NUCLEAR KNOWLEDGE MANAGEMENT OVERVIEW AT EDF

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This paper gives an overview of knowledge management practices within the French nuclear generation park. The study was initially partnered by one of the 19 Nuclear Power-plants, located at Golfech near Toulouse, and then extended to a more general overview. Golfech is a 650 people unit, from which 25 of them were interviewed to carry out the study. This staff was made of managers, experts, seniors and juniors, all of them being working at Golfech in the different skills for nuclear generation needs : driving, engineering, maintenance, safety, environment, etc. They were questioned about their practices, tools and organisations concerning creating, sharing, transferring, and renewing knowledge.
A general knowledge management model was derived from this study. It shows that the professional knowledge, in any industrial sector, is the result of four learning processes: an education-oriented process, a codified and normative learning process, a context-based collective learning process and an experience-based individual learning process. These learning processes interoperate through any kind of activity, and they induce four knowledge structures : the basic knowledge, the technical knowledge, the know-how and the experiential knowledge. In conclusion, the model explains how the firm learns and, in the same time, how everybody as a single individual learns. It is a crucial point to understand how the knowledge-based economy runs, as a constant interconnection between two opposite but complementary forces : the collective and the individual ones.

CONTEXT AND PURPOSE OF THE STUDY

The nuclear power park is an excellent case for studying the learning process in a firm. We will see that this process has to be considered simultaneously from the individual and the collective points of view. This study was initially partnered by one of the 19 Nuclear Power-plants, located at Golfech near Toulouse, and then extended to a more general overview. Golfech is a 650 people unit, from which 25 of them were interviewed to carry out the study. This staff was made of managers, experts, seniors and juniors, all of them being working at Golfech in the different skills for nuclear generation: engineering, driving, maintenance, safety, environment, etc. These people were questioned about their practices, tools and organisations concerning creating, sharing, transferring, and renewing knowledge.
The study was then extended to a more general point of view. The nuclear park is made of 19 nuclear power-plants, which means 20 000 people in charge of exploitation and several other thousands of people centralised in expertise departments. This is called the Nuclear Park Division.
The study pointed out how useful it is to understand, in one hand, the local KM practices of each power-plant, and, on the other hand, the global KM practices which are equally applied throughout the park. As a matter of fact, when you meet people in one plant, you can make out a great variety of KM practices: those related to IT tools (groupware, document management, intranet…), those related to HR domain (education, mentoring…), and also

those related to the art of management (communities of practice, innovation processes, taskforces, networking, evaluation, benchmarking etc).
The study proposes a very general model that helps to understand what the learning process is made of in a firm, and what the knowledge management practices look like. It also emphasizes that professional knowledge is fundamentally made of four layers which are embedded from individual to collective and from collective to individual. To make it more explicit, let us briefly recall the historical context of nuclear field in France.

FROM THE HYDRAULIC TO THE NUCLEAR CULTURE: THE FIRST LEARNING CHALLENGE

EDF was born in 1946, from the nationalization of the generation and distribution processes in the electrical industry (or to be more precise, of a great part of this sector). EDF is a firm based on an engineering culture, and it first developed a strong experience in the hydraulic domain. All the knowledge that was accumulated in this domain was derived from organisational and technical choices which were deeply embedded in the culture and competences. That was the first stage of EDF, and when the nuclear era began, at the end of the 50s, it was a very crucial challenge to make this knowledge capital change and adapt to a very new context. As a matter of fact, the hydraulic generation industry was based on a well-tried capital of knowledge and know-how that had lasted from decades and been improved in the long term.
On the contrary, the nuclear field was very new and everything – technical, organisation and culture – had to be created from nothing. Moreover, at the beginning of the 50s, the nuclear knowledge was concentrated in a single place : the CEA, which was sponsored by very famous scientists like Frederic Joliot-Curie, and moreover had very power-full politic supports.
The initial step was the period which led the firm from the first experimental nuclear battery to an industrial process. It was quite long because it lasted about two decades (the 50s and the 60s). This was a very rich period, made of innumerable difficulties and challenges, both in scientific, technical, financial and politic points of view. During this period, EDF gradually developed a R&D structure which began to concentrate high competences, managed by people like Pierre Ailleret or Claude Bienvenu.
In 1957 came the decision to build the first nuclear power plant, in Chinon, based on the CEA technology (graphite-gas). This technology will be abandoned later to be replaced by the American technology of Westinghouse (PWR). This was the second period, which led us to the actual park, made of 19 power plants. In this period, the knowledge capital was largely extended with the competences of the Equipment Division, which now represents a strong capital of expertise.
All the knowledge developed in R&D and Equipment divisions is the heart of nuclear knowledge in EDF, which is usually called the “technical knowledge”. A major part of this knowledge has been archived as documents and is available by the means of the existing document management systems.
Only considering the R&D knowledge, an electronic document management system, called Galaxie, has been implemented in the early 80s. It gives the access to a library of 200 000 electronic documents, corresponding to the last 3 decades of R&D studies and projects. This electronic library is accessible through the intranet network using a full text retrieval software. Similar systems were put in in the Equipment Division at the same time. Beyond this technical knowledge capital, each division of experts and each power-plant have their own document management systems. So now, let us tell about the way this knowledge moves and growth day after day.

A CODIFIED AND NORMATIVE LEARNING PROCESS : THE REX

The technical knowledge has gradually grown all along these years, by the means of a very important learning process, called the REX (Return on EXperience). The REX is based on a simple principle which is systematically applied : every event is registered, analysed, discussed and evaluated inside the community of experts, managers, and other agents (including external stakeholders like the Safety Authority). For example, after a variation of waterproof capacities of the combustible at Cattenom in 2000, new demands were prescribed and the surveillance of the combustible conditions were improved. Every year, the REX database is increased with 10 000 new data records which describe the corresponding events and the subsequent decisions that have been put into action.

The REX leads to adaptations, modifications, evolutions, recommendations that can affect both the technical and organisational procedures. In this learning process, the performance, the safety and the security are the main objectives.

It is the reason why the volume of procedures and all kinds of normative knowledge has significantly grown during the last 3 decades of nuclear exploitation. This phenomenon is increased at the international level, because a similar REX process exists in each country and contributes to make the technical knowledge more and more normative. International networks of agents and firms are means by which the knowledge is shared throughout the nuclear community. It is fortified by various efforts of each power-plant to be connected to others, especially by twinning, relationship and benchmarking.

The REX is very well-known in the nuclear field, and it is a confirmation of the “Knowledge Based-View” model of the firm, that was popularised in 1959 by a famous economist Edith Penrose. It is interesting to highlight this theory, because in many industrial sectors this model remains theoretical and it is still not in practice in many firms today.

Another fact has to be pointed out. As the volume of normative knowledge, due to the REX process, strongly increased during the last 3 or 4 decades, all the people in charge of power-plants were gradually faced to more and more procedures and have, day after day, to deal with all these normative conditions. This is said to be a very constraining environment and it is a psychological challenge for everybody to manage this problem.

Older people have many stories which recall how the working conditions have changed. These people used to learn by experimentation (*learning by doing*), which means that they could test many ideas that they cannot do anymore, because of the procedures. This fact is easy to understand for all the performance, safety and security demands which are absolutely justified. But it has become a strong challenge the management. As a matter of fact, young people come into the firm with many useful new competences and a strong technical knowledge (*learning by concepts*), but they meet difficulties and often feel themselves quite bored with all these day-to-day constraints. It is a problem for HR people to attract young people, and afterwards to maintain the *procedure attitude*. We will come back to these human factors later in this paper.

To conclude with the *technical knowledge*, we have to remember that it has some specific properties. As a normative and codified knowledge, based on scientific and industrial experience, it is absolutely “copy-pasted” from one site to one another. It means that all the technical systems, from global aspects to detailed aspects, are exactly the same (or supposed to be); the procedures are identical from one place to one another; the legislation is the same for everybody. The technical knowledge is the result of a normative learning process, which make it induced from local contexts to non-local rules and procedures. It is created by a bottom-up learning process (the REX), and it is applied by a top-down process (everyone must conform to the procedures). In other words, the technical knowledge is the same from one place to one another. And, moreover, let us say that it is clearly visible from the

institution point of view, due to the fact that the firm and all the stakeholders deeply take care of it.

THE KNOW-HOW : A CONTEXT-BASED KNOWLEDGE

On another point of view, let us underline the fact that each power-plant keeps the hand on a certain number of management options. If the technical knowledge is normative, the know-how, which is made of specific and local organisations, practices and tools, is based on the context of each plant. It depends on the local history, on the specific personality of leaders, on the geographic particularities, on the experience of people. So, the know-how is a crucial dimension of the human capital which fortunately always differs from one place to others!

Let us give an example. Each plant has its own team of chemists, made of one or two dozens of technicians. These people incorporate in their competences a combination of technical knowledge in physic and chemist on one hand, and of a specific know-how related to the way to using instruments, working together, creating good practices etc. This know-how is *context-based* because it largely depends on the history of each team..

All these 19 chemists teams represent together a community of practice which is able to share their know-how throughout the 19 power-plants. For this reason, the groupware techniques were successfully implemented a few years ago to help the technicians sharing their knowledge and their good practices. It is important to notice that this know-how is an extension to the chemist technical knowledge that is capitalized in the expertise departments, near Paris, Lyon, Marseille or Tours. So the community of practice is made with the different staffs of technicians located on each plant and of the experts in the central departments.

A second example of the know-how is made of a large set of tools, organisations, options, good practices of the managers, considerably depending on the contexts and history of each plant. For example it can affect specific communication practices and tools, HR practices like twinning and mentoring young people etc.

The know-how thus appears to be another part of the knowledge capital of the firm, and its characteristics notably differ from the technical knowledge. As a matter of fact, the second is normative, codified, identical from one place to one another, and very visible by the institution ; since the know-how is not codified, not normative, but out of the institution point of view, and made of context-oriented and practical knowledge. And this is a general observation that can be extended to any kind of professional branches.

At this stage, we considered two different parts of the knowledge capital – the so-called “technical knowledge” and the “know-how” – but we don’t have yet a complete landscape of what knowledge is made of. These two parts of knowledge have a common dimension: they are the collective and social dimension of knowledge. As a matter of fact, the technical knowledge represents the way by which the institution learns, and the know-how represents the way by which local teams learn. But these two collective dimensions of knowledge don’t explain how specific people learn. What about the individual point of view? We have now to consider the individual dimension and we will show out what exactly happens when a specific person learns.

THE BASIC KNOWLEDGE: AN “EDUCATION-ORIENTED” LEARNING PROCESS

The “basic knowledge” is the set of knowledge and capabilities that junior people have to take with them. It is delivered by the means of Human Resources and education systems : Learning & Training, Simulators, juniors mentoring, and other skill development processes. This basic knowledge is the result of a long term collective learning process : a 50 years old nuclear history, during which a part of the professional experience was evaluated and transferred to the education field (engineers schools, universities…). In return, the schools and

universities largely contribute to enrich this knowledge and of course to train young people. Let us briefly describe how the HR processes play a role in the KM perspective :

- Recruitment: it is the first leverage because it connects the firm to the education field. It needs several challenges for HR people: they must have a clear idea of what specialties the firm will need in the next decades (and it is a perilous exercise!); and they also must evaluate which schools are able to provide these capabilities. Other challenges are still more complicated: does the nuclear sector still remains attractive for young people, who often don't appreciate the numerous constraints related to the job inside nuclear power-plants? It is rather a strong problem, at the time when 50% people are going to get retire in the next decade!
- Continuous education : At EDF, the *Service de la Formation Professionnelle* (SFP) has been in charge of this process since the 40s. This long tradition of training and professional education is a reference in the HR domain and many sociologists and educator from universities have collaborated with the SFP. Nowadays, the SFP is challenged by many other societies who have been emerged on the professional education market. So the SFP has considerably moved on since the last decade, so that it could face new challenges: quality management system, accounts department, data wharehouse etc. The SFP is structured by the heart of business of the firm, which means specialize departments for driving activity, nuclear generation, thermo-hydraulic generation etc. This structure allows many agents depending on the power-plants to alternate, in their professional carrier, some specific moments devoted to a training and teaching function. Every year, dozens of seniors have thus the possibility to join the SFP for becoming instructor for a while.
- Mentoring: the practice of mentoring between seniors and juniors is a century old practice. At EDF, it has been encouraged and facilitated in many business units, and the SFP used to play a central role in this good practice. But, in many cases, the business units has a tendency to neglect the mentoring, because of day to day priorities concentrated on the short term performance. From several years yet, some power-plants have been make efforts to re-enforce the mentoring practice. For example, it is the case of Tricastin in the Rhône valley. The challenge is to make the cost and the benefits of mentoring visible, and to make managers aware of its utility. HR consultants have a great role to play in this challenge for next years, especially if you consider that lots of seniors will get retire in the next decade.
- Simulators : More specifically, EDF is now being developing a range of new simulators upon each power-plant, which represents a great financial investment. On each power-plant a local HR team is in charge of training programs on the simulators for driving technicians. This program is ensured in collaboration with consultants from the SFP who supervise the process and control the results. The simulators allow each agent to train on many types of situations : standard contexts, quasi-incidents, incidents and accidents eventualities. This opportunity to regular training sessions for each agent is very important, if you remember that unordinary situations have become more and more rare in the nuclear sector. For example, the unexpected stop of a nuclear reactor was quite frequent some decades ago, and the seniors were used to the non-standards situations. The young operators nowadays are much more familiar to simulation exercises than to real unexpected situations. This is the reason why many people are concerned by the simulator programs: technical agents, managers, experts, instructors, educators, HR consultants, human factor consultants, psycho-sociologists etc.
- Competences management system : All these HR-oriented learning processes are framed by a strong competences management system at EDF (called GPEC in French, for *gestion prévisionnelle des employs et competences*). This system is managed by top-down policies, budgets and logistic, and it is completed by a local competences management system on each power-plant (called SLDC for *système local de développement des compétences*). These

systems allow to manage with annual evaluating, progress actions, certificating trainings and other ways of learning. Moreover, a new program has been put in place recently for dealing with the future challenges. It is called "Renewing the competences", and it is structured in 5 programs respectively called: business prospective, critical competences, Turn over, GPEC, and competences transfer. The leading objective is to face the future needs for new competences and also to maintain the knowledge capital adequate in the long term.

THE "EXPERIENTIAL KNOWLEDGE" : AN EXPERIENCE-BASED INDIVIDUAL LEARNING

This landscape of the different learning processes in the firm is now made of three main layers that we called here : "basic knowledge", "technical knowledge", and "know-how". The first is related to a specifically individual learning process that we said to be "education-oriented" ; the second is related to the normative and collective function of learning in a professional field like nuclear sector ; the third is related to collective but located and "context-based" learning processes like team working, groupware, communities of practice etc. At this stage, we did not mention a fourth level of knowledge that is related to the own expertise of seniors and all kinds of the "experiential knowledge".

The concept of experiential knowledge has been studied in the education field from 3 or 4 decades. Let us mention the example of authors like Carl Rogers[1] or D. Kolb[2] who is very famous for his model of learning based on four steps: concrete experience, reflexive observation, conceptualisation, and active experimentation. These works were themselves deeply influenced by former works of philosophers like the famous John Dewey and education specialists like L.S. Vigotsky[3] whose studies refers to the central importance of communication and language in the learning process. In France, a review called *Education Permanente*[4] has published a large range of papers on this subject. Nowadays, the European legislation on what is called the *life long learning* (see the new French law on VAE, "Valorisation des Acquis de l'Expérience", 2001) is a very good example of a new awareness upon the experiential learning. But a long way is before us if we want to really take it into account. The first step will be to perform new approaches to identify and validate this knowledge. The second step will be to integrate the culture of recognizing the experiential knowledge, in a very elitist society modelled by high-degree schools attitudes.

What does it mean, the experiential knowledge, in the firm? Let us give an example that our study pointed out, in the power-plant of Golfech. We have collected some story telling from seniors in this place, so that we could identify critical and rare experiences and knowledge. The following example is of a senior whose the carrier took place in the maintenance field:

" A technical incident occurred in 1986 on a turbine. The default revealed design problems that finally led us to modify the whole maintenance program of the nuclear park. […] I personally learned much about this event. It was crucial to be clear with the lessons to learn from this turbine incident. And I felt strange, when I considered the way everybody uses to deal with his affairs and solve a problem. I realized that the technical knowledge is necessary, but is not the crucial point of the competency. The main point is how to solve a problem, when you are faced to un-expected situations ?

The ability to think-and-act quickly, to get out usual schemes, to catch invisible links between different parts of the whole system, the memory of similar facts in the past, all these capabilities are the *critical knowledge*. For example, before opening the turbine body, various

[1] ROGERS Carl, *Freedom to learn*, Charles Merring Publishing Company, London, 1969

[2] D. KOLB, *Experiential learning, experience as the source of learning and development*, Englewood Cliffs, NJ, Prentice-Hall, 1984

[3] L.S. VIGOTSKY, *Thought and Language*, Cambridge, MIT Press, 1962

[4] *Education Permanente review*, n° 100-101 « Apprendre par l'expérience », december 1989

kinds of information has to be collected first : were could we find the best provider? how should we organize the transport of the new piece, considering that in 1985, because of the cold winter, only one bridge over the Loire was able to hold this rotor ? Etc. The true expertise means thus the ability to get out the usual frame when you are faced to unexpected problems."

One could ask "why should we care collecting such anecdotes" ? But it is a crucial work to do, if we care to make sense and to share sense ! The history of problems and decisions, the links between parts of complex systems, the particularities of each context, all this knowledge is the *distinctive knowledge*. This is a pure "experiential knowledge", which means that it is *never* taken into account, whatever our management systems are. Nor identified as a knowledge, from the institution point of view. Moreover, the experiential knowledge, in most cases, is deeply unconscious – even in the mind of the experts that it belongs to…

The concept of *experiential knowledge* is closely bounded to the concept of *experience*, but with a noticeable difference that has to be pointed out. The experience is a raw material, something like what we perceive in the course of living and in the course of working. As the philosopher Emmanuel Kant explained: "Knowledge comes from the experience, but it does not end at the experience", which means that it needs something more. As a matter of fact, very few people are in situation to have the availability, the willing, the awareness, and also the methodology so that they could be able to take knowledge from their own experience. That needs also specific processes like "distanciation", observation, analysis, elucidation, comparisons etc. In the process of day to day working, these conditions merely do not exist, unless one has a strong willing for it.

Only specific initiatives like the story telling we mentioned above give a hand on this invisible, high-degree knowledge that is the most value-added of the four layers we discussed in this paper. The fact that the experiential knowledge is widely tacit and deeply incorporated in the mind of some people explains that no existing KM systems will ever be able to capture this knowledge. As a matter of fact, it cannot be captured : it is like a big ice cube; when you try to get it out of the water, it will quickly dissolve itself in the air. It cannot be captured, but it is possible, with a good story telling competency, to identify it and to make a special work with the senior. Which needs confidence, discussion, and a strong effort to elucidate the potential innovative ideas that this exploration allows.

The experiential knowledge does not belong to the firm, because it is absolutely individual. It cannot be captured without reducing it in powder without any consistency. But it can be questioned, in a confident and respectful way, so that the group could extract good ideas, consistent souvenirs, and new gates to the future. That suppose confidence, objectivity, and a sort of courage for facing buried and underground questions.

This way of considering what knowledge really is, remains quite unusual, but it is very important to understand that it is a tremendous opportunity. It helps us to point out the crucial point where the firm and the individual connect their capital of knowledge and combine them to find creative and successful roads.

KNOWLEDGE IS STRUCTURED AT FOUR LAYERS

Figure 1 illustrates the four knowledge structures that have been discussed here and the set of various KM systems that correspond to each of them. We will call this model the *Normalization-Emancipation Model*. Normalization refers to the collective learning process and emancipation refers to the individual learning process – the two of them being crossed and highly complementary.

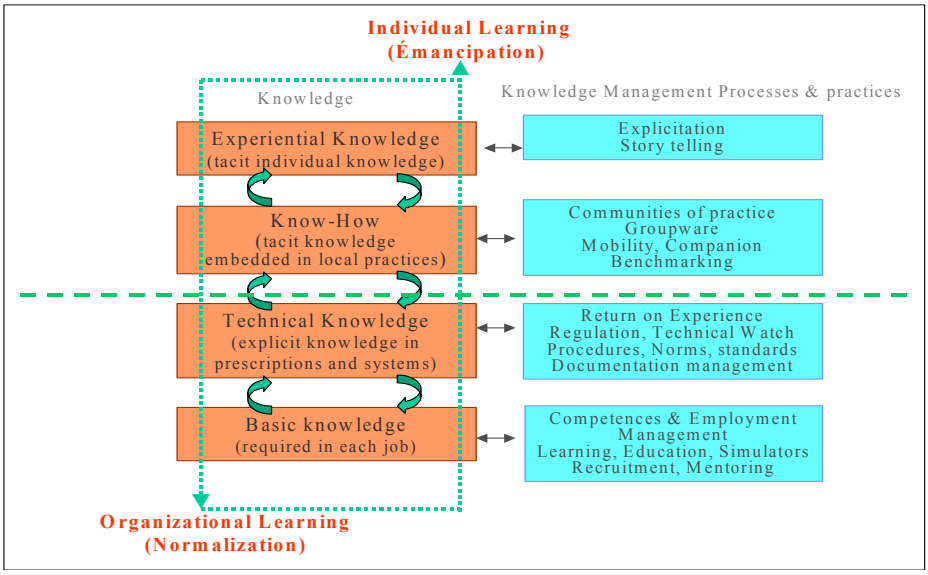

Figure 1: The Normalization-Emancipation Model of Knowledge

This model of knowledge, layered in four structures, is very important because it is the only way to understand that every KM system is adapted to only one of the four layers, and not for the others. For example, teaching and HR tools are very well adapted for the basic knowledge, but has no chance to leveraging the experiential knowledge. On the other hand, IT and KM tools like intranet portals, groupware and data-management systems are very useful for sharing technical knowledge and know-how within communities of practice, but they are of no effect on the 4th layer of knowledge that remains unconscious in individuals.

Thus, other KM projects might consider this model, so that they can chose the right KM system for each layer of knowledge structure. Many KM projects all around the world have failed because of their ignorance of this complex structure. They often only focus on the problem of overwhelming information today, which is a real problem. But it is a pure illusion to hope that IT techniques would ever be able to extract *the right information*, wherever it could be, and return it to *the right guy at the right place*, as it is claimed in the ready-to-wear advertisements… In fact, information is indeed a problem, but Knowledge is *the* problem. It means that the priority is on competencies and knowledge management policies performances, rather than in IT systems performances (which are quite good).

Knowledge is not a simple *stock of information* (as it is suggested by the computer's metaphor) : it is highly structured within the *human brain* – as we showed it in this paper, and its characteristics strongly differs from one layer to one another. At the 1st and 2nd layer, it is explicit and thus can be transferred and shared by KM processes like education, training, procedures, norms and documentation... At the 3rd layer, it is quite hard to take knowledge out of its context which is limited to close and tiny teams or communities; thus it has to be shared in a largely tacit way through communities of practice (though a part of it can be tracked in groupware forums, mails and other context-oriented documents). And at the 4th layer, knowledge cannot be shared, without being considerably altered in an explicit form. The lesson learned from the concept of *experiential knowledge* is that the human being cannot be replaced by any kind of knowledge management system.

Another lesson is that, simultaneously, the firms do learn *and* the individuals do learn. The individual and the collective learning processes are two opposite polarized processes, but they can be combined and they can help each other – if KM systems and policies care of it. This is

the most profitable way, we think, for the knowledge-based economy to grow more and more in an ethic perspective.

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