Towards Participatory Methods to Take into Account Future Users and Future Usages of Hydrogen Energy: a Prospective Ergonomics Approach.

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Abstract - **The energetics transition will be a major challenge in the next years. Today, we must imagine needs and uses of alternative energy such as hydrogen. But how can we evaluate the technological acceptance of products and services where they do not yet exist? In this presentation, we introduce our theoretical approach of Prospective Cognitive Ergonomics, our methodology and the results obtained through the Hydrogen project, a research for exploring what might be the future use of this energy. For collecting data, we created three staffs of professionals (production, transport and energy distribution) and we analyzed their conversations (lexical analysis). This paper presents the entire process of this lexical analysis, which enabled us to validate four user models and to position them along two axes.**

Keywords - prospective; ergonomics; energy; user-centred concept.

I. INTRODUCTION

Trying to understand how an object (a phone, a watch, a car) or a computer application will be accepted by users is relatively simple. We can create specific groups, asking people to manipulate objects and analyse the strengths and weaknesses. What can we do when the object does not exist and when the concept is very fussy?

As Gibson stated [1], *"to see things is to see how to get about among them and what to do or not do with them"*. This seems obvious because as we move around our environment we learn and become conscious of its possibilities. The question is can we perceive things that do not exist and their possibilities.

On one hand, traditional points of view about creativity and problem solving, as gestalt theorists, assume that a new idea or creative act must be preceded by a period of incubation, before the idea appears by an unconscious mechanism called illumination. On the other hand, researches in the Ergonomics field consider that we can foster creativity and generate knowledge about the present or future use of a product by applying adequate methods, such as « scenarios based reasoning », [2], « personas creativity » [3], « analogy based approaches » [4] or « counterfactual reasoning » [5].

The objective of this work is to anticipate the hydrogen uses and identify the bottlenecks that constrain energetic transition. Since the use of hydrogen as energy is still anecdotal, it is a complex matter to require users to respond how they feel about it. This paper proposes a method called "Staffs of experts", based on the participation of professionals from three areas: production, transport and storage of hydrogen. We asked them to imagine the uses, the barriers and the behaviour of future users. After this introduction, we give the theoretical background. We describe in section 3, the method used for this study. The first results are given in Section 4. The last part is a conclusion.

II. THEORITICAL BACKGROUND: PROSPECTIVE ERGONOMICS APPROACH

Prospective ergonomics is defined as being an ergonomic intervention mode which on one hand identifies current needs, foresees changes and anticipates future users, and on the other hand, it creates systems, products or services which meet those needs according to health and safety, comfort and well-being, performance and satisfaction criteria [6]. Prospective ergonomic intervention is therefore speculative and inventive. Prospective ergonomics place the human in the central position in new practices, behaviour, and organization. Focusing on changes in human activity, the ergonomist takes on the role of a pilot who initiates, defines and manages the project from beginning to end, bringing in other actors to implement, or execute his/her plans. To achieve these aims, prospective ergonomics must fulfil three kinds of tasks:

- Identify current needs, understand their changes over the long term, anticipate future needs, define, reference, validate and asses them, put them in order of priority, and carry out simulations;
- Study technological, social, cultural, and economic factors which accelerate changes in human activity situations to which humans are required to adapt;
- Imagine, invent, create and build systems, products and services beneficial to humans, providing comfort, well-being, allowing for personal progress and a better quality of life in general.

Based on the same principles as corrective and preventive ergonomics, prospective ergonomics will complete the scope of ergonomic intervention modes by taking the future into account. This will enrich its relationship with other fields, not only psychology, biomechanics, physiology, cognitive sciences, scientific engineering, but also with sociology, anthropology, design, marketing and business management.

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A. The part played by prospective ergonomics

Let us start from a widely shared definition (European Commission, 2002): «The prospective approach is a participatory process to design possible futures in the medium or long term, with the aim of shedding light on decisions made in the present and mobilizing the necessary means for a common commitment to action. It is above all a state of mind (anticipate and wish for) and behaviour (create and hope) in the service of present and future existence». Let us then observe all the fields involved in the prospective approach. Medicine, particularly epidemiology, has been using a prospective approach for a long time. The same goes for economics, marketing, demographics, business management, and even work organisation, etc. What motivated a prospective approach being integrated into these fields is simple and pragmatic: the prospective approach offers tools and methods which enable professionals to focus on the right questions and reduce inconsistency in reasoning for developments in the future. However, ergonomics has delayed integrating this forward looking perspective.

Our research project aims to address this delay. Applying a prospective approach in other fields will undoubtedly cause changes in our vision for the future. It broadens the perception of the problem by including demographic, economic, social, cultural, technological, historical, and legal data that highlight changes in future, trends. It keeps a watch on technologies, checks patent deposits and seeks to identify tomorrow's technologies. The prospective approach enables forecasting (often statistical but not only) related to «what will be done» from «what is being done» and «what has been done». It establishes data on changes in behaviour, consumption patterns, lifestyles, etc., and seeks to understand trends through curve models. In short, the prospective approach presents two major advantages:

- Enrichment of multi-disciplinary content: An interest in data from fields which study population, population trends and behaviour patterns (sociology, history, demographic, etc);
- Improved methods: An interest in statistics relating to large workforces over greater periods and data on the creativity of the actors involved.

B. Prospective ergonomics approach

Prospective ergonomics' aim is to develop prospective schemas by mobilizing a body of knowledge relative to the human and capable of describing needs, products, services and future systems. Through its focus and objectives, prospective ergonomics clearly differs from corrective and preventive ergonomics while being complementary. It adds little explored dimensions, including knowledge (methods, concepts and processes) that will enhance traditional approaches such as:

- Producing knowledge about future users: These are techniques that are able to understand future clients, such as the technique using personas [7][8], and scenarios. The scenario technique enables the pre-testing of new concepts and evaluation of their impact on target users.
- Stimulating creativity and organisation in innovative projects. This includes various techniques of constraint management [9] or social development of future needs [10][11] which will support user creativity.
- Previewing artefacts so as to tailor product use or future services. This involves not only making models, and prototypes, but also system simulation in immersive environments.
- Understanding forms of appropriation of artefacts, beyond the functional approach which limits usage to realizing the system's functionality. Artefacts are designed for users who in turn redesign them. Understanding this to-ing and fro-ing between the artefact and the human enables us to understand the particular sleights of hand, misuse, usage deflection, and users' creativity, which not only shows appropriation of the technology, but also sources of innovation of unprecedented usage. Exploring hitherto unseen usages is in fact an important source of innovation.
- A priori identification of errors, drop in user rates, performance reduction and other unfortunate experiences. Understanding unfortunate experiences provides suggestions for improvement while estimating performance for the future use of the artefact.
- Studying products and services successes and failures comparable to the ones we wish to create or belonging to the same technological ecosystems, in order to learn more about functionalities connectivity, mobility, user interfaces, aesthetics, etc.
- Using trends to define the direction innovation needs taking.
- Taking into account specific problems, this involves developing trend statistics, (demographics, sociology, ethnology, and economy), listing technological possibilities (patents, intellectual and industrial copyrights, development opportunities) to try and foresee market changes (sales, consumption, buying patterns). This process of putting trends, industrial and marketing data face to face serves to hone and assess prospective scenarios. In doing so, prospective ergonomics includes trends, statistical projections and market data in its reasoning, these aspects were not previously taken into consideration in the field.

III. METHOD

In the framework of the Hydrogen project, our objectives were to understand how the experts perceive the possible, the acceptable, the potential and the uses of hydrogen technology in the near or more distant future. We have used a variety of methodologies and analysis techniques.

To do so, we have adopted a step-by-step approach, where we have used and analysis techniques linked together in this order: 1-staffs of experts, 2- card sorting, 3-,thematic analysis of content 4- personas and 5- lexical automated analysis.

A community of expert staff is a group of experts [10][12] representing actors directly or indirectly involved in a community project. The experts were welcomed under the

responsibility of animators in a controlled, scripted and filmed situation.

The main goal of those staffs of experts was to collect data that could enable us to use the other methods for finally, define scenarios of future use for a technology, product or service.

The role of the animators (2 or 3 in our case) is, for example, to create a dialogue between the experts, to react on existing products and services, to express the needs, expectations and requirements of target users, and to explain useful knowledge necessary for the use.

For our study, we created three staffs of professionals on three themes: 1-Transportation (2 + 2 experts animators), 2-Producing (4 + 3 expert animators), and 3- Energy distribution (3 + 2 experts animators). Each session lasted three hours. The process of each expert staff was done in four phases:

1- Each participant's presentation,
2- Knowledge generation and discussion about needs on hydrogen and its use,
3- Presentation of a movie on the discussed theme and experts reactions/discussions on it,
4- Organization of knowledge about hydrogen and its use (card sorting method).

Discussions and interactions were filmed using the living lab of our laboratory Perseus / UL. The different groups watched videos and reacted over the content (Figure 1).

Figure 1. Powertech Hydrogen Fueling Station Overview for Fuel Cell Cars

A focus group lasted three hours. At the end of the meeting, one main question was asked:

- What is the most important ingredient for success in energy transition to hydrogen?

IV. RESULTATS AND DISCUSSION

A. Lexical Analysis

We have chosen to make a lexical analysis of all conversations. The objective was to find the significant words, to build thematic classes and find patterns to understand the blocking points of the acceptance of an energy transition. In addition, the analysis of the conversations was used to validate four user models and to position them along two axes.

For the lexical analysis, we started by faithfully transcribing 9 hours of recording that resulted in a text of 160 pages. After cleaning all unnecessary words, repetitions, hesitations, errors, etc., the document was still 157 pages.

To analyse the document, we used the Iramuteq software. Iramuteq stands for "Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires", in English, "interface of R for multi-dimensional text and questionnaire analysis". Iramuteq is built on top of R. This software allows analysing documents that are segmented into chunks. Input documents are plain text files that contains simple mark-up that identifies variables and topics. This allows distinguishing between:

- A text
- A text segment
- A combination of text segments

Analysing a text with Iramuteq require introducing different tags in the text. A tag is a string beginning with an * (eg *firstexpert). These tags allow cutting the corpus produced, for example, by speakers or expert.

Iramuteq analyses verbs, words, adjectives and carry out a top-down hierarchical classification. For this, it is necessary beforehand to define different parameters like number of classes or the minimal size of segment (of text). From this analysis, Iramuteq builds a dendrogram (hierarchical tree, see Figure 2).

For our study, the software generated 8 classes. The percentage for each class indicates the proportion of the class in the text. Each class contains a set of words. The first words are the most representative of the class, those that were more frequently reported.

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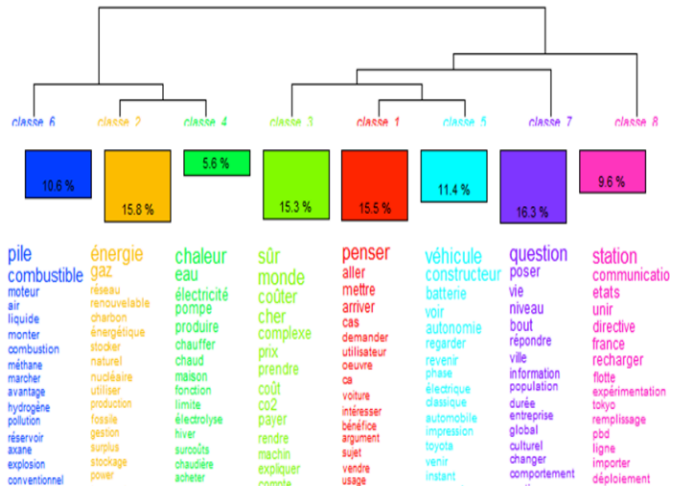

Figure 2. Our 8 classes from analysis

We can read on the first line different words like battery, energy, heat, safe, thinking, vehicle, and petrol station. The next step was to group these different classes which covered three main topics (Figure 3)

The main topics found are:

- Benefits of hydrogen and the multiplication of energies
- Choices and improvements to make in the future
- Desires of politicians and consumers

Classe 6	Classe 2	Classe 4	Classe 3	Classe 1	Classe 5	Classe 7	Classe 8
Pile	Énergie	Chaleur	Sûr	Penser	Véhicule	Question	Station
Combustible	Gaz	Eau	Monde	Aller	Constructeur	Poser	Communication
Moteur	Réseau	Électricité	Coûter	Mettre	Batterie	Vie	Etats
Air Liquide	Renouvelable	Pompe	Cher	Arriver	Voir	Niveau	Unir
Monter	Charbon	Produire	Complexe	Cas	Autonomie	Bout	Directive
Combustion	Énergétique	Chauffer	Prix	Demander	Regarder	Répondre	France
Méthane	Stocker	Chaud	Prendre	Utilisateur	Revenir	Ville	Recharger
Marcher	Naturel	Maison	Coût	Œuvre	Phase	Information	Flotte
Avantage	Nucléaire	Fonction	CO2	Ça	Électrique	Population	Expérimentation
Hydrogène	Utiliser	Limite	Payer	Voiture	Classique	Durée	Tokyo

Hydrogène (aspects positifs)	Multiplication des énergies	Utilisation stationnaire	Points négatifs	Aspect prospectif, tourné vers le futur	Choix industriels	Interrogations (comportements utilisateurs)	Situation actuelle et gestion politique

Avantages de l'hydrogène et de la multiplication des énergies	Choix et améliorations à effectuer dans un avenir proche	Interrogations sur la volonté de changement des politiques et des consommateurs

Figure 3. 8 classes grouped into three themes

In a bi-dimensional graph that resulted from a factorial analysis of morphological variables, we obtained a clear differentiation between four variables. The first two are on the X-axis (Figure 4). On the left, we can find a set of references to a social logical with words like "concern", "charge", "effort", "communication", "trust". On the right we read more technical terms like "engine", "fuel cell, energy, gas, heat, produce electricity".

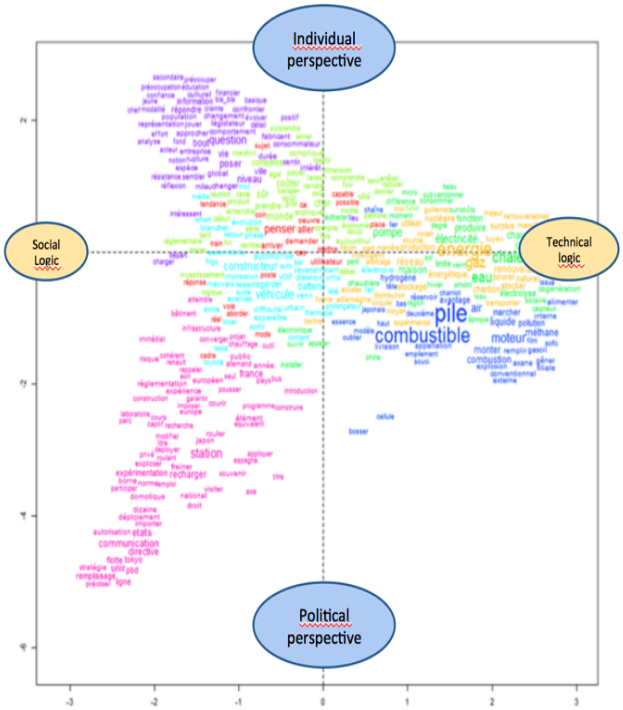

Figure 4. Factorial analysis and axes categorization of thematic content

On the Y-axis we have a comparison between what is done today in other countries and questions about what will happen in France in a more or less near future. At the bottom of the axis we find a "political concerns" with the words like "states directive, national, Tokyo, unite, etc.". At the top the preoccupation there are more individual terms like : "consumer, financial, complicated change, worry, to evolve ..."

This factorial analysis enables us to categorize future users. By placing on the axis the characteristics of a person (more individual, more social, more technical) we can find the words that characterize the potential user in terms of their expectations, needs and fears. This characterization of users can help to find for each of them the best solutions in an energy transition.

B. The elaboration of "Personas"

The concept of the personas was defined by Cooper [2] (and used by Brangier [7]) who based his facts on the notion that a user was too confusing to serve as a reference within a product team. The notion of a user was a too generic concept leading designers to develop products, which were designed for everybody but which finally, did not suit anybody. Another idea of the personas is that the necessity of adapting the product to each person will provide designers with an essential guide for a product for everybody. The persona can also serve as a communication tool, for all the stakeholders involved in the product development process.

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The lexical analysis had two major impacts on the elaboration of user models, or personas. Firstly, the analysis enabled us to validate four profiles of users that had emerged from a thematic analysis of content

- Cécile sees hydrogen as a new constraint. For her nothing must change. She is a passive consumer
- Pierre is an active consumer. He compares, changes, manages. He likes new technologies and wants to use them to manage their energy ration.
- Laurent works in a company specialized in hydrogen. For him, the future of hydrogen depends on political decisions. For him, consumer is not important today.
- Martin's company is also specialized in energy. He thinks that hydrogen is an interesting approach but raises questions about the attitude of future consumers.

The attitudes, values and behaviors of these personas were in line with the classifications.

Secondly, personas were positioned along two axes (Figure 5): Individual perspective versus political perspective and social logic versus technical logic. Indeed, even if they share common lexical fields, each of them points out a major concern:

- Cécile : time required for energy management and safety
- Pierre : new opportunities in every day life
- Laurent : technological issues
- Martin : technological acceptance from users.

The lexical field at the lower left corner of the graph has not been purposely illustrated by the four personas. It is made up mostly of comparisons between countries, although personas, as prospective users are future orientated.

Figure 5. Positionning personas on factorial analysis graph of discourse.

Laurent is a technician. It is not concerned by the daily use difficulties. He thinks that Hydrogen is the solution to the problem of declining fossil fuels. For him, there is no alternative. He thinks the change is also a political will. Martin is a professional too. But he thinks that using hydrogen will impact the lives of people (price, constraints, etc.). For him customer perception and opinion are important. Pierre is the example of the optimist user. He enjoys new technologies. He expects to manage its energy with automation tools. This is an optimistic environmentalist. Cécile is a dubious user. She does not want changing her habits. She knows that the ecological factor is important and she wants to make an effort but she refuse to be impacted by technical constraints.

V. CONCLUSION

Our work presents a perspective design method based on lexical analysis from speech of professionals of hydrogen. We categorized into 8 classes major areas of inquiry. From classes we built a model on essential needs. We identify three major themes

- Benefits of hydrogen
- Making in the future
- Desires of politicians and consumers

The most reported words in the lists are: "battery, energy, heat, safe, thinking, vehicle, petrol station". From this, it is possible to construct a sentence that summarizes all the speech:

- "*The batteries are sources of energies of tomorrow. They can generate heat, they are safe.*"
- *"I think that vehicles in the future will be self-sufficient and hydrogen stations will be easily found".*

The "persona based" method proposes that one fictitious character can individually represent a whole category of likely future consumers (4 personas in this study). To summarise, on the one hand, the persona's features enable professionals of hydrogen to create scenarios for the use of products or services and on the other hand, they enable distributers to develop a marketing strategy for the same product or service. This work shows also that the persona based method can be enriched by a lexical analysis and it contributes to construct representations of hydrogen uses:

- In the stationary area
- In the mobility area
- In the distribution and petrol station.

This work is the beginning of a larger project. Our future works will be:

- Through a European project, we will be working on theperception of hydrogen as alternative energy. The main idea of this project will be to build information environments for specialists but also for novices. We want to develop different applications for daily users or occasional users. For example we want to build a series of online training courses for young learners (hydrogen sensitization) as well as technical training for professionals of hydrogen as the heating engineers, electricians or garage mechanics.

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- Build Living Lab (two hydrogen pumps for cars and trucks) will study the behavior of future users.

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