

R&D Portfolio Management: The Case Study of a Big Energy Company in Brazil

Mariana Savedra Pfitzner, Ruy Quadros
State University of Campinas, Science and Technology Policy Department
IG/UNICAMP, Rua Pandia Calógeras, 51, CEP: 13083-870, Campinas – São Paulo, Brazil

Abstract:

The Portfolio Management is a process that belongs to innovation management, whose objective is to translate the company's technology strategy. Portfolio Management entails the systematic evaluation, selection and prioritization of R&D projects in the organizational context. The aim of this article is to discuss the use of tools for managing the R&D portfolio in the Brazilian electrical sector, using the case study of an energy distribution company as an analytical support. The Brazilian electrical sector was chosen due to the significant resources invested in R&D over the last 10 years, which surpassed US\$ 1 billion. In this sector, investment in research projects and guidelines for their completion are enforced by law. Otherwise, energy companies would not invest in R&D, they would rather buy equipment and systems from international suppliers. For this reason, the government agency ANEEL (Agência Nacional de Energia Elétrica) enforces Brazilian energy companies to invest in R&D, aiming at the creation of a national innovation system. Through this, companies are obliged to invest around 0.5% of their EBTs (Earning Before Taxes) in R&D projects. The execution of these projects is also strongly supervised by ANEEL, which guarantees that their results will turn into new products, patents, job creation, tariff reduction and operational efficiency for the company. Then, R&D projects do not only pursue technology risk but also the so-called regulatory risk. If projects do not accomplish with government criteria, energy companies may be strongly penalized. In order to avoid such regulatory risk, companies shall implement Portfolio Management tools to guide their technology strategies.

Regulatory risk should be prioritized in the evaluation and selection of research projects. Hence, the company's R&D portfolio must be balanced in such a way that the expectations of all stakeholders, namely, society, government and company's board, are attended. Therefore, the use of Portfolio Management tools like technology roadmaps and strategic baskets communicate company's strategy to their external R&D partners and help it manage regulatory risks much better. In the end, this article shows methods of selection and prioritization of R&D projects, which were developed by a big energy company. The methodology used in this article includes a literature review and interviews carried out with the Innovation Management Area of the selected company. The results help the authors make practical suggestions to support the R&D Portfolio Management of all energy companies whose research activities are also regulated.

I. Introduction: R&D Portfolio Management and National Regulation in the Brazilian Electrical Sector

The Portfolio Management is a very important activity which belongs to the process of strategic innovation management [19] [20]. R&D Portfolio Management means the evaluation of new ideas which go through the innovation pipeline as well as the selection of the most suitable project portfolio.

The primary objective of this paper is to discuss challenges and recommend the application of tools to manage the R&D portfolio in the Brazilian electrical sector, using as case study a national energy company. It is worth noting that the Brazilian companies and their R&D activities are strongly regulated by the National Agency of Electric Energy (ANEEL – “Agência Nacional de Energia Elétrica”). The authors have chosen to study the electrical sector in greater details because of the significant amount of R&D budget invested by generation, transmission and distribution companies. From 1998 until 2007 more than US\$ 1 billion was allocated in 4,500 new research projects. From these projects, 25% have turned into new software and systems, 21.3% into methodologies and 11.2%, into new equipment [4].

Session II presents the methodological steps. The research strategy used in this paper was based on a careful literature review, as well as the analysis of the science policies for the national electrical sector and interviews, which were carried out in the energy company from 2009 to 2010. The authors have also analyzed company’s R&D portfolio and its scoring methods. All these documents were available for the authors, that could compare theoretical and practical features regarding R&D Portfolio Management. In the end, the authors could formulate a group of good practices which may be applied by other energy companies. Considering that the R&D resources are determined and controlled by the ANEEL Agency, these good practices aims at adjusting company’s strategies with governmental and societal interests.

Session III of this paper presents a theoretical background with respect to different approaches adopted by organizations to manage their R&D Portfolio. The authors emphasize the so-called top-down approaches that employ the methods of strategic baskets and technology roadmaps (TRMs). These two methods can be employed to select R&D projects as well as to mitigate possible regulatory risks that may emerge from ANEEL’s strong regulation.

Actually, ANEEL has conceived the R&D Program for the electrical sector through the Law 9991 from 2000 [15], which states that every energy company that provides electricity shall invest a percentage of its EBTs (Earning Before Taxes) in R&D (around 0.5%) to increase its operational efficiency and, as a consequence, reduce customer’s tariffs. The Agency not only expects tariff reduction through the improvement of company’s operational efficiency but all R&D investment shall also foster the generation of research networks, start-up companies, universities, research institutions and national equipment suppliers. Besides, R&D results may also be transferred from universities to the industry.

Session IV shows the main guidelines from the R&D Program in order to present the regulation environment in Brazil, in which the main energy players live and operate. This session underpins the application of approaches, methods and tools of Portfolio Management to mitigate regulatory risks of energy companies.

The main thesis of this paper is that the top-down methods of Portfolio Management play a crucial role by measuring and managing regulatory risks in energy companies and communicating strategic research programs to companies’ R&D partners.

The regulatory risks arise from the evaluation of R&D projects, which is performed by ANEEL, after they have being concluded. If the Agency evaluates that the finished project was not related to R&D indeed, the energy company may be strongly penalized. Hence, energy companies must consider regulatory risks when selecting their R&D portfolio, not to mention the technical and economic criteria. Conciliating regulatory demands from ANEEL with company's economic returns means meeting all stakeholders needs (society, company's board, government, shareholders, etc.). In other words, it is recommended that regulation aspects are taken into account by Brazilian's energy companies when managing R&D portfolio, so that R&D results can generate direct benefits for the society. As the Agency states in [2]:

“for the energy companies, R&D results shall be turned into new businesses, revenues, productivity gains, process optimization, quality improvement, cost reduction and, as a matter of fact, tariff reduction for the final customer.” (p. 18, authors' translation)

Then, methods of Portfolio Management such as strategic baskets and TRMs may help balance R&D portfolio of energy companies, harmonizing all demands coming from this complex environment. But prioritizing regulatory risks in Portfolio Management may provoke a trade-off between company's business objectives and societal interests. Sometimes, company's growth strategy coming from its strategic planning has nothing to do with societal needs.

On the one hand, Brazilian energy companies tend to use R&D resources to buy existing equipment and systems just to improve their network, instead of developing R&D. According to Freemann's classification of technology strategies [13], energy companies are more imitative, that means, they basically depend on external suppliers to buy equipment and their focus lie upon quality management and engineering processes. None of these activities have something to do with ANEEL's definition of R&D [2]:

“R&D projects are supposed to develop capabilities and technologies for the energy companies, aiming at the creation or improvement of new processes and products. R&D projects shall be managed by company's own staff”. (p.16, authors' translation)

After discussing evaluation methods of project portfolio (Session III) and R&D structure in the electrical sector (Session IV), **Session V** will present the case study carried out in a private energy company, which applies TRMs, strategic baskets and scoring methods to select research projects. The concluding remarks summarize a group of good practices to improve innovation management processes at energy companies which operate in regulated environments. The expected results from using these portfolio tools are the better management of regulatory risks as well as the maximization of projects' benefits for the companies and society.

II. Research Methodology

This paper uses a literature review considering important authors who deals with innovation management and R&D Portfolio as in [9][10][11][14][20][21]. Brazilian's regulation for R&D in electrical sector was also studied to design sector's path and institutional framework. The sector's trajectory is based on the Law 9991 from 2000 and performance indicators are issued by the Agency in its R&D Magazine called “Revista de P&D ANEEL” [4].

A case study was also conducted in one of the biggest private companies which generates and distributes electricity. The question guiding this work is: “What are the possible forms to use R&D Portfolio Management methods in the Brazilian electrical sector, under the condition that R&D investment is regulated by a public Agency and the society must take advantages of research results?”

The literature review has enabled the construction of a theoretical approach which included the different methods of Portfolio Management and their importance for the whole process of strategic management. Nonetheless, understanding sector’s trajectory and institutional framework is the cornerstone for the case study. According to [12], case studies are used to provide a descriptive illustration, explore a phenomenon and test or generate a new theory. The present case study from Section V illustrates a practical way to apply R&D Portfolio Management methods which aims at selecting research projects strategically. At the same time, it allows the exploration of empirical knowledge of R&D management practices in a national energy company.

The results from this analysis can be presented to the international research community and used by other energy companies to improve their R&D project evaluation and selection. On the one hand, companies will be able to select a more adequate R&D portfolio, conciliating governmental issues with private interests.

The interviews carried out in the Brazilian energy company as well as a deep look into the R&D Portfolio documents have permitted the evaluation of the following categories of analysis:

- **Types of top-down methods to manage the R&D portfolio:** with respect to strategic baskets, the authors have analyzed how R&D investment is allocated by the energy company. In the case of TRMs, the authors gathered information concerning TRM models and updates;
- **Criteria used to score and prioritize R&D projects:** the authors have analyzed how important is the regulatory risk for the company to select the most suitable R&D projects.

The interviews were conducted with two innovation analysts and the innovation manager of the energy company. The authors could also take part of some meetings from the Innovation Area whose focus was selecting and prioritizing R&D projects. Some TRMs and project ranks could also be examined. A roadmap for combustion, hybrid and electrical vehicles could be used as an example in this paper (Fig. 4). It is important to mention that in the Brazilian electrical sector, companies do not have to face competition and their markets are captive¹. For this reason, the authors did not have problems to access this kind of information, as long as company’s name would be kept in secret. Then, the content analysis of interviews and documents has enabled to evaluate the effectiveness of all methods deployed by the energy company. Fig.1 summarizes methodological steps taken by the authors.

¹ Exception is granted to customers with outputs exceeding 0.5 MW, who are free to choose the energy company.

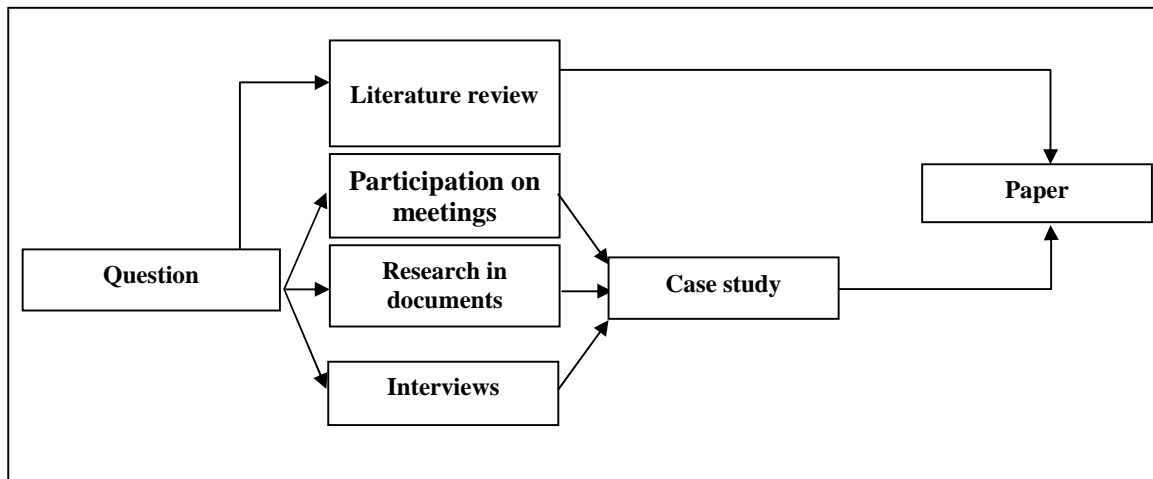


Fig. 1 Research Methodology

III. Theoretical Approach: Methods to Manage R&D Project Portfolio

Companies which develop new products face the challenge of choosing the most suitable project portfolio for their needs. The distribution of R&D resources into the best projects is not a simple task, because R&D budget is normally limited and projects present different return functions [16] and lead times. The “Science of Portfolio Management” considers the R&D portfolio the concretion of company’s business strategy, because portfolio rules the distribution of R&D investment in time [10] [21]. Project portfolio, also named aggregate project plan [22], reveals existing gaps and suggests where firm’s capabilities needs to be stronger.

Generally, methods of Portfolio Management are used by companies for financial (profit maximization) and strategic reasons (strategy support), as well as to communicate business guidelines to employees, suppliers and external partners. Moreover, Portfolio Management intends to enhance objectivity, market-share and focus [9]. There are three different approaches to manage R&D portfolio, namely the top-down; bottom-up; top-down and bottom-up (hybrid) ones.

The top-down approach is basically related to strategic baskets and TRMs. Strategic baskets are the systematic allocation of R&D resources, using criteria previously defined by company’s board. The allocation of R&D resources into baskets may consider strategic objectives (diversification or expansion), product lines (equipment, methodologies, systems, etc), market segments (big industries, residential customers, etc) and types of technologies or projects.

Some possible ways to allocate projects into strategic baskets encompass the histograms and bubble charts, which compare variables such as risk, financial returns and project size in one figure. Also, the net present value, payback period, internal rate of return, scoring and check lists belong to the strategic baskets approach, helping take better go/kill decisions.

With respect to TRMs, these are multi-layer models that show possible technological developments aligned with market trends and regulatory framework [18]. Their design involves specialists from different fields of knowledge who indicate possible evolutions for technologies and their applications into products, services, systems and capabilities. Actually, these applications are the bridge between the market and technology [6].

In the case of the bottom-up approach, R&D projects come from all areas. Because of that, sometimes they are not compatible with company's strategic planning. Methods coming from this approach evaluate the alignment and contributions of R&D projects to company's strategy. The hybrid approach is a combination of top-down and bottom-up methods: The company's board decides about strategic themes (top-down) and R&D projects proposed by company's employees are evaluated and judged according to such themes (bottom-up).

Cooper's study concludes that companies' portfolio seeks for the achievement of results in the short run. That means, companies' R&D projects tend to be more incremental than disruptive in terms of innovation. The word "repacking" is used for products which are customized in a fast way to attend customer's demands. Then, disruptive projects are becoming less frequent in the world of corporations. The cause for this phenomenon is the limited R&D budget. Nonetheless, companies' face a specific dilemma ("The innovators dilemma") in which they "hear" customers' demands and make a few changes in existing products, forgetting to focus on technological breakthroughs [8].

Top-down and bottom-up approaches help selecting projects which go through the innovation pipeline (Fig. 2). The innovation pipeline is a group of different gates that select projects which will become market products. The main function of innovation pipelines is to improve the quality management of project's portfolio. The first gate of the innovation pipeline is called "ideas", in which market demands are identified and TRMs can be used. The go/kills decisions are made during the "charter gate". The "contract gate" evaluates technical and economic potentials of projects in greater details. And last but not the least, the "launch gate" comprises the business plan, which turns projects into market products [14].

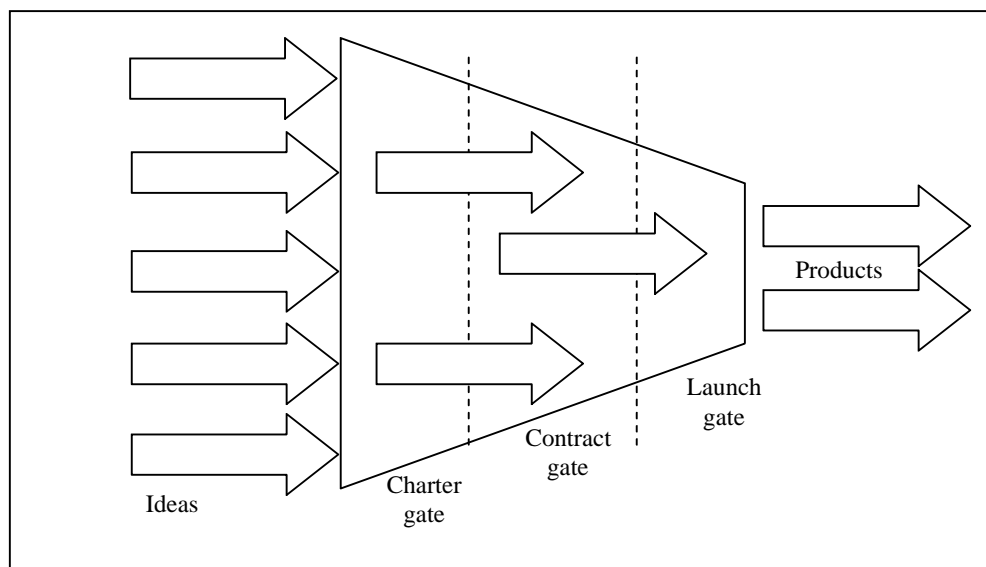


Fig. 2 Innovation pipeline and gates for project portfolio management

Source: Modified from Gavira, et al. (2007, p.89)

It is worth noting that along the pipeline, ideas turn into products but R&D projects may be discontinued if they are not interesting for the company anymore.

IV. Electrical Sector and R&D Portfolio Management

a. Path Dependence and Science Policy at Brazilian's Electrical Sector

Given the amount of R&D budget that Brazilian companies must invest, the issue that comes out is how to distribute project portfolio so that projects are interesting for the Agency, society, shareholders and company's board.

R&D investment is conditioned by the Law 9991 from 2000 and the main guidelines to execute, contract and evaluate R&D projects are written in ANEEL's R&D Handbook for the electrical sector ("Manual de P&D ANEEL") [2] [3]. The main motivation for the creation of this Law is a national plan towards mitigating country's dependence on multinational suppliers. Historically, energy companies were used to buy equipment and systems in the international market because their core business is limited to the generation, transmission and/or distribution of energy. Reference [19] suggests that technological trajectories determine company's innovation potential.²

When creating the Law 9991/2000, the Agency was also motivated to reduce customers' tariffs and structure a national innovation system through stimulating R&D activities in the sector. Through R&D investment, companies could provoke spillovers to the society by means of tariff reduction. In other words, R&D projects should increase company's operational efficiency by sinking expenditures which should reduce customers' tariffs³.

Other expected results coming from R&D investment are the creation new jobs for researchers, competence building of human resources and technology transfer from universities to national suppliers [1] [2].

Since the Law exists, ANEEL is responsible for evaluating all R&D projects from the energy companies to assure that the society (universities, customers, start-up companies and research institutions) also take advantages of R&D spillovers.

In the past, all energy companies had to send their projects for approval before they begin. For this reason, regulatory risks were too small, which means that companies could not spend the R&D budget without ANEEL's previous approval. After 2008, these guidelines have changed and energy companies can do "whatever they want" with R&D budget, being evaluated after project's conclusion. The new evaluation criteria used by ANEEL are originality, applicability, relevance and reasonableness of costs. Originality means that R&D projects must be at least new for the energy sector. On the other hand, applicability means that every project shall be potentially used by the electrical sector. Project's relevance is measured by its contributions in terms of science, technology, environment and economy. Reasonableness of costs means whether project's costs are adequate to their expected economic results.

For each criteria, projects may receive from 1 (minimum) to 5 points (maximum), depending on ANEEL's judgment [5]. Projects which receive less than 3 in one criteria are disapproved by the Agency.

Thus, after 2008, project's regulatory risks have increased because energy companies can manage the R&D budget without ANEEL's previous signalization. If ANEEL disapproves a project after its conclusion the energy company is penalized and must pay the same amount of money spent on the project. Because of these regulatory changes from 2008, energy

² Company's technological paths may be divided into science-based, scale intensive, specialized-suppliers, information intensive and supplier-dominated firms. Brazilian energy companies have always imported systems and equipment, being considered as supplier-dominated firms.

³ Brazilian energy companies have always imported systems and equipment, being considered as supplier-dominated firms.

companies must consider regulatory risks as essential criteria in their Portfolio Management. All R&D projects can be included in one of the following stages of innovation chain determined by ANEEL's R&D Handbook [2]:

- Basic research: This is a quite theoretical stage of the innovation chain, which is supposed to generate new knowledge from natural laws and phenomena;
- Applied research: This is the application-phase of knowledge generated during the basic research;
- Experimental development: In this stage the technical and economic feasibility of research has to be demonstrated;
- Prototype: This stage aims at improving results from experimental developments, creating and testing better prototypes;
- Pilot plants and market penetration: The energy company is allowed to use the R&D resources to “prepare” their R&D products for internal use or even the market. The application of R&D budget on marketing and product's commercialization is permitted, as long as the project has gone through the other stages of innovation chain.

R&D has never been a part of energy companies' routines in Brazil. They are rather focused on providing energy to their customers. Instead of creating internal structure and capabilities to perform R&D activities, they have been investing R&D budget in universities, national suppliers, start-up companies and research institutions, which have become partially responsible for research activities. This R&D network is one of the spillovers provoked by the Law 9991. The theoretical approach of such arrangement is the open innovation model (Fig. 3).

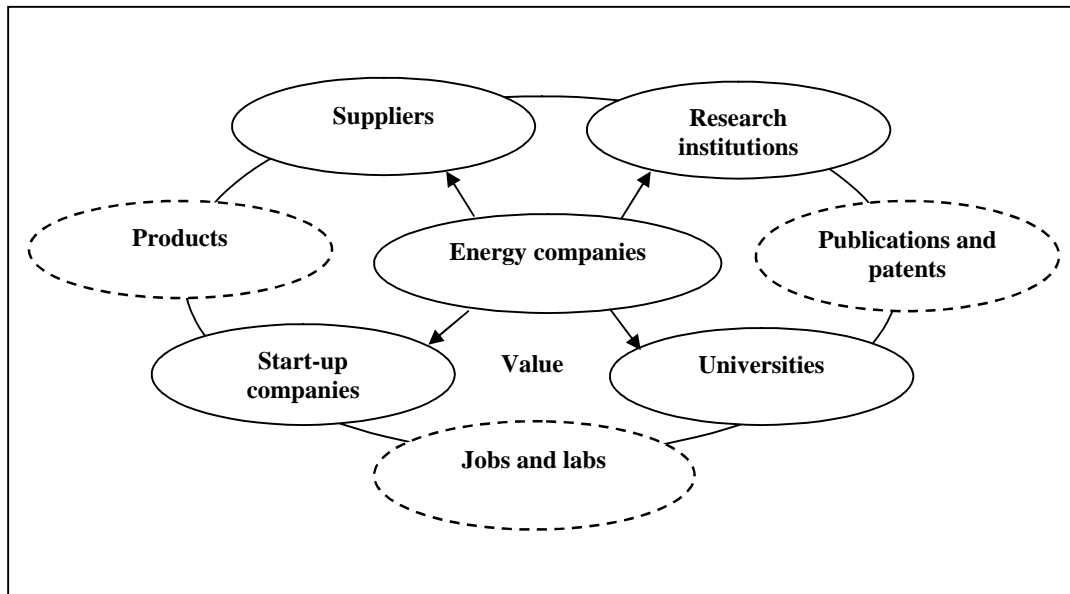


Fig. 3 Open innovation in the electrical sector

According to the open innovation model, the energy company (Fig.3) is the so-called industry shaper of partner's network. Within the network, there is a relation of cooperation and interdependency among the participants (non arm length transaction), based on value creation and appropriation [7]. ANEEL [4] has measured the total size of this network in Brazil, which

comprises 87 universities, 54 research institutions, 260 suppliers, 149 generation companies, 63 transmission companies and 74 distribution companies.

Each of these actors produces value and takes the benefits from R&D results⁴. For instance, universities and research institutions can publish project's results, get more research labs, increase the number of jobs and grants as well as apply for patents with energy companies. These patents can be negotiated with national suppliers, completing the process of technology transfer.

b. Regulatory Risks and Portfolio Management

Despite the Law and all the criteria used by ANEEL to evaluate R&D results, energy companies tend to behave opportunistically, trying to invest R&D resources in the purchase of existing systems and equipments just to improve the quality of their networks in a fast way. As mentioned above, R&D resources shall not only bring results for the company, but also for the society, which includes customers, universities, start-up companies, national suppliers and research institutions.

In order to combine and balance stakeholders' interests and demands, Portfolio Management methods such as strategic baskets and TRMs must be taken into account when selecting the most suitable R&D projects.

During the selection of ideas, all network actors can propose new projects or forms of cooperation. In this stage of the innovation pipeline (ideas gate), companies should measure the regulatory risk of each proposal. If the proposal does not fulfill ANEEL's evaluation criteria (originality, applicability, relevance and reasonableness of costs), it should be eliminated. On the other side, a proposal can be considered advantageous for the company, which means that its economic returns may exceed ANEEL's penalties. In other words, regulatory risks must be previously known so that they can be mitigated or accepted by the company.

As mentioned, hybrid and top-down approaches underpin two different methods to improve Portfolio Management, namely, the strategic baskets and technology roadmaps. Both of these methods are important to optimize R&D budget allocation and help projects' selection along the innovation pipeline. TRMs communicate companies' future research projects for the long run through representing potential and critical technology themes (Fig. 4). Then, roadmaps are essential methods which keep energy companies at the heart of their R&D networks and enable them to define their technology themes. The latter may split up into potential research programs and projects, within the roadmap's design. It is worth mention that TRMs can also refer to the very long run, depending on industry's cycle time. For instance, Japan's energy TRM published by MITI (Ministry of International Trade and Industry) [17] shows different technological paths and options for the next 100 years.

⁴ In contrast to many actors involved in Brazilian's R&D, in the US, utility companies have founded just one research organization. The EPRI (Electric Power Research Institute) is a non-profit institution that promotes collaborative R&D in the energy sector. Each of EPRI's members contributes for the whole research budget.

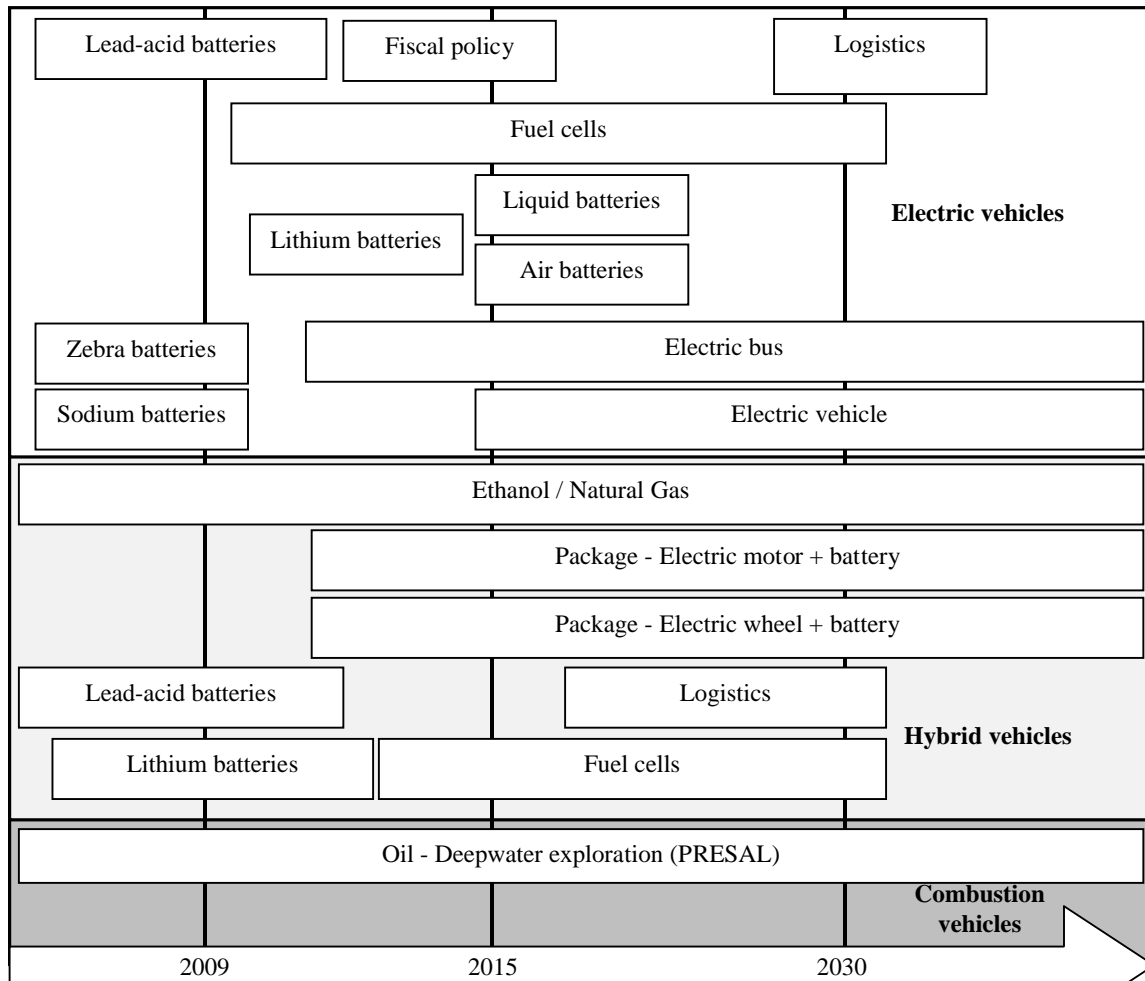


Fig. 4. Example of a TRM considering research themes (combustion, hybrid and electric vehicles until 2030)

Source: Energy company

The regulatory risk may be crucial and mandatory in the beginning of innovation pipeline (ideas gate). After measuring the regulatory risk, technical and economic feasibilities of projects must be analyzed. They are the calculation of market and technical risks as well as payback period, internal rate of return and project's net present value. R&D projects that belong to earlier stages of innovation chain (basic and applied research) do not have to demonstrate an economic feasibility.

Strategic baskets represent optimizing the R&D budget allocation. They are normally executed by company's board, given strategic dimensions previously defined. These dimensions may encompass market, regions, technologies and so on. The different grades of projects' regulatory risks can also be used as strategic dimensions to balance projects' portfolio (Tab.1).

Tab. 1 Regulatory risks as strategic dimension of R&D budget allocation

Regulatory risk	Low	Medium	High
R&D Investment allocation	X projects Total planned: US\$	Y projects Total planned: US\$	Z projects Total planned: US\$

Another possibility is to consider the different stages of innovation’s chain as a strategic dimension to allocate R&D investment. Through this, it is possible to characterize R&D projects much better, positioning them within the innovation chain determined by ANEEL.

V. Case Study: Management of R&D Portfolio in Practice

a. About the Energy Company and Its Strategic Baskets

The energy company of this case study has 7 million customers and covers more than 500 cities in Brazil. It generates and distributes energy, investing around US\$ 18 millions in R&D per year. These resources are mostly invested in research institutions, start-up companies and universities, which develop new products and systems for the energy company. On the whole, this company pursues roughly 40 research partners and put its resources in strategic baskets which are divided into new materials, sustainability, corporate integration and smart grid. The basket named “new materials” involves new physical and chemical structures for cables, poles, crossarms, isolators and transformers which are supposed to reduce operational and maintenance expenses. The “sustainability” basket refers to alternative energies and “corporate integration” aims at developing communication protocols between existing software and hardware within the energy company. The “smart grid” basket comprehends disruptive projects which may design a telecommunication infrastructure in the electricity network. It is important to mention that the company keeps around 50 ongoing R&D projects, whose values varies from US\$ 180,000 to US\$ 7,000,000.

b. Methods to Prioritize R&D Projects

The Portfolio Management comprises the evaluation, selection and prioritization of ideas and projects. It also helps measuring regulatory risks and communicating company’s technology strategies to its partners’ network. The company analyzed has considered a scoring tool to rank the most suitable R&D projects regarding the criteria presented on Tab. 2.

Tab.2 Criteria to score R&D projects

Macro criteria	Weights of Macro criteria	Indicators	Weights of Indicators	Ranges
Added value	20%	Internal rate of return	50%	Very good (5), good (4), regular (3), bad (2), very bad (1)
		Net present value	50%	Very good (5), good (4), regular (3), bad (2), very bad (1)
Project’s risk	10%	Technical	25%	High (5), medium (3), low (1)
		Market	25%	High (5), medium (3), low

				(1)
		Costs	25%	> 90% (5); 60% to 90% (4); 30% to 60% (3); 10% to 30% (2); < 10% (1)
		Time to market	25%	<1 year (1); 1 to 3 years (2); 3 to 5 years (3); 5 to 10 years (4); > 10 years (5)
Focus on corporate strategy	20%	Product importance	25%	High (5), medium (3), low (1), none (0)
		Innovation	25%	Radical (5), incremental (4), engineering application (2), non applicable (0)
		Strategic alignment	50%	Yes (5), no (0)
Possibility of application in other companies	10%	Applicability	100%	Weights distributed according to the number of target companies considered in the analysis
Competitive advantage	15%	Formal protection of invention	33%	Patent (5); No formal protection possible (0)
		Lead time	33%	> 5 years (5); 4 years (4); 3 years (3); 2 years (2); 1 year (1); < 1 year (0)
		Sustainability of advantage	34%	High (5), medium (3), low (1)
Technology	15%	Impact of technology	50%	Short run (5); medium run (3); long run (1)
		Creation of new knowledge	50%	High (5), medium (3), low (1)
Regulatory risk	10%	Regulatory risk	100%	High (5), medium (3), low (1)

Source: Energy company

The scoring tool adopted by the energy company pursues macro criteria which are divided into indicators. Dimensions such as added value, project's risks, focus on corporate strategy, applicability, competitive advantage, technology and regulatory risks were used for the evaluation. Company's Innovation Area has assessed and judged all projects using these criteria by means of meetings, which were held during six months. Then, they have come to a final project rank, which was presented to company's board in the end of the year.

The added value is graded through financial indicators such as the internal rate of return and net present value. If they were unknown or could not be calculated, the innovation team used the "rule of thumb" to attribute a grade (from 1 to 5). The project risk has encompassed the technical and economic risks. In the meanwhile, regulatory risk was treated as a separated macro criteria. In spite of that, little significance (or weight) was attributed to this criterion.

The focus on corporate strategy was supposed to be the alignment among R&D projects and corporate strategic planning. The applicability referred to the possibility to use project's results in other companies, considering different characteristics of the electricity network.

The competitive advantage should express the possibility of applying for a patent as well as project's lead time, which means, the total time from the prototype stage until product's launch in the market. The macro criteria "technology" was supposed to measure technological impacts of the project as well as competence building of human resources.

After the scoring process, projects were put in a histogram comparing their total scores, which could vary from 0 to 100. Projects with scores lower than 70 were eliminated from the R&D Portfolio and could not go along company's innovation pipeline. All the scores were presented to company's board which has only validated the results. Given these methods and criteria of projects' selection, some improvement strategies were suggested by the authors of this work.

Firstly, the energy company should have attributed more importance (says "weight") to regulatory risk because company's R&D budget is regulated by ANEEL. If this strategy had been followed, there would be more balance between risk and return. Nonetheless, different weights should be attributed depending on the project's stage in the innovation chain. For instance, projects of basic research could not be evaluated by means of financial indicators because their impacts are mostly unknown. Another strategy for a better selection of R&D projects could be the combination of TRMs and scoring methods.

Company's TRMs were used to forecast technology trends rather than communicating research themes to company's research partners. TRMs were mostly built *ad hoc* by means of experts' opinions. They could be updated more often to reflect market and technology dynamics.

On the other hand, all economic analysis held by company's Innovation Area did not take the whole potential market into account. They were just restricted to company's environment and could not demonstrate the real market attractiveness R&D project results. The authors have also recommended the incorporation of competitive and technology intelligence activities in the Innovation Area in order to evaluate possible competitors as well as potential suppliers for technology transfer.

6. CONCLUDING REMARKS: PRACTICAL RECOMMENDATIONS

Portfolio Management methods are the cornerstone of the innovation management process. These methods aims at selecting R&D projects that go through the innovation pipeline and become real products for the company or even for the market. Besides, they represent important methods to communicate company's innovation strategies to its R&D partners, considering the paradigm of open innovation.

As above mentioned, there are three different approaches for Portfolio Management, namely, top-down, bottom-up and hybrid ones. In the present work, the authors have focused on the exploration of top-down methods, choosing the electrical sector as the analytical framework. While TRMs identify new market and technological opportunities, strategic baskets allows the optimal allocation of R&D investment by employing different strategic dimensions. Thanks to the Law 9991/2000, Brazilian electrical sector must invest a large amount of money in R&D. Energy companies normally invest their R&D budget in start-up firms, research institutions, universities and national suppliers, building research networks to perform research activities.

In the case of energy companies, the top-down methods help managing the regulatory risk, which is a part of Brazilian's R&D Program held by ANEEL. The Agency evaluates all R&D projects after they are concluded using originality, relevance, applicability and reasonableness of costs as criteria. Projects which do not comply with these criteria are disapproved and, as a consequence, energy companies are penalized. Then, R&D projects carried out by Brazilian energy companies pursue technical, market as well as regulatory risks.

The main challenges of Brazilian's electrical sector are to optimize the investment of R&D budget in a complex environment, where key stakeholders have different (and opposite)

demands. While the Agency wants to reduce tariffs for the final customers, company's shareholders wish to maximize their dividends and company's board, increase firm's profits. On the other side, universities and research institutions want to publish scientific articles and increase the number of grants. As a matter of fact, regulatory risks coming from R&D projects must be measured and previously known by company's decision makers. As already discussed, strategic baskets may allocate R&D project budget according to the degree of risk (high, medium or low). The case study did not intend to build a general model. The energy company was analyzed so that the authors could raise some Portfolio Management methods in practice and illustrate the theoretical approach. To sum up, five good practices coming from the case study can be applied by other energy companies:

- 1) Use top-down methods to manage R&D portfolio so that the company's decision makers take part of the strategy and allocation of investment;
- 2) Use strategic baskets to allocate R&D budget according to projects' degree of regulatory risks. Then, company's decision makers can previously measure regulatory risks and make better go/kill decisions;
- 3) Assign more importance for regulatory risks when evaluating projects during the scoring process;
- 4) Considerer the regulatory risk as critical in the innovation pipeline, measuring it through the usage of ANEEL's given criteria (originality, relevance, applicability and reasonableness of costs);
- 5) Build and update TRMs periodically so that the company knows the state of art and partners can propose new ideas of R&D projects.

The combination of regulatory requirements with the expectations of other key stakeholders is one step ahead to come to a more balanced portfolio, which is more compatible with the nature of Brazilian's R&D Program.

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