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PLANNING TEN YEARS AHEAD A MULTIDISCIPLINARY NUCLEAR RESEARCH AND TECHNOLOGY INSTITUTE: THE CASE OF IPEN

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ABSTRACT

Planning is always a problem in government organizations whose mission involves the development of R & D activities. The current issue of the Institute of Energy and Nuclear Research (IPEN), one of the institutes comprising the National Nuclear Energy Commission (CNEN), is to plan the reconciling the long-term ramifications of a large project whose funding is primarily derived from the budget Union with the R & D agenda of IPEN which is largely driven and funded by science and technology funding agencies. This paper aims at reporting the results of one of the stages of the work developed by IPEN to deal with this problem. In mid-2010, top management of IPEN approved the implementation of a participatory planning effort with the following guidelines: (1) focus on two of the three finalist functions of IPEN - Research & Development (R & D) and Products & Services (P & S), (2) results orientation with a time horizon of 10 years, (3) incorporation of the unfolding of a large project in this planning effort (this project has its own planning) and (4) the source of information of the planning process would be the teams involved in the research lines and projects (LPP's) and the lines of production activities (LAP's) – the lowest grouping level in the current planning framework of IPEN. The planning process developed was based on an adaptation of a technique known as technology roadmapping. The data were collected through a web questionnaire. At the end of the data collection in mid-December 2010 89 LPP's and LAP 28's responses were recorded. For the purposes of this article the following groups of information related to R&D finalist function are presented: Where are we now?: (1) Profile of the current team; (2) Motivation of research and (3) Sources used for identification R & D goals. How can we get there?: (4) Profile of research partners, and (5) Profile of the necessary changes. Where do we want to go?: (6) Classification of results by areas and (7) Nature of potential outcomes. Conclusions of this experience are presented at the end of this article.

1. INTRODUCTION

Research and Technology Institutions (RTI´s) are organizations whose mission involves the development of institutional activities that can generate results to both the short term and the long term depending on strategic decisions taken by their supporters as well as decisions taken internally. In order to have their mission successfully accomplished RTI´s should desirably plan in advance their goals established and actions to reach them.

This work has the objective to describe the experience of the Institute of Energy and Nuclear Research (IPEN) - one of the institutions that comprise the National Nuclear Energy Commission - in its recent effort to plan their R&D agenda and expected results considering a 10 years' time span.

This paper is organized as follows: the next section presents a brief history of the efforts of long-term planning developed by IPEN, the section three describes the methodology

developed for the planning of its R & D agenda; the section four presents part of the results of planning effort and the section five synthesizes the conclusion of this experience.

2. BRIEF HISTORY OF PLANNING IN IPEN

2.1. First effort of a planned repositioning

Since the mid-80 and particularly during the 90's, transformations in the role of the state, scientific-technical changes and new patterns of competition and globalization of markets are factors that are altering the relationships between the models of public research institutions and the current environment context of technological innovation to public research institutes. Current issues are no longer resolved by mere adjustments in the paths - new institutional standards need to be discussed [1].

This situation characterized by Salles-Filho et al. became a reality for organizations linked to the nuclear area in the 90's, especially between 1991 and 1994, when the Brazilian nuclear program suffered a void in terms of its importance and that is evidenced by the decrease in its budget [2].

Thus, in the context of the State Reform prepared by the Federal Government in late 1997, the CNEN hired the Getulio Vargas Foundation to assist in the implementation of an Advanced Program for Managers addressed to call them the attention to the transformations that were in course within the public organizations. This program developed a project called "Rethinking CNEN" [3]. This project has been developed with extensive participation of employees and resulted in important settings for the CNEN, such as Mission, Vision, Business, Strategic Planning and Mission definition for the IPEN but, after these definitions, there were no additional unfolding for the Strategic Planning of the IPEN.

2.2. The new institutional positioning of IPEN

In 2000, observing the need to develop its strategic planning on its own, IPEN has developed its first Master Plan and established a new organizational structure based Research Centres. This Master Plan defined three finalist functions: (1) Research, Development and Engineering, (2) Teaching and (3) Products and Services. It also established a programmatic hierarchy in order to operationalize the execution of these three functions in the form of 6 programs (Applications of nuclear techniques, Teaching and Scientific Information, Materials, Environment, Nuclear Reactors and Health), 20 subprograms and 112 Activities. In order to execute this Master Plan also 10 Research Centres were established: Radiopharmacy, Nuclear Engineering, Research Reactor, Accelerator Electrons, Molecular, Nuclear Fuel, Radiation Technology, Laser and Applications, Environment and Science and Technology of Materials.

The implementation of the Master Plan pointed out the need of an information system to manage the finalist functions and the need of having greater integration of information between the finalist and support activities. To address these issues two initiatives were implemented: the development of Management Information System of IPEN (SIGEPI) and the development of the Balanced Score Card [4].

Since then the Master Plan has been reviewed annually and after a few cycles of implementation initiatives were taken in order to evaluate the advances reached. On the one hand, the progress in the planning of R & D & E effort was recognized with the introduction of these initiatives and others, for example, with the preparation of business plans by the Research Centres. But on the other hand, room for further improvements in the planning processes, such as the use of technological forecasting and assessment of R&D impacts methods were detected. Difficulties concerning the consolidation of an integrated Master Plan based on projects financed by funding agencies which emphasize the individual performance instead of organizational performance were also reported [5].

2.3. The next cycle of strategic reviews

In 2002 and 2006 distinct scenario-building experiments were developed for two major revisions of the Master Plan. Although these efforts were helpful for the final document, these two planning experiences also highlighted the difficulties in harnessing the potential of such type of planning tool for complex organizations as in the case of the IPEN [6].

In 2007, the Ministry of Science and Technology published the Action Plan from 2007 to 2010 [7]. Since then the IPEN started to review every four years its Master Plan. In the 2007 - 2010 Master Plan edition, the organizational structure of the IPEN has undergone some changes - two Research Centres were merged and now have a status of Board (Radiopharmacy), a new Research Centre was created (Fuel Cells and Hydrogen), a new Board was created (Safety and Radiation Protection) and 3 of the former Research Centres were linked to this Board and have gained the status of Technical Management (Metrology Nuclear, Radioactive Waste and Radiation Protection). Existing programs were reviewed and new programs were created resulting in 10 finalist programs (Radiopharmacy, Applications of Ionizing Radiation, Science and Technology Nuclear Reactor and Nuclear Fuel Cycle, Environment, Renewable Energy, Materials and Nanotechnology, Biotechnology, Technology Laser and Safety nuclear) and 3 supporting programs (Teaching, Technology and Innovation Management and Administration and Infrastructure). Another change was made with the addition of a new layer at the bottom of the program hierarchy: Research and Projects Lines (LPP's) and Support Activities and Production / LAP's). 170 LPP's and 33 LAP's were included in the Master Plan.

Between mid-2010 and the end of the first half of 2011, the IPEN has developed the edition 2011 to 2020 of the Master Plan, based on an information structure derived of the technology roadmapping methodology. The next section will detail how this planning cycle was executed.

3. PLANNING FOR TEN YEARS

3.1.The planning guidelines

The year of 2010 was the last of the IPEN 2007 to 2010 Master Plan, so it would necessary to initiate a process that would guide the actions of IPEN for the next quadrennium. In May 2010 the Management Centre for Strategic Studies (CGEE) together with the Ministry of Science and Technology (MCT) organized the 4th National Conference on Science and Technology. This event highlighted the importance for Sustainable Development and Innovation also continued to hold a strategic status for the Nuclear Technology among many other recommendations.

In July 2010 began a new cycle of review of the Master Plan of the IPEN taking as a starting point one of the shortcomings pointed out in earlier planning processes: the need to develop a deeper insight concerning technologies trends. In addition, this plan would need to consider the unfolding of a large-scale project, in case, the Brazilian Multipurpose Reactor - a project coordinated by the CNEN and developed jointly with the IPEN, the Development Centre of Nuclear Technology (CDTN), the Institute of Nuclear Engineering (IEN), the Regional Centre of Nuclear Sciences (CRCN) and the Navy Technological Centre in São Paulo (CTMSP).

Thus, from a more clear government standpoint in terms of the expectations for the nuclear sector as well as terms of a Science, Technology and Innovation agenda, it was proposed for the Top Management of the IPEN by its planning department a planning approach that would provide the framework to discuss and to review the R & D agenda for the next 10 years. The details of this proposal and its implementation results will be presented in the next sections.

3.2 The construction and execution of the planning process

At the beginning of the planning process, it was recognized by the Top Management the need to start a major revision to the Master Plan then in effect, taking as references the "ranks" of the scientific community of the IPEN. This view was backed both the analysis of previous experiences of strategic planning as well as the observation of the scientific community of the IPEN broadening in the last 10 years (IPEN in 2000 had 139 doctors, ten years later doctors and have passed 234, i.e., an increase of 68% over this period).

Thus, considering that technology roadmapping is a tool that can be used for foresight efforts [8] as well as goal-oriented [9] and considering the need to incorporate the "newly-PhDs" ranks into the planning process, it was proposed to use an adaptation of the technology roadmapping methodology as a tool to help to guide the construction of this new future and to draw up a plan for a period of ten years instead of four.

In order to enhance to the feasibility of this study, it was established the premise that the availability of human resources in the future would be kept at levels close to current levels given the likely intensification of retirements over the next 10 years.

The next step involved the research and development of an instrument that was capable of understanding what scientific leaders - new and established - envision for the future for the institution in their technical areas. In this sense initially we looked for and selected a tool

used for web-design questionnaires and questionnaire analysis and then we built up a web template directed to be answered by those responsible for LPP's and LAP's - existing or to be created - nominated by managers and technical units of the IPEN.

Two types of questionnaires were elaborated: one to gather information in relation to the finalist function of R & D (LPP´s) and the other one in relation to the finalist function of products and services (LAP´s); it was also deliberately chosen to not include the Teaching finalist function in this planning process due to the understanding that these definitions need to be developed from an top-down approach rather than bottom-up.

The roadmap architecture has an underlying information-based structure [10]. Thus, in common, the two types of questionnaires were built in order to collect information concerning the two axes of the roadmap. Representing the abscissa axis, the following three key questions were addressed: “Where are we now?”, “How can we get there?” and “Where do we want to go?”. Representing the ordinate axis, the following viewpoints were addressed: “Commercial and strategic perspectives”, “Design, development and production” perspectives and “Technology and research perspectives”.

Specifically, on the one hand, the LPP questionnaire was organized to raise the following pieces of information: (1) Basic characteristics about the LPP, such as title, link with the existing Master Plan and current profile of the team involved, (2) The profile of the research objectives and the factors that influence the definition of these objectives, (3) What are the bottlenecks in terms of technology and knowledge and where they may be being researched, (4) Information in terms of partners needed - internally and / or externally, (5) Facilities - its description and investments needed and (6) What are the expected results to be achieved in the next 10 years, the patentability and the potential beneficiaries of such results.
On the other hand, the LAP questionnaire, was organized to collect the following pieces of information: (1) Basic characteristics about the LPP, such as title, link with the existing Master Plan and current profile of the team involved; (2) What are the opportunities and how they were identified, (3) What are the threats and how they were identified, (3) Bottlenecks preview, (4) Facilities - its description and necessary investments and (5) Characteristics of the potential markets and goals.

In order to operationalize the collection of information the following steps were proposed:

- Step 1 – Survey: (1) Nomination by the technical managers (the Director of Research Centres and technical managers) of those LPP and LAP coordinators that would be responsibles for the web questionnaire answers, (2) Forwarding the questionnaire via the web by the planning department, (3) Discussion and completing the questionnaire with the involvement of the LPP/LAP team members (4) Collecting and sending of the responses to the technical managers;
- Step 2 – Synthesis: Synthesis by the technical managers of the information collected;
- Step 3 – Evaluation: presentation and discussion between the technical managers and the Top Management of the IPEN followed by a synthesis review in line with the recommendations presented by the Top Management;
- Step 4 – Decision: resets (or not) by the Top Management of the Mission of the IPEN, Strategic Objectives, Values, identification of any new large projects, and its final completion of the new Master Plan.

After an initial consultation of this proposal with the Administrative Director and then with the Superintendence of the IPEN, a pre-test questionnaires involving four researchers with experience and knowledge in the two finalists functions was carried out in order make fine adjustments in this questionnaire.

In September 2011 the proposal was presented to Top Management of the IPEN. At this meeting it was discussed and decided that: (1) the Teaching finalist function would not be included in this process and (2) only the unfolding of the large project - the construction of the Brazilian Multipurpose Reactor, scheduled to be operational in 2016 - would be bound to this planning effort. The proposal was approved in October 2010 and then presented to the technical managers of the IPEN.

4. RESULTS

Data were collected between October and early December 2010 and the presentations and discussions with the managerial techniques developed over three days in mid-December 2010. In these three days were made a total of 11 presentations by the technical managers and a presentation by the planning department with a preliminary analysis of the main quantitative results.

In order to improve the data quality, the participation and the transparency of the planning process, intermediate outcomes (e.g., questionnaires with answers and managerial presentations) were publicized during the data collection process in a specific link of the planning department on the intranet of the IPEN.

The results presented below were reviewed considering the purposes of this publication and are based in part of the data obtained in the Step 1 described in the previous section.

4.1.General characteristics of the process

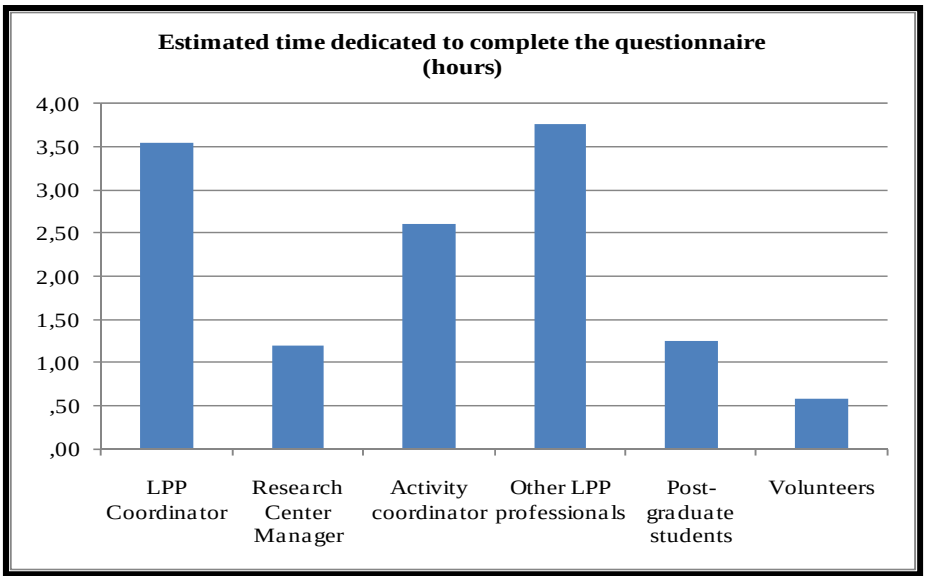
All the 13 Technical Units of IPEN´s organizational chart participated in the planning process (09 Research Centres, 03 Technical Managements and 01 Technical Directorate). The Table 1 summarizes the number of questionnaires submitted to and answered by LPP's and LAP's technical coordinators. In total 89 LPP and 28 LAP questionnaires were answered, representing a return rate of 86% and 76% respectively. The Technical Units TU-9 and TU-10 concentrated the lowest return rates, meaning a smaller validity of the results for these units.

Table 1. Number of questionnaires proposed and answered

Technical Unit	LPP´s			LAP´s		
	proposed	answered	%	proposed	answered	%
TU-1	9	9	100%	1	1	100%
TU-2	8	8	100%	-	-	
TU-3	3	3	100%	-	-	
TU-4	4	4	100%	2	2	100%
TU-5	19	19	100%	-	-	
TU-6	7	7	100%	-	-	
TU-7	7	7	100%	1	1	100%
TU-8	14	14	100%	4	4	100%
TU-9	16	10	63%	7	5	71%
TU-10	7	3	43%	6	2	33%
TU-11	8	7	88%	10	8	80%
TU-12	1	1	100%	5	4	80%
TU-13	1	1	100%	1	1	100%
total	104	93	89%	37	28	76%
not concluded		4			0	
	104	**89**	**86%**	**37**	**28**	**76%**

Considering the purposes of this article, the information and results presented in the following sections are focused on R & D finalist function.

The Figure 1 presents information on the different categories of participants in the planning process and the average time spent for each category of participant. As it can be seen, the questionnaires were answered with the participation of different representatives of the workforce - some were hierarchically above the questionnaire respondent (Centre Manager, Technical Manager, Director or Activity Coordinator) others were below (Other professionals involved in the LPP, Post-graduate students and Volunteers). On average, a LPP coordinator devoted 3.5 hours to complete the questionnaire.



Graphic 1. Estimated time to complete the questionnaire

4.2. The results

The volume of information obtained from the 89 LPP´s was significant - in terms of qualitatively and quantity. Thus, we selected and grouped the following information to be presented in the present article:

- Where are we now?: (1) Current Team Profiles; (2) R & D Motivation and (3) Sources used for identification of the objectives of R & D;
- How can we get there?: (4) Profile of research partners, and (5) Profile of changes needed;
- Where do we want to go: (6) Classification of results by areas and (7) Nature of the expected results.

The analysis presented in the following sections should be considered preliminary.

4.2.1. The profile of the R & D team

The profile of the team composition that integrates a LPP provides important insights about the longevity of LPP. The survey of this information is important to identify the LPP's showing up is most critical in terms of loss potential in the next years in terms of specialized ranks and/or in terms of specialized knowledge dissemination capability to the society. In the Table 2 are presented the number of people linked to a LPP by different category of connection. The first four categories represent connections of the permanent members; the last three links represent transitory members.

Table 2. The number of persons per LPP´s and its profile

persons per LPP in a specific linking category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**> 10**
	Number of LPP´s									
LPP linking category										
doctor	18	26	12	12	9	2	2	0	3	0
masters	25	8	5	2	1	0	0	0	0	0
graduates	8	6	1	0	2	1	0	0	0	0
high school	23	8	8	5	2	0	0	0	0	2
post-graduates students	10	16	11	8	9	4	4	3	1	9
graduates students	17	10	10	2	6	0	0	1	0	2
volunteers	21	6	2	0	0	0	0	0	0	0

Analyzing these results, most importantly, it appears that 18 LPP's have only one doctor and 21 LPP's rely on one volunteer. This information suggests that these LPP's will need to receive greater attention in terms of replacing their more specialized staff in the coming years because of potential retirements.

4.2.2. The R&D motivation

The identification of the profile of the motivational aspects for R&D activities within a LPP allows a better understanding of what are the mechanisms that are currently helping to guide the construction of the IPEN´s technical future. According to the methodology adopted in the planning process a LPP could present up to three different motivations. The results for this part of the questionnaire answers are presented in the Figure 2.

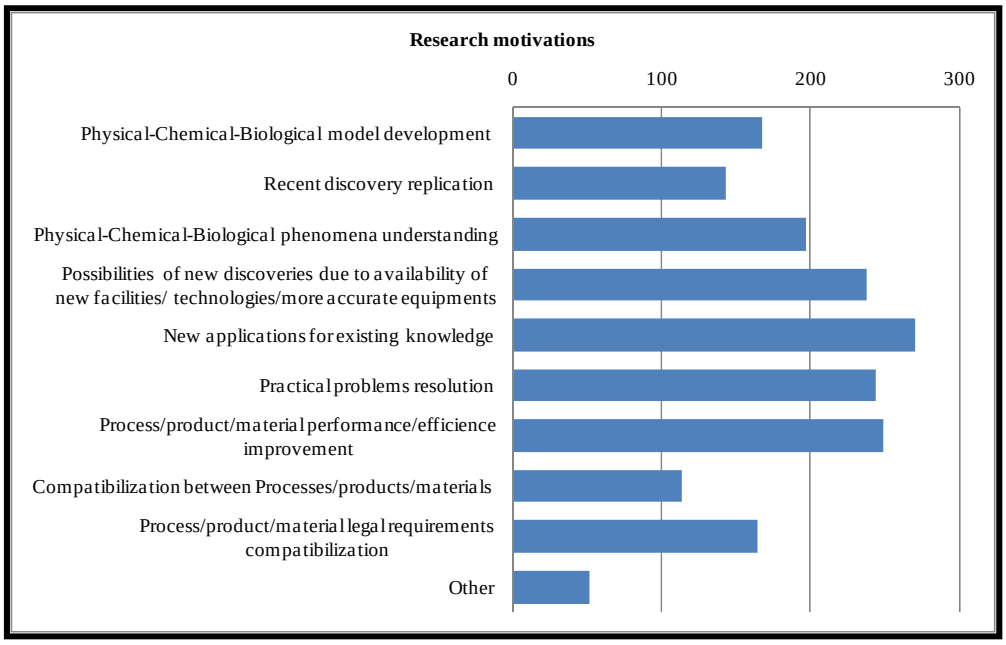


Figure 2. The LPP research motivations

According to these results, the main motivation is the search for *New applications for existing knowledge*. In sequence appear nearly tied *Practical problems resolution*, *Process/product/material performance/efficiency improvement* and the *Possibilities of new discoveries due to availability of new facilities / technologies / more accurate equipments*. These results suggest that the applied research predominates among the R&D motivation factors, something that is in line with the mission and the characteristics of the IPEN´s mission.

4.2.3. The sources used to identify the R&D problems

This block of information characterizes the sources of information that are helping the definition of the research problems and/or goals, thus, are also helping to guide the R&D activities and, consequently, helping to shape the expected results in the future. The results are presented in the Figure 3.

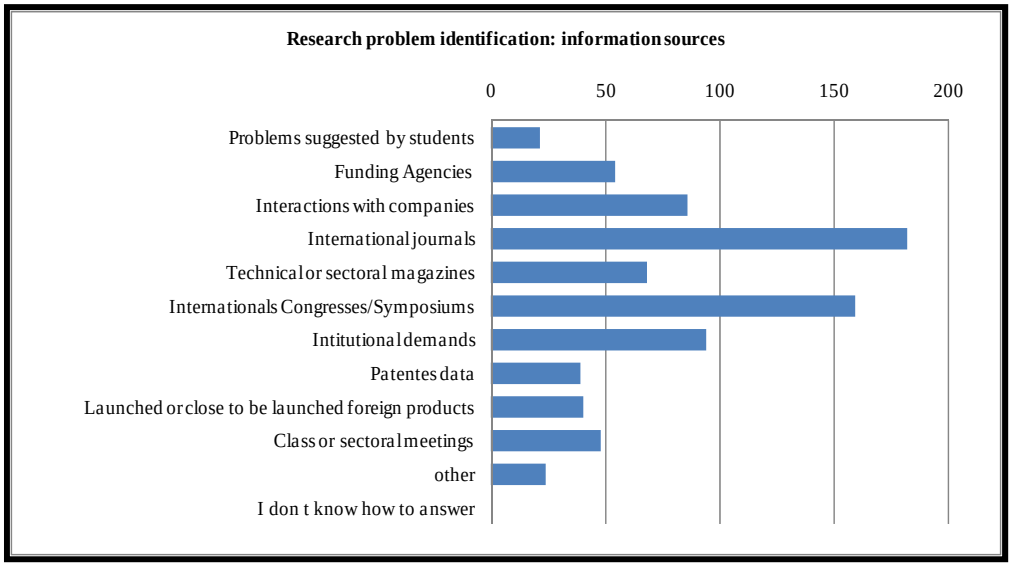


Figure 3. The sources used to identify the R&D problems

These results highlights the main sources of information for R & D *International journals* and *International congresses/symposiums* followed by *Institutional demands* and *Interactions with companies* as the main sources for the research problems and/or goal definition that somehow shapes the research agenda of the IPEN.

4.2.4. The profile of the research partners

Assuming that the researches need to be developed with a partnership involving other organizations, we sought to evaluate the profile of these future partners of a LPP. According to the questionnaire methodology up to the three partners could be indicated by one LPP. The results are presented in the Figure 4.

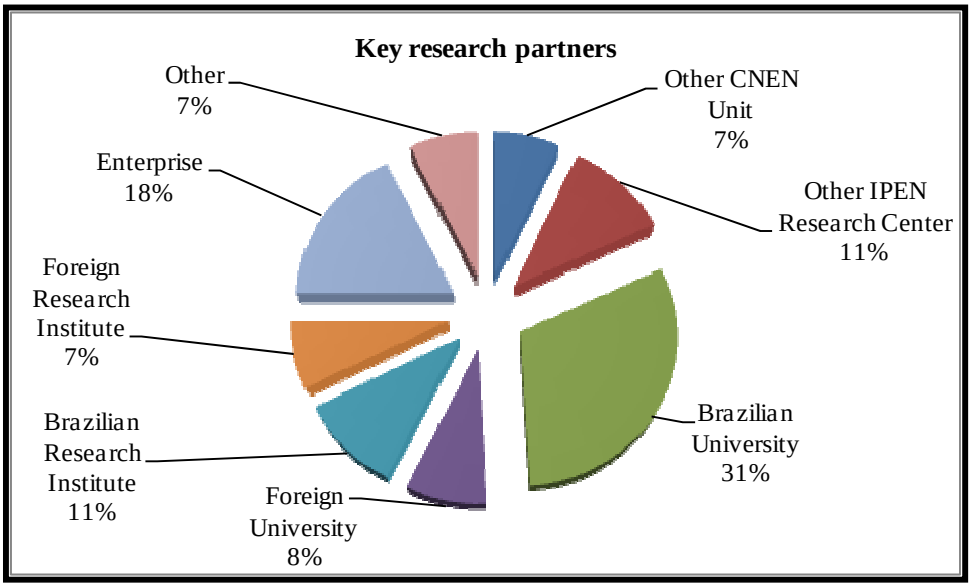


Figure 4. The partners for the development of research

The results indicate that the main partner for the development of research is the *University*, with 31% of cases, ranked second with 18% *Companies* and third tied *Other Research Centre of IPEN* and *Other research institute*.

4.2.5. The changes and the investments

The range of results expected for the next 10 years also depends on the changes that require investments in terms of renovations and equipment purchases. According to the questionnaire methodology up to 3 changes could be indicated per LPP. These changes were classified into categories of investments laboratory. The profile of these categories of changes is presented in the Figure 5.

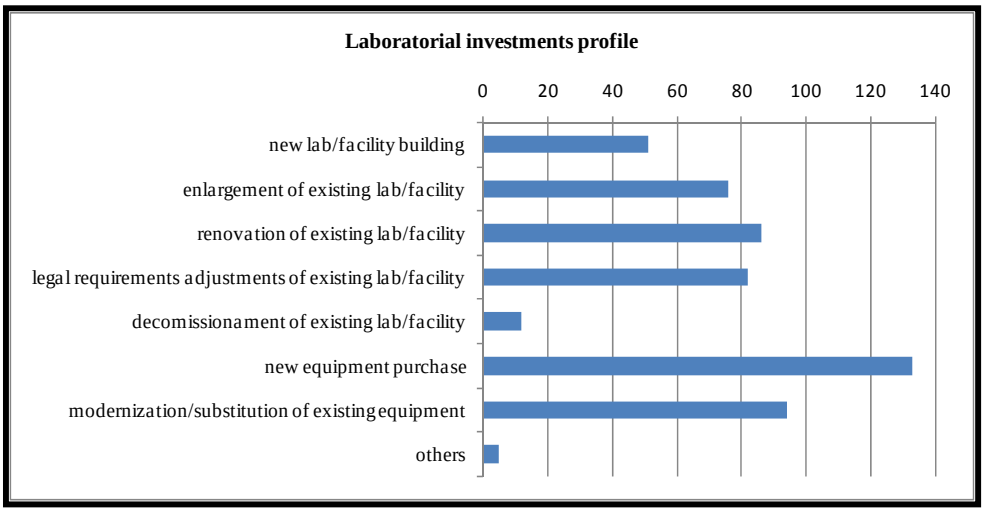


Figure 5. The laboratorial investments profile

Looking at the Figure 5, the investment in equipments (new or upgrade) followed by investments in laboratory facilities (reforms, adjustments to legal requirements and extensions) are highlighted. The estimated value needed to implement these changes amounted R$ 400 million, or about R$ 40 million per year.

4.2.6. Classification of the results by applied areas

The block of the questionnaire that collects the data concerning the expected results for the next 10 years, requests a description of them as well as the indication of the year when they are expected to be reached. Up to 5 different results could be indicated. During the data analysis, the results listed as training human resources, publications generation and attend conferences were excluded because they didn´t fit the established planning scope; in addition, results with generic information (e.g., to produce products, processes or patents) without a more qualitative description associated were also excluded.

The valid expected results were then classified in terms of application area. Only one application area could be indicated. A total of 294 results met the above criteria. A summary of this analysis is shown in Figure 6.

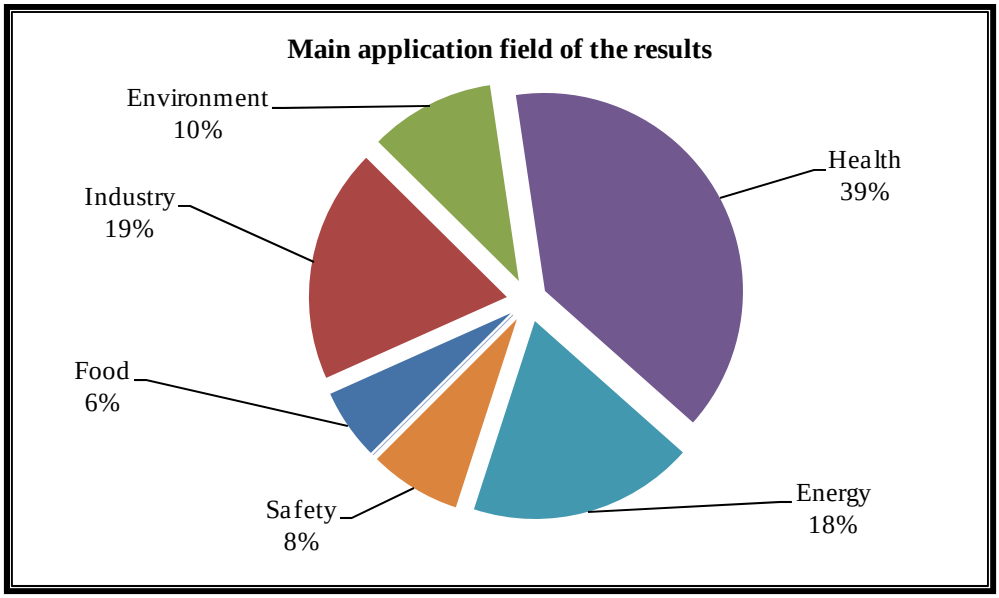


Figure 6. Classification of results in terms of application area

Looking at Figure 6, the results that are expected in the next 10 years can be segmented with the following distribution: 39% in the *Health* area, 19% in the *Industry* area, 18% in the *Energy* area, 10% in the *Environment* area, 8% in the *Safety* area and 6% in the *Food* area. None of the results listed after filtering by the criteria mentioned above were formerly classified as "not applied perspective."

These results should be viewed with some caution, because the classification of results in its main area of application is subjective considering that many of them produce results in more than one area and only one could be selected. Despite this limitation, analysis of these results somehow formalizes something that until then was observable only in an intuitive way: a tendency of IPEN on focusing a significant portion of its expected results in the Health area.

4.2.7. Development stage of the expected results

The expected results were also classified in terms of the development stage with more than 50% chance of being achieved. According to the questionnaire methodology, the same expected result could more than one stages of development. Figure 7 shows the profile of the development stage for the expected results for the next 10 years.

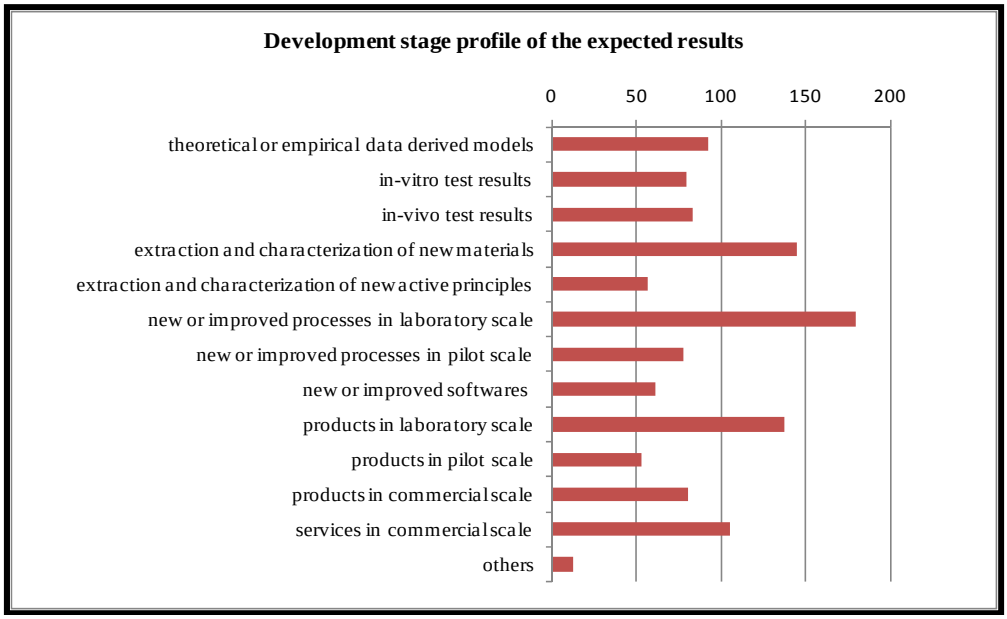


Figure 7. Development stage profile of the expected results

Looking at Figure 7, the most frequent categories of development stage of the expected results are *New or improved processes in laboratory scale*, followed by *Extraction and characterization of new materials* and *Products in laboratory scale*.

5. CONCLUSIONS

The Research and Technology Institutes are organizations that can run an agenda that can range from services whose results are meant for the short-term as well as activities whose results may take several years as in the case of the R&D. Some institutes pose themselves in the "lower" spectrum of the activity range in order to develop results for the short term, others pose themselves in the "higher" spectrum in order to develop long term results and others can act on the entire spectrum.

Although the autonomy to decide on this positioning or repositioning may vary from one institute to another, the trajectory of these decisions are also influenced by internal decision [11].

In the specific case of IPEN between the mid-90s and 2000, more informally, and since then, more formally through the Master Plan, the fulfillment of its mission has been achieved by combining two major decision-making approaches: one that follows the hierarchical institutional structure, in this case defined and operationalized through a budget by CNEN, and the other one that follows the academic structure, which is operationalized through funds granted to researchers who submitted their research proposals in response to the bids of the funding agencies.

For the near future, considering that a large project (the Brazilian Multipurpose Reactor) is already defined and planned and the IPEN is one of the main participants, this work presents the results obtained in a process designed to help the IPEN to set its R&D agenda.

A planning process with ten years horizon was developed based on an information-structure of the planning methodology called technology roadmapping. This method was adapted in order to have all technical areas of activity of the IPEN – currently prominent and future potential - involved. Though simple, an ample, objective and practical web information collection process was established. Information concerning 89 research lines organized in a structure combining the questions “Where are we now?”, “How can we get there?”, “Where do we want to go?” with information concerning “the commercial and strategic perspectives”, “the design, development and production perspectives” and “the technology and research perspectives”- the basis of technology roadmap - were collected.

The evaluation of the whole experience is positive given that the objective of implementing a rapid assessment, participatory and comprehensive information data-set at low cost with quality has been achieved.

The main operational difficulties and limitations of this effort can be summarized as follows: (1) the data collection was developed during a competitive period in terms of tasks (the collection was made at the end of year when normally reports need to be closed, and many theses and dissertations are defended, and completion took place in a period preceding the holiday period), (2) limited participation of external stakeholders - only graduate students and volunteers (usually ex-employees of the IPEN) - were involved and (3) failures in communication with the coordinators about the purpose of the study (for example, many LPP's listed as a result the formation and training of human resources although it was not objective of this process planning the Teaching finalist function), (4) difficulty to see concrete results to be achieved considering a horizon of 10 years and the subsequent presentation of generic or vague results, (5) difficulties to evaluate the potential beneficiaries and potential clients of the expected results, consequently, difficulties to set R&D priorities from a bottom up perspective.

The results presented in this article represent some of the information collected and the analyses performed but provide a significant idea about the planning effort as well as an interesting and wide sketch about the IPEN´s expected future.

The significant fact is that from this process - a complex and multi-disciplinary institution like the IPEN - managed to consolidate a significant set of information that pinpoint which contributions the IPEN´s technical-scientific community is proposing to the Brazilian society in the coming years. However, in order to materialize this proposal we need to sensitize the same society and make all necessary investments, mainly in the form of renovation and expansion of human capital.

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