ECO-INNOVATION METHOD IN A RESEARCH AND TECHNOLOGY ORGANISATION: NEED ANALYSIS AND IDENTIFICATION OF THE MAIN FUNCTIONS OF THE METHOD (JUDAIS 2023)

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ABSTRACT

Research and Technology Organisations (RTOs) develop and transfer new technologies to industry. Considering environnemental and social challenges in their activities is becoming more and more important. Integrating these challenges within an organization requires a global and coherent method, but also flexibility to adapt to the various activities of the organisationz. Eco-innovation is an approach that can meet these goals. However, literature has already shown that the main obstacles for the integration of eco-innovation come from the lack of global approaches adapted to companies' practices. In this paper, we characterise the specific activities of RTOs. Then, we specified the need for an eco innovation approach for RTOs. We carried out a functional analysis to formalise the need and identify the main functions that the eco-innovation approach must fulfil. We conducted exploratory interviews with various stakholders from an RTO in order to validate the identified needs and functions.

Keywords: eco-innovation, Design methods, Sustainability, Research and Technology Organisations, Ecodesign

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1 INTRODUCTION

To reduce industrial activities' impact on environment and society, it is necessary to take into account the impact of the technologies under development from the very first stages of their development (Chebaeva et al., 2021). An emerging approach in several research areas is eco-innovation (Xavier et al., 2017). Eco-innovation is the integration of sustainability into all activities of a company, based on life cycle thinking (United Nations Environment Programme, 2017). There are several definitions of sustainability, but we can define it as taking into account the three pillars of sustainable development: economy, society and environment (Giddings et al., 2002). To be efficient, eco-innovation needs to be integrated into all company activities (Lozano and Garcia, 2020). However, the eco-innovation methods described in the literature often have partial approaches, meaning that they only consider one specific activity of a company (ideation or conception process, business model, etc.). Overmore, they focus on the functioning of industrial companies (Michelin and Janin, 2018). Among the actors in the development of new technologies, Research and Technology Organisations (RTOs) have a special role. Their main missions are to develop and transfer technologies to industry in order to support the competitiveness of companies and respond to societal challenges (OECD, 2022). In the same way as companies, RTOs have an urgent need to leverage research and technology in order to develop more sustainable innovations. Therefore, RTOs are increasingly concerned by eco-innovation but with some pecularties due to their specific organisation and aims compared to industrial companies. This work is part of a research project that aims to develop a unified eco-innovation method for the Technological Research Directorate (DRT) of a French RTO: Alternative Energies and Atomic Energy Commission (CEA). The objective of this article is to explain and validate the need of an eco-innovation method for an RTO and to define the main functions of this method, through exploraty interviews. To achieve this, we look for RTOs specificities (2.1) and analyse three eco-innovation methods that seems applicable to them. Following this, we detail the research methodology (3) and present the results (4).

2 PRACTICES ANALYSIS

2.1 Functioning and specificities of RTOs

According to OECD (2022), "Research and Technology Organisations (RTOs) are non-profit organisations whose core mission is to produce and assemble various types of knowledges, skills and infrastructures to provide a range of research and development activities in collaboration with public and industrial partners of all sizes. These activities aim to deliver technological and social innovations". RTOs have different ways of organising their expertise. However, they all work around societal themes (health, energy, agriculture, etc.), in specific fields (such as implants and protheses, renewable energy or automotive technologies) with apropriate capabilities (human resources and infrastructures) (Martínez-Vela, 2016). These expertises may be specific to one application area or applicable to multiple industries. The activities of RTOs are centered on the implementation of projects that can be divided into two categories: resourcing projects that enable the development of specific new knowledge, and industrial projects (applied research, technology development, applications), which aim to exploit these knowledge and transfer them to industry (Arnold et al., 2010). As shown in Figure 1, parallel to their projects, RTOs provide innovation support activities such as ideation and foresight, as well as dissemination of research activities: transfers to industry, production and licensing of intellectual property, support for entrepreneurship (Martínez-Vela, 2016). Because they operate on a project basis, in relation with external partners (institutional or industrial), RTOs do not have a single development process. Moreover, they work with a variety of partners (start-ups, SMEs, large groups) in a variety of sectors (OECD, 2022).

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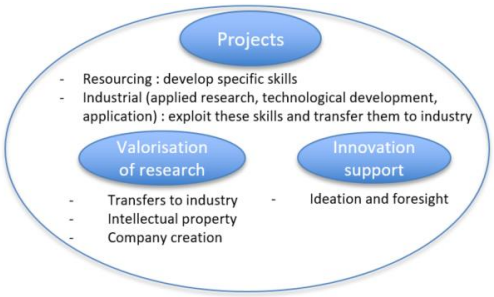

Figure 1. RTO's activities

One other major characteristic of RTOs is that they work on the development of low maturity technologies ("Technology Readiness Level" (TRL) 2 to 7), bridging the gap between fundamental research and industry (Figure 2). This positioning creates several specific issues regarding ecodesign. One of the most known is the "eco-design paradox" (Chebaeva et al., 2021). This paradox argues that although it is during design stages that there are most possibilities to improve sustainability, the low maturity of the technologies developed makes it difficult to access reliable data, and therefore it is difficult to anticipate the evolution of technical parameters (Baldassarri et al., 2016). Within an RTO, this uncertain context affects all the company including support activities and decision-making processes for exemple.

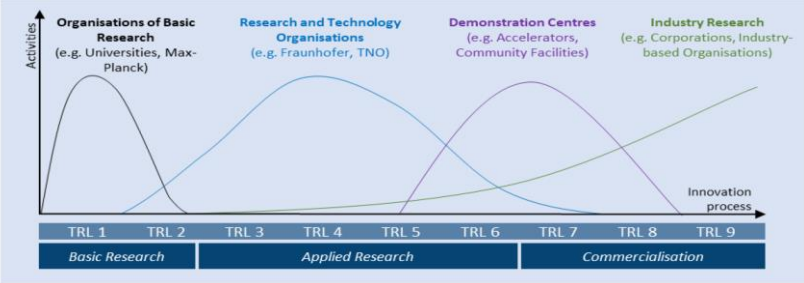

Figure 2. Positioning of RTOs on the TRL scale (Hecklau and Kidschun, 2020)

To summarize, Research and Technology Organisations work to develop and transfer new technologies to industry. Compared to industrial companies, RTOs have major differences: their main activity is to carry out projects of different nature and purpose; they work on technologies of low maturity, in various sectors of activity and with various actors. They also carry out specific activities such as research development (which includes intellectual property, spin-offs) and innovation support (ideation, foresight).

2.2 Analysis of three eco-innovation methods

The implementation of an eco-innovation approach requires changes in all company activities and implies collaboration between several fields of expertise (Lozano and Garcia, 2020). Many methods and tools already exist to integrate eco-innovation in different activities and contexts (Bovea and Pérez-Belis, 2012). However, many short-comings of these methods were identified in the literature, such as the lack of global approaches adapted to company practices (Steux and Aggeri, 2020), the lack of integration of environmental issues within the different hierarchical levels (top management, middle-management/expert level, product development and production level) or the lack of skills (Michelin, 2015). To be effective, the approach of eco-innovation must be adapted to the processes in the company and to the expectations and constraints of the future users of the method and tools. This integration must be done in a coordinated and coherent manner between the various activities which cannot be adressed in the same way (Zhang et al., 2013). To address these short-comings, we selected and analysed three eco-innovation methods in the literature that distinguish several "axes" also called "company practices" or "activity levels". These axes are declined into "activities", which represent the actions and missions related to these axes. The three studied methods are: Eco-Mi (Xavier et al., 2020), Convergence (Zhang et al., 2013) and GECO (Michelin, 2015). The Eco-MI method developed by Xavier et al. (2020) proposes four distincts axes to classify companies' activities: structure, strategy, resources and culture. Michelin (2015) distinguishes organisational learning, tactical and

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operational axes. Zhang et al., (2013) proposes three axes: strategic, tactical and operational. Each author associates specific activities and/or objectives to each axis. Figure 3 presents the axes and associated activities of these three methods. We grouped together tactical axis (Zhang 2013 and Michelin 2015) with structure axis (Xavier 2020) and culture axis (Xavier 2020) with organisational learning axis (Michelin 2015) as they have similar objectives.

Figure 3. Axes and associated activities from eco-innovation methods in the literature

In relation to an eco-innovation method, the strategic axis has to define the strategic objectives (Zhang et al., 2013). To do so, it has to diagnose and formulate an eco-innovation strategy and set up monitoring indicators at the highest level. The tactical axis must organise the integration of the environmental dimension into operational processes by analysing and organising the company's resources and developing tactical roadmaps. The operational axis supports the development of processes in accordance with the chosen tactics and tools and promotes coordination between usual tools, well integrated into their activity, and ecodesign tools. The resources axis defines the employees training strategy, builds the communication and the environmental policy. Finally, the culture/organisational learning axis must disseminate environmental knowledge to all departments and professions.

To summarize the practices analysis part, we have seen that RTOs have several operating specificities compared to industrial companies (2.1). We have also seen that an eco-innovation method needs to distinguish various axes of a company and to adapt to the functioning of the structure where it is applied. To take into account these two aspects, we have chosen to study three "global" eco-innovation methods in the literature, to understand the various axes and the related activities they integrate. These axes include strategic, tactic, cultural, resources and operations-related activities. We notice that some elements are missing in this axes list to include all RTOs activities, like for instance research valorisation or support to innovation. Moreover, specific methods and tools are needed in each axis to adresss the low maturity issues.

3 RESEARCH METHODOLOGY

In this paper, we aim at identifying the needs of an eco-innovation method within an RTO and at expressing the main functions that this method must fullfill. We can fomulate the following research question: "what is the need and what are the main functions of an eco-innovation method for an RTO?" To answer it, we have chosen to use a functional analysis methodology. This approach is often applied to the wider product development (product, systems, methods, organisations, software). It consists in analysing needs in order to to identify the expected functions (external functions) at the level of the solution satisfying the requirements of stakeholders involved in the product lifecycle. This allows to highlight and take into account the views of all interested parties and to define the expected results before the means to implement (AFNOR - Agence Française de Normalisation, 2013). This approach has two distincts parts: the functional analysis of the need (also refered as the external functional analysis), and the technical functional analysis (or internal functional analysis). The aim of this paper is to conduct the first part of this methodology (i.e. the external functional analysis), to explicit needs that are not necessarily easy to formalise or express, to validate these needs and to identify the main functions expected by the various interested parties.

To conduct this analysis, we used references published in the literature about eco-innovation and RTOs, we studied internal documents (flowcharts, job descriptions, quality handbook), and we conducted exploratory interviews. We interviewed nineteen actors, from various departements within the studied RTO, who seemed relevant for eco-innovation (eco-innovation managers from all

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institutes, director of innovation-support direction, managers in scientific direction, deputy director of research-valorisation direction, quality managers), as well as linked to sustainability aspects (Environment Health and Safety (EHS), Corporate Societal Responsability (CSR)). In order to have a global and transversal vision, these actors have strategic or eco-innovation-related functions in their department. Figure 4 illustrates the functions of the interviewed actors; we will explain the organization of our structure in section 4.1. These interviews took place mainly in person and lasted approximately one hour. They began with a brief presentation of the aim of the study (15 minutes) and then included several questions on the following topics: description of activities, example of eco-innovative projects, societal impacts linked to activities, expectations and role in relation to the method, needs, levers and risks of integration. We recorded all the interviews and transcribed them entirely. We presented the results of the analysis to the interviewed actors during two collective restitution sessions, to collect feedbacks and validate the outcomes from these interviews.

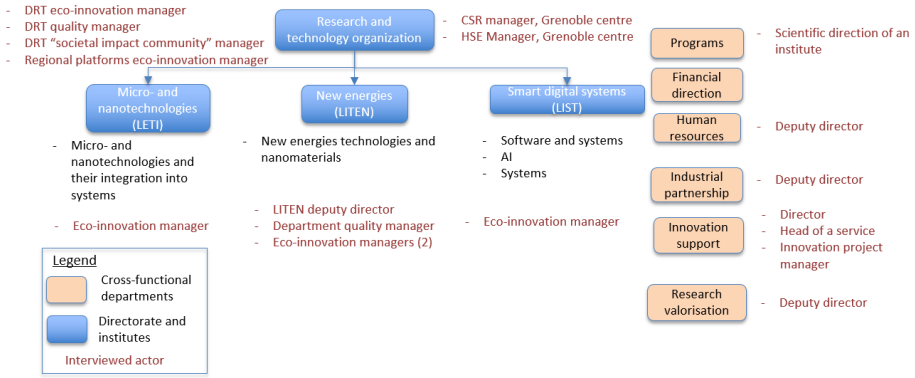

Figure 4. Organisation of the research and technology directorate (DRT) and functions of the interviewed actors

To answer the research question, we conduct two distinct analysis, using differents tools and information sources (Figure 5). The first one aiming at formulating and justifying the needs is mainly based on exploratory interviews. We also apply "the Horned Beast tool", a functional analysis tool used to express the need. Then, we support its formulation with verbatim from the exploratory interviews. To do this, we identified in the interviews scripts the main arguments for the validation of the need for an eco-innovation method in our RTO. With an iterative process, we identified two main categories: external and internal needs. External needs deal with how an eco-innovation method can answer external RTOs partners' demands. Internal needs deal with how an eco-innovation method can answer to internal demands or problems. The second part of the analysis aims at defining the main functions that the method must fullfill. We develop an eco-innovation activities' classification adapted to RTOs. Then, we use internal documents and exploratory interviews to group actors from our RTO in their corresponding axes (Figure 7). To express the main functions of the eco-innovation method, we use the method of interactions with the external environment (a functional analysis tool (AFNOR - Agence Française de Normalisation, 2020)).

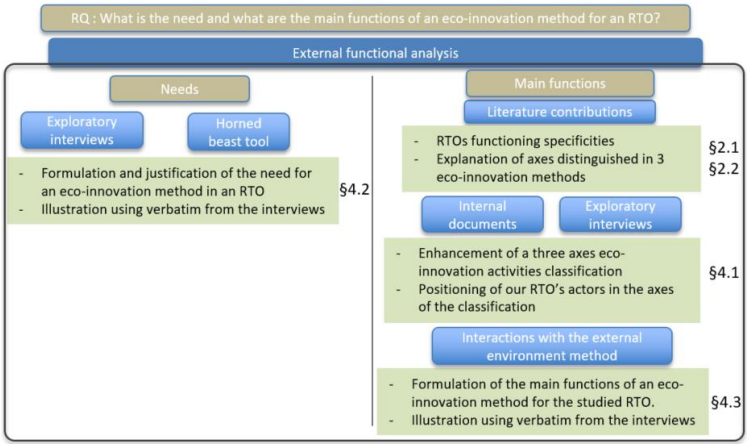

Figure 5. Research methodology

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4 RESULTS

4.1 Functional characterisation

The French Alternative Energies and Atomic Energy Commission (CEA) is a key actor in research, development and innovation in France. It operates in four areas, managed by separate directorates that operate independently: defence and security, low-carbon energy (nuclear and renewable), technological research for industry and fundamental research (material and life sciences). The eco-innovation method studies in this paper is focusing on the Technological Research Directorate (DRT). This directorate employs about 4500 people and is located in France, mainly in Grenoble and Saclay. It is composed of three institutes (LETI, LITEN and LIST, in blue on Figure 4) which work respectively in the field of microelectronics, new technologies for energy, and computer science/digital technology. Within each institute, there are several departments, specialised in sub-fields that are more specific. These departments are then divided into services and laboratories. Several transversal directorates structure these activities (in orange on the Figure 4). To model the functioning of RTO in relation with an eco-innovation method, we complete the activities usually integrated in the methods in the literature (2.2) with the specific activities of the RTOs (2.1). figure 6 shows the classification of activities of the RTO according to axes of the eco-innovation methods identified in the literature (Figure 3). We consider three axes from Zhang et al. (2013): the strategic axis, the tactical axis and the operational axis. We integrate the other axes identified in the literature in these axes: the "culture" axis into the strategic axis and the "resource" axis into the tactical axis. We also add the specific activities of the RTOs "ensuring the valorisation of research" to the tactical axis and "setting up and carrying out projects and ensuring innovation support" to the operational axis.

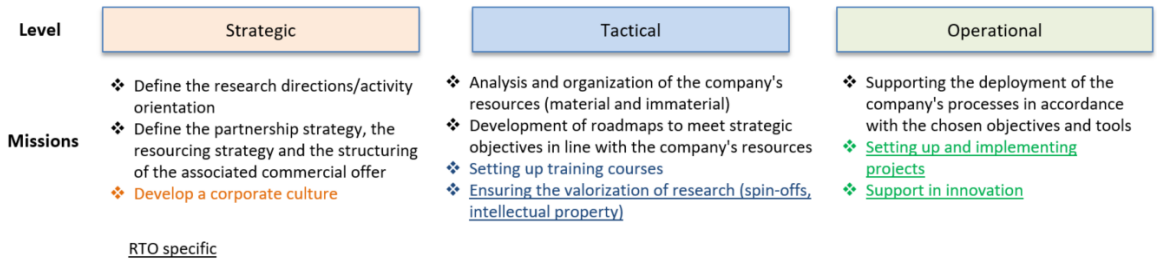

Figure 6. Classification of specific RTO activities, according to a classification adapted from (Zhang 2013)

To create links between levels of activity and the actual functioning, we identify the main actors of our RTO according to the three axes and the associated activities, using internal documents and asking information during interviews. We group the various actors according to correlations between their job descriptions and figure 6 classification. For instance, communication employees' job description mentions among their missions to "transmit and share the strategy to all the employees, and inform them about professional life in the company", which matches strategy axis mission "develop a corporate culture". figure 7 shows partial and anonymised results, in a graph inspired by the method of interactions with the external environment.

Analyzing internal documents and carrying interviews help to understand better the functioning of our RTO. An important point is the networking aspect: although actors at each level carry out their missions, some of these missions are the result of collaborations and interactions between the different levels of actors. Networks plays a major role in these actions. They are responsible for passing on relevant information from the operational to the strategic level (bottom-up), from the strategic to the operational level (top-down) and from the tactical level to both sides (middle-to-side). Figure 7 highlights the three main networks within our organization: the commercial network, the scientific network and the management network. We identified these networks through the internal document study and interviews.

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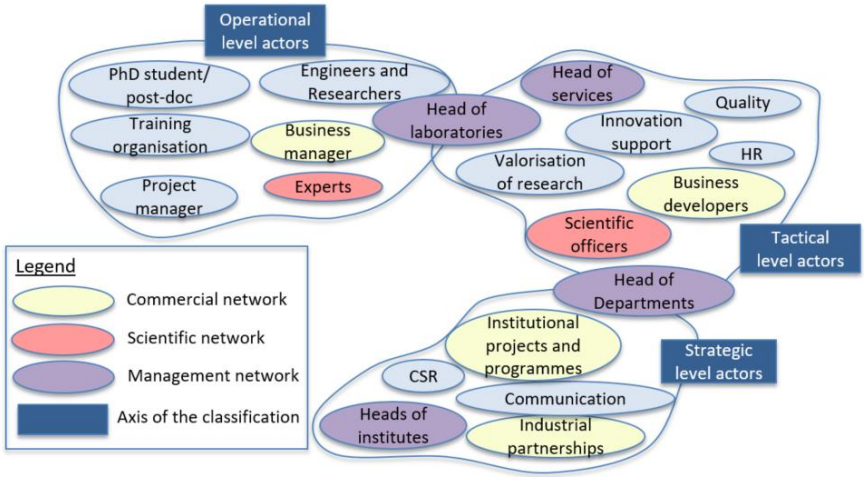

Figure 7. Positioning of DRT actors in the axes of our classification

In this section, we cross axes and activities of eco-innovation methods from the literature with RTOs specificities, to develop a classification of eco-innovation axes and activities adapted to an RTO. This classification distinguishes three axes of integration, with associated missions and objectives: the strategic, tactical and operational axes. Then, we position several actors of our RTO in relation to these axes, with the aim of making the link between the levels of activity and the current functioning. Having this clear positionning is usefull in order to understand better the functionning of our RTO to propose an adapted approach. This will help us to formulate the main functions of the eco-innovation method.

4.2 Validation and justification of the need for an eco-innovation method for our RTO

Before developing an eco-innovation method within our RTO, we need to validate the need, which is the first step of an external functionnal analysis approach. We illustrate and develop this need with "*verbatim*" from the interviews (in italics and quotation marks in the text). To do this, we first use a functional analysis tool (the horned beast) to express the need that our method must satisfy. This tool allows expressing the need by answering three questions: who does the method serve, what does it act on, and what is its purpose. The answers appear on the Figure 8. We can formulate the need as "the unified eco-innovation method should enable DRT employees to modify their research practices and activities to take into account environmental and societal impacts".

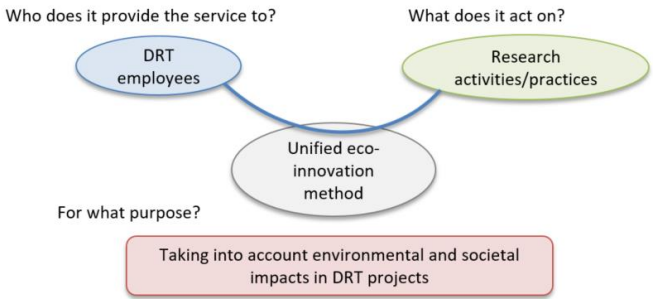

Figure 8. The horned beast

The verbatims helped us to complete and justify this need. We decided not to show the associated function of speakers' quotes, because we did not analyze in a first intance the correlation between quotes and speakers. We selected these verbatims according to the aims of our study, and cited only one quote even if several actors expressed the same idea. We divided the needs in two categories: external needs and internal needs.

Firstly, integrating eco-innovation meets an external need: RTOs missions have evolved to "transition architect" role, with more and more emphasis on societal issues (OECD, 2022). Industrial and institutional partners have increasingly important specific demands on these subjects. Institutional funders were "*the first to integrate these criterias in workpackages and projects*". These have become mandatory in European projects and the French Agency for Ecological Transition (ADEME) has

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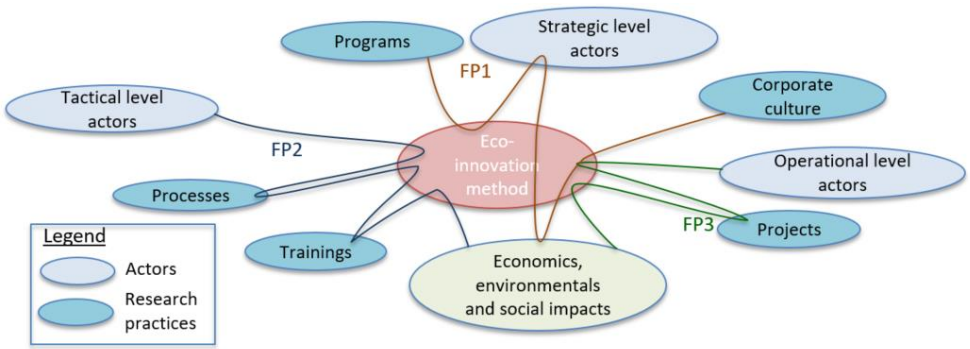
recently developed a method called "Project footprint", which will become mandatory in its calls for projects (Olivier et al., 2021). Industrial partners are increasingly in demand for topics- such as "*circular economy and industrial ecology* ". The risk of not being able to meet the needs of industry is perceived, even to the extent risk of seeing "*an erosion of our technological advantage"* and to not "*be able to remain an innovation partner"*.
Internally, there is an acceleration of eco-innovation initiatives within DRT. This concerns commercial offers with "*the development of multilateral thematic offers"* and the search for "*new innovation models through usages"*, but also the structuration of eco-innovation networks within the institutes, which enables "*to disseminate specific skills in technical-economic and environmental analysis, which were present in some laboratories"*. Training courses were developed, on the circular economy, on life cycle assessment and on the setting up of eco-innovation projects. Some departments have initiated approaches around circular economy, with the development of specific tools or with eco-ideation workshops. However, there is still significant room for improvement, because if "*we have made progress on dissemination of the culture linked to evaluation and ecodesign [...], we are not yet eco-innovating, only some projects are starting to integrate this approach"*. This unequal progress leads to a need for structuring and a framework at the global level: "*this is a new theme which, even if it is specific to the work of each institute, is transverse with tools that may be the similar, so it is necessary to share"*. Moreover, there is a genuine "*interest in steering and controlling data for environmental and techno-economic analyses, even if not funded"*. If integrating eco-innovation "*must not be a brake for innovation"*, it can be a real innovation lever and "*a real opportunity for collective development, highly mobilising"*.
Work conducted in this section aimed at answering the first part of the RQ "what is the need for an eco-innovation method in an RTO?" We divided the needs for the eco-innovation method in two parts: external needs and internal needs. Then, we justified it with "*verbatim"* from exploratory interviews.

4.3 Formulation of the main functions: translation of the needs and classification according to the activity levels of the company

To express the main functions of an eco-innovation method, we use the method of interactions with the external environment. This tool consists of linking elements of the external environment with a verb or verbal group characterising the action. The objective is to make the link between the actors of each level of activity and their activity or research practices, as defined in the Figure 6 and 7. We defined three main functions corresponding to each one of the three axes (figure 9). For the strategic level, the eco-innovation method should support the definition of a structure for eco-innovation and manage the integration of economic, environmental and societal impacts into the company's research programs and into the corporate culture. At the tactical level, it should allow the integration of economic, environmental and societal impacts into processes and the diffusion of appropriate training. At the operational level, it should allow to integrate economic, environmental and societal impacts into the projects.



FP1 : The eco-innovation method support strategic level actors to define a structure for eco-innovation and manage the integration of economics, environmentals and social impacts within the programs and the corporate culture
FP2: The eco-innovation method allow tactical level actors to integrate economics, environmentals and social impacts in the processes and to diffuse trainings.
FP3: The eco-innovation method allow operational level actors to take into account economics, environmentals and social impacts in their projects.

Figure 9. Main functions of an eco-innovation method for an RTO

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We illustrate and develop these main functions with the help of "*verbatims*" from interviews. For the operational level, the low maturity of technologies developed in research and technology organisations makes it difficult to conduct a conventional Life Cycle Analysis (LCAs) because of the limited reliability of data. There is a need for tools and methods to integrate these issues right from the project design phase. It includes "*data collection methods"*, "*process databases"*, "*simplified LCA methods that can be carried out over a short period of time"*, "*methods for estimate learning economies"* and "*anticipate industrialisation"*, but also "*auditable performance metrics"*. It is necessary to integrate these issues into projects from the seting-up, which requires training "*both technical experts and commercial functions"*. However, it is "*difficult to integrate tools at their (commercial) level, they don't have the time and we get into technical aspects"*. They need "*to be aware (knowledge of offer, issues, demands, vocabulary)"*.

The role of the eco-innovation method at the tactical level is to integrate environmental and societal impacts into processes (quality, valorisation of research) and to ensure good management of jobs and skills. An organisational structure for eco-innovation should "*be inspired by the cultural elements that make DRT successful and needs to understand our culture well, to make it a real lever"*. It can be inspired by the way we conduct other activities, like "*state of the art or costing"*. To this end, eco-innovation can be integrated in quality processes and particularly in the project processes from the first stages of opportunity formulation by "*starting to mention eco-innovation demands*" or by "*systematically analysing the environmental criteria"*. This approach "*must* [also] *be part of our industrial property process and spin-off strategy"*. Finally, it is necessary to "*train people in the labs in the use of tech-eco/LCA tools and in the future to carry out an eco-innovation approach (like workshop facilitation)"*.

At the strategic level, which role for eco-innovation includes guiding the activity, it is necessary to define "*a real corporate strategy [...] that will set the curse and outline the DRT's eco-innovation strategy"*. The action must be long term:*"Initial work has been done. We have to move gradually; we have to set annual objectives. It's a 5-year plan but it's essential"*. There is also a need to develop a culture for eco-innovation, starting with a "*common frame of reference on what is eco-innovation"*. This includes "*defining the relevant environmental and societal criterias to be taken into account"*, so that "*we stop having subjective views"*.

This section aimed at answering the second part of the RQ "what are the main functions of an eco-innovation method for an RTO?" With the method of interactions with the external environment and interviews results, we defined and illustrated three main functions of an eco-innovation method in an RTO. These functions are linking actors, their research practices and economic, environmental and societal impacts.

5 CONCLUSIONS AND PERSPECTIVES

The literature has shown that an eco-innovation approach must integrate several activities of the organisation in a coordinated way in order to be effective. The axes of eco-innovation incorporated in the methods in the literature include strategic, tactical, operational, resources and culture activities of companies. By understanding the specificities of RTOs, we have developed a classification to characterise the activities of an RTO for eco-innovation. This classication has three axes (strategic, tactical, operational) and associated activities. We have made the link between these axes and the actual functionning of the studied RTO by identifying corresponding actors for each axis. We used the functional analysis method in order to express the need for an eco-innovation method in the studied RTO. We studied internal documents and we conducted exploratory interviews to feed this analysis. It confirms the need of an RTO for an eco-innovation method. We illustrated this need with quotes from exploratory interviews. The interests for eco-innovation are external (fulfill their missions and response to partners needs) but also internal (innovation lever, need for structuring in eco-innovation approaches, interest in steering and controlling the data needed for technical, economic and environmental analyses). Finally, we have formulated three main functions of an eco-innovation method for an RTO (one for each axis of the classification). The first function is "supporting strategic level actors to define a structure for eco-innovation and manage the integration of economics, environmentals and social impacts within the programs and the corporate culture". The second is "allowing tactical level actors to integrate economics, environmentals and social impacts in the processes and to diffuse trainings". The third is "allowing operational level actors to take into account

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economics, environmentals and social impacts in their projects". We have validated and illustrated these functions with verbatim from interviews.
The next steps in the development of the method will be to detail the main functions into technical solutions and to propose adapted tools and processes for each axis and activity. The choices will be made in an iterative process, integrating the future users as much as possible. Eventually, the proposed eco-innovation solution could be tested during various projects within our RTO.

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