high dynamic environment, the different changes the industry has experienced, and threatened by the apparent extinction of resources (oil) on which it has always depended, the company was forced to change its strategy and open to new markets to achieve new benefits. Therefore, for the last 5-7 years the company has experienced many changes which have made it aware of the importance of innovation in the fulfillment of its provocative and aggressive objectives. In this sense Ecopetrol S.A. structured in 2012 the Vice-presidency of Innovation and Technology to align and achieve synergies from the multiple innovation efforts of different areas inside the company.

Up to now, results from innovative efforts, especially technological ones, have been more representative in the downstream areas (particularly in transportation and refining) rather than in the upstream. In this sense, innovation in the company has been strongly linked merely to technological innovation, and there is not clarity about how innovation efforts have leveraged the objectives of the core areas. It is in part due to the long existence of the ICP in the company, which is focused on research and technological development.

The organizational strategy in Ecopetrol S.A. has been focused on growth which has been achieved mainly by acquired companies in the sector. However, capabilities development is something that the company requires to strengthen, and that is not hardly

to be developed since the company has oriented its efforts in acquiring specific knowledge instead of creating and developing it. Although the strategy has paid for the company during its transformation for the last years, some still criticize it with the argument that a strategy which is just focused on growing by acquiring companies, may let the company unprotected for the long-term. For example, the company should focus also on knowing other energy sources or in developing new technologies or ways to do things; in this case it should build capabilities to support this purpose.

> *There is a clarity about in what Ecopetrol S.A. wants to build competitive advantage, but this advantage is oriented towards a product line (heavy crude oil). The question that arises is whether this really should be the competitive advantage of Ecopetrol S.A. or rather should be based on a basic technology that has transverse impact and allow us to generate a range of products and services. Heavy crudes will fulfill their cycle, for any reason, and it may take time. (…) We should engage in mastering in basic technologies, so that there we jump to develop the entire set of products and services. (...) I believe that we should build our competitive advantage in that, in core technologies, where regardless of the service or product we can adapt over time. For this reason is that in Ecopetrol S.A. people confuse the milestones of a project with the milestones of the competitive advantage.*

Nevertheless, due to the fact that capabilities in specific topics cannot be done just in Colombia where there is not valuable knowledge about them, the company is planning to have an offshore excellence center and an advanced exploration center in Houston where trained international people can work and transfer knowledge to the company in these issues. It shows how the company is being aware of the importance of capabilities building processes and open innovation management.

Despite general perceptions to the strategy, Ecopetrol S.A. has a clear strategy of the business and an approach about the technologies it needs. It also has identified critic processes to achieve that strategy in the organization such as supply chain management, project management, and human talent management. What is needed to achieve the objectives is innovation, and further than this, to have clarity about what kind of innovation is needed and how to produce and manage it. In this way, although the corporative strategy is not the focus of this research it is important to consider it since innovation efforts must leverage and be aligned with that strategy in the company. In this sense, innovation must support both the development of capabilities, and the company´s growth. In other words, innovation must support the challenges in consolidating the capabilities building while sustaining growth levels.

> *The only way I have to transform something in competitive advantage is throughout innovation, if it is not through innovation it would never be a competitive advantage. I can be good or not, I can be recognized because I´m important on the subject of heavy crude oil, but I'll never be recognized for being innovative. Only the day I can put to that the innovation component is then when there is a competitive advantage.*

In this way it is not enough to know that the strategic frame for Ecopetrol S.A. indeed exists. Beyond that there must exist a culture of innovation which leverages what the strategic frame indicates and allows the alignment between the business workers and who produce innovation.

Currently, Ecopetrol S.A. is hardly working on focusing on business process management (in Ecopetrol S.A. the project which is in charge of this is called GENOMA). In this way, people see innovation as a status which the company can get after standardizing and improving processes, which is thought to be achieved by implementing Lean and Six Sigma concepts (Lean tends to eliminate waste in process by using the least in everything, while Six Sigma ensures quality through the elimination of variation in processes). The next figure, which was obtained from a respondent in an interview represents this perception:

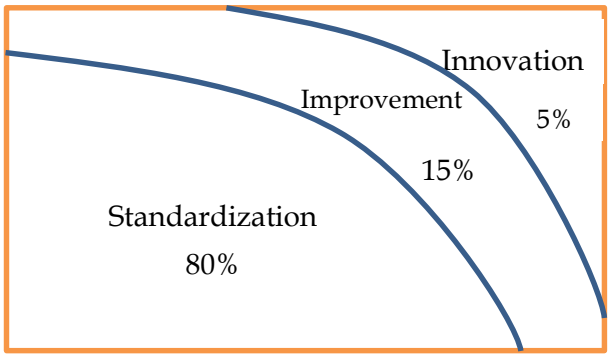

Figure 32 Perception of innovation opportunities in Ecopetrol S.A. based on a business process management approach

Source: Information given by a respondent

Under this context, and based on the innovation literature given in this document, it seems to exist a partial understanding about innovation scope and its relation with process improvement. It is because what is called in Ecopetrol S.A. process improvement can be sometimes incremental innovation, and what they call innovation may be just radical innovation, since it relates to new and different stages in any operation. This perception can be seen in the next declaration given by a respondent:

> *People have to understand that innovation strategy is based on our capacity to standardize and improve our processes, otherwise we'll never get it. We also have to differentiate that suddenly we're talking about process improvement and not necessarily about innovation; then, we must distinguish the subject. At the end, innovation will be the last link, although perhaps we are talking about process improvement and not about innovation.*

Under this context, some people perceive that innovation only may happen in processes, just after their standardization and improvement. However, process innovation is not the only way the company can innovate. This perception may be in part due to the lack of clarity about the innovation understanding and scope for Ecopetrol S.A, and the difference between innovation and improvement.

In this way, one of the first things the company has to do is to clarify what is innovation in the context of the company, and what is its scope in order to leverage company´s goals. By doing it the company has to identify in which situations something can be classified as an improvement or as an innovation. With this in mind the innovation process may be more precise and impacts better the results of the company.

Moreover, the definition about innovation in Ecopetrol S.A. cannot be too generic because everything may be considered innovation and efforts around it may lack value generation. In this point it is important that, based on the gap the company has identified it has to achieve its goals, the innovation definition focuses on the way the company has to fill that gap. In order to this, the definition of what is innovation under the context of Ecopetrol S.A. is highly related with the innovation strategy, and should orientate people about: how much the company needs to innovate, where it needs to focus its innovation efforts (incremental, radical, and/or disruptive innovation; process, delivery, offer, market), tactics needed to innovate, and finally, the needed resources to manage an innovation portfolio.

The innovation strategy is not totally well-known by the employees of Ecopetrol S.A. It impacts significantly innovation efforts since people do not have clarity about how to innovate and how their efforts in this issue may be considered. Consequently, there is not clarity about any innovation road map which shows how a company will achieve its innovation goals which in turn support the organizations´ strategy.

A necessary element for the establishment of innovation as part of the culture is the definition of the innovation policies and objectives, which up to now seems to be unclear for the employees. Through the innovation policy the company declares its principles and doings regarding innovation within the time, and through the innovation objectives it describes what the company expects to obtain from the innovation efforts. Cou-

pled with the definition of an innovation policy and its objectives, the company needs also to define the organizational structure which is going to support the management of it.

> *We do not have the horizon clear, and when we discussed the strategy with the ICP that is not so clear, because I used to say that I have a need and I have to solve it, and what I have to do is adapt technologies, but beyond that what?*

Product cycles in the oil and gas industry are long and slow, however it is necessary to know what is the goal and after achieving that goal to recognize what comes after. Furthermore, the company needs to define, throughout its innovation strategy, the focus of its innovation efforts. In this way, it can associate the current initiatives which are working and which have shared elements, and prioritize its project portfolio which in turn defines the resources allocation. Indeed, Ecopetrol S.A. cannot focus its efforts on innovating in everything because it increases the probability of wasting resources without achieving the expected results. Thus, it should concentrate on keeping a mixed innovation portfolio focus on developing both, incremental ideas, to improve current services and products, and disruptive ideas to establish an added value in the long term.

> *Ecopetrol S.A. lacks of specialization because at the end you cannot be good in everything or an innovator in everything, you can be good in almost everything, but an innovator in 1, 2, or 3 things which are your market differentiators.*

The company subcontracts around 60-70% of its core activities. It means that the company also should develop a capability in there, as market leaders and negotiators leaders. This is possible to get throughout the innovation.

Ecopetrol S.A., as an energy company, has identified challenges on which innovation can help to fill the gap between the current trend in these matters and the expected goals. They can be summarized in 5 topics: heavy crude oils, recovery factor increase, well´s water management, offshore, and unconventional hydrocarbons. Everything must bring the company to have clean and sustainable operations, it is without impacts on the environment and communities.

Ecopetrol S.A. wants to achieve a competitive advantage mainly in heavy crude oils, which goes from the extraction and transportation, to refining and the sale to final costumers. However, this is not the only one advantage it should achieve, the company needs to innovate in what it has done constantly during its existence: producing fields. Therefore, it should focus on increasing the recovery factor by drilling quicker, more

efficient and cheaper. Unfortunately, innovation has not been very representative in this topic, therefore the company does not distinguish itself for being innovative in it.

> *It is a little like to left aside the game of reserves and production, which is important in the sector, but rather emphasizing on which is the approach, in which we want to differentiate ourselves, which is the innovative capacity that we are going to have. We say for example that our strength is heavy crude oils. Is it? No. Actually do we have a differentiated capability? No. So innovation can play a role there.*

The other focus has to be with the well´s water management. Ecopetrol S.A. produces more water than oil, and it is getting higher places in the list of companies which produce more well´s water in the world. The estimated figure is 10 million barrels of production by 2020, and how it is being managed today is costing too much for the company. Therefore, there is a big challenge in this sense, in how to manage it better and get an expertise of it. Although this is a huge projected problem, in EOR (Enhanced Oil Recovery) the company has not probed new methods such as injecting gases, chemicals and polymers which are being applied by other companies in other countries such as Saudi Aramco which is using microbial EOR (injection of bacteria to either change the porosity or permeability of the well, or to change the characteristics of viscosity of the oil).

Additionally it is necessary to understand where the industry is moving on. Around 70% of crudes availability is offshore, it is that in offshore there are the largest hydrocarbon resources base for the future. It means that the company has to develop technologies in this matter and innovate in it. However, there is a big gap between Ecopetrol S.A. and the industry in this matter, especially in the learning curve. In this way, the company has to do both, innovate and develop capabilities to equate and surpass the industry.

In general, what is clear, as well as demanded by employees, is that innovation may leverage Ecopetrol S.A. to achieve its goals and generate a differentiated value in the market. However, it is not clear how innovation can support this purpose, therefore there is not clarity about the demands for innovation in the company. Throughout the construction and implementation of the innovation strategy, which must be aligned with the corporative strategy, it is possible to build an innovation road map which allows the company to know in which specific points or issues innovation is going to help it to succeed. Nevertheless, this work seems not to be easy, since based on the analysis of the information given by respondents, there is a great lack of knowledge and expertise about how innovation should be structured and managed across the company in order to leverage the different efforts that the company is doing in other issues, instead of work-

ing double on the same but building synergies and increase the company´s value generation.

About unconventional hydrocarbons, Ecopetrol S.A. does not have neither the specific knowledge, nor the experience, since this is a new topic on which the company planned to move recently. In this sense, there is a huge opportunity with the development of alliances with other companies which in fact have the knowledge and expertise in it. Throughout the development of these alliances, open innovation can be done and knowledge and technology can be generated and transferred to Ecopetrol S.A.

> *A few months ago I brought a choice in the Gulf of Mexico and everyone was excited about the amount of reserves that it could incorporate to the company. But at the end of the day I said, just with signing the agreement with the other company, you can block reserves, and I asked myself: is that the game we want to play? I do not think so, I think the issue has to be more with skills development, knowledge transfer, new technologies transfer. To me, that is the game in the long term, because that will leverage that we can increase production, generating reserves and be sustainable in the long term. To me, that is the fundamental issue.*

If unconventional hydrocarbons is the "hot topic", as soon as possible the company has to adopt technologies, innovate and learn how to exploit unconventional reservoirs. To do this it is important to understand where the industry is, what is changing in the world and how it is seen in the future. Based on this the company can identify a gap to be fulfilled throughout innovation. In this way, the innovation strategy and road map plays a key role in identifying how innovation will leverage the process to place the company in the position it wants to be in the industry and in the world. As pointed out by a respondent:

> *When you see the world, you can see that the industry is here and that in the future of 10-15 years the industry will be here. However, if you follow a program of innovation and technology that is not as aggressive instead of growing parallel to the growth of the industry, you'll be suddenly below, then you will have a decrease, even though you feel you've grown up with some of what you've done. So you have to understand the world, it is vital to understand where and how we go.*

Based on how product and services relate with markets and customers in the strategy definition, the innovation radar, developed by Sawhney et al. (2006), was applied to the company and the results are shown in the next figure.

Figure 33 The innovation radar in Ecopetrol S.A.

Source: Based on Sawhney et. al (2006)

The radar allows the company to identify all the opportunities it has to innovate in the 12 mentioned dimensions. Nevertheless, from all the dimensions, Ecopetrol S.A. needs to focus its innovation efforts, mainly radical and disruptive ones, on the dimensions of processes (redesigning processes and services as well as incorporating or developing new technologies) and offerings (new products, platform and solutions). It does not mean the company does not have to innovate in presence and customers dimensions, but those innovations could be more incremental since they do not seem to be the ones which give to the company a competitive advantage in this kind of industry or help them to close the gap in the achievement of its goals in 2020. The next table summarizes this approach and shows the most representative type of innovation which should be developed in each dimension.

Dimension	***Incremental innovation***	***Radical innovation***
Offerings		***XX***
Customers	***XX***	
Processes		***XX***
Presence	***XX***	

Table 9 Dimensions on which Ecopetrol S.A. should focus its efforts on innovation.

Source: Based on the dimensions identified in the innovation radar by Sawhney et al. (2006)

Under this context, the next matrix was built with the respondents regarding the core activities of the company (exploration, production, transportation, and refining). The matrix classifies the current operations and what is expected by 2020. In this way the company should consider both, a strategy which covers the current and short term, and a strategy which also contemplates the future.

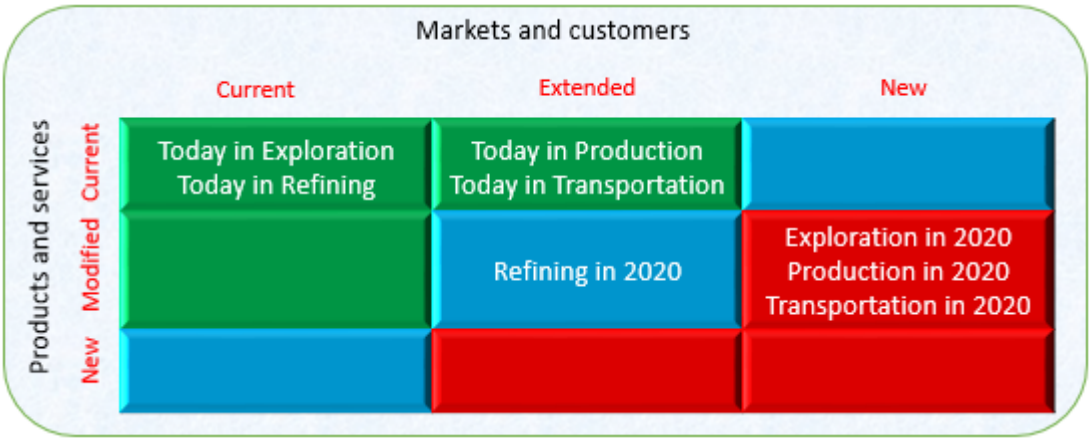

Figure 34 Innovation typology in Ecopetrol S.A.

Source: Based on an integrated approach to managing innovation (2012)

Under this classification, Ecopetrol S.A. actually works on green area, in the fields of process improvement and market development. It means that the company can innovate in incremental levels with existing resources and skills because normally new ideas tend to focus on expanding the current range of products and services.

Nevertheless, for the future, and based on the company´s goals for 2020, the company plants to operate in blue area and also in red area, in new capabilities and new business development respectively. To do this the company will need to address a crisis for which new capabilities and resources are required, and it will have to operate with higher risks because it will be trying with something totally new to the business. For this the company will need the acquisition of new resources, capabilities, ideas and management.

Under this scenario, Ecopetrol S.A. created a M&A department, which is the area responsible for mergers and acquisitions and which has to ensure the incorporation of new knowledge, technology and capabilities to the company, inorganically. Nevertheless, it is important to highlight that when merging or acquiring another company innovation, as well as knowledge management is impacted in the holding company and these situations must be considered when managing innovation. Although this is not the main scope of this research, the author finds it important to consider for the future in the company.

This classification also currently shows how aversive the company is to take risks, and, based on this, the number of implemented ideas may be greater when compared with sceneries where risks are higher. In general people perceive that the company has had opportunities in which it needed to be more risky, but due to its afraid to fail it has not taken advantage of them despite the maturity process it has obtained in some issues

Finally, this classification indicates the way as the company should focus its innovation strategy in order to keep the focus on the efforts and resources it allocates to innovation. It means that the strategy in innovation for exploration, production and transportation in a timeline to 2020 should be oriented to modify the current products it works with (i.e. biofuels) as well as to create new markets and customers for those modified products. Similarly, it should consider for refining business the modification of products and the extension of markets and customers for those products. The main reason behind why the company should focus in the modification of its products instead of in creating new ones, is that in this kind of industry the time that an invention takes to be an innovation with generation of benefits for the company is very high (around 15 years, it is 3 times more than in a normal sector and 15 more than in the technological industry). Therefore, when thinking for a strategy to achieve the 2020´s goals, the modification of products seems to be the more realistic perception in the company.

> *I think that energy is the dominant power, and energy consumption will depend on electricity but not on fuel; at best in the better scenario, not too distant from now. For that you need to be a master in company power issues, although you follow for a while producing fuel, that's a radical transformation in the company. Now, I would not want to bet to new products, I think that instead of new products we can develop the markets we already know: for example I could not become an energy company in Russia.*

Although the company has clear goals for 2020, it may be necessary to dimensioning the innovation strategy for a longer period of time, it is beyond 2020, when the company will need to develop new products and services (alternative energies), while targeting new customer segments and markets (unexplored markets or unknown market niches). Moreover, because the company is considering itself as an energy company, which means more challenges to be solved.

Innovation process: When analyzing the selected concept of innovation for this research, which is ”the successful generation, development and implementation of new and novel ideas, WHICH introduce new products, processes and/or strategies to a com-

pany OR enhances current products, processes and/or strategies LEADING TO commercial success and possible market leadership AND creating value for stakeholders, driving economic growth and improving standards of living", innovation can be understood as a process where the different activities that integrates it must be executed systematically and as a whole.

As mentioned before, due to the approach Ecopetrol S.A. is developing to business process management, in some way innovation is seen just as an element of any process, rather than as a process where ideas are analyzed, selected and transformed into new products or services which generate more value for the organization. In this way, the company is training people under the Lean Manufacturing discipline, with the aim of improving things at low costs but with enough arguments to change things.

Under this context the company has faced a debate about the interaction between two couple of elements: innovation and standardization, and innovation and improvement.

On the one hand, when an organization is focused on business processes management, people are moved to do correctly always what they have to do, and it is not common to ask them to think differently. However, it is necessary to know where and when is necessary to innovate, and how to do it.

> *If you do not standardize you cannot think in improvement: those are basic principles in engineering. If you do not standardize and do not make that whether good or bad results are always a minimum range of variability, you cannot go to improve it (…) Improvement and innovation are two complementary things, but different from each other.*

Although the company has invested a lot of resources in business process management, it is necessary to focus also on innovation, which is not independent of improvement. The path to the achievement of the strategy has to be in double way, it is that the company cannot just focus on standardizing because it is going to lose time and the market is more aggressive in its learning speed. Therefore the company must be able to innovate as well as to standardize, and if the company innovates in something which was already standardized, then it is necessary to standardize again the new practice.

In this way, if innovation is perceived just to be part of the "check" process in the PDCA cycle, instead of being a unique process of innovation, the fuzzy front end stage of innovation can be given although the other activities of the innovation process, required to transform an idea into benefits, may be more difficult to be developed. In any case, an innovation process is required into Ecopetrol S.A. which integrates the different elements that are present in the company, such as the project maturity model, and the process for prioritizing initiatives, among others. When structuring that innovation process, the company has to be aware of not losing the essence of the process in order to

keep it attractive for employees to execute it, instead of feeling it as something bureaucratic and not effective. It is said because in Ecopetrol S.A. people perceive the implementation of any process as something that involves the use of a lot of documents and filling out many formats, which demotivate them to take part in.

Although some people perceive innovation as an element of any process (in the "check" stage of the PCDA cycle), what is really required is that people are aware about what they do and how they can innovate in their daily activities. It takes part of the innovation culture construction which is considered further later in this document.

On the other hand, due to the great efforts the company is doing on developing to business process management there is a continuous overlapping about what is considered innovation and what is considered improvement or enhancement of something. As mentioned previously, innovation is understood merely as radical innovation, and what can be incremental innovation is perceived by the company as just a mere improvement of something (process, product, service, etc).

> *People need to be clear: they are running by process, then, ensure the process flow. But at the same time we have other initiatives to which I work in parallel with its own identity. These initiatives allow us to innovate, and there just move to other levels. Nevertheless, those things are not well differentiated. When you look at the business process management focus, you have specified a verification process which is: make learnt lessons, study, see how you improve your process, but always in the same instance. And that must be done, but another thing is to tell people: we are improving, but can I make changes? Through innovation I do transformations, and through improvement I get efficiencies. So I should bring innovation to transform things, and improvements to increase process efficiencies.*

In this way, Ecopetrol S.A. needs to define and clarify what can be considered as innovation and what as a mere improvement of a process, product, etc. Without this clarification in mind, there will continue an eternal discussion between areas such as the Vice-presidency of strategy and growth, and the Vice-presidency of innovation and technology, around when and where something should be managed as an improvement and what as an innovation.

> *In Ecopetrol S.A. we do not have an innovation process. When we catalogue innovation as an element, the same as it can be with knowledge management, it is because it exhibits some characteristics which need to be modeled in different process. Processes have to be modeled for inno-*

> *vation issues. When we define these as elements of the management system it is because do exist processes which need to comply with some characteristics from that framework.*

As mentioned previously in Ecopetrol S.A. there is a procedure which seeks for prioritizing the people´s initiatives in the organizational consolidation guideline (based on the company´s strategic framework). This procedure was created with the aim of organizing the way as employees propose ideas to improve current processes conditions and performance. The procedure, which is not totally known by people across the company, is about taking decisions on what to do, which resources are required, how to optimize the portfolio and how to make change controls.

In this procedure an initiative is understood as a set of actions which in a direct way help to achieve the strategy, has a start and an end point, has clear deliverables, allows the transformation of a process, and produces competitive advantages. From all the ideas people can suggest, some are selected based on an analysis of two main aspects: complexity and impact. The complexity is valued based on the required capabilities for the implementation. Additionally, the initiatives are classified according to their impact, like this: initiatives which impact processes, initiatives which impact the company´s management, initiatives which impact the company´s structure, and initiatives which impact the technology.

After classifying the initiatives according to their complexity and impact, a couple of committees are developed in order to prioritize the initiatives and select which can be developed. After this, the portfolio is consolidated and resources are allocated and authorizations are asked to the steering committee. Depending on the selected initiatives and their nature (required resources to be done: time, money, people, etc), they can be developed by a formal project (using the company´s maturity project model) which go to the company´s project portfolio, or as an improvement plan executed with resources of an area (it involves a work schedule and some formalities to track the execution and measure performance) which are controlled by the Vice-presidency of strategy and growth.

Up to now, this procedure, coupled with the maturity projects model, is the one which is closest to what an innovation process could be, however the evaluation criteria should be more flexible depending on the nature of the initiative in order to consider properly the scope of every initiative in any category. Additionally, the scope of it relies on initiatives given for just one guideline of the strategic framework. There is not any formal procedure for the other guideline in profitable growth, despite the existence of the company´s maturity project model.

The model for the maturity of projects in Ecopetrol S.A. involves 5 phases or stages which go from the identification of the opportunity (phase 1) and the possible alterna-

tives for its solution (phase 2), to the execution (phase 3 and 4) and close of the project. In the latter stages is where there is less opportunity to innovate than in the initial stages, since the company has focused the resources allocation according to a business plan developed in the second phase of the model. The methodology goes around the stage-gate process explained in the first chapters of this document.

> *The success of the project maturity model is to first make a good identification of the problem and then give a good identification of alternatives, in a serious and sincere way. On average, from 100 ideas that are generated, only 10 pass to the next stage.*

Although the model complies with the best practices in projects maturity in the world it lacks of accountability and people do not respond properly in what they are responsible for. Furthermore, it is complex in its own development which impacts the required speed in the innovation process.

In general in Ecopetrol S.A. there must exist three kind of initiatives which can be associated to three big levels in innovation in the innovation portfolio of the company:

Incremental innovation: These initiatives, which normally represent around 70% of the innovations of a company in this industry, can be implemented by local teams and with local resources. It can be possible since the capabilities required for these initiatives are not necessarily new. In this way, a representative of each area involved in the solution can integrate a team in charge of the execution of the initiative and throughout a work schedule the results can be tracked. People involved in the execution of these initiatives can dedicate a portion of their normal work daily or weekly to work on the execution of the schedule.

Radical innovation: These initiatives, which represent around 20% of the innovation of a company in this industry, demand for extended and modified capabilities and knowledge. Due to this, they must be executed by a multidisciplinary team dedicated to them the majority of their work time. The team must include representatives from the Vice-presidency of innovation and technology, as well as from the Vice-presidency of strategy and growth. Due to the nature of the initiatives they may require the formalization of a project, so then they must be executed by following the company´s maturity stages model.

Disruptive innovation: These initiatives represent roughly 10% of the innovations done by a company of this industry. They require totally new capabilities and knowledge in the company. Therefore, a team must be integrated by people from all the areas which are involved in the solution in the company, and they must be dedicated 100% to work with those initiatives. The team must also include representatives from the Vice-presidency of innovation and technology, as well as from the Vice-presidency

of strategy and growth. Additionally, the team may include people from external parties. Due to the complexity of the initiatives they have to be executed as formal projects, it is by following the maturity project model of Ecopetrol S.A. Moreover, due to the novelty of the initiative it may require the involvement of the investigation and technology process, which make the innovation process more rigorous. The different probes do not go directly to the fifth stage or phase of the model, but they must be tested many times in small scale in order to identify and test the success of the solution.

Under this context, the innovation portfolio in Ecopetrol S.A. would integrate what is known today as the project portfolio and the incremental innovations developed by different areas. This portfolio must be balanced according to the typology of the innovation, but especially according to the involved risks. The innovation projects are vague by nature and involve a risk which can vary depending on the kind of innovation (incremental innovation commonly involves moderate risks, but radical and disruptive innovation normally involve very high risks). In this way the innovation portfolio of Ecopetrol S.A. should involve innovation development with different kind of risks. The innovation portfolio is one of the key aspects for the allocation of resources for innovation.

All the initiatives must be compiled in a technological platform which concentrates all the information around them, and allow the company to know what is happening with their suggestions about a problem. It is highly important because in general employees feel that their efforts at suggesting solutions and new options for the company are not valuated and they just are compiled into an “excel file” and then nothing else happens about it. However, it is relevant that the company integrates all the information technology it may have around innovation and idea generation and implementation, otherwise it is going to be very tedious for normal employees to follow their ideas and to participate in every stage of the innovation process.

In this way, Ecopetrol S.A. should develop innovation programs from two perspectives: one focused on oriented ideation (looking for solutions to specific and defined problems), and another focused on opened ideation (which at first does not have a clear problem to be solved). The oriented ideation program may be developed from the initial stages of the implementation of the innovation framework since it eases the analysis and selection of submitted ideas while pushes people to focus their efforts to the solutions of one or more specific problems in the company. The program based on oriented ideation must have a specific time for each stage of the process, especially in the front end of innovation, it is when defining the problem to solve, there is also a limited time defined for the submission of ideas and evaluation of them.

Later on, when the model is more mature in its implementation and the innovation process is better known and applied by people, the company can start working on

opened ideation processes, where people submit ideas which must be oriented to the company´s goal achievement and evaluated periodically by an innovation committee.

On the other hand, around the innovation process exist other processes which also impact the performance of innovation. One of them is the supply process, which in Ecopetrol S.A. is very slow and complicated due to the huge amount of documents, requirements and times involved in the supply of any service or purchase of any item. In this way, when the company needs to hire someone or some company for any service, this process takes too much time which does not contribute to the velocity and flexibility that the innovation process demands for the company.

Another process that needs to be adjusted has to be with human resources, and special with the cases when people has to be in charge of a position different to his/her position. Due to the long times these replacements can take, and coupled with a culture of fear in the company, people are not willing to take decisions, instead of that they elude to take any decision. In this way processes are slower which difficult and delay work schedules.

To conclude, the company has different elements which need to be linked in order to integrate an innovation process. Those elements are the efforts in ideation processes done isolated for different areas of the company, the procedure for the prioritization of the initiatives of organizational consolidation, project portfolio and maturity project model, and the business process management orientation in standardization and improvement of processes. Based on the TEMAGUIDE model, the company can integrate and structure an innovation process which covers all the three kind of initiatives described above, as follows in the next figure.

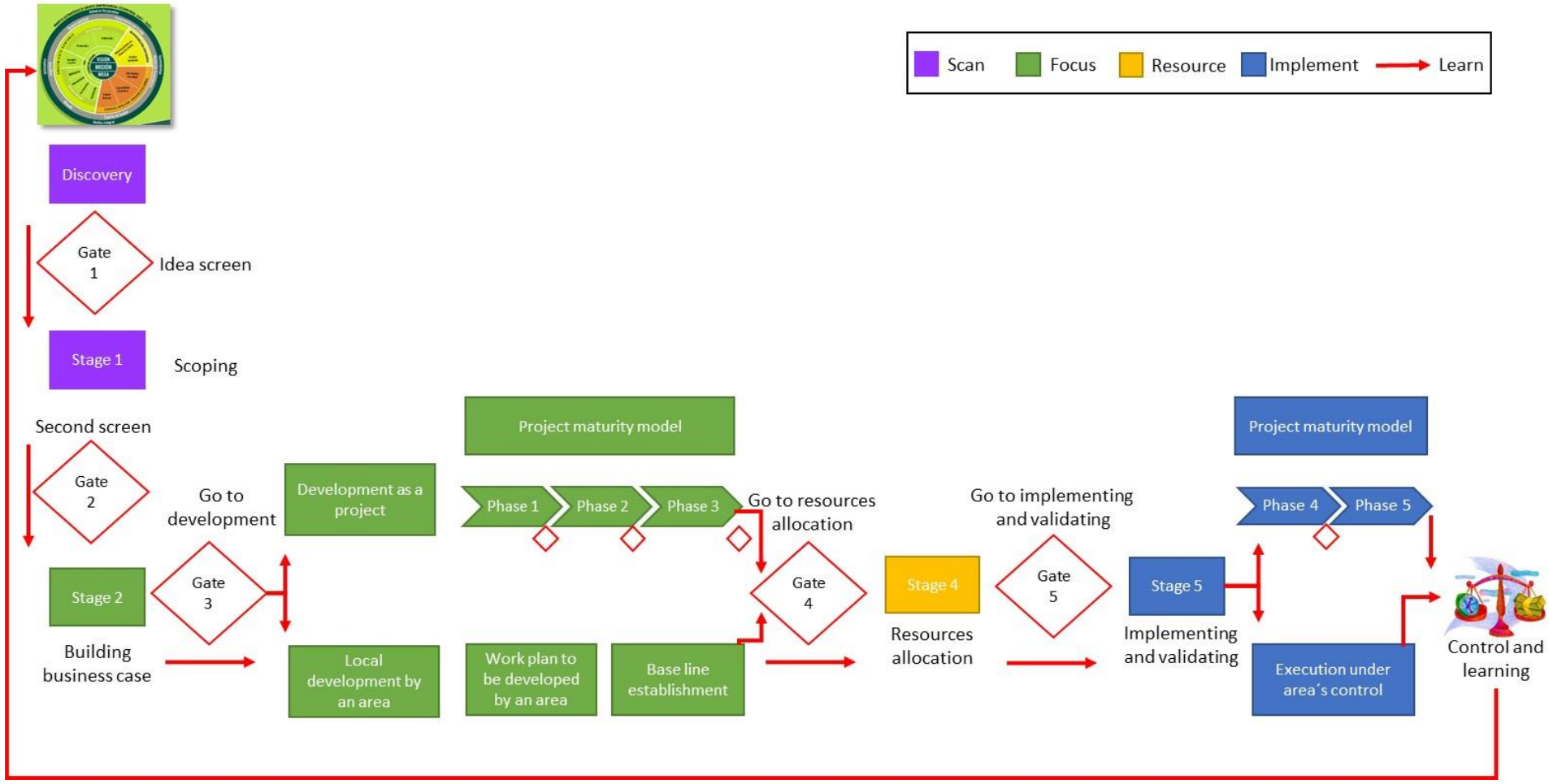

Figure 35 Suggested innovation process for Ecopetrol S.A.

Surrounding the innovation process, some other elements are identified to be critical in the process performance. Some of the most representatives are organizational structure, innovation value generation, innovation tools, and innovation idea sources.

Regarding organizational structure, the company has already structured the Vice-presidency of innovation and technology with the aim of defining, implementing and controlling the company´s innovation strategy. The definition of a specific area which manages innovation indicates that the company is aware of the importance of this topic for the organization, which has decided to manage it with a centralized approach. In this way, this Vice-presidency has to define the guidelines and roles in innovation in the company, as well as measure the generation value throughout innovation efforts. People in the Vice-presidency, specifically those working in the strategic direction in innovation, technology and management, must accompany people working in innovation across the company, and support them with methodologies and orientation about how to proceed in the innovation process.

The implementation of a centralized methodology means the creation of a common approach to innovation as well as its application. It represents a benefit for the organization since there is a well-known and unique process, tools, methods, language, evaluation criteria and tools within the organization. Additionally, a centralized approach create value because many tasks within an innovation program, such as management of trends, idea facilitation, sponsorship, managing third parties in collaborative innovation, and innovation training, are more effectively accomplished in a centralized role.

> *If the new Vice Presidency wants to be trusted in innovation and technology matters, it has to take an active role in the company (…) people working in there must be perceived as critical for the company´s goals achievement in the long-term. It is a perception matter, they cannot be perceived as laboratory mice… however that does not happen suddenly, they will need time and hard work.*

Nevertheless, due to the fact that trained people are very coveted by different companies at the same time, it is likely common that people acquire knowledge in one or two companies and then a new one offers an attractive benefit for the trained person and takes advantage of the efforts that others have done before. Additionally to this, trained people, who are aware of their value in the market, are difficult to hire in third developing countries, because they prefer developed nations with better living standards. Due to this, the company also has to consider the option of having a kind of decentralized approach to manage innovation, throughout the creation of excellence centers outside the country, where people with high qualifications, knowledge and experience, can collaborate with the innovation strategy.

> *Bringing trained human talent to Colombia is not an easy thing, bring to Colombia people with a background or large background… difficult! You tell them you're going to Bogota, do you want to come?... maybe no. I do think you have to decentralize it, but how we can put it together with our internal innovation processes? There is nothing up, and it should be a company´s concern to avoid having two separate worlds, because I do believe deeply in the need for decentralized structures outside the country, a truly international Ecopetrol S.A.*

Under this context, the company faces a critical point when projecting its future in innovation. Everything relies on how to build dynamic capabilities, especially innovation capabilities which allow the company in the future to acquire knowledge and apply it from other external contexts as a holding group. In this sense, it is probably that the organizational structure to manage innovation in the business group is decentralized in the medium and long-term.

Currently, despite de existence of the Vice Presidency of innovation and technology, depending on the initiatives to be developed, improvement plans or projects execution are carried out by different teams which are defined according to the nature and complexity of the initiative. Those teams must be integrated by multidisciplinary people across the company and they must be able to work constantly on the initiatives execution. It helps the company to improve the value generation since an initiative can be rated and worked by people with different backgrounds. Shell makes something similar at ensuring that every initiative that is born in the company has to be analyzed and executed by a team integrated by experts in different topics (from technical to administrative issues) who integrate an innovation committee and can identify how this initiative can impact them and how it can be improved to get better results. This work must be supported by people in the Vice Presidency, although the role of them has to be more with the coordination and control of execution rather than the direct implementation of the initiative, which depends directly of other areas.

> *The new Vice Presidency sounds like a good initiative, it is a good step, but how far are we sending the message that the issue of innovation is just of an area? So, I think that it is a message that should at least be transmitting throughout the organization, i.e. the vice presidency was created here but innovation is not going to take from here. We need to take that message for people not to misunderstand it and just wait for others to do what they also have to do.*

Due to this, people highlight the importance of a network integrated by representatives of different areas of the company. This network could be built by capitalizing the experience that the team of knowledge management has acquired, which actually is integrated by 20 persons from different areas of the company. However, at the initial stages, for the network of innovation it is necessary to have more people involved which represent more areas inside the company. The innovation network has the responsibility of promoting innovation in every area of Ecopetrol S.A. as well as helping in the construction of guidelines in this matter (with the orientation and guide of the Vice-presidency of innovation and technology) and in testing their impact across the organization.

People involved in the innovation network initially has to dedicate a part of their work time to innovation issues. As the innovation model matures, people should dedicate more time to this purpose, but this time cannot be when there is nothing else to do, because innovation is not something people do when they have time, it is something for which people have to take time for it. The challenge behind this relies on the methodology for working on innovation given to them.

> *Physically each initiative cannot have an organizational structure. There is a group in the Vice President of Innovation and Technology leading the innovation, a group that was created to work on the issue. They must make the process works naturally. They are not to create more organizational areas (...). They cannot dream they can ask for more people for innovation; the challenge is: very few people wondering how this is done in a natural way, but not how to create a program of innovation with sophisticated use.*

Beyond the Vice-presidency of innovation and technology, and the innovation network, at initial stages the company does not have to make more changes in its internal organization. Later, when the model is more mature it will be necessary to adapt some roles of employees which work directly on innovation. Furthermore, what will be relevant is to identify some transversal capabilities which must be shared across the organization by any employee, as well as to use the current organization structure and teams which are focused on the different elements across the innovation process, such as the Projects Direction, the New Business Direction, and the Vice Presidency of strategy and growth, among others.

> *We have the innovation strategy committee, and all that stuff. I think the work spaces exist, I do not think it's an issue of having more work spaces. The problem is to make room for things that occur in these spaces, that*

> *they have possibility to exist by the required resource allocation, support, acceptance, and importance in the company.*

Regarding innovation value generation, in the company there have existed many efforts at collecting ideas around new opportunities to innovate or to improve some conditions or processes. Unfortunately, these efforts have been in vain since the majority of those initiatives still remain in electronic files without execution, therefore, without value generation. It has been in this way because in Ecopetrol S.A. there was not a common and formal structure to be followed by employees in order to potentiate their efforts and concentrate themselves in something which generate value for them.

> *It should not be what every person thinks it is, because each person has a different version. This is about having a common language, a defined process, and a clear practice of how to structure an initiative. In this way everyone speaks the same language, in the same terms and not over there ethereally with things and assumptions! No, you should tell people: tell me what concrete things change, when you change, what is the value proposition, how is it, what's the working plan, what are the major milestones, and what areas will be involved. It is about a common language around innovation and generation value.*

In the ICP, there is a document called project benefits certificate which allow to identify the benefits that is generating the technology which is being developed. It is possible due to the establishment of an initial point (current status of the problem, statistics, etc) against which any advance is compared and measured. Due to this, from the technologies and products developed, the ICP generates six times more benefits than is invested.

Another way the company has actually to generate value from previous efforts has to be with the licensing of technologies which it has developed and does not want to exploit directly.

> *All research unquestionably must end in profits, if not it is not innovation. So, if I apply an idea into a process, how much I am optimizing costs in my area?, how much I am improving the response times?, What is the impact I'm having?, what´s the benefit?. If I see no benefit it is difficult to justify.*

Definitely the company can ensure that its efforts in innovation are worth by selecting initiatives which are self-financing, it is initiatives that show that they can be paid

and that their benefits are greater than their costs of implementation. Any initiative can generate benefits in two forms: by affecting the income and the organization (economic impact), and by affecting the company`s goodwill and reputation (which will allow the company to make more businesses and impact the income). Finally every innovation initiative must be focused to generate value throughout the optimization and creation of benefits which at the end go to the financial statements of Ecopetrol S.A.

Innovation plans must be aligned to the big challenges of the organization in each area. Due to this it is necessary to define very well the initiatives the company wants to work with and which areas are going to be impacted with them. Furthermore it is relevant to know which benefits the initiatives are going to generate, which are the value promises of the initiatives, and how they are measurable in the work schedule. In this way, it is also critical that the plan is rated and controlled, that the resources are correctly allocated, and that continuous feedback is given, in order to identify whether the value is being created or not.

> *One of the key elements in the implementation of any innovation model is that it has metric measurements, controls and that is aimed at generating profits. If there is no clear benefits, it can end up becoming a fashion which will happen because it does not generate profits. And I think, at the end no matter how many good ideas you have, what really matters is to have good ideas that generate profits, two or three, it does not matter. And that people who are working on the issue are serious and convinced that they are working at something that is not only innovative but is growing up. Because you might have great ideas but if you do not grow up it does not work.*

Both, internal and external customers are who can also define what can or not generate value. In this way, internally as well as externally people should work always in the client´s hand because this is the only way it has to know and surpass their expectations. If so, the customers will be willing to pay for it, and if it happens the company is generating value.

Regarding innovation tools, in general in Ecopetrol S.A. there is not enough knowledge and clarity about innovation tools in each of the innovation stages. The most common and used technique is the classic brainstorming which does not have the same utility for every type of innovation.

> *We conduct workshops of ideas, workshops of learnt lessons. We could say that these are all elements and tools that help us, but are not de-*

> *signed exactly to innovate, but to produce improvements and learn from the things we have done, well or badly.*

With the innovation process definition it is necessary to identify for each category of innovation (incremental, radical and disruptive / product, process, service, offer, market, business model, etc) which tools suits the most in order to potentiate the value generation.

Finally, regarding innovation idea sources, due to the maturity of the knowledge management practices, the company has different scenarios where new ideas and opportunities can be identified and that somehow impact innovation results. Some of those are communities of practice, key practices, knowledge miles strategy, technological forums or summits, the yellow page strategy (website for people to know each other and share their likes), among others.

In general there are many sources of idea and opportunities generation, which are partially recognized by employees. The most popular is the idea opportunity as a result of the execution and analysis of the operations and processes across the value chain. This can also be a result of the PCDA cycle, where opportunities to improve a process are known. In this way, the company has identified many opportunities to improve processes which have been registered in a platform the company has for it, but the majority of them have not been executed. Although the number of initiatives to improve are vast, many of them are not well defined and it seems that people are not applying some techniques like "the 5 Wh questions" which help people to really understand what the problem around something is.

At external levels people just focus their attention in finding opportunities in the analysis of what the industry is doing and how it is projecting itself in the future. However, there are other idea sources which may be underestimated by people, such as suppliers and customer`s experience, the academy, consulting companies, experts, other communities, etc, which can be estimated by open innovation.

> *The innovation opportunities could be found by listening to our customers, the risk is to generate expectations to these publics and nothing happens. I think that until Ecopetrol S.A. does not have, or at least propose in the short term, initiatives related to the customers desires, it should not open more channels. But I am sure that through open innovation is the best option.*

Ideas and opportunities for innovation come out from the combination of the analysis of different sources, internal as well as external. In this way synergies can be done

through the shared results extracted from the environment monitoring, the searching of technological advances, purchase of information about the environment, participation in international and technical summits, technical visits and internships, steering committees, and alliances with strategic suppliers, among others. Finally, another big source of opportunities to innovate may be given in the synergies across the companies of the holding group, which should be analyzed carefully in other research under the light of M&A literature and the innovation management experience of merged and acquired companies.

Technology management and innovation management: Ecopetrol S.A. has lot of opportunities to develop or buy and adapt technologies. However, it still depends greatly on the technology purchase and its adaptation to the company and this exercise is not accompanied by the development of conceptual models which allow the company to develop more things. In a logical way, the technology should enable standardized, safe and controlled processes execution, which in turn are improved through innovation in order to have better efficiencies and more productivity.

> *We have not been lower than the industry on issues of incorporating technology (...) However it is not enough that you have and incorporate all new 3D seismic issues, advanced processing of 3D seismic or even 4D. If you are not simultaneously doing development of conceptual models, for example deep-water basin, and understand it conceptually. If we do not carry that on hand, technology by itself is not going to be the result, because everyone has the technology, everyone can buy it, except those who develop their own. (...) And off course, there are technologies that you have to have in-house, there are things you must have today, especially in exploration, today we do not have a set of distinctive technologies in exploration, we have our own processing algorithms? No! We do the industry standard. And in such a competitive market it is not enough, the possibility of error is high besides the natural hazards of this type of business.*

In the oil and gas industry the technology development is not lead by the operators companies, it is led by the service companies. In fact, around 60-70% of the core operations in these companies are subcontracted. Therefore, Ecopetrol S.A. has to work on hands with services companies in order to have technologies which suit the needs of the assets (oil wells) of the company and what the organization wants to develop. Actually there are not enough collaboration scenarios with the companies which develop tech-

nologies in order to have technologies designed for the assets managed by Ecopetrol S.A. In the adoption of technologies there are also opportunities to innovate in the way as the technology is used in the company and how new developments can be done from it.

While technologies can be present in the value chain, information technologies support all the operations in the company. The information technologies seek for connecting people across the organization. Nevertheless, the appropriation of these technologies in the company has taken more time than needed and actually people still are not aware of the utilities of those technologies and their use is limited. For example, SAP was implemented in the company around 9 years ago, and there is just a small percentage of people who know and use the system. In this way the company still focuses on managing data since information is not yet an input for the decision making process because it is not accessible. Due to this Ecopetrol S.A. needs to check all those technologies it has implemented across the company and define a plan to improve the use and experience of the customer with it, otherwise it is necessary to take more aggressive decisions about them because it costs too much for the company to have them working (costs of licenses).

Technological factor is important in the company, but it needs to be more at people´s level because it is an instrument to work and make things better and easier to achieve the corporate strategy. In this way, technology management needs to be better shared and understood to all levels in the company. This is now more possible with the existence of the Vice presidency of innovation and technology which integrates areas that were before working isolated. In this way a clarity about how to manage technology, what and how to control it, what to plan, what to adapt or buy, and what to transfer, is given.

Nevertheless, the company needs to be careful in how to send the message to employees. Currently many people think that all their problems can be fixed through technology, so then they start working for the technology and do not allow technology to work for their processes. Then, in any project committee people exhibit their problems with processes and they suggest that their main solution relies in the purchase of technology. In the medium-term, after adapting the technology to the conditions of the company people are working for the technology and asking for more developments or new solutions.

> *(…) I think that's the big mistake we have made in the organization: making that technology becomes an end in itself while forgetting that at the end it is only an enabler that leverages many solutions.*

The company has established and improved a model to the management of technology. This model works well in the purpose of acquisition, creation, development, transfer, protection and use of technology. Thus, this framework needs to be considered when defining the innovation management framework, since it establishes how the technology strategy is built and executed from a process of competitive intelligence to the incorporation of technology, and transfer and assurance of knowledge and technology.

Finally, there is an interesting option on which the company needs to start to work on: corporate venturing. This has been highly applied by large corporations around the world (i.e. Shell, Nestle, Nokia, Intel and Google, etc) with successful results and in response to new ways of competing, such as those based on disruptive innovation (Crockett, McGee & Payne 2013). In the oil and gas industry there are small industries which develop specific technologies which can be used by large companies which in the medium-term tend to acquire those smalls companies. It also may happen when there is an opportunity to develop new technologies which at first are not the core of the company but may represent a future benefit in any market, the company should have the possibility of investing in it and developing it. The benefits of it rely on the fact that those small companies are born to be more flexible and that is precisely what allows them to test and develop new ways of doing things. This process is more complicated in large companies, and despite the resources availability, large companies do not move as fast as start-ups do. Corporate venturing is definitely something which should be considered by the innovation strategy of Ecopetrol S.A. and in the technology management guidelines of the company.

People and innovative culture: As mentioned previously, it was one of the most common elements respondents identified when talking about innovation framework elements. In fact, companies are not innovative, but are their employees. Without people involved into an innovative culture, innovation results are difficult to achieve. Therefore, it is relevant to engage all the employees into the innovation model.

> *Our aspirational is that one day this is an innovative company, which every day is making new ideas, no matter if they do not succeed. That would be a hit, if we could one day understand that all we owe to a common cause and not to an individual effort!!!*

In this way, the key for innovation success in Ecopetrol S.A. is to have the ability to make it very easy for people to do. In this way, every element involved into the innovation model has also to be very simple to understand and practice, otherwise people

would not like and accept the cultural transformation and will produce the same results, so then innovation efforts will be senseless. At the end, people should be able to understand innovation as something practical in their natural work and way of doing things.

> *What concerns to me is that the creation itself of the structure is not a guarantee that things happen, because we must permeate the entire organization, touching, make it something transversal. Today I feel that although things are written, because we could not ignore them, they are not appropriate in the organization. But being innovative is something that comes from within, as being a good leader. We have a good model of leadership, but there are good leaders and bad leaders. Same thing, we could have a good model of innovation, but there are those who exhibit it and those who do not.*

It does not mean that the innovation process and all the elements in the innovation model do not have an order. In fact, it is highly necessary that an innovation structure, which leverage the objectives achievement, does exist, otherwise people´s efforts may be senseless and they demotivate to continue working on innovation.

> *If we innovate with an order, with a methodology and in a clearly way, we hit the rock!!! I have no doubt that we would achieve results, even those unexpected ones.*

Due to the strong focus on business process management the company has developed for the last 3 years, people have been oriented to do their job in a standard way. However it is something on which the company continues to work because people have not acquired completely that discipline. In the program established around this, there are some trainings in six sigma methodologies and reengineering. The purpose behind this training is to teach people about how to improve their processes and perhaps think them differently, of course after ensuring they are standardized. Although this leverages innovation goals, somehow, people need more tools to think different and make innovation something they can use to improve their current conditions and generate value for the company. In this way, the purpose in people´s change and transformation should be to create culture from the bottom, and despite how standard are their processes they can improve it through the implementation of good ideas.

Ecopetrol S.A. needs to work urgently on some aspects related to culture, such as those shown in the next figure.

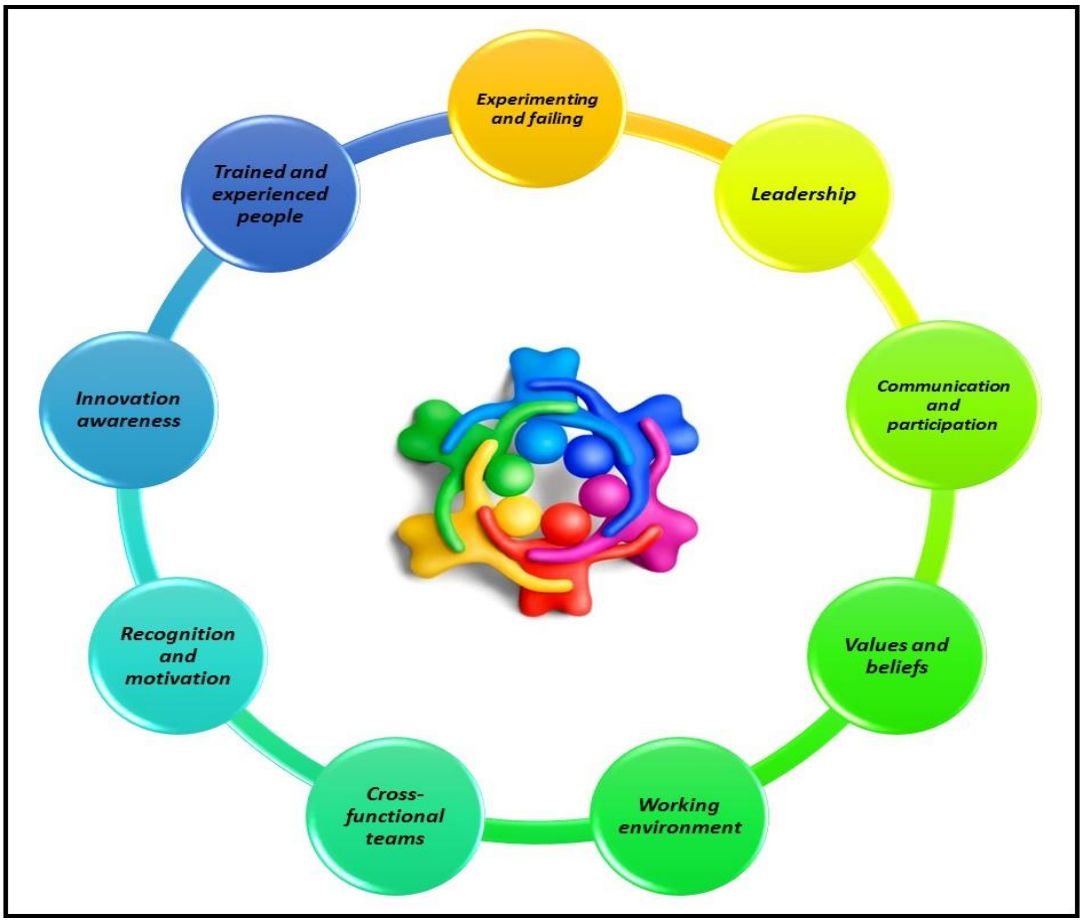

Figure 36 Elements to be considered into the transformation to an innovative culture in Ecopetrol S.A.

First of all it has to work hardly on changing a culture which is afraid of failing. It has been a result of the continuous control done by different governmental institutions which are always looking for the minimum failure to punish employees. It is impossible to think in innovation without thinking in failing some time to time. Through experimenting and failing innovation efforts are enriched and the innovation process is improved. Therefore, failure at innovation has to be seen as part of the natural learning in the organization.

The company also needs to focus its efforts on sensitizing people across the organization and making them aware of the importance and relevance that innovation has for the company. To do this, the company has to allow the resources it may require, and give people time and spaces to work on it. It also should consider the adaptation of some elements which innovative companies have adapted, such as flexible working times and open and funny working environments. Nowadays companies have to adapt to the needs of their employees; it was different before, but now companies have to con-

sider the surrounding conditions of employees such as their traditions, believes, physical conditions, etc., to engage people in any company program. This consideration of conditions may be sometimes more relevant than a motivation program.

> *People in the company have very good ideas, but if you do not give them the time, space and resources to work on them, they will prefer, somehow, to keep doing business as usual. Because if they do new things, create new things, but at the end those things are not sold or not recognized, it won´t make sense for them!!!*

In this way, a recognition program should accompany the innovation framework development, to motivate people to join it. This program must be carefully designed because in general employees of Ecopetrol S.A. feel that the scenarios and programs of people´s recognition that the company has already implemented have lost their essence, and actually everybody by doing minimum efforts may receive recognition. In this vein the recognition program must consider previous experiences and how people in the company may feel attracted to take part in the cultural transformation.

Moreover, the program has to consider that some people are moved by intrinsic motivators in innovation matters while the majority are moved by extrinsic motivators. There are people for everything, it is that are people who are good at ideating while there are others who are good at executing and controlling. Normally people who give many ideas and spend time discovering new opportunities are moved by intrinsic motivators. Those who are good at executing are normally motivated by extrinsic motivators, such as economic benefits. In this sense, economic benefits should be proportional to the input of people in innovation results, so then when people make huge contributions to innovative results through the proposal of good ideas, he or she should be awarded with a proportion of the generated value. It is that if a person generates savings for the company or new income, he or she should receive a bonus with a sum of money which depends on the impact of his or her idea.

Besides getting money proportional to the efforts in innovation, new ways of recognizing people should be exploited. For example public recognition, new work positions, or awards where the family of the employee are involved (i.e. paid vacations for the family during a week), will attract more people to participate. Furthermore, new work spaces, which allow people to work in attractive and relaxed environments, and more time to work on different things will encourage people to innovate more. In this sense, the company should establish and implement a new policy of time, in which people are allowed to work on their ideas during “x” number of hours a week. If the company does not do that, people won´t have time to work on it.

> *We need to set up the house and sweep underneath if we want to leave the day-to-day!!! When you make these important breaks to organize certain things, you reduce re-work and can devote yourself to creating ideas. The second step is to give faith to your ideas. I think that having leaders that challenge others to do new things is a way to go out from day-to-day activities: leaders who challenge you to do different things and build on it together. Part of leaving the day-to-day is definitely asking a question: how have we been doing things along? Then, we will not do so, we will do that differently by exploring of course how the best in the industry are doing that!!!*

Additionally, leaders have to support employees and oriented them to develop innovative behaviors, such as those identified by Dyer et al. (2011) to be more innovative on a daily basis. This, coupled with a measurement of innovation efforts in the BSC (Balance Scored Card) of people, will produce better results in innovation matters in the company and people won´t feel it as an extra work they have to do beyond their normal activities and without any time for it (as it happens currently).

In this way, innovation measurement, which is explain later, is very important, too, because if the company decides to give new spaces for people to work on their ideas, it needs to measure if those practices are giving results for the company. Additionally, when people feel they are also measured for how innovative they are, they start changing behaviors and performance.

> *Actually people in Ecopetrol S.A. are so busy in administrative issues that innovation issues seem to be something remote and alien to them. They may see innovation topics with some curiosity, but prefer not to serve them with all the concentration that should be, because they have too many administrative and management issues in their BSC from which they are measured and ranked if they are successful or not. The people focus on that, but if that does not change it´s going to be very difficult for them to commit with it. Finally, no matter how much people love innovation issues, but if at the end of the year people do not comply with the expected, they will be measured in a bad ranking.*

As mentioned before, trained and experienced people in this industry are difficult to get. There is a high rotation level of employees with good backgrounds and knowledge. Therefore, in Ecopetrol S.A. technical people are junior, and need to acquire more international experience to propose more in the company. In this way the company needs to focus on developing strategies through it can work with high experienced people who

do not necessarily have to work in Colombia (since the low level of attraction the country may offer). Currently the company is creating the excellence centers in Houston, where trained people will work on the most important issued in exploration and production matters. In this way, Ecopetrol S.A. may get an advantage in innovation construction, from the articulation of knowledge sharing and innovation development between two group of employees with different experience and background.

Consequently, Ecopetrol S.A. needs to define the human resources it needs to make innovation happens. It does not mean that the company has to transform its current recruitment process, but to transform the process through the company defines the human resources it wants. Nowadays the best people are recruited based mainly on three characteristics: commitment to life, passionate to excellence and work team abilities. However, beyond that Ecopetrol S.A. should look for innovative people, and to do this it needs to define the innovation capabilities it needs to build, and the behaviors which may be associated with them. Finally, with a good definition of the roles of the employees the company wants and where the company needs them, the valuation tools will give the company the opportunity to find and hire that people.

Surrounding the innovative culture in the company, some other elements are identified to be critical in the cultural transformation of the company to support its objective of becoming a company leader in innovation in the oil and gas industry. Some of the most representatives have to be with what people understand or perceive by innovation, and how leadership impacts innovation results and what is the role of leaders around innovation.

Regarding innovation meaning and perception is clear that there is not a common definition about innovation under the context of Ecopetrol S.A. Many times it tends to be confused with technology, improvement and enhancement. Due to this, it is highly likely that people get confused when trying to define innovation because everyone interprets it in a different way and from different perspectives. As a result of it, and as mentioned in the innovation strategy, the company needs urgently to define innovation under the company´s context. In this way, people would know how to focus their efforts around innovation and everyone will share a common language about it.

> *When one speaks of innovation, and it sounds very nice, when I have conversations about it, people define innovation per se, like: innovation is to innovate...!!!*

Contrary to the innovation meaning, the perception of innovation in the company is shared similarly: the most of people believe the company is on the way to become an innovator, but it is just starting and there is a long way to go.

> *I think our ability to make effective innovation is still limited, and it is expressed in that when one tries to take stock of the competitive capabilities of the company, this is not easy. Perhaps those differentiators we would like to have on the market already exist, but we may not be entirely convinced that we already have them. To me that´s the biggest constraint to growth, because if you do not have clearly identified how you, differentially, add value to the market, then your future in the market is quite uncertain.*
>
> *At the end I think innovation, eventually, must prove its benefits through explicit advantages, and not in a way in which Ecopetrol S.A. by itself divulge or show them, but that such benefits are perceived by our stakeholders. Then those benefits must be shown when I am really an innovator in heavy crude oil and other companies come near me, in example a client or a partner, and tell me: Oh! You are on the top one in heavy crude oil, then we want to maintain a relationship with you!!!*

In this sense, although Ecopetrol S.A. has an element in its strategic framework which state the relevance of innovation and technology, it does not mean that the company innovates because it has been greatly linked to technology. Therefore, in parallel to the definition of what is innovation to the company, it is necessary to analyze the implications it may have for the organization and people´s perception about it.

To support this Ecopetrol S.A. needs a leadership model which cover innovation capabilities in leaders. Without this, the possibilities to move people to be innovators will be limited, because what happens in organizations depends greatly on their leaders.

As a matter of cultural transformation Ecopetrol S.A. needs leaders who boost the innovation model in the company, who always think there is something to be improved and there are no limits to imagination in order to get better results. However, this can be achieved by changing behaviors and routines within people, by starting initially with the transformation of leaders.

> *Recently we are working many approaches to culture, and I believe that culture is transformed under the action over behaviors. In that sense, what to do? Having exemplary leaders in this!!! (…) If leaders do not mobilize organizational innovation as a key element in the daily dynamics of work, innovation is not going to happen. If leaders do not challenge innovation to be an important issue with facts, innovation is not going to happen. If leaders by example do not attempt to modify the realities we have had always, innovation is not going to happen.*

In this way, there are two main approaches for culture change. One is to start working with leaders from the top of the company, and another to start working with the whole population in the company, from the bottom of it. Both approaches may work, even at the same time.

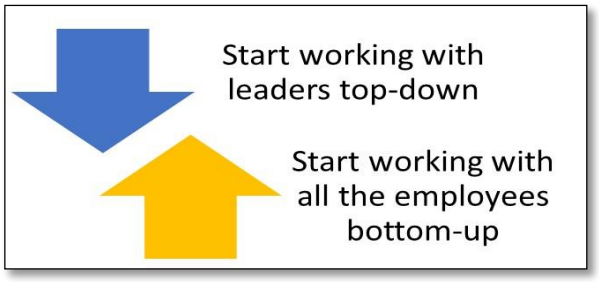

Figure 37 Two approaches to start working on cultural change in innovation in Ecopetrol S.A.

By approaching the whole population, it is necessary to consider the current characteristics of employees. Actually, the demographic population in Ecopetrol S.A. shows that around 60% of employees have worked for the company for the last 6-10 years, around 30% have worked for more than 10 years, and around 10% are new in the company (less than 3 years). New people have different expectations, they normally move constantly between one and other organization. And in an industry like the oil and gas industry, people are willing to work for a while in a company, learn, give their best, and then move to a new place. The question is how to approach those new populations. The answer may be through the challenge, it is through using different motivators, not just money, which are based on big challenges solution. Through them, people may feel more motivated and engaged to work on something for which they are going to be recognized and attracted. Consequently, to approach the whole population in the company, it is necessary to consolidate and mature development and mobilization plans for employees based on challenging the status quo. Through them, people may support better and with more conviction innovation efforts.

> *We should migrate toward retention of people, not a retention given not only through the profits for them, but through challenges and a work development through innovative, flexible and collaborative environments. It will allow us to produce and create jobs in which people do not feel forced to innovate, but to work in different dynamics and work spaces. The new populations, the new workers, are managers who do not believe in ties, indoors, or conventional standards, they believe in challenging the status quo and that's what moves them.*

By approaching the change through leaders, there are multiple strategies to be considered by the company: motivating, communicating, telling others what is happening, and leading by example. The best way a person has to lead a team is by the example. If a leader innovates or support innovation, everyone is going to engage on it. In fact, according to the study of Dyer et al. (2011), innovative organizations are led by innovative people. It means that if a company wants to make innovation as part of it, it has to have innovative leaders. In any case is easier for innovation engagement to go top-down, rather than to go bottom-up direction.

> *Leaders are those who should promote spaces to innovate and implement the tools required to innovate. Leaders have to be the engines which encourage people to use the tools the organization has. Unfortunately today people do not define the spaces in which they can develop new topics and induce teams to do that. Additionally, every leader do not have a basic background and training in innovation level, therefore they do not know what they should transmit in this matter to employees.*

Definitely, innovation is part of the culture of an organization, and culture does not change or transform without a visible and exemplary leadership. In Ecopetrol S.A. who innovate are not necessarily the leaders or bosses in the company. Therefore, leaders need to acquire and develop behaviors which move them to have and foster more innovative behaviors in their teams. Then, if leaders do not understand that innovation is a practice which needs time to be executed, and if they do not understand that they need to be trained about it, they are not going to inspire people to move those issues and think different. Depending on leaders´ attitude to innovation, employees will be more opened or closed to receive and adapt innovation topics in the company. Therefore, it is fundamental to train leaders in innovation matters and focus in their development as innovative leaders who are able to foster innovation issues in the day-to-day activities of their work team. Actually, Ecopetrol S.A. do not count with leaders who are expert in innovation management, which causes loss of efforts in this matter. They need to be formed about innovation basics and attitudes, in order to identify which are the behaviors they need to communicate and foster in their teams.

In this context, communication plays also a relevant role. This is key to transform culture. But when talking about communication this is not about communicating messages by e-mail, but ensuring people knows the message, understand and appropriate it. It demands from bosses to have continuously innovative conversations with employees and in spaces designed to innovate in what people do. It also requires from leaders to identify roles in their teams, it is to be able to know who are good at ideating, who at executing and implementing, and who at controlling. Though the identification of peo-

ple´s abilities and skills to be developed about innovation, the leader will be able to manage better the innovation efforts in the team and get better results from it. In this way innovation can be something which is introduced into the normal routine of people.

Knowledge management and innovation management: Ecopetrol S.A. has a mature level in knowledge management which has allowed the company to get awards and recognition in the market. Nevertheless, many employees feel that although the model is fantastic, it is still very conceptual and people still needs to appropriate it more. Therefore, there is a big opportunity to identify how the knowledge management may leverage innovation efforts and how the company arranges work spaces in which innovation is pushed and everyone is aware about their role in the model.

> *If the knowledge management system, which is an issue that supposedly has taken several years here, was so mature, we would not have the experiences we already have (…) Knowledge management is not just about to know what is the critical knowledge, it is also about how to acquire, adapt and apply it… how to make it a reality.*

Knowledge management in the company has been seen as something in which just a few work, despite the importance it has for an organization in order to continuously check if what one needs is or not inside the company. For example the knowledge network has representatives from different areas but still there are areas which do not have a knowledge actor which focuses on implementing and controlling the model. No matter the big efforts the company has done in the model, there is still a big opportunity to make people feel this as an everyone´s issue.

During the past years it has been possible to ensure critical knowledge. Actually Ecopetrol S.A. has corporative university, which seeks for ensuring the internal knowledge in the company. Additionally the company has made great efforts at documenting knowledge in an attempt to convert intrinsic knowledge into extrinsic knowledge. However this is something that does not happen in all the areas of the company. For example in the ICP everything related to research and development is documented by a technical documentation center. However, innovation results in other areas are not documented which is critical to ensure organizational learning and capabilities building.

Despite the different efforts on knowledge management, the company still has many initiatives which are being developed apparently without focus or priority. For example, the company has implemented a platform to share knowledge and information which has everything an employee may need to share knowledge but which is not used effec-

tively by every employee. In fact, many of them use it to asses an indicator which is in the BSC of every employee. Additionally, when people work in teams, every group of people works as better they think they can. However, silos of information are likely to be established because information and experiences are not totally shared across the organization, and because they work with information sources which can also be employed by others in the company and are not shared. There is a need for sharing more and creating knowledge as a team.

> *If you see it as existence indicators, then you say we are ok!. But when you see the impact of the model I think we still have opportunities to improve it and get more impact through the use of those tools and the results it has generated.*

For many years the company has matured different practices around knowledge management. One example are the knowledge and technological summits which are developed about an interesting topic in the industry and with interdisciplinary teams. As a result of these events, different initiatives are identified to be implemented to generate value for the company. However, these initiatives are not completely implemented and due to this these scenarios have lost credibility in employee's level.

> *Forums of knowledge management have become a mechanism to sell initiatives. Thus, who wants a budget for an initiative just have to go to a forum because the president of the company is there and money can be gotten for the initiative.*

Beyond the current practices around knowledge management, the company should also focus on moving employees to different areas, it means that they are allow to get experience in different areas of the company which may help them to open their mind and share knowledge with others. This is important because around 70% of the knowledge is intrinsic (it is in people´s head and not in manuals) despite the great efforts the company has done on documenting knowledge to ensure and transfer it. In this way, for example, when there is an acquisition of a new company specialized in offshore, then the knowledge transfer is not limited to have a manual, but on to identify who are the resources and how they are going to be moved to acquire the knowledge. That knowledge management is crucial because the knowledge is hold by a few, and considering the high rotation level of trained people in the industry, when experienced people leave they keep all the knowledge with them and then the company returns to a starting point.

The next figure shows how knowledge management can leverage innovation efforts through the use of the existing scenarios and practices established in the company where people interact and share knowledge.

Figure 38 Innovation results leveraged by knowledge management in Ecopetrol S.A.

As shown in the figure, innovation must take advantage of the walked path that knowledge management as a discipline and methodology in the company has achieved. Due to this, those scenarios which already exist as well as those tools for knowledge management, which are known by the majority of the employees, are in fact scenarios where people can innovate and identify new opportunities for the company. Therefore, the knowledge which is captured, transferred, created, shared, leveraged, registered, and allocated can be used to innovate through organizational learning processes.

Finally, knowledge management is like innovation in the sense that if a company wants it to work and generate value, it must be on people´s heads and hearts, otherwise it is likely impossible to achieve the best results from it. This is the aspect in which Ecopetrol S.A. still needs to work hard.

Innovation measurement: Actually in Ecopetrol S.A. there are just a few metrics used to measure the innovation efforts and how they are generating value. Many of those metrics are well developed in the project maturity model, which allow the compa-

ny to measure the benefits that a project can have and how it is achieved through the time. However, those measures are exclusive of those who work with projects, it is that in general to measure innovation efforts across the company there is not a common metric, except from those regarding patents number and investigation investment.

In general, there are different and multiple ways to measure innovation. However, the company has to focus in defining the way as it is going to measure innovation efforts in employees and the transformation of culture to an innovative one, as well as how it is going to identify whether innovation is impacting the income and reputation of the company in the market.

Regarding the employees' measurement in innovation and the culture transformation, in the company people´s performance is rated by using BSC (Balance Score Card), and in the learning and growth perspective, issues about knowledge and innovation are considered. However, there is not a standardized metric used to measure innovation and in some cases the closest approach to it is to measure the number of ideas generated to improve a process. Unfortunately this measure does not suit well for everyone since many people just feel they have to propose something, no matter its quality. It is a matter of obligation if it is directly in the BSC of employees.

Nevertheless, there is an opportunity to include something in people´s performance measurement with which people may feel more comfortable. It is about something the company calls "organizational capabilities". These capabilities are measured periodically in a work session between an employee and his/her boss. In this work scenario three capabilities are valuated: life commitment, work team skills, and operational excellence. Due to the fact that innovation should be something which is across the organization and should be present in everyday activities, what is purposed by the author is to include a fourth organizational capability called "innovative skills". This is proposed based on the study done by Dyer et al (2011) in which the researchers suggest 5 discovery skills related to the most innovative companies and people around the world. Those skills are associating, questioning, observing, experimenting and networking. According to Dyer et al (2011) innovative companies are almost led by innovative leaders whose exhibit these discovery skills to spark new ideas. Therefore what they suggest is that if a company wants to be innovative, people across the organization should develop these skills through the change of their behaviors in order to improve their creative impact.

> *Nowadays in Ecopetrol S.A. we measure organizational capabilities and we have already defined who we are and what our responsibilities as collaborators and leaders are. But if you explore today, there are not specific skills to innovation. We are committed to life, passionate for excellence and with team spirit, and suddenly there, on the side of passion for excellence, there is an element out there related to innovation, but only tan-*

> *gentially. However if you go back and incorporate the theme of innovation as one of the cultural components, and say: innovation is a competence that every employee should exhibit in some level, then innovation would become an important component in measuring individuals' performance.*
>
> *Organizational competencies weigh today almost 30% of the performance agreement of an employee, and they are defined in terms of behavior associated to some capabilities. It could work better if I start to demand behaviors from my colleagues that demonstrate daily and systematic efforts to be more creative and innovative… Now, these issues have to be installed well in the minds of employees and leaders.*
>
> *Suddenly, it may help us to push more innovation across the company, because currently if you do not have it included into your performance agreement and if you do not feel it impacts your personal results, surely it won't attract you (…) In that way we could make that innovation becomes behaviors that can be transformed in measurable capabilities in Ecopetrol S.A.. It may take around two years or less to be implemented.*

To do this, the company needs to be aware about the importance of innovation in the goals achievement and about how relevant is to measure innovation results. This is something that apparently the company is cultivating, and for which the company may be ready to implement.

However the implementation of those metrics and measurement ways must be done according to the evolution of the innovation model. At first the metrics must be arranged to measure people´s participation into the model throughout the incorporation of the fourth organizational capabilities rank into the BSC. Additionally the company has to continue with the current metrics it uses related to the investment in R&D activities, number of patents registered and obtained, and expected benefits from the execution of projects. Then, when the model is more mature and the company has implemented the model with third parties and using corporate venturing, besides the use of metrics associated with the benefits generated by innovations, the use of metrics associated to the creation of start-ups. This is shown in the next figure.

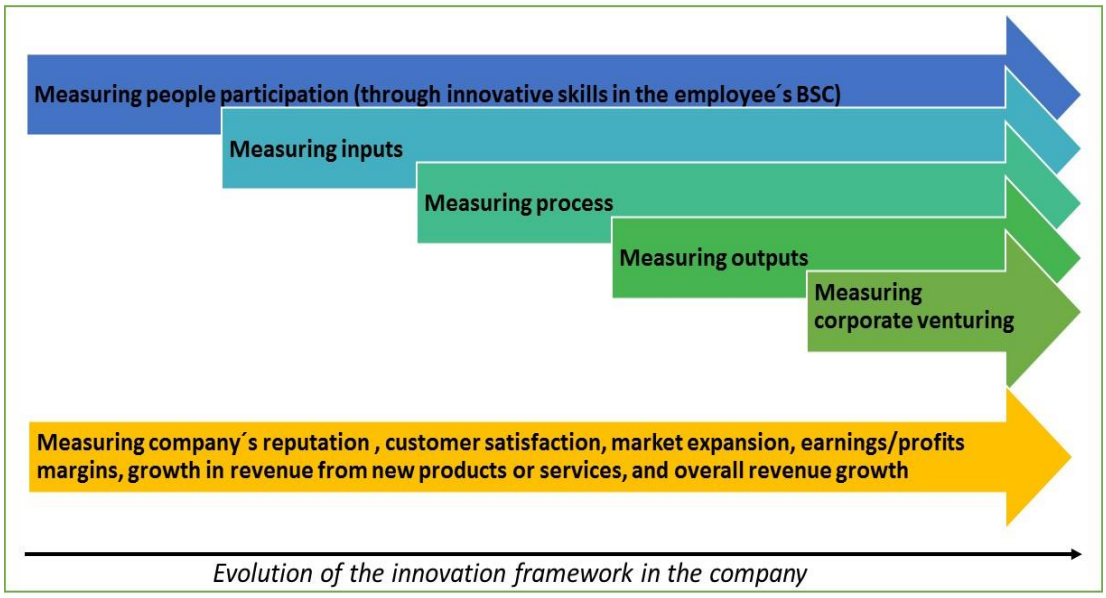

Figure 39 Implementation of metrics to measure innovation in Ecopetrol S.A.

Based on this and what was proposed by Cooper (2009), the metrics proposed to measure the model and innovation elements such as inputs and knowledge management, innovation strategy, organization culture and structure, portfolio and project management, and commercialization, can be summarized as follows:

Inputs: R&D expenditures, number of application for a patent, number of ideas proposed by employees per year, percentage of employees for whom innovation is a key performance goal, percentage of employees who have received training in innovation, number of innovation tools and methodologies available to employees, and the existence of an innovation leader and an area to guide innovation among the company.

Process: Percentage of workforce time that is currently dedicated to innovation projects, implementation rate (i.e. number of ideas implemented in a year), level of people´s participation in ideation programs, averaged time from ideas submission to commercial launch, and percentage of executive´s time spent on strategic innovation rather than day-to-day operations.

Outputs: Number of approved patents, benchmarking innovation capacity, number of new products, services, or business models launched in a year, the change in the company´s market value during the past year divided by the change in the total industry's market value during the same period, number of new competencies measured as a simple count among a threshold proportion of employees, and return on investment on innovation projects.

In a general way, the company can also use other metrics to measure how effective is innovation for the whole company and its results. Some of them are customer satisfac-

tion, market expansion, earnings/profits margins, growth in revenue from new products or services, and overall revenue growth.

Finally, regarding the measurement of the reputation of the company and according to the vision of Ecopetrol S.A. by 2020, the company needs to know if it is seen as an innovative company in the oil and gas. To do this, it is necessary that the company list in international rankings such as those published by Bloomberg, Forbes, Fast Company, Top 100 innovators, etc. For example, and according to what was researched by Dyer eta al (2011) in the Innovator´s DNA, in a recent issue of Forbes the authors created a list of the most innovative companies operating in the world today by measuring something which is called "the innovation premium" a metric defined as the proportion of a company's market value that cannot be accounted for from cash flows from its current products (Forbes 2012). The list was limited to companies with large market caps and those that are publicly listed, from which several oil and gas contractors firms made the list of the top 100 innovative companies, including FMC Technologies (in the ranking 18^{th} is the highest among oil and gas firms), Schlumberger (ranking 27^{th} is the second among oil and gas firms), China Oilfield Services, Cameron, Tenaris, and Halliburton.

Open innovation: In general, this a concept which is not well known and understood by everyone in the company, and even in other company of any industry in the country. Just up to now the term is being developed by some companies in other sectors, and in the oil and gas sector, especially in Ecopetrol S.A. the issue is not used appropriately. Nevertheless, open innovation is something on which the company has to be involved if it wants to really be an innovative company, because the organization alone won´t be able to achieve its strategic goals. Definitely it needs to have partners in its innovation efforts.

When asking people about this topic, they tend to suggest that open innovation can be done through working with third parties such as Colciencias (Colombian center for science and technology) and universities. These are the most common parties people identify since they have worked on hands with the ICP. In fact, since 2004 the institute has managed others in academic institutions work for Ecopetrol S.A. technological challenges and actually has around 500 people in universities working thanks many alliances with different schools and universities, even outside the country.

> *We are seeing that in Colombia we have not managed to consolidate a relationship with the industry, the operating companies, the service companies and the academia. The academy has a potential industry level we have not taken advantage of. I think that we are missing more collaborations, and I think that we can push the issue of innovation in an orga-*

> *nized and systematic way and while generating value. Nevertheless, the current work with universities seems to be lost and efforts are nonsense.*

However, there is still a big opportunity to work with scientific and research institutes, and strengthen this alliances while giving more focus to the current efforts with these parties and open up the options to do open innovation. This good practice the ICP has with third parties in the academic world, has not been replicated in the rest of the organization. Therefore there is a big opportunity to spread this experience across the company so other areas can make alliances with universities and manage to have others researching and working for the solution to their problems.

> *I feel that each of us in the company could have a group at a university giving them ideas and taking advantage of mine. I could multiply it by the number of employees that I have and the number of contractors would be unlimited. Each group could have freely its own team at a university working on the company´s issues. This is also a win-win relation because students need topics which to work on, that in turn give them productive experience and prepare them to work in the industry. The company also wins because it is captivating talent who are better prepared!!!*

Another options that the minority of employees perceive in open innovation have to be with other parties such as suppliers, clients, communities and other kind of stakeholders. In fact, there is a great opportunity to work open innovation with suppliers considering the huge amount of core operations which are subcontracted with a third party in this industry. Therefore it is necessary to develop a strategy which involves suppliers into the innovation model and leverage their knowledge and expertise, as well as their willingness to do business with the company in order to solve current challenges and create more value for the company.

To do this the company has to work on simplifying its supply chain practices, because although it has the figure of long-term contracts, there is not anything identified in there about innovation relationships. Of course there is not option to work collaboratively with all the suppliers, so then the company has to prioritize in which kind of contracts, purchases or services, the company can focus its efforts to have long-term relationships which consider investments in R&D activities (i.e. drilling projects, engineering projects, etc). Furthermore, there must be people at managing these relationships in innovation matters with suppliers which are responsible for controlling the contracts and ensuring the value generation.

> *I believe that strategic alliances has been something that we have not been able to build in Ecopetrol S.A., neither with suppliers nor with partners. This is a speech we have not been able to do well! And we have not been able to do it because we do short-term calculations in everything and our financial concerning weighs too much. It does not mean that we will not now consider it, that nobody here is going to do business, no, but one has to find that balance. That's a job for partners and suppliers as well as for the inside of the company.*

Open innovation with competitors and other companies in the same industry is both easy and difficult, it depends on the situation. In the oil and gas industry companies sometimes are rivals in the same project or market demand, while in others they are partners for any business. It is because companies need to share risks when they bid for a new territory where they may find oil. In this way, if a company in the sector is directly asked to share knowledge with another company it is likely that the company does not give it so easily. But, in another situation when working together it is likely that knowledge is transferred, then it depends on which people are acquiring that knowledge in the field, to transfer it later to the whole organization. Finally what links companies is a common objective: an oil field drilling.

Another way the company has to open up to the world in innovation matters is by having an open platform in which third parties can participate and add value to the system. Many companies actually do not have a R&D department but they use a lot portals which are opened to general people (other companies, partners, competition, etc) and they are having good results from it: by telling the world their problems and receiving from external parties possible solutions.

> *A few years ago I did not know the portals but today there are already very used by companies. Then one says, Ecopetrol S.A. is in default of doing it!!!*

However, and as suggested by Enkel et.al (2009) and Ollila and Elmquist (2011), there are some risks which must be contemplated by Ecopetrol S.A. related with intellectual property rights in the country, the natural position of the company (the biggest in the country), and the various interests of different external parties surrounding the company. The next figure shows the comparison between risks and benefits of open innovation.

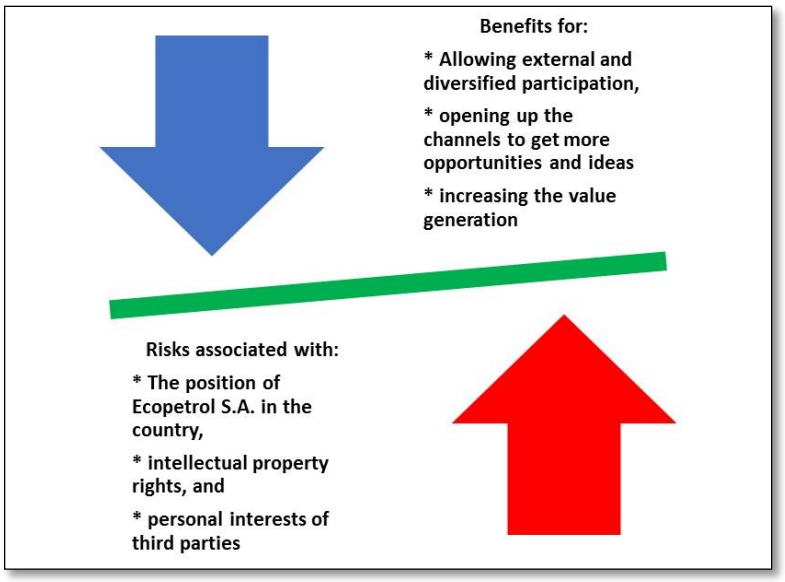

Figure 40 Benefits against risks for implementing open innovation in Ecopetrol S.A.

Legislation about intellectual property rights has not been clearly defined in the country which still has many gaps about this matter. This, coupled with the size and impact of the company in the country and the interest different parties such as suppliers, communities and customers may exhibit, make open innovation something which has to be implemented very carefully by the organization. For example, there are many suppliers and communities whose businesses depend on having Ecopetrol S.A. as a customer, and due to their problematic behavior when they do not succeed in their contractual proposals they dedicate a lot of time to sue and fight against the company in order to get some money.

This situation can also happen when the company opens up its innovation network and gives them the opportunity to suggest ideas to improve or change current conditions. Thus, if they are not chosen for having very good ideas or something similar, they will sue to the company with different arguments in order to get some future benefits. That is just one of the many examples and scenarios that can be possible when interacting in this matter with external parties.

> *Open innovation works when I have allies and I'm thinking more in long-term relationships. We should perhaps function more like private business, perhaps. We have many model constraints!!! So I cannot select allies deliberately, I would have to do a thousand things to have an ally in the supply of everything (i.e. suppliers of pipes, sheets tank, pumping production wells). I think there are some restrictions that do not let as to make different things.*

In this vein, at implementing open innovation the company needs to be aware of the various interest different parties may have with it. By being the biggest company in the country and the one that impacts the most the national economy, the company is seen by many as an opportunity to get money. Therefore, many companies want to develop alliances with Ecopetrol S.A. and many others around them are ready to claim legally for some extra participation.

Consequently, at first, it is highly important to identify preliminary criteria to select the participants in open innovation programs in order to clarify with which companies Ecopetrol S.A. is interested in working on innovation. Otherwise, there is a high risk at opening the system and create expectations in many parties which will end in lawsuits and problems. The identification of participants would be easier when Ecopetrol S.A. identifies the innovation focus because with this in mind it can define which are the best companies and institutions in those matters. Nevertheless, the company needs to keep opened its external communication channels to listen to everybody who wants to take part in the program, and with a clear strategy it may be possible to tell others what is the orientation of the program and what Ecopetrol S.A. is looking for.

Based on this, the company needs to create a relations plan to identify potential partners in technology, knowledge and innovation matters. With the identification of those parties which can help the company with its innovation objectives, the company needs to contact them and through a consolidated and well-structured strategy identify how to leverage efforts in a consolidated way. It also helps the organization to validate and consolidate its vision about the industry and strengthen its relations with academic institutions, other companies and governmental institutions.

Beyond this, at first Ecopetrol S.A. needs to identify which are the issues it wants to solve through open innovation and which internally, and which technologies it needs to buy or to develop inside the organization. On the one hand, there are other issues which involve intellectual property rights and generate competitive advantage for the company. These issues should not be worked completely with third parties, but conserving the great efforts for Ecopetrol S.A. On the other hand, there are many things which results depend on different actors, therefore it won´t be a problem to share benefits with them and collaborate collectively in the construction of those things. Ecopetrol S.A. does not have the experience in many fields in which it is going in (i.e. unconventional hydrocarbons). Due to this the company needs to develop innovative business models in order to attract another company which has the expertise and needed knowledge to develop collectively those unknown issues. It is important that in these alliances the knowledge and technology transfer is given.

> *It is different if we develop unconventional theme for ourselves than if we do this by having a partner to help us which already has experience.*

> *Ding it by ourselves it could take 10-15 years, whereas if you go with a partner it could take 5-7 years!!! There's a tangible benefit. Then it is about identifying sustainable growth opportunities where we can develop skills as well as generating or transferring knowledge or technology. That is the main topic which we should attack.*

Despite the huge opportunities the company has at doing open innovation, it is highly recommended that the company first implement its innovation model and with a level of maturity around it, opens its innovation channels and programs to work with others. Although it sounds a little late, it seems to be the best path to avoid problems for the company´s reputation. It means that if the company continues during 2013 with an implementation of an innovation model, by the end of 2014 it can practice in a consolidated way open innovation with third external parties which are expert in those matters the company has defined in its innovation strategy.

> *Doing open innovation in Ecopetrol S.A. requires a lot of efforts to make it well. Generating open scenarios when you are the first company in the country can overwhelm your ability because not all the suppliers, communities, citizens, and customers can build on it. This is a complete challenge which we must do, but we have to focus very well in what issues we manage through this and how we do open innovation!!!*

The next figure summarizes the mentioned steps that Ecopetrol S.A. should follow up to implement open innovation while balancing risks and benefits from it.

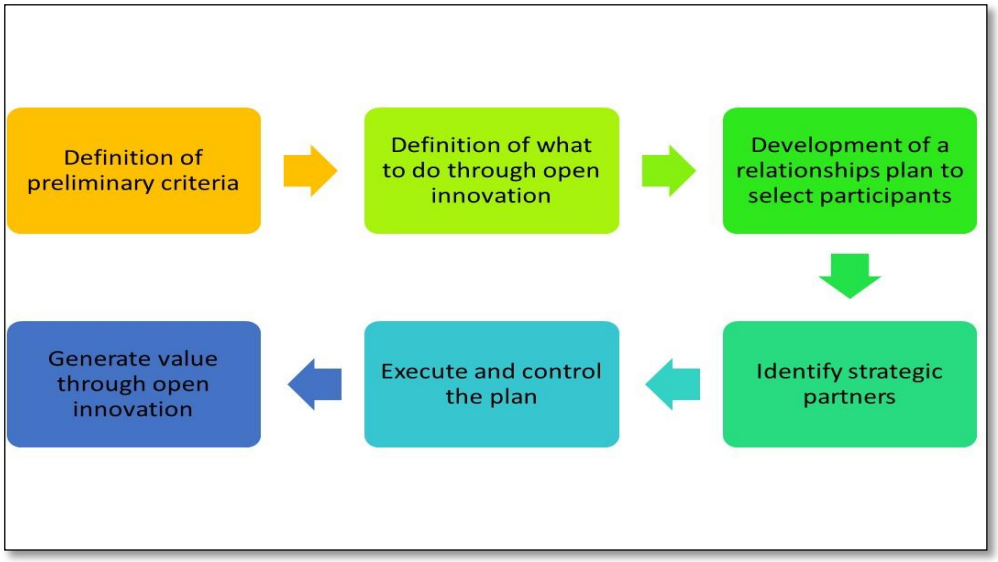

Figure 41 Steps in the implementation of open innovation practices in Ecopetrol S.A.

Due to the importance of open innovation in any company today, this topic constitutes something the author suggests needs a deeper research in the future in order to analyze the best way of implementing and sustaining this practice based on aspects like open innovation in third developing nations and in state companies.

Resources for managing innovation: Actually Ecopetrol S.A. has an austerity policy since it has realized it needs to reduce its operations costs. Throughout this policy the company has restricted the resources it normally allocates to the development of projects and some other activities. Due to this, resources are more limited and for the next years this policy is planned to continue across the company.

Under this situation people are asked to do what they did before but without less use of resources. Although it stimulates innovation in the sense that people need to think how to do things differently and more efficient, it also impacts the innovation model since the resources designated to this purpose are more limited. Therefore it constitutes a limitation the implementation of the model may have.

No matter this limitation, the company needs to allocate different resources in order to get different results throughout innovation, especially if innovation can help the company to look for efficiencies and find new cheap ways to operate.

In this way, resources to innovate in the company could be divided into resources to enable innovation efforts and resources to make innovation works.

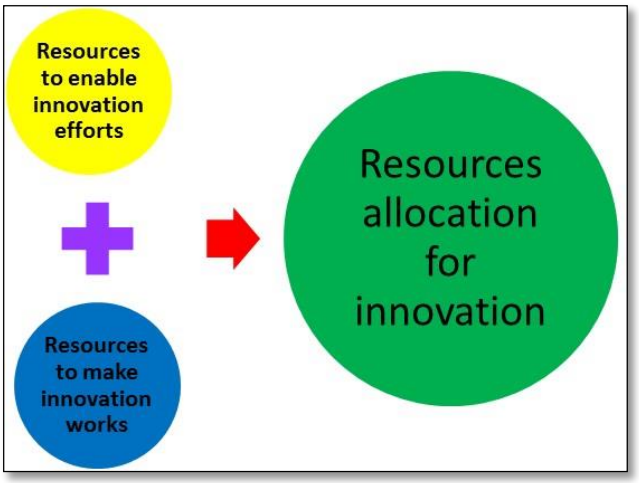

Figure 42 Type of resources required for innovation in Ecopetrol S.A.

On the one hand, resources to enable innovation efforts have to be with flexible work schedule, collaborative work environment (open areas to share experiences, knowledge and ideas), time to work on innovation, and money. On the other hand, resources to make innovation works have to be mainly with trained people and money to support the innovation portfolio and a recognition program for participants.

> *I do not think we have not done innovation because of economic or financial problems. In Ecopetrol S.A. we have had abundant resources during the last years. Contrary I think that our biggest resource has to be with human resources. I think we have had obtuse recruitment policies, and we still continue to move with them, so then we have in many areas people who lack of enough experience, background and academic levels.*

Besides money, people is the most common and asked resource to innovate. Trained people in technical issues are difficult to find, hire and hold in a company of this industry. Therefore, the company needs to focus on developing strategies which allow them to attract and keep experienced people inside the company, and if not possible strategies to work with them externally in order to use their abilities and backgrounds to build on the company´s innovation objectives. It goes on hands with motivation (incentives, cognition and career plan) and cultural issues explained previously.

The innovation portfolio is the base for the allocation of the resources for the development of the innovations the company has selected. In this way, in the portfolio the different projects must be prioritized to select those who are going to be developed in a year. This selection should consider that projects in the oil and gas industry and in the public sector normally take more than 3 years to be completed, and that other kind of improvement plans normally take from 1 to 3 years to be completely done. After defining the projects and plans to be executed the company will know the money it needs to execute them, but it also needs to define the allocation of human resources to work on them.

Finally, with these selections and definitions, Ecopetrol S.A. will be able to build its innovation plan which integrates the projects to develop and the resources it needs to allocate to execute the plan. This distribution must be coupled with a continuous allocation of resources to support the development of an innovative culture and the implementation and control of the framework for the management of innovation.

5.3.2 Defining the interrelation of the elements into the system

An analysis of possible relationships and interactions within categories and between them is presented in the next table. Those relationships were built on a matrix (2x2) in which the categories were listed in column “a” as well as in row “b” to be compared. As a result, and based on the literature review, three kind of relationships were identified between the different categories, as follows:

Relation of content: The aspect in the column “a” contains the aspect in the row “b”.

Relation of impact in the definition: The aspect in the column "a" impacts the definition of the aspect in the row "b"

Relation of impact in results: The aspect in the column "a" impacts the result of the aspect in the row "b"

As a result of this analysis, it is possible to see that results of categories such as innovation framework, innovation strategy, innovation process, people and innovative culture, and resources for managing innovation, are impacted by all the nine defined categories. It means that the results of the mentioned categories depend on the performance in every category into the innovation system. In a similar vein, technology management results are impacted by the identified categories except from innovation process since the relation between those categories is a relation of impact in the definition.

The only category which has relation of content with another category is the innovation framework which exhibits relation of content with innovation strategy, innovation process, knowledge management, technology management, innovation measurement, and open innovation.

Moreover, innovation measurement is the unique category which is impacted on its definition by all the nine identified categories. It happens similarly with resources for innovation category, which is also impacted on its definition by all the identified categories except from innovation measurement, and also with people and innovative culture category, which is impacted in its definition by all the identified categories except from innovation measurement and resources for innovation.

Finally, there is a vital connection between innovation strategy and all the categories, since innovation strategy impacts the definition of all the categories, which in turn impact the results of innovation strategy.

Table 10 Interrelation of elements involved into the innovation framework in Ecopetrol S.A.

	1. Innovation management framework	***2. Innovation strategy***	***3. Innovation process***	***4. Technology management and innovation management***	***5. People and innovative culture***	***6. Knowledge management and innovation management***	***7. Innovation measurement***	***8. Open innovation***	***9. Resources for managing innovation***
1. Innovation management framework		Relation of content	Relation of content	Relation of content	Relation of impact in the definition	Relation of content	Relation of content	Relation of content	Relation of impact in the definition
		The innovation management model contains the definition of the strategy as well as works according to it.	The innovation management model contains the steps defined in the innovation process as well as works based on them. It is what allows an idea to become real.	The innovation management model contains the technology management which leverages the innovation process in two ways: as part if the innovation	The innovation management model defines the north of transformation in innovative organizational behaviors. It also defines how people should adapt	The innovation management model contains the knowledge management which leverages innovation results. If knowledge and its transfer are not	The innovation management model contains the innovation measurement which allows to identify if the model is developing as expected, if the strategy is	The innovation management model contains the process of open innovation which let innovation to be leveraged from	The innovation management model defines the resources required for the model implementation and strategy achievement.

				itself, and as a platform for innovation development.	innovation to their operations and common routines.	ensured the innovation value generation is highly affected.	being achieved and if the innovation is generating value for the company.	external parties participation; based on this more synergies can be possible.	
2. Innovation strategy	Relation of impact in the definition		Relation of impact in the definition	Relation of impact in the definition	Relation of impact in the definition / Relation of impact in results	Relation of impact in the definition	Relation of impact in the definition	Relation of impact in the definition	Relation of impact in the definition
	The innovation strategy guides the innovation management framework by defining how to achieve the		The innovation strategy impacts the definition of the innovation process due to that, depending on what the company	The innovation strategy defines whether the company should focus on acquiring the required technologies or on	The innovation strategy defines the innovative culture which needs to be developed. It also defines what human	The innovation strategy defines what knowledge is needed to achieve the company´s goals. Based on this, it	The innovation strategy defines what the required value needs to be generated. In this sense, the innovaiton measurement	The innovation strategy defines in which situations open nnovation is the most suitable for	The innovation strategy defines where the firm should go in innovation matters, and the roadmap for

	goals. It establishes a road map to be followed by the company.		wants to achieve, the selection criteria and prioritization at every stage of the process also vary to focus on one or another type of innovation or domains of innovation	developing them. It also establishes which platforms leverage the innovation process. The definition of the company growth impacts the technologies which will be required. It also defines the technology appropriation, commercialization and licensing levels.	resources are needed and their leadership skills, organizational behaviors and motivators. On the other hand, the results of achieving the strategy impact the results of cultural transformation since they influence people´s organizational culture understanding and perception	defines the knowledge sources and the knowledge strategy by defining whether the knowledge must be transferred/acquired or developed inside the company	defines which metrics must be controlled in order to identify the innovation strategy achievement.	the organization. It also defines which are the potential partners or allies whom develop open innovation with, and the value that is expected to be obtained.	it. Based on this, it defines which resources are required to leverage this purpose.

					which define people`s willingness to leverage innovation				
3. Innovation process	Relation of impact in results	Relation of impact in results		Relation of impact in the definition	Relation of impact in the definition / Relation of impact in results	Relation of impact in the definition	Relation of impact in the definition	Relation of impact in the definition	Relation of impact in the definition
	The innovation process definition impacts the definition and structure of the other elements to manage innovation. Therefore, the value	The innovation process definition impacts the innovation strategy achievement due to that its successful development depends on the complexi-		The innovation process defines what are the technologies required to support the innovation process execution. In the same vein, inside of the innovation	The innovation process defines, somehow, what are the capabilities that people should develop as well as the organizational culture and other cru-	The innovation process, supported in the strategy, defines the knowledge to be managed and guaranteed across the different stages of the innovation	The innovation process, supported in the strategy, defines the metrics that must be considered in each stage of the process to measure the value genera-	The innovation process defines how to apply open innovation depending on the solution that is searched or the need that must	The innovation process, supported in the strategy, defines what resources are needed for the implementation of each stage of the innovation process.

	generation is also impacted throughout the implementation of the model. Following to the strategy and innovation roadmap, the innovation process is the core of the innovation model.	ty and rigidity levels of the innovation process. In this way, the total time required to develop completely the innovation strategy is also affected.		process, there is a stage where the technologies that are required to innovate are defined.	cial aspects which need to be considered and developed for a successful implementation of the innovation process within the company. On the other hand, the innovation process´ results impact the results from cultural transformational efforts and human talent development, since the more good results	process.	tion, and the resources use and status of the work schedule of each initiative that is developed.	be satisfied.	

					people see from the innovation process, the more people feel it pays and the more they feel motivated to engage into the process and change their innovation company´s perception				
4. Technology management and innovation management	Relation of impact in results	Relation of impact in results	Relation of impact in results		Relation of impact in the definition / Relation of impact in results	Relation of impact in the definition / Relation of impact in results	Relation of impact in the definition	Relation of impact in the definition / Relation of impact in results	Relation of impact in the definition
	Technology	Technologies	Technologies		Technology	Technology	Technology	Technology	Technology

	management impacts the results of the the innovation framework since it leverages the way as the innovation strategy is achieved. Its mission is that of offering a platform for an efficient execution of process and operations within the company.	make possible the strategy, so then innovation strategy results depend on technology management	act as a platform for the innovation process as well as for process innovation. In the same way, during the implementation of some technological initiatives, it makes part of the innovation process, since the final product is the development or acquisition or a new technology. In both cases, technology acting as a		management defines what capabilities and organizational culture should exist in the company to enable the use of technologies (development, appropriation, adaptation, patenting, licensing). On the other hand the results obtained from the management of technology impact the results from	management defines what technologies are required for the management of knowledge as well as what kind of knowledge is needed for the management of technology. On the other hand, Technology has a great impact on organizational learning since technical systems within a company define	management defines what metrics are needed to measure the effectiveness of technology management within the firm.	management defines the platforms in which open innovation can be done. It also defines what should be the focus in the searching for technologies when practicing open innovation. On the other hand, the results of open innovation	management defines what resources are needed to make possible the achievement of the technological goals.

			platform or as part of the innovation process, technology management impacts the results of the innovation process. Finally, how able is a firm to develop innovation depends on its scientific and technological capabilities as well as its technological management capability		cultural transformational efforts and human talent development, since the more good results people see from technology management, the more people feel it pays and the more they feel motivated to engage into technology management and change their innovation company´s percep-	the way as knowledge flows and is accessed by employees and third parties. Additionally, results in knowledge management are impacted by the use that people give to the technological platforms designed for it. For example due to a bad use of those platforms information may		are impacted by the use that people make of the technological platforms for open innovation. In this way, a deficient use of the technological platforms may produce loss of information and opportunities in the market.	

					tion.	be lost and knowledge may be transferred inappropriately.			
5. People and innovative culture	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results		Relation of impact in results	Relation of impact in the definition	Relation of impact in results	Relation of impact in the definition
	A transformation in culture is fundamental for the success of the innovation model. If there is not an innovative culture within the company the framework hardly will	Having human resources with the capabilities and required knowledge, and in parallel experiencing an innovative culture across the company, impact the results of the innovation strategy. It is	Having human resources with the capabilities and required knowledge, and in parallel experiencing an innovative culture across the company, impact the results of the innovation process. The more compe-	Having human resources with the capabilities and required knowledge, and in parallel experiencing an innovative culture across the company, impact the results of technology management. It is because if		Having human resources with the capabilities and required knowledge, and in parallel experiencing an innovative culture across the company, impact the results of knowledge management.	Having human resources with the capabilities and required knowledge, and in parallel experiencing an innovative culture across the company defines what metrics are needed to measure the	Having human resources with the capabilities and required knowledge, and in parallel experiencing an innovative culture across the company	Having human resources with the capabilities and required knowledge, and in parallel experiencing an innovative culture across the company defines what resources are

	give good results. Skilled and trained people in innovation is a critical factor at innovating in Ecopetrol S.A.	because the strategy may take more time to be fulfilled if people take more time in adopting the required innovative behaviors and routines.	tent and skilled the human resources are, the better the results of the innovation process and the more the value generation from the innovation efforts.	people do not have the knowledge and the required competences, it is likely that results cannot be achieved in the level of technological development, appropriation and commercialization.		In this way, when people do not open to change and do not engage with cultural transformation and organizational learning in pro of innovation, it is not possible to ensure the innovation results.	evolution of the process of transformation to an innovative culture, and the value generation from innovation.	impacts the results from the practice of open innovation. It is due to people who practice open innovation in the company need to know how to proceed in order to get the expected results; if people are not trained to do it, results are not as ini-	needed to make possible the continuous transformation of the company´s culture to a more innovative one.

								tially projected.	
6. Knowledge management and innovation management	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in the definition / Relation of impact in results		Relation of impact in the definition	Relation of impact in results	Relation of impact in the definition
	Knowledge management impacts the results from the model, since it is responsible for the strategies for the acquisition and transfer of knowledge for innovation across the organiza-	Knowledge management impacts the results from the development of the innovation strategy. It is because knowledge management allows the value generation while avoiding the	Knowledge management impacts the results from the innovation process since knowledge needs to be managed in each stage of the process in order to ensure the expected results and support the	Knowledge management impacts the results from technology management. It is because if technologies for knowledge management are not employed properly, these technologies will be underuti-	Knowledge management defines what capabilities and organizational culture should exist in the company to ensure the knowledge generation and transfer. It also defines what kind of knowledge		Knowledge management defines what metrics are needed to measure if knowledge is being generated, ensured and transferred, and if it is supporting innovation efforts.	Knowledge management impacts the results from open innovation practice. It is due to the need of ensuring the knowledge generation and appli-	Knowledge management defines what resources are needed to leverage innovation from knowledge management.

	tion.	wheel reinvention. It also impacts the definition of clear needs and the identification of viable alternatives which generate benefits.	organizational learning. This in turn allows the innovation capabilities building.	lized and will cost more for the organization. Additionally, the knowledge to manage each aspect of technology must be ensured and managed in order to get the expected results.	(explicit, implicit) is to be developed in each stage and how people should focus their daily activities to organizational learning. On the other hand, results gotten from knowledge management impact the results from cultural transformational efforts and human talent development, since the more			cation in each stage of the practice with the purpose of guaranteed the expected results. If it is not possible organizational learning may be limited and the company can loss valuable knowledge acquired from the work with third par-	

					good results people see from knowledge management, the more people feel it pays and the more they feel motivated to engage into organizational learning and change their innovation company´s perception			ties. Then, innovative capabilities building may be hardly achieved.	
7. Innovation measurement	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results		Relation of impact in results	Relation of impact in results
	Innovation measurement impacts the	Innovation measurement impacts the	Innovation measurement impacts the	Innovation measurement impacts the	Innovation measurement impacts the	Innovation measurement impacts the		Innovation measure-ment im-	Innovation measurement impacts the

	results from the innovation framework implementation. Throughout the use of metrics it is possible to assess the implementation of the innovation framework, the strategy achievement, and the levels of value generation for the company.	results from the strategy development. It occurs in two aspects: firstly, without the use of metrics it won't be possible to identify if the strategy is or not achieved; secondly, based on the results of measuring innovation performance, it is possible to know what elements need to be rein-	results from the innovation process. It is because without measuring, it won´t be possible to identify the progress in the generation of value in each stage of the process. Furthermore, without the use of metrics it would be difficult to know the advance of work schedules and use of resources. Finally when	results from technological management because without measuring it won´t be possible to identify the impact that different technologies are exhibiting. It also allows to identify if what has been established related to the technological adaptation, appropriation, commercialization and licensing, is	results from the transformation of culture into a more innovative one. Without measurement it won't be more difficult to identify if the culture is evolving to leverage innovation, and if human resources support the innovation efforts.	results from knowledge management because without the use of metrics it won´t be possible to identify if the knowledge is being ensured and used to leverage innovation.		pacts the results from the open innovation process. Throughout the use of metrics it is possible to assess the value generation in each stage of the process. Furthermore, without the use of metrics it would be difficult to know the advance of	results from the resources´ consumption while letting to assess the effectiveness level in their use. At the same time it allows to identify corrective and preventive actions to be taken to improve or maintain resources consumption for innovation.

		forced or adjusted to achieve the main purposes at innovating.	measuring, the obtained results allow to define corrective and preventive actions to guarantee the value generation throughout the innovation process.	being achieved as expected.				work schedules and use of resources Finally when measuring, the obtained results allow to define corrective and preventive actions to guarantee the value generation throughout the work with third parties in open inno-	

								vation.	
8. Open innovation	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in definition / Relation of impact in results	Relation of impact in the definition	Relation of impact in the definition		Relation of impact in the definition
	Open innovation practice impacts the results from the innovation framework because throughout open innovation it is possible to build more value from the participation of third parties in the problem	Open innovation practice impacts the results from the strategy development. It is because the strategy defines where and when open innovation should be developed, and based on the execution of what has been estab-	Open innovation practice impacts the results from the innovation process. Depending on how open innovation is carried out, more value from innovation efforts can be generated. Additionally, results from open innova-	Open innovation practice impacts the results from technology management. It is because what is defined for technology management depends on the performance obtained at practicing open innovation, especial-	Open innovation practice defines what are the people´s required capabilities and behaviors in order to create innovation value. On the other hand, results from open innovation impact the results from cultural trans-	Open innovation practice, leveraged on the innovation strategy, defines what knowledge is required to manage the open innovation stages, and what knowledge is required to be ensured with third parties.	Open innovation practice, leveraged on the innovation strategy, defines what are the metrics required to measure the open innovation results, especially the value generation and the assessment of work schedules at prac-		Open innovation practice, leveraged on the innovation strategy, defines what resources are needed and how they should be distributed to leverage open innovation practice.

	solution or identification of needs.	lished in this matter, value generation can be possible from practicing open innovation.	tion can be sometimes inputs for the whole innovation process in the company.	ly when technologies have to be developed with allies or other external bodies to the company.	formational efforts and human talent development, since the more good results people see from open innovation practices, the more people feel motivated to engage into practicing open innovation and change their innovation company´s perception		ticing open innovation.		
9. Resources for managing	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in results	Relation of impact in the definition	Relation of impact in results	

innovation	The definition of the resources for innovation impact the results of the innovation framework because if there are restrictions or limited resources it is likely that the strategy cannot be achieved as expected. In parallel, if there are too much resources, the innovation	Knowing the resources for innovation impact the results from the innovation strategy achievement. It is because if resources are scarce, the strategy may not be achieved as expected, and if they are too much, there is a high risk of losing effectiveness in resources´ consumption, which as a	The definition of the resources for innovation impact the results from each stage of the innovation process, as well as the final results and the value generation. Depending on the resources availability, results from the innovation process also may vary.	The definition of the resources for innovation impact the results from technology management because d because depending on the resources availability, results from the technology management may also vary.	The definition of the resources for innovation impact the results from cultural transformational efforts and human talent development, because without resources the cultural change could be impossible as well as having the human resource required.	The definition of the resources for innovation impact the results from knowledge management because without resources organizational learning is difficult as well as the assurance and use of knowledge across the company.	The definition of the resources for innovation define what are the metrics required to assess the use and efficiency of the resources for innovation.	The definition of the resources for innovation impact the results from open innovation practice because without resources it is difficult to create value from the collaborative work with third parties.	

	framework may lack of effectiveness.	consequence may produce people not to look for effi-ciencies.							

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Based on the identified relationships between all the elements, and on the analysis of information collected from the company, a framework for managing innovation in Ecopetrol S.A. was built. This model is presented in the next section of this chapter.

5.3.3 Structuring an integrated approach for managing innovation

As mentioned in the last section and based on the analysis of the information, Ecopetrol S.A. definitely needs to work in parallel in different aspects in order to build confidence on managing innovation and generate value from its efforts on it. It is possible by integrating all the elements into a framework and by defining how these elements should be structured and developed across the company.

In order to this, and aware of the importance of understanding how the different elements of the innovation management framework interrelate with each other, the author built an analogy between the core value chain in Ecopetrol S.A., and the mentioned elements of the framework. This analogy is shown in the next figure.

In the center of the figure there is the innovation strategy which gives focus to the innovation efforts in the company and is aligned with the MEGA or strategic company´s framework. The innovation strategy defines the path to innovate and get value from the efforts made in innovation.

The earth in the graphic represent all the opportunities from which the company can get new opportunities to create and generate value, which at the beginning are born as ideas, which in the figure behave like oil or gas. Knowledge management supports the idea generation within the company, due to the maturity level that this component has achieved and the different practices around opportunity searching and idea management. For this reason, and because the company can leveraged its efforts in innovation through knowledge management, this element was mainly placed as the basement for the extraction and generation of ideas.

Ideas are transported like oil and gas through pipes, which represent in the framework the resources for innovation. Without pipes and a whole infrastructure to move the oil from one place to another it would be almost impossible, considering the Colombian geography and unsafety conditions of some areas, to transport the crude or gas from the different fields to the storage centers, then to some customers and refining, and finally to the final customer. Because of this, resources for innovation are compared in the framework with pipelines and the infrastructure needed to move the ideas. Without this, it would be almost impossible to get value from ideas, and they would be wasted and taken by others.

Innovation measurement is represented in the model like those valves, sensors and measurement instruments which are used to test and check the quality and characteris-

tics of oil, gas, and refining products. Across the value chain there are many checking and measurements points which exist with the aim of knowing how is the process going on, and if there are any atypical results from it. In the same vein, innovation measurement was exemplified like those checking points from which is possible to know if the results during the whole course of ideas (development, implementation, and value generation) are according to the plan or if there is a need to adjust something on the way.

The innovation process is represented in the graphic mainly by the refining process, since this is the most representative process which the company has, from which raw materials, like oil and gas, are transformed into refining products which have high value for the market and society. In a similar way, the innovation process looks for transforming ideas into products and services which add value to the stakeholders, and consequently to the company. Ideas, like oil and gas, go into the process plants of the company and are treated (scaned, filtered, selected, tested, implemented) and transformed into valuable products, services, business models, markets, strategic alliances, processes, etc.

Technology management was represented in the figure like the different technologies the company needs to ensure the extraction of oil and gas, the transportation and refining of these products, and the final sale to markets. In this way, technology management is shown as an enabler of the idea identification and implementation (innovation process), as well as of the value generation. It also helps to link the different elements of the framework and to develop competitive advantages due to the efficiency and effectiveness it may push.

Due to that not all the oil which is produced in the country is refined, and that the country buys also crude from other sources (countries and companies), open innovation is compared with the open process of sale and purchase of crude in which the company interacts. In this process, oil crude, like the ideas, are exchanged and the company acquires products from other sources. Similarly, through open innovation the company can open its networks to exchange problems and receive powerful ideas which can help it to create more value and solve current challenges.

Finally, people and innovative culture are represented in the figure like all the employees which work for the company, as well as the contractors it has. People are essential for any business, and this is not exception. For this reason the cultural believes and behaviors around innovation are so important to ensure that the innovation framework works, like in the value chain, where people are who guarantee the execution of the company´s processes.

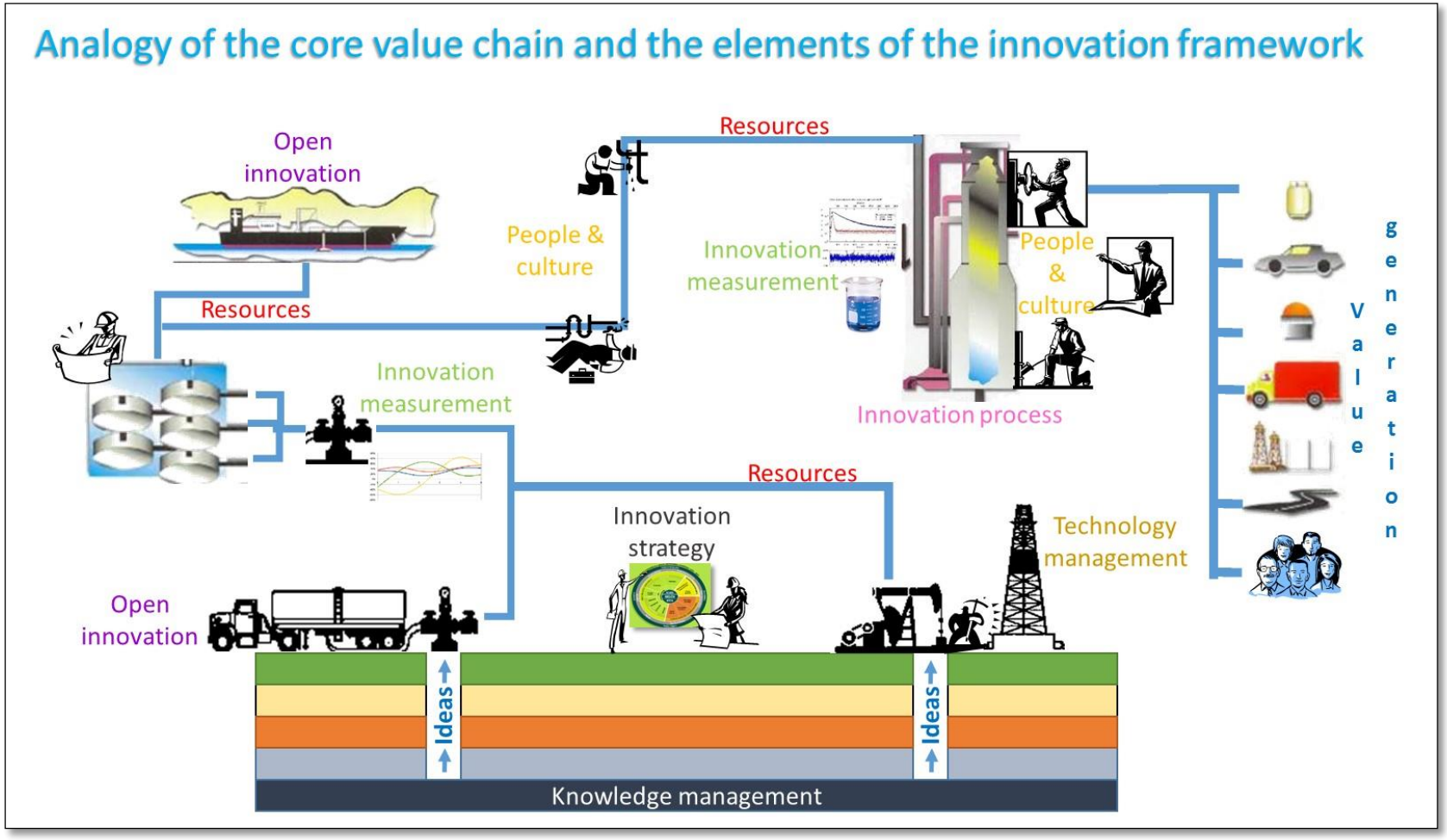

Figure 43 Analogy of the value chain of Ecopetrol S.A. and the elements of the innovation framework

By using the explained analogy, the company will find it easier to understand the importante and role that the different elements play into the innovation management framework.

When analyzing the information, different decisions were considered related with strategy and structure, operation and scope of innovative teams, and with the structure and process of innovation, as follows in the next table.

Table 11 Decisions at building the innovation framework for Ecopetrol S.A.

	Suggestions
Decisions related with strategy and structure	*Open vs. Closed Innovation*: In the medium term the company needs to engage in open innovation, but after ensuring external elements of participation and its unique position in the country. *Few people working on innovation vs. a broadly participative model:* Ecopetrol S.A. needs in the medium term to have a mixed innovation portfolio focus on developing both, incremental ideas, to improve current services and products, and disruptive ideas to establish an added value in the long term. In this way, it needs smaller teams to work on disruptive innovations on specific issues, and many employees across the company working on incremental and radical innovations. At first the company should focus on developing idea campaigns in order to attract and engage people. *Suggestive vs. directed:* Due to the difficulty of managing many ideas from all the employees in any topic, at first the company should focus on developing idea campaigns oriented to propose ideas for solving a specific issue, to ensure that submitted ideas are aligned with the organization goals and strategy. Later, in the medium term, the company may be ready to have an open suggestion box where employees submit their ideas. There, in order to ease the analysis of ideas, people must be asked to supply as much information as possible in order to provide a clear context, and communicate the challenge or need which they think the idea addresses, and its potential benefit.
Decisions related with operation and scope of innovative teams	*Incremental vs. disruptive*: As it has been mentioned before, due to the current culture of the company, it needs to focus on incremental innovations in order to involve employees in the cultural transformation, but it also has to invest resources in the development of radical and disruptive innovation. However, the development of radical and disruptive innovations means the need to tolerate failure and being able to

	take risks. This is something the company is not familiar with, therefore it may need time to structure the efforts on this kind of innovation, and mature the abilities and culture for focusing on disruptive ideas. *Centralized vs. Descentralized:* Ecopetrol S.A. through the creation of the Vice Presidency of Innovation and Technology looks for unifying the innovation process, tools, methods, language, evaluation criteria and tools within the organization. Nevertheless, ideas come from all the employees and people who analyze and select them are also from those areas that have the innovation challenge. The unification of the innovation program may take time due to the size of the company and the geographical dispersion, which has fostered the existence of different process and languages used around innovation practices which need to be aligned with the strategic goals across the company. *Product/Service/Operations/Business Model:* As explained better in the innovation strategy, Ecopetrol S.A. needs to focus its efforts in disruptive and radical innovation in products and services, as well as in alliances and markets, which may include business models. Regarding incremental innovation it should focus on process innovation and innovation in customers.
Decisions related with the structure and process of innovation	*Recognition and compensation:* Ecopetrol S.A. must balance the methods it chooses to reward and recognize people with the aim of encouraging the right behaviors and incentivizing people to participate actively in the innovation process. Therefore, the recognition and compensation programs should include both, measures for submitting ideas but also for active participation within the program, along with peer recognition. In this way the company may attract employees which just look a prize for their performance, and those who really like to engage in innovative programs by hearth. As a part of the recognition and compensation program the company should give the employees the possibility of investing initially 5% of their time to work on innovation projects, which should be supported by an indicator which allow the company to measure the outcome of this efforts and with resources to develop the projects. Later, when the culture is more mature around innovation issues, the company should increase that time to 10% of the employees´ time to work on innovation and adjust the portfolio of services of every area in order to include the commercialization of the results of innovation. *Wisdom of crowds versus defined criteria and "experts":* In general, when evaluating ideas the company must include both methods wis-

	dom of crowds (for radical and incremental innovation) and evaluation criteria and use of experts (for incremental innovation).

With this in mind, and employing all the information the respondents gave during the research, as well as all the documents and information about the company that the author managed to get, a model for managing innovation is presented as follows:

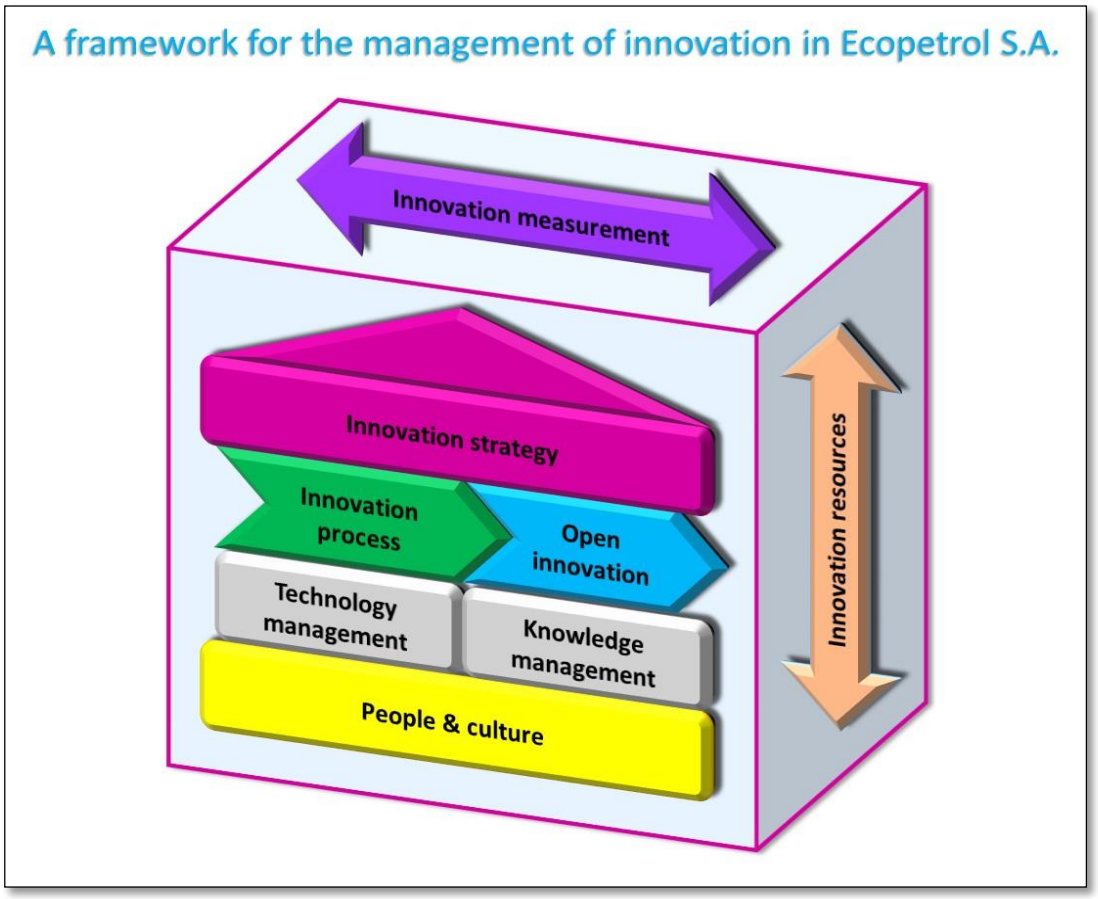

Figure 44 Innovation management framework for Ecopetrol S.A.

The framework involves all the elements which have been mentioned as well as explained within this chapter and the previous one. It has been represented in a cube since there are three axis which must be integrated continuously.

In the frontal side the innovation strategy gives the orientation of the framework while the innovation process and open innovation are supported by technology management and knowledge management. Innovative people and culture support all the elements of the framework, given the importance and relevance it has for the achievement of the innovation objectives.

The other two axis of the cube are integrated by the resources for innovation (vertically) and innovation measurement (horizontally). The direction of the resources for innovation is given due to the fact that they leverage the planning, control and execution

of the elements of the other sides of the cube. Consequently, the direction of innovation measurement is given due to the fact that the evolution and implementation of each element must be measured constantly and according to the evolution and maturity of the framework in the company.

As it has been said previously, without the integration of the elements of the framework it is likely difficult to achieve the expected results and leverage the company´s goals. Due to this, each element should guarantee its own inertia in order to ensure the results to support the development and performance of the other elements. To do this, the model also works internally by collecting the more important aspects that the company actually needs to engage in innovation and improve its current innovation outputs, as shown in the next figure.

Finally, the suggested model takes into consideration all the interrelations between the elements of the framework described previously, as well as the main and common aspects about them, which were highlighted by the respondents and found in the collected information of the company. At linking all the elements into the framework in the way it is shown, if an element does not work properly, the other elements can be affected so then the results may not be as initially expected. In this way is very important to follow the recommendations given by the author in this research for each element and the whole framework in order to ensure the generation value through innovation efforts.

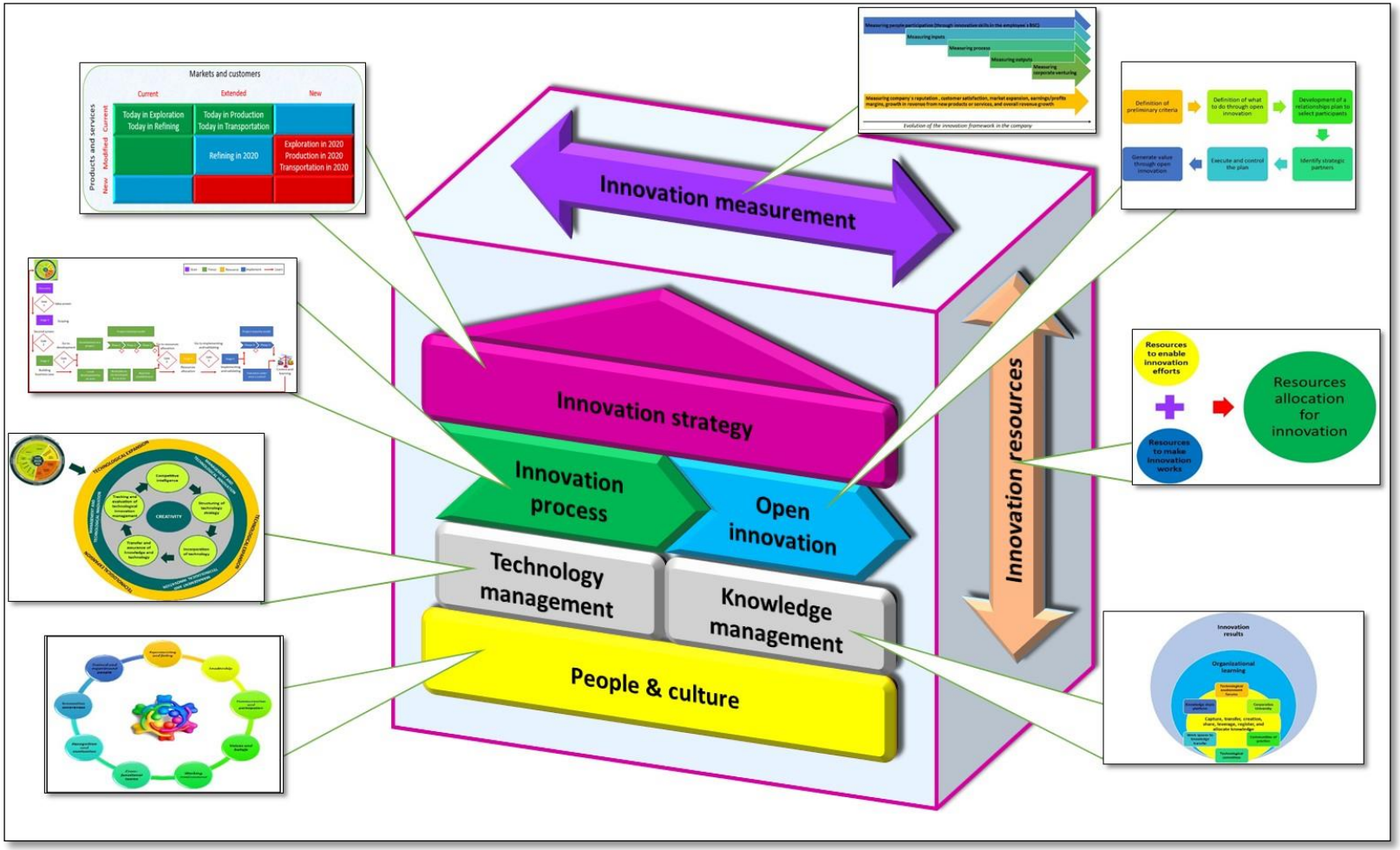

Figure 45 Internal composition of each element of the innovation framework

6 CONCLUSIONS

The great impact that innovation has on a company and on its competitive advantage is something which cannot be refutable. It, further than being an imperative of the moment, is an aspect without which any organization could survive in a sustainable way.

Nevertheless, the generation of value through innovation is not something easy to get by a company, given the challenging nature of the management of innovation. In fact, innovation is messy, involves false starts, recycling between stages and jumps out of the normal sequence (Tidd 2006). Because of this, the management of innovation demands for wise practices to extract the value which it represents while dealing with complexity and risks.

Although different models have been proposed around the way as innovation should be managed, there is not a magic formula for an organization to do this. In general, when reviewing them, the majority of them involve common elements such as strategy, process, structure and culture, but when they are applied to the real business life, they need to be adjusted according to the nature of every company on which they are being applied. In this way, it is necessary to consider the particular conditions of every organization into its industry and environment in order to define and probe the way as innovation should be managed.

The oil and gas industry has experienced different changes for the last years, and the future seems to be challenging for the traditional companies, especially National Oil Companies (NOC´s) which were depending before on their oil reserves levels, rather than on their innovation capabilities and their capacity to anticipate changes. Currently, what pays in the industry is to develop competitive advantages based on the exploitation of internal capabilities and the generation of value to the stakeholders through internationalization and anticipation to future global trends, such as alternative energies, global growth and sustainable consumption.

Due to this, companies in the oil and gas industries have realized that they cannot rely just on their domestic markets and traditional focus. In fact, they are going international and developing new oil reserves overseas as well as investing in international refining and retail activities. However, this movement is not enough for them to survive in the market. As pointed out by Dicken (2011), companies in this sector face mainly two big challenges, one associated to innovation in procedures and technologies for exploration, extraction, production and commercialization of the product, and other related to the investment in alternative fuels, in order to satisfy the future energy demand which seems to be shaped not by natural limits but by social choice.

In this way, although innovation is “a must” in the companies of the industry, its management is still on its initial steps and the majority of the companies in the oil and

gas industry do not have a history of innovation and have transformed it mainly as an R&D issue.

For the purpose of this research, finding literature and facts about innovation in the oil and gas companies was in general not an easy task, which could have been for any of the next reasons: there is not much research about it, or, due to the great focus on investigation and intellectual property that surrounds the topic in the industry, the companies are not willing to show the way as innovation is managed within them. Similarly, it was much easier to find information about innovation management in companies from developed nations than from companies of the rest of the world, in special from Latin America, which supported the notion about the precarious status of innovation in companies in the sector in developing countries. This coupled with information about the informal level of innovation and weak innovation processes in this part of the world (Latin America), impacted the construction of points of reference to guide or compare the findings of this research in the case study company.

The importance of the oil and gas sector for the global economy, the dynamics and changes of the energy market, and the role that innovation is playing in organizations around the world, were the drivers for the author to identify and analyze how the oil and gas companies manage innovation effectively and which are those elements to be considered and structured into a framework for innovation management, despite the low evidence about how companies are structuring innovation and turning it into a reality within their organizations, especially in late-industrializing economies.

Based on this, the present research identified the main elements, their interrelation and structure required for managing effectively innovation in a company in the oil and gas industry from a developing country, throughout a holistic single case study. The company was selected based on the author´s knowledge and relationship with it. This company, which name is Ecopetrol S.A., has been, and still is, the biggest company in Colombia, and the national economy is highly impacted by the results of it. Due to this, and given the dynamics of the market in the oil and gas sector, the author found the analysis of innovation and the structure of an innovation framework for managing innovation in the company an interesting issue which could also contribute to the research of innovation in the world.

The development of an innovation management framework required asking specific questions for which the research provided answers. The research question for this study was: *How to manage innovation in the oil and gas industry?* This question was approached through the answer of the next two sub questions:

1. *What kind of innovations do the oil and gas companies make?*
2. *What are the principal elements on which companies focus to manage innovation?*

These sub questions derived from the research question enabled the categorization and analysis of the research findings.

Regarding the first sub question, the results of the study showed that the sector in general is slow (compared with the change speed of other industrial sectors) and that the main direction on which the biggest companies in the oil and gas companies have focused their innovation efforts has been on the research, development and acquisition of technologies for the development of new extraction and production processes and methodologies, and strategies to explore and drill new oil fields. This trend is very common in NOC´s given the dependence they have on the state and the few freedom they may have to try new markets and businesses. In general, some scientific journals in the industry and certified websites show practical applications about how technology is adapted in the core processes of companies of the sector (exploration, production, transportation, refining, distribution), but it is not the same for other kind of processes which are necessary for the company to operate (i.e. accounting, supply chain, legacy, etc.) since there is few practical evidence and literature about how companies in the oil and gas industry innovate in non-operative processes.

In this sense, companies in the oil and gas industry have had a strong focus on R&D in their core processes, especially in the process of discovery, exploitation and extraction of oil and gas since their common goal is to increase their oil reserves and production levels. However, with this perception and practice, the scope of innovation and the power of it across the companies have been limited to investigation, technological and process innovation, and they have not been able to exploit totally other opportunities present in practices such as open innovation or in developing other kind of innovations in product, alliances, business models, etc.

It allow us to understand somehow why innovation in the oil and gas companies may be something which is not widely lived and understood by all the employees, no matter the area which they work for. Particularly in Ecopetrol S.A. it was common to find that innovation has been normally perceived as technological innovation. In general, employees are rarely aware of the scope of innovation across the company and how they can impact the innovation results from their daily work. Thus, rather than understanding innovation as a leverage for the achievement of the company´s goals, employees perceive innovation as a job of a few who are focused merely on invention and research of technologies.

Another aspect which is interesting from the oil and gas companies is that the operators (which license the oil and gas rights) rely heavily on other companies which play also like operators, contractors or suppliers. Normally, oil and gas companies tend to outsource around 60-70% of their core operations, and they frequently make alliances with other operators to explore and exploit a new field. Some technical literature highlights this phenomenon which show how important is the role that other companies in

the sector play in the value generation chain. In this way, due to the fact that critical knowledge and experience are acquired by third parties (other companies), open innovation should be a well-known practice in the sector. Nevertheless, except from some big private oil and gas organizations from developed countries which have shown advances with some contractors and suppliers, companies continue to work isolated and are not aware of the importance of joining contractors, operators and suppliers to the development of innovation efforts.

What some people say that the world is running out of hydrocarbons has been interpreted by the oil and gas companies from two perspectives. On the one hand it has pushed companies to explore more and make advances in exploration technologies (i.e. research and development of technologies in recovery factor: secondary and tertiary recovery) which have increased the number of proven reserves of oil. Every day more companies are seeking out new sources of fossil oil in extremely distant places and using new technology to extend the lives of old oil fields. In this sense, what people say about the close extinction of hydrocarbons is not totally true, at all.

On the other hand, although new technologies and methodologies continue to be discovered, there is a social phenomenon which is pushing people to demand for alternative energy sources. In this way, oil and gas companies are facing a new kind of demand in the market and due to this they have been pressed to reinvent their business and wider their strategy to include the development and exploitation of alternative energy sources. It has demanded from these companies new resources to innovate in the discovery, invention and generation of alternative energies. This is the reason for which some companies in the oil and gas sector have expanded their scope and now they belong to the energy sector.

Regarding the second sub question about the principal elements on which companies focus to manage innovation, there are a couple of aspects to be highlighted. First of all there is very few literature, about how oil and gas companies manage innovation, especially in third world nations. From the few literature in the industry and in other industries it is possible to see that there are common elements which are present in many innovation models in different companies from various sectors. In general, those elements relate people, process, and strategy. Nevertheless, although those elements are common, they are structured differently between companies and none model is defined and implemented the same way to another. This is because every company, depending on their own conditions and characteristics, decides how to manage innovation in a way in which innovation leverages the goals´ achievement of the specific company.

On the other hand, oil and gas companies, which are seen as innovative ones in the industry (i.e. Shell, Statoil) tend to include innovation as a part of their strategy to achieve their goals. In this sense, they have clear policies where innovation is encouraged through the employees, and many stakeholders are part of the innovation ecosys-

tem. Without any doubt, innovation is part of the DNA of these companies, and due to this they have broaden their operations scope and currently use many tools to encourage innovation within the organization while trying open innovation and corporate venture to support start-ups creation and evolution. In contrast to the innovative companies in the sector, other companies, which still strive to get results from innovation, lack of a clear definition of the innovation strategy and innovation objectives, which seems to be the first cause for which these companies have not achieved better results from their efforts in innovation.

These innovative companies are aware that people is the most important asset they may have. Therefore, they foster innovation through motivation and recognition plans which include elements that interestingly reward people´s participation. However, across the companies, the policies to recognize people as well as the motivation activities they do differ from company to company. Additionally, although the construction of an innovative culture in those companies have taken lots of time, nowadays employees´ behaviors as well as thoughts are focused on generating value through innovation.

In a similar vein, people´s knowledge in the oil and gas companies is one of the most valuable assets. Specific knowledge from people is always demanded, so then specialized people in the sector (i.e. petroleum engineers, geologist, etc.) move from one company to another which offers better benefits to them. In this way, innovative companies in the industry have realized about the importance of managing critical knowledge, and due to this they have developed systems or programs which allow them to manage knowledge within and outside the companies. As specialized people with critical knowledge move among companies very fast, companies in the oil and gas sector need to retain people´s knowledge and ensure it is transferred to other employees on time. Furthermore, those companies have identified that knowledge and innovation interact in the same way and that they support each other in the generation of value for the company. Therefore, they have implemented tools and practices which allow employees to acquire, develop and transfer knowledge to support innovation efforts. In this way, what those companies have shown to others is that without managing effectively knowledge, it is not possible to innovate, since the company may lack of the ability of building innovation capabilities and learn.

In general, there seems not to exist a common trend in organizational structures and innovative oil and gas companies have different internal structures which support their operations as well as the management of innovation to generate value. Nevertheless, there is something common in those companies: R&D centers, in which they develop new technologies and try new concepts. These kind of institutions are also present in other companies which are not known as innovative ones. Therefore it seems that R&D centers are not a guarantee for oil and gas companies to be innovative but how all the elements are integrated and structured in the management of innovation within the com-

pany. It may be because the use of central R&D with the aim of developing emerging technology to support current firm-based competences, or to develop new as well as differencing competence platforms, is hard (Wu & Haak 2013).

In order to support the innovation systems, the innovation process normally implemented in the oil and gas companies follows the Stage-Gate model proposed by Cooper. Nevertheless each company organizes the process and involve parties in different ways depending on the organizational structure and how well they have defined and identified their innovation strategy. Additionally, companies in the oil and gas sector have focused their efforts more on project management than in structuring and developing an innovation process which includes project development as part of its stages.

On the other hand, in the last years, innovative companies in the oil and gas sector have realized about the importance of practicing open innovation. It has been possible due to the dynamics of the industry and the evolution and interaction between operators, contractors and suppliers in the sector. Nevertheless, this is a new concept which is applied in developed countries better than in companies from under developed countries since in third world countries there are still many aspects which need to mature and stabilize associated with intellectual property and regulation. Furthermore, there are multiple interests from different parties in the market, which are not regulated, yet, and what can be seen as an interesting opportunity for companies to develop can represent at the same time something which goes against citizens´ interests. Therefore, there is still a big opportunity for those nations to develop their laws and offer more autonomy to the national companies to open up their markets and reduce their barriers to third parties at practicing open innovation.

In general, making efforts in innovation in the oil and gas industry involves the investment of huge amounts of resources, especially money. It may be explained from different perspectives. First of all the oil and gas sector has focused its biggest innovations in technology and markets, and it is just achievable by investing in technologies and new markets exploration and expansion. Second, developments and research in this industry also takes a lot of time to get results, given the complexity of the industry, and during this time companies need to support the teams and the things required to make it real while surviving in the market with the current capabilities but different external and evolving conditions. Finally, innovation requires a management system which must be implemented and controlled by someone or a team, and it demands for resources to move culture to an innovative stage and recognize people participation in innovation efforts.

Technology management is one of the strongest focus developed by many of the companies in the industry. However, there is a huge difference between innovative companies and those who are not. The former invest in the development of new technologies, which can also be developed with third parties, while the latter focus their

efforts in acquiring technologies and adapting them to their particular conditions. In third world countries, this phenomenon is not exclusive of the oil and gas industry, in general it is the same in the majority of economic sectors of the country.

Unfortunately, despite the efforts in innovation done by the biggest or by the more innovative oil and gas companies and their strong focus on technology management, when checking lists or rankings of innovative companies in the world, those companies in the sector, which act as operators and sometimes like contractors, are not in the top of the lists. Normally one can find companies which are focused on alternative energies development, and even suppliers and contractors of the industry such as Schlumberger, China Oilfield Services, Atlas Copco, Tenaris, ABB, and Halliburton (places 27, 40, 67, 92, 93, 97 in the Forbes ranking, respectively) (Forbes 2013).

Finally, oil and gas companies rank their efforts in innovation with some of the metrics that the literature offers. Consistently with the strong focus on technology management, the most common metrics used to do this seem to be investment in R&D activities, number of patents, and number of people working on R&D. Actually there are a couple of lists published by some organizations which measure the innovation levels of companies. The most common seems to be the Forbes list, which works based on the "innovation premium" defined by Dyer eta al (2011) in the Innovator´s DNA, as the proportion of a company's market value that cannot be accounted for from cash flows from its current products. In the Forbes list, as mentioned before, one cannot find easily operators in the oil and gas industry, which makes it more complicated to compare a company in the sector with others since there is not an official reference point or benchmark regarding innovation.

Given the approach to the two sub questions of this research, the main research question, *how to manage innovation in the oil and gas industry?,* is answered by considering the type of innovations done in the industry surrounded by the dynamics of the market, and the main elements on which companies focus to manage innovation.

In this vein, and taking into consideration that innovation management differs from company to company, even in the same sector, the most critical point has to be with the definition of the innovation strategy for the company and the construction of a framework to manage innovation in a systematic and effective way, despite the unorganized nature of innovation. The innovation strategy is the departure point since it gives the focus of innovation efforts aligned with the company´s objectives.

In the innovation framework, which depends on the innovation strategy, it is important that oil and gas companies consider at least the next elements: people (the most valuable asset in the company), knowledge and technology management, structure (innovation process and project management), and resources. These elements seem to be critical for managing innovation in oil and gas companies due to some of the next reasons:

People and knowledge are a critical and valuable asset for oil and gas companies since specialized people (i.e. petroleum engineers, geologist, etc.) with specific expertise and knowledge move constantly across companies since they are easily attracted by better conditions, therefore retaining human talent for just one company is not an easy and likely task.

Oil and gas companies rely a lot on technological developments to explore, exploit, extract, transport and sale more oil and gas while incrementing their reserves levels. In the need for finding new oil reserves and produce more for the world, oil and gas companies are moving to places where nobody was before, dealing with extreme conditions which make more expensive the process of finding, extracting and moving the products. Moreover, they are trying new options and sources such as shale gas and shale oil, or third recovery methods, in order to find and produce more oil and gas. Under these new conditions of operations, companies need to develop technologies more effective which help them to increase their production rate while reducing their lifting costs.

Project management seems to be critical in the innovation process, given the long time and high amount of resources demanded by every project. In this way, it is not enough with defining and implementing an innovation process, as well as managing and controlling the fuzzy front end of the innovation process, which is important of course, but to manage, control and measure the development of projects in order to get better results. One limitation in this way is that given the fact that projects in this kind of industry take a lot of time to be completed (3-7 years) and lots of resources to be executed, innovation is not incorporated into the matured phases of projects execution, and some opportunities may be missed due to the rigidity of the maturity phases of project development. It represents one of the big challenges that companies face nowadays in managing innovation and projects.

Innovation in the oil and gas sector demands for considerable amounts of resources, especially money, since the type of innovation which impacts more the results of the companies have to be with technological innovation. Discovering new ways of extracting oil and gas as well as new sources of energy and new ways of generating energy for the world, demand years of research and development, and therefore money for people, equipment, laboratories, and so on. Additionally, in order to move the culture of companies to innovation practices, the implementation of recognition and motivation programs is required which also requires the allocation of resources for it.

From the identification of these elements companies need to recognize which are the aspects that integrate them according to their relevance for the goals of the company. With this in mind what follows is to identify the interaction between those elements and how they support each other in the generation of results. From these definitions companies, even in the same sector, start to differentiate in the way as they give more rele-

vance to one element or another, because this prioritization depends on the strategic goals of the company and the current capabilities of it.

This is reason for which in parallel it is necessary to consider the external conditions which surround the companies in the sector to define the way in which innovation is going to support the generation of value and the sustainability of the business. It means that companies need to broaden their innovation scope and structure, as well as develop, a mixed innovation portfolio. This portfolio should integrate technological innovation, which up to now has shown to be the strongest focus that innovative companies have in the sector, as well as innovation of other types in which the companies in the sector should also innovate, such as business models innovation, product and process innovation, supply chain innovation, and market innovation. By broadening the scope of innovation meaning oil and gas companies would be able to generate more value and go into new businesses which can give them more opportunities to be sustainable in the short and medium term.

Additionally, the innovation portfolio has to include different innovations with different impacts for the company and the markets. In other words it should include incremental, radical and disruptive innovation. To do this, it is necessary to be clear about how every kind of innovation is going to be managed, since they need different attention given the characteristics of each type. In this sense, to manage radical and disruptive innovation oil and gas companies should continue to have R&D centers with the option of open up the innovation efforts to work collaboratively with suppliers and stakeholders. In order to do radical or disruptive innovation it is important to identify an internal team who can work, preferably, the whole time on this purpose, as well as the opportunities to do this with stakeholders, especially with suppliers and contractors who are more specialized in developing new concepts and probe them in the market. On the other hand, companies need to have clearly defined the tiny dividing line between continuous improvement and incremental innovation, to be able to manage incremental innovation. With this in mind, incremental innovation can be managed with the support of innovative platforms with access to every employee, it is information systems in which people can register their ideas for the solution of specific problems (that have been previously defined as meaningful improvements for the company), or openly for the achievement of the goals of the company. Having a mixed innovation portfolio is a key for the results that oil and gas companies can get from innovation.

Due to the high levels of hierarchy exhibited in the majority of oil and gas companies (given their size), it is critical to ensure an organizational structure to manage innovation which allow people to move to an innovative culture and take decisions faster. There are some ways to organize a company around innovation, however in this industry it seems that the more the people are widespread across the organization, the better the results the company has. It may happen because there could exist more understand-

ing about the employees´ role in the path to innovation as well as more commitment and engagement with the achievement of the final goal. Furthermore, when having a team responsible for moving the message of innovation across the areas, and this team is built with people from every area, it is more likely to know from heart which are the needs of every area which can be supported by innovation as well as to know the final requirements from the final customer of the value chain. This is a key element to increase value generation because innovation may not have any application if it is not helping or solving a current or projected issue in a company.

Given the strong dependence of the oil and gas companies from their suppliers (other operators, contractors and suppliers), it is relevant to clearly define the strategy to manage collaborative innovation with them. It is very worth to make them a part of the innovation system through open innovation exercises and development of strategic alliances and joint ventures. However it is very important to have clearly defined what kind of innovation or goals are going to be managed with the collaboration of third parties. Otherwise it could happen that the company always use this mechanism to work on every kind of innovation and in any kind of challenge to achieve the goals, which seems not to be the best recipe to succeed. Due to this it is highly important to include this declaration in the innovation strategy to orient the efforts with third parties.

Moreover, considering the dynamics of the industry and especial of the society and their trends in energy consumption, oil and gas companies should consider to move to new kind of businesses through corporate venture models. Actually there are some companies, such as Shell, in the oil and gas sector which have developed this concept. Through this, companies can try or test new concepts, methodologies, technologies, products and services in other fields which may not be included initially in the strategy and goals of the company, but that given its nature and impact may represent new opportunities in the market, therefore better reputation and more income. This unit is recommended to be managed by people in charge of the strategy definitions in the companies and as an independent business.

Finally, companies in the oil and gas should control their efforts in innovation in order to know whether they are impacting the achievement of the corporate strategy, or not. Although innovation tends to be messy, it does not mean that it cannot be managed and controlled in a systematic way. To do this, oil and gas companies have to broaden their classics metrics used to measure innovation, such as patents number and investment in R&D activities. Although they are a good index about how innovate is a company, they are limited in many aspects since innovation impacts can be considered from other perspectives.

6.1.1 Applicability of the constructions

Initially, the results of this research help the case study company, Ecopetrol S.A. to improve the way as it manages innovation, and so then it can achieve the strategic goals in the long term. The innovation framework can be implemented and developed through the whole organization and then through the holding group to consolidate the synergies among companies. With the implementation of the model the company can get more value from the innovation efforts and be clear about what to do, how, when and with whom innovate. With this in mind, the company can realize that although innovation by nature seems to be something messy, the management of innovation is thought to be organized and systemic to ensure the value generation.

Additionally, with the results of the study, Ecopetrol S.A. can know in which elements of the model it should concentrate better its efforts and which aspects should be strengthen, such as innovation culture (training and leadership), innovation process and open innovation, innovation strategy (objectives, focus and measurement), and innovation resources. Moreover, it can recognize that the company cannot innovate alone and that it depends heavily on their allies and the way as innovation is given with their help. The company can also identify the need to expand its approach of the future and think better about alternative energies and radical technologies to new markets and customers to ensure a sustainable growth and competitive advantage.

Interestingly, the results and findings from this research can help different actors in the market which interrelate continuously in a country: government, academy and industry. On the one hand, with the results of this research, and considering the size and relevance of the company for the country, the government of Colombia, as well as the governments of other countries in similar economic conditions in Latin America may have a better support for the structuration and implementation of programs which seek for improving competitiveness levels. Actually these programs are similarly implemented across companies and they normally do not differ from one sector to another (i.e. the national policy in science, technology and innovation of Colombia – CONPES 3582 (2009), and the innovation program offered by the Bogotá´s Commerce Chamber (2013)). In this way, having into consideration that there is not a unique formula for managing innovation and that it depends on the company´s conditions, capabilities and external environment, those programs developed by the government and its entities could be less generic but considering better the characteristics and conditions of every industry and company inside it.

In a similar way, the academy can benefit from the research´s results and findings given the importance of the linkage between the oil and gas companies and universities and research centers. Due to the necessity of developing new products and processes in the industry, and the limitation of specialized people in the companies, having alliances

with universities seems to be one of the ways to ensure the identification of insights and trends as well as the development of new technologies and knowledge. Additionally, universities can develop new services to offer to the companies in order to help them to develop and implement innovation management systems and be more competitive. In this sense, universities can develop new options for companies in innovation culture construction, innovation process development, innovation strategy construction, etc…

Moreover, from what was found in this research, the academy can identify the need for exploring and study more innovation management cases in companies of other sectors in third developing countries. As an experience lived by the author in the development of the study it was highly difficult to find information about how other companies in the oil and gas sector or in another industry manage innovation. It may be because companies are not willing to share information and/or there is not enough analysis and applied research around this phenomenon in Latin America.

Similarly, from the results and findings of the study other companies, which act as suppliers or customers in the value chain and play a key role in the system, can also be benefited given the relevance of doing open innovation in the case study company and in another in the oil and gas sector. Furthermore, there is a big opportunity to innovate in the supply chain, son then those companies should also define and implement an innovation framework which consider the innovation interaction with other companies. To innovate with allies, it is necessary also that allies also know what and how to do things better in order to support the innovation goals of the relationship.

Moreover, consultancy companies can also use the results and findings to identify how oil and gas companies move and change, and which are the more relevant elements when managing innovation within and across them. With this in mind, they can develop better products and services for other companies and support them to achieve their goals in a better way and through innovation.

Finally, the findings of this research help other companies in similar conditions, whether they are in the same sector or in another, to have better clarity to approach innovation and learn from other´s experiences in the sector, especially when companies share similar external conditions. With this knowledge, a company´s innovation efforts could be better focused on the generation of value for the company, so then, generation of value for a nation.

6.1.2 Theoretical contributions and implications on further research

This study has helped to confirm what Tidd et al (2005) have suggested about that innovation management is about learning to find the most appropriate solution to the problem of consistently managing this process, and doing so in the ways best suited to the

particular circumstances in which the organization finds itself. In this vein and based on the experience acquired with the development of this research in the oil and gas industry, similarly to what the authors pointed out, it seems not to exist the "one best way" to manage innovation. This proposition is supported on the different external, economic, strategic, technological, and market conditions that companies face, even so they are in the same sector. So then, instead of finding the magic formula, it is better to explore which are the links between structure, processes and culture of an organization, the opportunity for and characteristics of technological innovation, and the competitive and market environment in which the firm operates.

In general, the number of articles and studies around innovation management has increased during the last years and this called young technique, apparently contrary to what has been expressed by Verloop (2004), has increased its level of popularity in journals and scientific websites. However, considering what some authors and surveys have suggested (Arthur D Little 2005; Tidd et al 2005; Lawson & Samson 2001) about that every individual case in innovation management may require the strengthening of different capabilities, there are not enough studies about the application of innovation management in companies in the oil and gas sector, or in different sectors in state-own companies, or in companies of third world economies (i.e. Latin America). It made it difficult to find points of reference for the study but at the same time confirmed the big opportunity that exists for researchers to look inside companies of this nature and determine how innovation is managed inside them. This finding seems to be similar to what was suggested by Wolfe (1994) a couple of years ago when he stated that no matter the perspective, results in innovation research are inconsistent, and today we continue to be far from the suggesting answers to questions related to the way as a company should manage innovation successfully.

Through the development of this research the author also realized that despite the few studies that have tested the effect of innovation-related variables (Souitaris 1999; Wolf 1994) there is still a huge need for further research in different aspects related to innovation management, on which there was not found enough literature which could be used as a guide in the matter. Therefore, it is not enough to have understood the innovation phenomenon as suggested by Coombs et al (1996), but to understand it according to the nature of companies and its surrounding environment. In the next paragraphs those findings are exposed to the reader.

Open innovation was defined by Henry Chesbrough in 2006 as the use of internal and external knowledge to leverage internal innovation. It is achieved by the interaction between firms and their stakeholders, throughout effective strategies, architectures, and models for creativity. Although the term is relatively new and research on this topic has significantly grown specially in large companies in developed nations (Hossain 2013), there are still many issues which need to be contemplated by researchers regarding the

application of this discipline in third world economies (Hossain 2013; Vrgovic, Vidicky, Glassman & Walton 2012; Rahman & Ramos 2012). Furthermore, it seems not to exist literature focused neither in how to do open innovation in state companies, which must follow a special regulation defined by the law of the country. This phenomenon has been rarely explored. Thus, there is a lack of research in open innovation in third developing countries and in state companies of these countries. Due to this companies are struggling with the way as they apply open innovation, and many of them still do not know what it is and how to apply it. Therefore, state companies in under developed nations are facing many obstacles that hinder them from innovating openly as much as they could.

It is likely common that companies in the oil and gas industry choose to grow through mergers and acquisitions (M&As), either locally or cross border with the aim of entering to new markets or acquire the assets (including knowledge) that a company has. Merging two companies or acquiring one, normally a smaller, involves dealing with a series of changes in order to align the final organization to the new strategy and vision. Nevertheless, how innovation should be managed during the due diligence process and especially after the integration of the companies in the oil and gas industry still needs to be further explored.

Besides studies done in other industries such as chemicals (Ahuja & Katila 2001), aerospace and defense, computers and office machinery, pharmaceuticals, and electronics and communications (Gantumur & Stephan 2007; Cloodt, Hagedoorn & van Kranenburg 2006), about the impact of M&As in innovation performance, there is not enough research in the oil and gas industry neither in third developing countries (where culture issues are different to the developed nations) about this phenomenon. Other approaches can be rarely found in the literature such as that of Gu and Chen (2011) which is focused on the components of collaborative knowledge management in post-mergers and acquisitions, which somehow, but not directly, is related to innovation management in one aspect. The methodology and basis employed in the studies done by Ahuja and Katila (2001) and Cloodt et al (2006) can also be used to analyze companies in the oil and gas industry, which share with the analyzed industries one of the reasons for which they choose the analyzed sectors: innovation performance can be also measured through the same indicator, the number of patents.

In general the issue of analyzing innovation management and M&As results of high importance since one of the greatest risks associated with the success of M&As has to be with strategy and people: their expectations and motivations, which at the same time represent key factors for innovation results. In fact, in 2011 Hitt, Hoskisson and Duane presented theory suggesting a tradeoff between growth by acquisition and managerial commitment to innovation. However, as stated before, there is still a need for further

applied research in companies in the oil and gas industry and, if possible, in third world countries.

As mentioned during the research, although different models have been proposed about innovation management, it seems not to exist a magic formula to manage innovation in a company, which makes difficult and challenging the generation of value through innovation (Tidd et al 2005). Furthermore, in order to define if value is being generated through innovation, it is necessary to measure somehow the innovation inputs, process, and outputs. However, measurement of innovation is hard to achieve, and within the time some researchers have focused their studies in identifying innovation measures who have been focused mainly on the measurement of innovation inputs and outputs in terms of expenditure in R&D activities and information technology (Becally 2007; Adams et al. 2006; Neely & Hii 1998), speed to market, and numbers of new products (Sumita 2008; Adams et al. 2006; Cordero 1990). Within the time, these indicators have shown to have many shortcomings. Additionally, these metrics do not help in the first stages of the innovation process to really know if some potential idea, when implemented and commercialized, is going to represent any value for the company.

Furthermore, the nature of the innovation measures relates with the innovation process stage. During the first stage of an innovation process, when ideas are being generated, measures are commonly quantitative and inexpensive (i.e. the number of ideas produced within a period of time) (Chiesa et al. 1996; Lee, Son & Lee 1996) or the extent to which firms use different tools and techniques (Thompson 2003; Cebon & Newton 1999; Chiesa et al. 1996; Loch, Stein & Terwiesch 1996; Szakonyi 1994; Rochford 1991).When idea goes through the different stages and arrives to the business case building stage, it is possible to use some calculations such as Return on Investment (ROI) or Net Present Value (NPV) to identify the possible value that the idea can give to the company. However, these calculations differ from reality and they are used to have just an estimative, which is very difficult to obtain since there is not enough information, yet. In this sense, there is a need for researching on the possible qualitative or quantitative methodologies with which value can be calculated from the first stages of the innovation process, it is in the fuzzy front end (FFE) process of innovation. It has to consider also what was suggested by Neely and Hii (1998) about that there is no unique best way to measure innovation performance because a particular set of indicators may not work in another organization. With new methodologies, or adjusted ones, companies could be able to reduce their failure levels at innovating and ensure from the early stages of the innovation process a more suitable value projection. Therefore it is necessary to research on this issue in order to improve innovation efforts.

Finally, based on the great interest that innovation capabilities represent for researching on innovation management (Essmann & Preez 2009; O´Connor 2008; Atoche 2007; Lawson & Samson 2001), and considering the surrounding particularities in technology

and economic matters of developing nations, more applied research is needed in third developing countries, especially in Latin America. Some studies have focused on technological innovation capabilities (Ali, Muhammad & Park 2011; Fan 2006) and have suggested that technological innovation capabilities in third developing nations can be achieved by following a spiral model with four steps; initiation-imitation-improvement-innovation. Nevertheless, many companies in some developing nations have developed their business during a long period of time by buying and adapting technologies, but just a few have been able to move on to the improvement and innovation stages. Therefore, companies need to know better how to build and maintain innovation capabilities, not just technological ones to get more value from innovation efforts.

7 SUMMARY

Given the relevance that the term innovation has nowadays for any kind of business, the role that the energy industry plays in the evolution of the world, and the importance that some developing countries are showing for the economy, the author presents a research done about innovation management in the oil and gas industry with the purpose of identifying how companies in the oil and gas sector manage innovation. Due to the professional linkages and knowledge of the author, the study is developed in a state company (National Oil and gas Company – NOC) from Colombia, a developing country in Latin America.

Throughout the study, the main research question defined as "*How to manage innovation in the oil and gas companies?*" is approached by two sub questions, as follows:

1. *What kind of innovations do the oil and gas companies make?*
2. *What are the principal elements on which companies focus to manage innovation?*

In order to give answer to the main research question and sub questions, the author follows a disciplined and logic structure. To do this, the author first gives an introduction about the relevance of the topic and how important is innovation for the real business world, therefore for the national economy of any country. After this, a literature background around innovation, innovation typologies, innovation models and elements, innovation capabilities, and innovation and competitiveness, is given. From this it is possible to see that despite the great efforts on the research of innovation management, it seems not to exist a magic or unique formula to manage innovation within companies, even though within companies in the same sector.

After building the innovation literature background, the author approaches the oil and gas industry as well as its performance regarding innovation in a general sense and in Latin American main oil and gas companies. Although the author hardly manages to find literature about it, from what is identified it is possible to see some similarities and common trends that companies share in the industry, but also how every company has approached them in a different way. Basically, companies in this sector face mainly two big challenges, one associated to innovation in procedures and technologies for exploration, extraction, production and commercialization of the product, and other related to the investment in alternative fuels, in order to satisfy the future energy demand which seems to be shaped not by natural limits but by social choice. Nevertheless, although innovation has proved to be a "must" in companies of this industry, its management is still on its initial steps and the majority of the companies in the oil and gas industry do not have a history of innovation and have transformed it mainly as an R&D issue.

Having the literature background and the general approach about the analyzed industry, the methodology used for the study is introduced and explained. The research fol-

lows a single case strategy due to the fact that it provided the author with an opportunity to observe and analyze a phenomenon in the case company that no one has analyzed before. The research is carried out during the year 2012 and the first semester of 2013, in a company called Ecopetrol S.A which belongs to the oil and gas industry from a developing country, Colombia. Qualitative data is collected based on non-standardized interviews (which were designed by the author) one-to-one and the collection of information about the company taken form its website, and the documents and procedures the company provided to the author for the analysis.

The sample for the interview is selected based on people´s hierarchical position, experience, professional roles and responsibilities, direct relation with the innovation process and with the different elements that could integrate a common innovation framework. Finally the author manages to have 11 interviews from 15 people who were contacted at first. These interviews are recorded and then transcribed in Spanish language, which was a time consuming task, but very relevant for the development of the research.

Complementary, secondary documentary data is also collected based mainly on the information given by the company directly to the researcher. This information was mainly in electronic format (pdf, word, excel, ppt, project, etc…) downloaded from the company`s website, and internal published documents and procedures.

The research follows an inductive approach, therefore the author uses data categories to understand and manage data, integrate related data drawn from different transcripts and notes, identify key themes or patterns form them for further exploration, develop and/or test theories based on these apparent patterns or relationships, and draw and verify conclusions.

From the data the author builds the possible relationships and interactions within categories and between them, from which three kind of relationships are identified between the different categories: Relation of content, relation of impact in the definition, and relation of impact in results. Furthermore, the author analyzes the data from other perspective: by analyzing the answers given by three groups of people (according to the nature of their jobs) finding interesting patterns among this classification. Finally, the author builds a figure composed by blocks of 3 by 3 spaces which includes the most common responses in each selected category. The way as the information is presented is easy to understand as well as novel.

For the analysis of the information triangulation in data collection, interview fidelity, and theoretical validity are used by the author to build confidence in the study and its findings.

After presenting the methodology used in the research, the author introduces the case company, its main facts, strategic frame, and innovation stage at the moment of the study. Thus, thanks to the literature background and the analysis and interpretation of the information collected through interviews and secondary data, the author builds an

analogy of the core value chain and the elements of a framework to manage innovation in the case study company through the identification of the main elements to be considered, their interrelations and impact in the company´s goals. The framework construction is supported on a series of decisions that the company should consider related with strategy and structure, operations and scope of innovation, and the structure and process of innovation.

Within the construction of the framework the author integrates in a cube shape the next elements which cannot exist independently and need to be aligned with the strategy of the firm: Innovation management framework, innovation strategy, innovation process, technology management and innovation management, people and innovative culture, knowledge management and innovation management, innovation measurement, open innovation, and resources for managing innovation. These elements are introduced and explained based on the results obtained from the interviews and data analysis. In parallel some recommendations are given for the company to develop those elements within the framework.

Finally, the author concludes about the main findings from the research, highlighting interesting characteristics about managing innovation in oil and gas companies, and gives answer to the main research question and sub questions. Subsequently, the author highlights the applicability of the constructions from a perspective of the case company, and from other and different actors such as government, academy and industry. At the end, the author presents the theoretical contribution and implications for further research in different elements related to innovation management in oil and gas industry and in developing nations.

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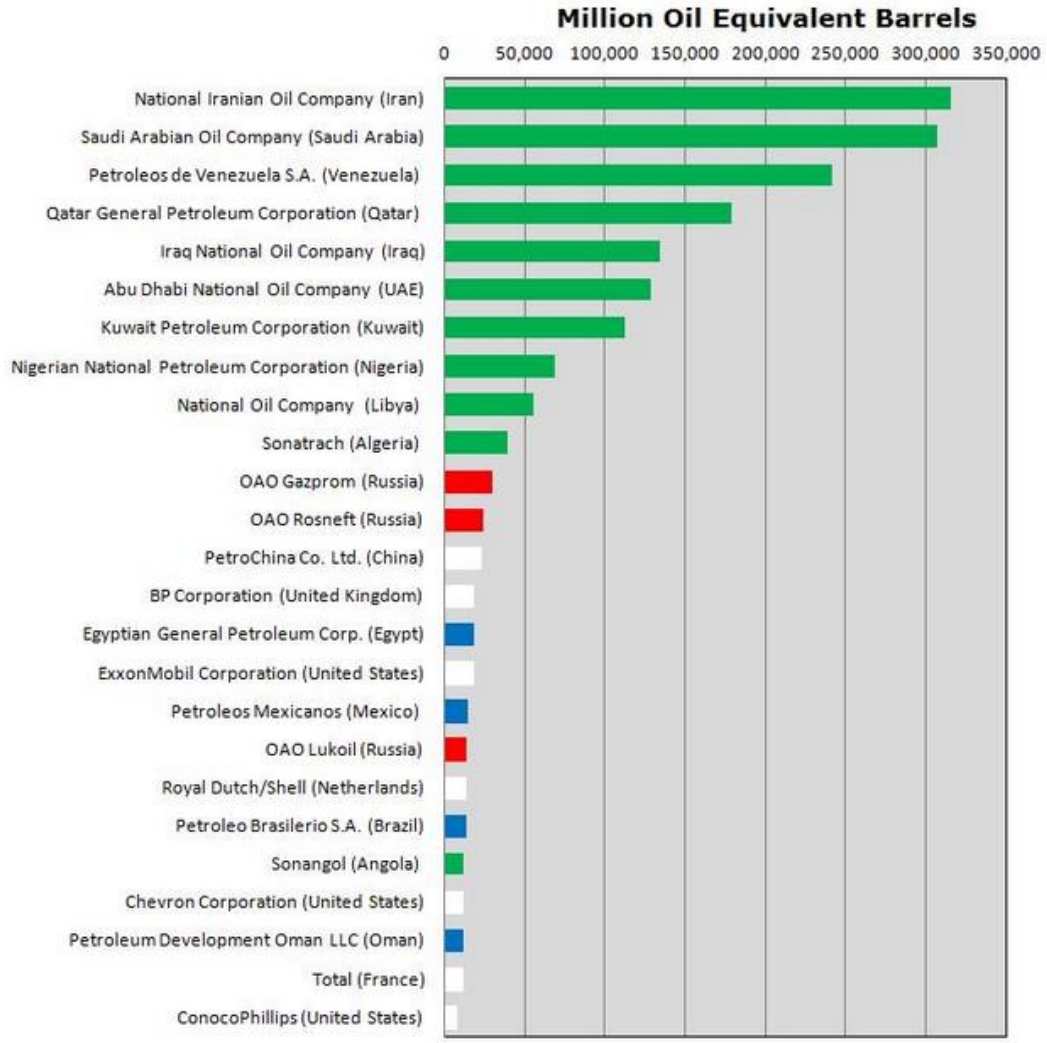
APPENDIX 1. WORLD´S LARGEST OIL AND GAS COMPANIES BY OIL AND GAS RESERVES



Source: PetroStrategies, Inc. February 2012

Notes: Green bars are OPEC members

Red bars are Russian companies

Blue bars are non-OPEC national oil companies

White bars are public multinationals

WORLD´S TOP 25 OIL AND GAS COMPANIES 2012 BY PRODUCTION VOLUME

Rank	Company	Production volumes* (million barrels per day)
1.	Saudi Aramco (Saudi Arabia)	12.5
2.	Gazprom (Russia)	9.7
3.	NIOC (Iran)	6.4
4.	ExxonMobil Corp. (USA)	5.3
5.	PetroChina (China)	4.4
6.	BP (UK)	4.1
7.	Royal Dutch/Shell (NL/UK)	3.9
8.	Pemex (Mexico)	3.6
9.	Chevron Corp. (USA)	3.5
10.	KPC (Kuwait)	3.2
11.	ADNOC (UAE)	2.9
12.	Sonatrach (Algeria)	2.7
13.	Total (France)	2.7
14.	Petrobras (Brazil)	2.6
15.	Rosneft (Russia)	2.6
16.	MoO (Iraq)	2.3
17.	QP (Qatar)	2.3
18.	Lukoil (Russia)	2.2
19.	Eni (Italy)	2.2
20.	Statoil (Norway)	2.1
21.	ConocoPhillips (USA)	2.0
22.	PDVSA (Venezuela)	1.9
23.	Sinopec (China)	1.6
24.	NNPC (Nigeria)	1.4
25.	Petronas (Malaysia)	1.4

Source: Helman (2012)

WORLD´S BIGGEST 20 OIL AND GAS PUBLIC COMPANIES 2012 BY PRODUCTION VOLUME

BROWSE THE LIST

Values calculated April 2012

Rank ▲	Company	Country	Sales	Profits	Assets	Market Value
1	Exxon Mobil	United States	$433.5 B	$41.1 B	$331.1 B	$407.4 B
4	Royal Dutch Shell	Netherlands	$470.2 B	$30.9 B	$340.5 B	$227.6 B
7	PetroChina	China	$310.1 B	$20.6 B	$304.7 B	$294.7 B
10	Petrobras-Petróleo Brasil	Brazil	$145.9 B	$20.1 B	$319.4 B	$180 B
11	BP	United Kingdom	$375.5 B	$25.7 B	$292.5 B	$147.4 B
12	Chevron	United States	$236.3 B	$26.9 B	$209.5 B	$218 B
15	Gazprom	Russia	$117.6 B	$31.7 B	$302.6 B	$159.8 B
18	Total	France	$216.2 B	$15.9 B	$213 B	$132.4 B
24	Sinopec-China Petroleum	China	$391.4 B	$11.6 B	$179.8 B	$104.2 B
27	ConocoPhillips	United States	$230.9 B	$12.4 B	$153.2 B	$98.8 B

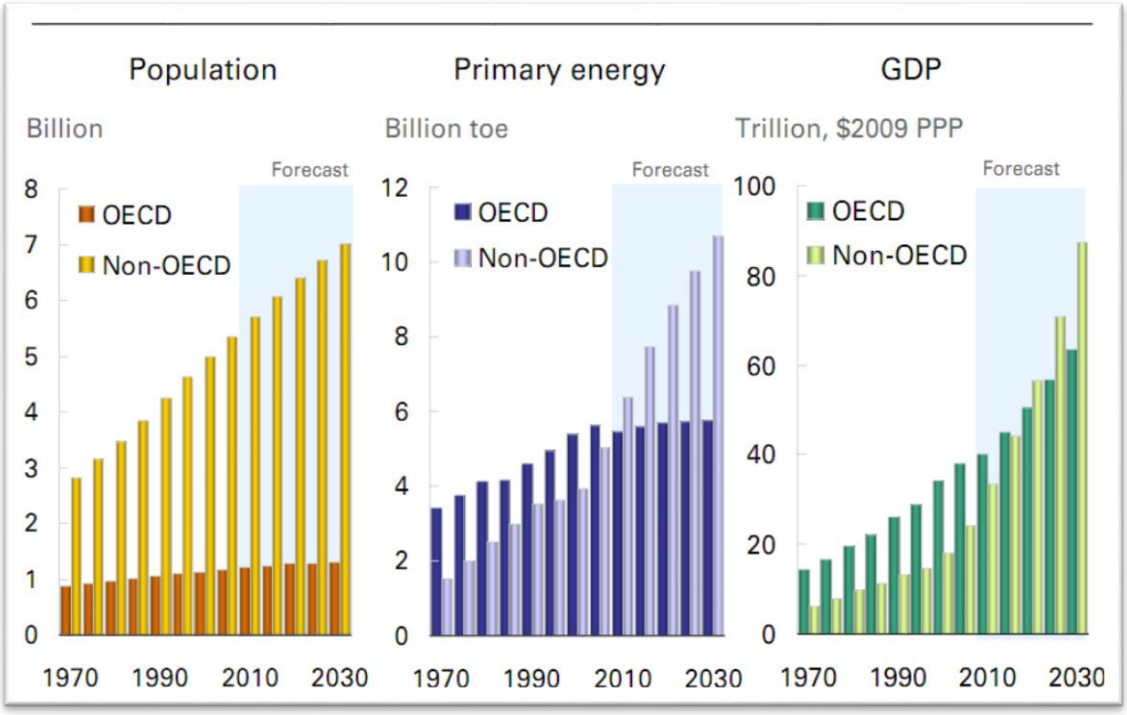
BROWSE THE LIST

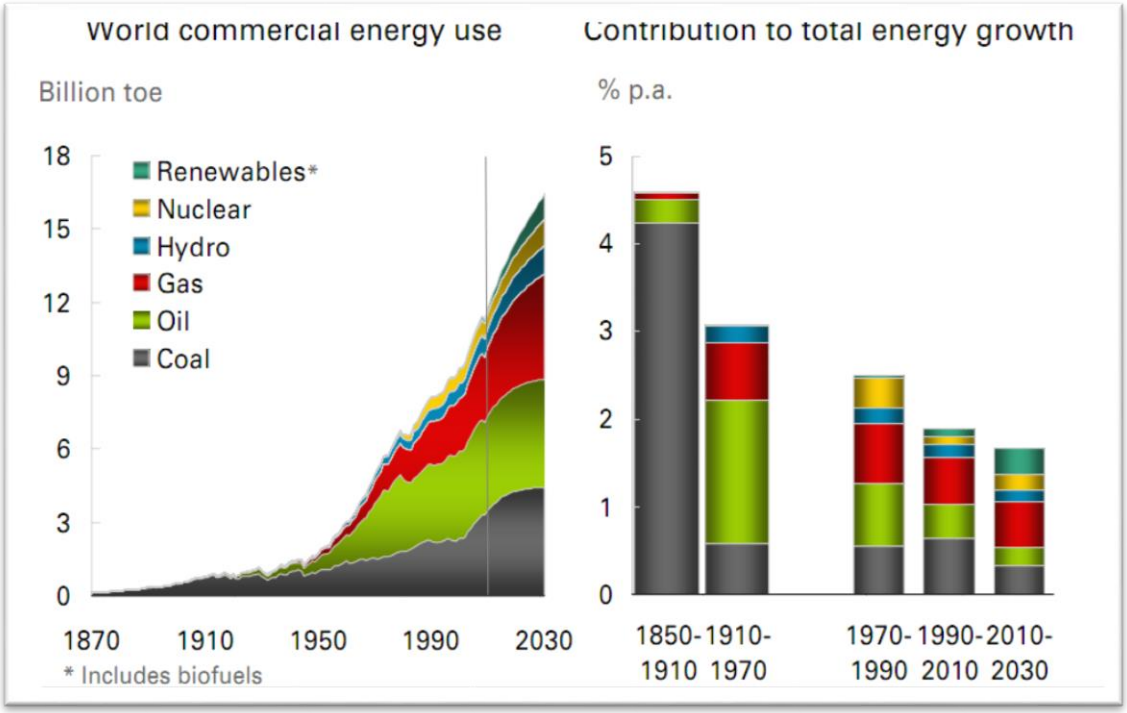
Values calculated April 2012

Rank ▲	Company	Country	Sales	Profits	Assets	Market Value
29	ENI	Italy	$143.2 B	$8.9 B	$178.7 B	$97.6 B
41	Statoil	Norway	$111.6 B	$13.1 B	$127.8 B	$89 B
68	Lukoil	Russia	$111.4 B	$10.4 B	$90.6 B	$55.3 B
71	Rosneft	Russia	$59.2 B	$11.3 B	$106 B	$79.6 B
124	Reliance Industries	India	$59.5 B	$4.3 B	$69 B	$50.4 B
134	Suncor Energy	Canada	$39.1 B	$4.2 B	$73.4 B	$51.8 B
137	Ecopetrol	Colombia	$35.6 B	$8.4 B	$47.6 B	$119.7 B
140	Repsol YPF	Spain	$72.8 B	$2.8 B	$88.8 B	$30.1 B
145	Occidental Petroleum	United States	$24.1 B	$6.8 B	$60 B	$81.6 B
146	Cnooc	Hong Kong-China	$27.1 B	$8 B	$49.7 B	$96.3 B
149	TNK-BP Holding	Russia	$60.2 B	$9 B	$37.1 B	$51.6 B

Source: Forbes (2012)

APPENDIX 2. 2030 ENERGY OUTLOOK





Source: British Petroleum (2011)

APPENDIX 3 INTERVIEW DESIGN

I really appreciate your efforts at answering this interview. The purpose of it is to identify relevant aspects which can be taken into account at building and developing Ecopetrol S.A. as an innovative company. It belongs to an academic study which may contribute the company to structure and improve its innovation management.

The interview contains 16 open questions for which I appreciate your honest answers.

1. What do you understand by innovation under the context of Ecopetrol S.A.?
2. Do you consider Ecopetrol S.A. as an innovative organization? Why yes, why not?
3. Do you know any innovation strategy at Ecopetrol S.A.? If so, is it shared and understood within the whole organization? If not, what should be the innovation strategy at Ecopetrol S.A.?
4. Do you know any roadmap for Ecopetrol S.A. in which the company specifies how innovation will take it forward in?
5. When thinking about an innovation management framework, which elements do you think must be considered at Ecopetrol S.A.?
6. What are the roles that the next factors play at developing and building innovation at Ecopetrol S.A. and how should they be defined for the innovation process?
    a. leadership,
    b. organizational structure (innovation managed centrally vs. decentralized),
    c. innovation process structure,
    d. communication, and
    e. culture and motivation (compensation and recognition / ideas worked in teams or isolated)
7. Do you know any technique or tool which can be used at identifying, selecting and implementing innovative ideas or opportunities at Ecopetrol S.A. or in your area?
8. How and where should Ecopetrol S.A. search for innovative opportunities and ideas? Which are the challenges related to this searching?
9. On what should Ecopetrol S.A. focus its innovation efforts and how to balance the different approaches (product innovation, process innovation, incremental or radical innovation, etc.)? Should Ecopetrol S.A. focus on current, extended or new markets and customers / products and services, when innovating?
10. What do you think about open innovation at Ecopetrol S.A.?
11. Which networks do you think Ecopetrol S.A. should have to develop joint innovation?
12. How does the innovation decision process work at Ecopetrol S.A.?

13. How do you think can Ecopetrol S.A. ensure that it captures value from its efforts at innovation?

14. How do you think knowledge management leverages the innovation process at Ecopetrol S.A.?

15. How do you think technology management leverages the innovation process at Ecopetrol S.A.?

16. What resources do you think are required for innovating at Ecopetrol S.A.? How should they be distributed?