MSc Human Resource Management (Full-time)

Dissertation

UK Nuclear Industry HR Challenges: Knowledge Retention and Transfer

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I hope you enjoy reading this research as much as I enjoyed working with you.

Declaration Statement

This Dissertation was prepared by Olga Zavatskaya, a student of Human Resource Management at the University of Strathclyde. I declare that this dissertation is my own work and that all documents (paper and electronic) used are done according to the University rules. I have not copied the work of others (including students) in any way.

Signed:.. Date: ....

Contents

ABSTRACT

Growing energy demands, urgent needs to address climate change, finite natural resources, instability and insecurity of energy supply on European market brought nuclear power back to the UK's Government agenda. Moreover, in 2008 the New Labour Government announced that nuclear power would play a key role in the UK's future energy mix, stating: "We are determined to get new nuclear up and running as soon as possible" (BERR, 2008a). As a result, energy companies have announced their plans to build up to 16 GW of new nuclear power capacity in the UK by 2025 (The Nuclear Energy Skills Alliance, 2010). New build will create approximately 10,000 jobs per year until 2025 which will require a high number of qualified and skilled engineers, scientists and technicians (The Nuclear Energy Skills Alliance, 2010). However, such trends as an ageing workforce and low numbers of students undertaking nuclear disciplines can put the new nuclear build programme at risk. More than half of currently employed experts will leave the UK nuclear industry in the next 10-15 years, taking with them knowledge that was accumulated for the past 50-60 years and potentially creating a significant skills shortage. Some of this knowledge can be critical for the safe, reliable and efficient operation of a nuclear plant, for design and construction of new nuclear plants and for decommissioning of the retired plants and if no action is taken, it could be lost. Therefore, in order to maintain a high level of safety in the UK nuclear industry and to meet a growing demand for nuclear experts in the nearest future, energy companies will not only have to attract new people and retain existing expertise, but also successfully replace experienced retired staff and transfer their knowledge to a new generation.

Despite the many challenges that the nuclear industry is currently facing, this research will focus on the biggest and most crucial one – maintenance of knowledge and skills in the UK nuclear industry. This choice was made as the safe and reliable operation of nuclear plants is the primary concern at all times which strongly relies on skilled people who have the right knowledge and experience. Such expertise can mainly be acquired through specifically designed in-house training programmes and work experience. That is why preserving and transferring the existing nuclear knowledge to new generation is the biggest and the most important HR challenge that the UK nuclear industry is currently facing. It has to be addressed promptly and effectively due to the safety-critical nature of the nuclear operations.

In addition, successful transfer of knowledge will create a strong base for young employees helping them to avoid the mistakes that previous generation made.

Therefore, the aim of this dissertation is to look at the HR challenges that the UK nuclear industry is currently facing and to analyse in depth one of them – knowledge retention and transfer[1] (KRT). To answer the research question the following objectives were set:

- to analyse the current labour market issues around the UK nuclear industry and look closely at the supply and demand side of it, focusing on expert workers such as engineers, technicians and scientists;
- to examine the key concept about theories and ideas of knowledge management (KM) and KRT in particular;
- to explore the relationship between theories on KRT and practices currently established in the UK nuclear industry and analyse the effectiveness of these practices in the context of the theories.

This research is based predominantly on information gathered from secondary sources. The following literature was examined: books, energy and management related academic journals, professional body's websites, industry-based research, publications and studies, official documents and statistical information.

The research main findings confirmed that there are many similarities between KRT approach used by the UK nuclear industry and the one discussed in the literature. Both have more or less similar definition of KM and refer to the same three elements of KM: people, processes and technology. They recognise the same personalisation and codification techniques, apply the same tools and instruments when transferring knowledge. They admit the importance of cooperative and collaborative organisational culture, advance technology and identification of business critical knowledge for successful KRT process. However, due to the nature of the business and its specific business goals and objectives the UK nuclear KRT process has some unique characteristics. Safe operation of nuclear facilities and global security is one of the imperatives of the UK nuclear KM which is reflected in the nuclear KRT process. Another, distinctive characteristic of the UK nuclear KRT is its preference to codification techniques. The last and unique characteristic of nuclear KM and KRT that was

[1] This is one of key elements of knowledge management. The connection between KM and KRT was emphasised throughout the dissertation.

established during this research is its universal application. To be more specific, the UK nuclear industry shares its successful experience in KM within the industry and internationally.

CHAPTER 1 INTRODUCTION

1.1 Overview of the Energy Industry

There are currently sixteen operating nuclear reactors in the UK with a total capacity of 10,048 megawatt (MW) (Department of Energy and Climate Change, 2012a). The share of electricity generated by the nuclear fission in 2011 was 18% (Department of Energy and Climate Change, 2012b). The nuclear electricity represented almost two thirds of the total low-carbon energy generated in the UK in 2011.

However, most of the UK's nuclear reactors are near to the end of their operational lives and scheduled to shut down by 2023 (Department of Energy and Climate Change, 2012a). Only one plant in Sizewell B will continue to operate (The Nuclear Energy Skills Alliance, 2010). Moreover, almost third of the country's coal fired power stations are due to retire by the same 2023 potentially creating an energy gap if no new nuclear power stations or other energy generating plants are built (BERR, 2008). It was estimated that 20-25 gigawatt (GW) of new generating capacity has to be built by 2020 so growing energy demand could be met (BERR, 2007).

Before the final decision was made with regard to the UK's future energy mix, many factors such as affordability, security, efficiency and safety of energy supply were considered. Energy security and climate change were named as the main drivers for new nuclear build in the UK (Goodfellow, Williams and Azapagic, 2011; Greenhalgh and Azapagic, 2009; Baker, Stoker and Simpson, 2011).

Natural gas is the main source of electricity in Britain. About 41% of all electricity in the UK in 2011 was generated from natural gas (Department of Energy and Climate Change, 2012c). However, Britain's natural gas resources are rapidly diminishing while the share of imported gas is increasing (Baker, Stoker and Simpson, 2011). Level of import dependency has risen from 26.6% in 2009 to 36.5% in 2011 (Department of Energy and Climate Change, 2012d). This means that Britain is heavily reliant on foreign gas supply which can negatively affect country's energy security. For example, gas and oil prices have risen dramatically since 2003 from $28/ barrel to $127/barrel in May 2011 (Lior, 2012). Moreover, any instability in supply can further increase the price or/and leave people without electricity (Watson, 2010). Another example would be the consequences of instability in gas supply. Europe is highly dependent on Russia for gas supply. About 40% of its gas is imported from Russia (Holz, Hirschhausen and Kemfert, 2008). Twice in 2006 and in 2009 due to some political issues in Russia some European countries were left without a gas supply for almost a week (Stern, 2006; BBC, 2009).

Another worldwide driver for new nuclear build is climate change. Its effects can be seen easily these days. That is why a number one priority for many countries is to stop further damage to the environment. As a result the UK Government introduced the Climate Change Act in 2008 which legally obliges the country to reduce the carbon emission by 35% by 2020 and by 80% before 2050 (Department of Energy and Climate Change, 2012e).

Thus, current instability in prices and supply on the energy market, the lifetime of existing plants, rapidly growing world's energy demand, finite natural resources, and increasing pressures of climate change played in favour of the new nuclear build (Goodfellow, Williams and Azapagic, 2011; Greenhalgh and Azapagic, 2009; Roelofs, Hart and Heek, 2011) and in January 2008, the UK Government published the White Paper on nuclear power where it stated that nuclear power was going to play a key role in the UK's future energy mix providing the country with secure, safe and affordable electricity (BERR, 2008).

Energy companies have announced their plans to build up to 16 GW of new nuclear power capacity in the UK by 2025 (The Nuclear Energy Skills Alliance, 2010). New build will create approximately 10,000 jobs per year until 2025 (The Nuclear Energy Skills Alliance, 2010). However, it could be very challenging to attract, recruit and retain qualified, experienced and competent staff, given the size and demographic of the industry as well as a huge difference in supply and demand side of nuclear experts (Simonovska and von Estorff, 2012). The number of graduates and young people entering the sector is extremely low and the number of scheduled retirements for the next 10 – 15 years is high. About 50-70% of the UK's experienced workforce will due to retire by 2025 (The Nuclear Energy Skills Alliance, 2010). For example, about 30% of staff of British Energy is over 50 and 70% is over 40 (Knight, 2008). Thus, in order to meet a growing demand for nuclear experts in the nearest future energy companies will not only have to attract and retain new people, but also successfully replace experienced retired staff and transfer their knowledge to a new generation which can take anything from one to eight years depending on the function (IAEA, 2004). Moreover, on one hand the average time graduates need to become fully professional (gain relevant skills and experience) is ten years. To make matter even more difficult, technical and professional staff for a new nuclear plant have to be recruited 5 years in advance before the plant starts its commercial operation (IAEA, 2004). Planned commercial operation for the UK's first new nuclear reactor is scheduled for 2018 leaving very little time to fulfil the future demand for nuclear experts. This situation potentially can create a skills shortage that can pose a threat to safe construction, commissioning and operation of the Nuclear Power Plants (NPP) and put the whole programme at a serious risk. In addition, UK new nuclear build faces a skills competition on national as well as international level from other big nuclear and non nuclear construction projects which require technical and engineering staff.

1.2 Definition of Scope

There are many challenges that nuclear industry is facing nowadays. This research will focus on the biggest and most crucial one – maintenance of knowledge and skills in nuclear industry. Safe and reliable operation of nuclear plants is the primary concern of all times. It strongly relies on skilled people who have the right knowledge and experience. However, there is a shortage of qualified people in the nuclear industry in the UK (Knight, 2008). The knowledge gap will only grow with time if no actions are taken, given the ageing workforce and very little fresh blood entering the industry. Most of the people who are due to retire have been working in the nuclear industry since the first plants have been commissioned. They carry a vast amount of tacit knowledge that can be only acquired over time through work experience. This knowledge is the hardest to manage and it can be very difficult to transfer it into any formal storage facility. It is even more challenging these days since the number of qualified replacements is very low. Thus, there is a high risk of losing nuclear knowledge if urgent measures are not taken.

1.3 Aims and Objectives

The aim of this dissertation is to look at the HR challenges that the UK nuclear industry is currently facing and to analyse one of them concerning knowledge retention and transfer (KRT) in depth. To answer the research question the following objectives were set:

- to analyse the current labour market issues around the UK nuclear industry and look closely at the supply and demand side of it, focusing on expert workers such as engineers, technicians and scientists;
- to examine the key concept about theories and ideas of knowledge management and KRT in particular;
- to explore the relationship between theories on KRT and practices currently established in the UK nuclear industry and analyse the effectiveness of these practices in the context of the theories.

1.4 Dissertation Structure Outline

This dissertation consists of six chapters. Chapter one is the introduction. Chapter two is the research methodology used to collect the data in order to meet set objectives. In chapter three current labour market of nuclear industry and its challenges are analysed with some perspectives made for the future supply of and demand for nuclear experts. The fourth chapter is devoted to existing theories on KM and KRT where these theories are analysed. Current practices in KRT in the UK nuclear industry are examined and compared against existing theories on knowledge management in chapter five. Chapter six will present the conclusions made based on this research.

CHAPTER 2 RESEARCH METHODOLOGY

This chapter discusses the methods employed in the collection and analysis of the data by the researcher as well as main approaches and data gathering techniques used in the relevant studies. Strengths and limitations of the selected approaches will be also discussed in this chapter.

2.1 Rationale for the Research

The aim of this dissertation was to examine HR challenges that the UK nuclear industry is facing at present with particular focus on the one crucial challenge – nuclear knowledge preservation and its transfer to the next generation. The review of various professional and academic views on the current situation in the nuclear labour market provided a necessary framework for a better understanding of the magnitude and breadth of knowledge transfer problem. By doing so it looked at the current and future supply of and demand for nuclear experts, analysed consequences of current low level of new qualified workers in this sector and examined the main reasons for the industry's low attractiveness in order to determine the best ways for retention and transfer of the vast amount of tacit knowledge. Many existing guides and industry related publications on knowledge management in the nuclear industry are based on the review and analysis of current effective practices used in the sector. Most strategies are focused on the increasing attractiveness of the industry to the young generation, the retention of current workers and the development of appropriate learning programmes on a State and company/industry levels. To be more specific, many specialized learning programmes, platforms, networks and forums have been organised and coordinated by the Council of the European Union (Safieh, De Regge and Kusumi, 2011). Among them are European Nuclear Energy Forum (ENEF), European Nuclear Energy Network (ENEN), Sustainable Nuclear Energy Technology Platform (SNE-TP), Education, Training and Knowledge Management Working Group and European Nuclear Energy Leadership Academy. Furthermore, mostly all of them have an international magnitude. Many training initiatives have been promoted by government and industry (Nuclear Technology Review, 2010). So for example, to meet the future demand for the nuclear expertise in the UK Government established the National Skills Academy for Nuclear in 2008 (Nuclear Technology Review, 2010). The core of current research was therefore to establish the connection between existing practices in the industry and current theories in KRT as well as to identify weaknesses and gaps in the existing KRT process.

Due to the complex nature of the chosen topic, many stakeholders involved and time constraints this research is based on the information collected from secondary sources. A range of social, technical, political and economic data were analysed including future scenarios of NPP developments and potential demand for skills in the coming years. That helped to create a full picture of the current and prospective situation on the UK nuclear labour market as well as a better understanding of the existing practices for transferring relevant nuclear knowledge. However, due to the difficulties experienced while finding the up to date information about the KRT practice in the UK nuclear industry it was decided to supplement this secondary data with a primary source of information.

2.2 Research Methodology

This research is based mainly on the information gathered from secondary sources. Nuclear labour market and knowledge management theories were analysed to gain a better understanding of the main HR challenges that the UK nuclear industry is currently facing as well as practices that are used for knowledge preservation and its transfer to the next generation workforce. A detailed review of current literature was carried out to create a theoretical foundation for KM, to gain a better understanding of current climate of nuclear labour market, and to analyse the effectiveness of existing practices in KRT in the industry. The following sources of secondary literature were examined: books, energy and management related academic journals, professional body’s websites, industry-based publications, official documents and statistical information. Amongst the energy related journals frequently used were: Progress in Nuclear Energy; Environmental Science and Policy and Energy Economics. With regard to the fourth chapter of this dissertation, mostly management related journals were employed such as Journal of Knowledge Management, Industrial Management and Data Systems, Academy of Management Review and Strategic Management Journal. Moreover, a wide range of information was sourced from industry-based publications, studies and research including Department of Energy and Climate Change, International Atomic Energy Agency (IAEA), EHRO-N, Office for Nuclear Regulations (ONR), Nuclear Industry Association (NIA), NUCLEUS, International Nuclear Information System (INIS) and COGENT (Skills for Science Based Industries). Relevant statistical information was found on two websites: the Office for National Statistics and The Department of Energy and Climate Change.

Due to the complex nature of the selected research question it was considered that a single study could not fully cover the selected topic and meet earlier set aims and objectives as it would require a great deal of time to collect and analyse information from all stakeholders from supply and demand side of the UK nuclear labour market. Moreover, there is no guarantee that the permission to access the information will be granted, or all chosen stakeholders will be able to participate in the research. In addition, there is no guarantee the response rate will be high enough to make any thorough conclusions. To meet the research objectives, at least two different surveys were needed: one to cover the current situation in the UK nuclear labour market and the other to examine existing UK nuclear practices in KRT. This seemed to be unrealistic due to set timeframe, limited human and financial resources. Hence, the use of multiple secondary sources was believed to be the most effective approach to gain a deep understanding of challenges and possible consequences that the UK nuclear KRT process is facing today. A wide range of existing information on the selected topic was found within academic books and journals, official governmental, industrial and technical documents, professional guides and recommendations, conference notes, academic based and industry based research and surveys. Access to all the above sources helped to generate enough reliable and accurate data to create a well rounded picture about the chosen topic and meet set objectives (Saunders et al, 2000). However, every research approach has its strengths and weaknesses which have to be assessed and acknowledged before any conclusions are made. Secondary research is not an exception.

The advantages of secondary research were the main drivers for selecting it as a main approach for this dissertation. Access to secondary data saves time and money. Compared to primary research, this information is ready to use without extra time spent on data collection and analysis (Saunders et al, 2000). Thus, secondary sources help the researcher to accumulate a wider knowledge and in contrast to primary research this can be done at almost no cost, with less effort and time. Moreover, it provides explicit information on the topic, supported by accurately evaluated and analysed data (if quality sources are used), hence, allows the researcher to better understand the chosen problem (Pervez and Gronhaug, 2002). Another advantage of using secondary sources is that multiple existing studies, research and surveys can be accessed at the same time providing author with enough comparative and contextual data to critically assess all available findings. This allows for in-depth evaluation of the findings and more objective conclusions to be made (Saunders et al, 2000).

However, secondary research has its weaknesses. The main difficulty of using this source is that already existing data might not answer exact project objectives (Saunders et al, 2000). Thus, secondary information cannot always be consistent with the research question and can be invalid for making any comparisons (Pervez and Gronhaug, 2002). For example, while assessing the demand for labour in the nuclear industry every researcher used slightly different scenarios for the new nuclear build programme; thus, made it more complicated to compare. However, where it was possible the data was analysed against the most current and realistic scenarios, keeping in mind time required for collection of complicated documentation, completing health and safety assessments and past and present delays in the nuclear projects. Another weakness of using secondary approach is the difficulty to obtain the most recent information on the research problem. Some data can be out of date very quickly due to changing political, economical and social factors. It is especially important in nuclear programmes as the time frame of the project can be changed depending on organisational, financial and political situation. Hence, most studies and research related to the industry and used in this dissertation were not older than five years with a few dated by 2012.

In addition, while using secondary sources it is recommended to use credible sources to ensure the accuracy and quality of the information collected (Pervez and Gronhaug, 2002). Saunders et al (2000) advises that reliable secondary information can be obtained from sources regulated by professional bodies. This is what the researcher tried to do, accessing such professional bodies as IAEA, NIA and the CIPD.

It is important to note, that in order to meet the last objective of this research it was decided to use a primary source. There were two main reasons behind this decision. Both of them related to the weaknesses of secondary research discussed earlier: difficulties obtaining up to date information that would answer the certain research question about KRT practices in the UK nuclear industry. In general, secondary sources provided a lot of information about nuclear KM and nuclear KRT experience in other countries such as France, India, Canada, Japan, USA and China. However, it was not directly relevant to the research objectives. Hence, the choice was made to analyse KRT practices established at Sellafield Ltd – one of the biggest nuclear sites in Europe that employs almost half of the UK nuclear workforce. For that purpose, semi-structured interview was conducted with John A. Day, Head of

Knowledge Management and Intellectual Property at Sellafield Ltd. The interview was recorded with the permission of the interviewee. Due to the fact that approach to KM developed by Sellafield Ltd is seen as representing the best practice standards in the nuclear industry it will be adopted across all UK nuclear sites owned by the Government, which is a majority (19 out of 27). In addition, privately owned nuclear sites will most likely employ the same approach with certain variations to meet their specific needs. Therefore, data gathered from the interview allows for generalisation since it is valid across almost the whole UK nuclear industry. This means that the information obtained from the primary source in relation to Sellafield Ltd KRT practices can be used to explore the relationship between theories on KRT and practices currently established in the UK nuclear industry and, hence, answering the third research objective.

2.3 Research Methodology Used in Other Studies

Most of the studies used for this dissertation were based on the primary data and used both quantitative and qualitative approach. The main reason of using primary data for a study is that it allows the researcher to gather specific, unique and the most recent information on the selected question which will be fully tailored to meet the research objectives (Saunders et al, 2000). Most of the studies the author came across started from desk research. Authors were studying and analysing relevant official documents and statistical information, existing nuclear organisations and higher education institutions in order to gain a better understanding of the problem and some insights on the current situation. The next step was collecting quantitative data through questionnaires about the supply and demand on the nuclear labour market from stakeholders, established through desk research. Data regarding future demands for nuclear experts for new nuclear build was also obtained. This data helped to answer questions about the current status and future needs for the nuclear skills in the UK (Bryman and Bell, 2003). At the same time, the analysis of this data can help to generate further questions for the research and create a sample of potential interviewees in order to get answers to more specific questions that can examine qualitative factors (i.e. why things are the way they are and the cause and effect) (Yin, 2003). Such questions would provide in-depth information on the problem, help to answer specific questions that came up during the research, get interviewees' professional opinion on the problem and explain certain actions and its causes (Biggam, 2007; Bryman and Bell, 2003). Thus, information gained during the interviews is usually deeper and brings the research to a new qualitative level. So, for example, after collecting primary data on the number of employees required for the new nuclear programme a lot of consultations and online surveys with experts have been held in order to validate some assumptions and create a comprehensive workforce demand model. To gain information on the UK practices in nuclear KM and KRT mostly a qualitative approach was utilised. Information was gathered through extensive consultations and interviews with professionals in nuclear sector, including representatives from the industry, government and academia, with professionals in HR, knowledge management and information technology field. Survey is another technique that was widely used to gather information. It was used to collect information about the degree of the problem and the most common methods that NPP use to transfer the knowledge to the next generation of employees.

The most significant shortcoming of the primary research is that no matter how representative the sample group for survey or interview was, it can only be generalised in the context of the particular research (Bryman and Bell, 2003). Any generalisation beyond the population from the sample group should be done very cautiously.

2.4 Research Limitations

- Firstly, mostly all data was gathered from secondary sources which limited the researcher’s ability to gather unique and the most up-to-date information to answer set questions. This limitation was perhaps more relevant as the time frame of future nuclear programme is constantly changing and it is already experiencing some delays compared to the original deadlines.
- Secondly, the scope of research was restricted to the UK situation on the nuclear KM and existing practices of KRT. Therefore, the findings may have limited validity to organisations operating outside of the UK.
- Finally, the research was limited by time as it had to be completed for a set deadline. That could affect the depths of analysis undertaken.

2.5. Conclusion

In summary, this research was mainly based on the analysis of information gained from secondary sources. This choice was made due to the time and financial constraints that usually associated with primary research. Moreover, a single study would not fully meet set aims and objectives of this research due to the complex nature of the selected question. To explore the current situation in the UK nuclear labour market and to study KRT practices in the UK nuclear industry, it would be necessary to conduct at least two different surveys across different stakeholders which seemed to be unrealistic due to set timeframe, limited human and financial resources. In addition, there is no guarantee that the permission to access the information will be granted by chosen stakeholders or the response rate will be high enough to make any thorough conclusions. Hence, secondary approach was chosen since it allows access to multiple studies, research and surveys providing enough comparative and contextual data to critically assess all available findings. However, since the most recent information about KRT practices in the UK nuclear industry was unavailable from the secondary sources it was decided to contact a primary source. The chosen source represents the best practice approach in KM in the nuclear industry which is utilised almost across the whole UK nuclear industry. Therefore, data gathered from a single interview in relation to KRT practices allowed for generalisation and was used to explore the relationship between theories on KRT and practices currently established in the UK nuclear industry. Hence, information obtained from the primary source helped to meet the third research objective with minimum time and cost. The following chapter will focus on the analysis of the secondary data that was selected to address the research objectives related to the UK nuclear labour market.

CHAPTER 3 UK NUCLEAR LABOUR MARKET

3.1 Introduction

Recent changes in the UK government stance towards nuclear energy have made the country more attractive to private investors who plan to build new NPP with a total generating capacity of up to 16 GW by 2025. This investment will approximately create 10,000 new jobs per year (The Nuclear Energy Skills Alliance, 2010). However, filling these jobs with qualified and experienced people will be very challenging as the country has failed to attract, recruit and retain young talented nuclear experts over the past 20 years. Moreover, a significant number of nuclear experts (nuclear engineers, scientists and technicians with nuclear related degrees or extensive experience in the nuclear industry) will be required, not only for the construction and operation of the new nuclear plants, but for the operation of existing plants and for the growing demands of the decommissioning sector as many skilled workers will be lost through the high level of natural attrition. This chapter will study the main reasons for a shortage of skills in the nuclear sector of the UK, the supply and demand of the UK nuclear labour market, and the main consequences of the increasing shortage of civil nuclear expertise.

3.2. Overview of the Reasons for Nuclear Skills Shortage in the UK

The world's first commercial power station was built in Britain in 1956 (Baker, Stoker and Simpson, 2011). The UK industry considerably developed over the next few decades with the construction of 33 new nuclear reactors between 1956 and 1976, which was followed by a significant drop in construction in 1980s (Department of Energy and Climate Change, 2012a). Only 10 nuclear reactors were built in the 1980s and the last reactor was commissioned in 1995. Goodfellow, Williams and Azapagic (2011) believe that two major accidents, namely Three Mile Island in 1979 and Chernobyl in 1986, had a great influence on the level of new nuclear installations. Public perception of the safety of nuclear energy was affected, which raised the profile of anti-nuclear movements (for example, Greenpeace) and forced many Governments to roll back with their new nuclear programmes and even to phase out existing ones in some countries (Kettunen, Reiman and Wahlstrom, 2007). Almost 20 years since the last major nuclear disaster, the UK Government still had doubts about the long term future of nuclear power.

As a result, in 1997, the UK's newly elected Labour party decided to focus on renewable energy by stating: "*We see no economic case for the building of any new nuclear power stations"* (Labour Party, 1997). In 2003, the Labour Government published its White Paper, where it reviewed the existing energy policy leaving the possibility of building new nuclear plants in the future if it will help to meet carbon targets (DTI, 2003). Five years later, in 2008, the New Labour Government announced that nuclear power is going to play a key role in the UK's future energy mix by stating: *"We are determined to get new nuclear up and running as soon as possible"* (BERR, 2008a). At the same time, devolved powers and internal politics within the UK still affect the development of new nuclear projects. For example, the Scottish Parliament voted against any nuclear construction projects in Scotland (Greeenhalgh and Azapagic, 2009).

Therefore, in 11 years the UK Government's position on nuclear policy had changed dramatically from opposition in 1997 to neutrality in 2003 and to advocacy and support in 2008 (Greenhalgh and Azapagic, 2009).

It is interesting to note, that the same uncertainty around the future of nuclear energy exists outside the UK too. In 1999, Germany was planning to phase out its nuclear energy by 2023. This position was confirmed by Chancellor Angela Merkel in 2006. Nevertheless, in 2009 the planned shutdown of nuclear power stations was postponed, so the ambitious 2020 carbon targets could be met. However, in 2011, after the devastating earthquake in Japan, Germany once again announced its plans to close all nuclear plants by 2023 (BBC, 2011).

To conclude on this point, the UK and European uncertainty about the future of nuclear programmes have made the British industry less attractive for the younger generation as it could not offer a secure career with a well-defined path (Kettunen, Reiman and Wahlstrom, 2007). As a result, fewer young people were choosing education and employment in this sector in the UK.

In addition, decline in the construction itself, with the last plant built in 1995, and low workforce turnover, which is typical for NPP, has lead to a steady decrease in the nuclear supply base over the last 20 years (Warwick, Penney and Krishna, 2012; Kettunen, Reiman and Wahlstrom, 2007; IAEA, 2004). Due to the lack of need for new recruits in the industry, very little attention has been paid to the development of an effective attraction and recruitment policy for the last 25 years. In other words, there was nothing done to promote nuclear engineering or nuclear technician professions to the younger generation. Moreover, the industry did not offer ample financial support to educational institutions as it was not interested in hiring young people due to the workforce stability (IAEA, 2004). Furthermore, due to the uncertainty about the UK's nuclear future, the Government significantly reduced funding for nuclear research and development. The combination of the above factors had a tremendous impact on the number of students taking up nuclear disciplines (e.g. nuclear physics, chemistry, decommissioning, energy and engineering) in universities and entering the nuclear industry. In some cases it even lead to the closure of the relevant faculties (Safieh, De Regge and Kusumi, 2011; von Estorff and Debarberis, 2010).

Another reason why the UK nuclear industry struggles to attract young professionals is that working in the nuclear industry is not prestigious as it used to be when the first plants were commissioned. Major nuclear disasters with long term consequences to our planet created a negative public perception and overall poor image of the industry. As research showed, many young people are not willing to work in an industry that is perceived to have negative impact on the environment (Hopkins, 2008). In fact, the younger generation want *"to be proud of their career choice and feel that they are doing something important to humanity"* (IAEA, 2006, p.23). So, for example, they would be more attracted to a career in medical application of nuclear technology as it could save lives if improved procedures for cancer diagnosis and treatment were developed. Thus, the civil nuclear power industry is facing high competition from more attractive jobs in the nuclear sector such as medicine and space technology, as well as from non-nuclear sectors such as civil construction and engineering, gas and oil, renewable energy and other alternative clean and safe energy sectors.

Another factor that adversely influences the influx of young engineers and technicians into the industry is slow career growth, lack of career opportunities and relatively poor salary in comparison with other graduate jobs (Hopkins, 2008). As Parry et al (2006) states, young engineers will need approximately 3 years to develop basic industry operating competencies and another 10 years to be promoted to a mid-level technical or managerial position which requires a high degree of competence and responsibility. Until then, they may have few opportunities for significant career development and their work tasks can be routine. Hence, it takes longer to forge a career in the nuclear energy sector than in other businesses. Young engineers are less likely to be given responsibility to run projects, whereas in other areas, graduates can manage projects in their late 20s and early 30s. Moreover, according to Graduate Market (2012) the median starting salary for graduate engineers in the UK is £26,500 which is much lower than investment banking (£45,000), law (£38,000) or consulting (£31,500). As a result each year 29% of UK engineering graduates are recruited by financially more attractive sectors such as investment banking and consultancy (The Engineering and Technology Board, 2007).

To summarise, uncertainty about the nuclear future, a break in the construction of new nuclear plants, reductions in government funding for nuclear research and development, negative public perceptions of the industry, slow career growth and low salaries has made the industry less attractive for the younger generation. As a consequence, the number of students choosing nuclear, as well as science, engineering and technology disciplines, has dropped significantly.

3.3 Supply of Nuclear Experts in the UK

Only 259 students graduated in nuclear engineering or nuclear related studies in 2009 in the UK. To be more specific, there were 10 graduates at BSc level, 217 graduates at MSc level and 32 graduates at PhD level (Simonovska and von Estorff, 2012). The number of students that entered the above mentioned disciplines in 2009 slightly increased to 313 people. However, the number of BSc students remained the same with the highest number of students at MSc level.

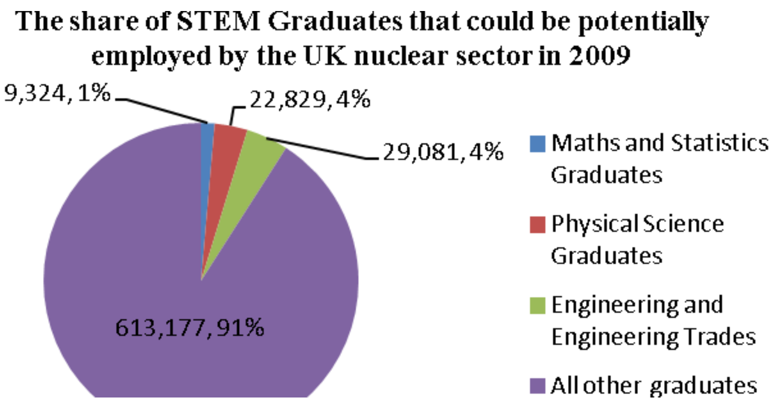
However, to build and operate new and existing nuclear plants, specialists across diverse disciplines are required (Simonovska and von Estorff, 2012; The Nuclear Energy Skills Alliance, 2010). STEM (science, technology, engineering and math) graduates have skills and knowledge that are important for the nuclear sector and can be successfully integrated into the construction and operation of NPP.

The statistical information on the number of students graduated in STEM disciplines was obtained primarily from Eurostat. The number of all graduates (BSc, MSc and PhD) in the UK in 2009 was 674, 411. Only 21.7% or 146, 395 of them were STEM graduates. Unfortunately, not all of them can be of particular importance to the nuclear sector. Mainly graduates from engineering, maths or physics disciplines are of value for the nuclear industry because they can be easily trained to work with the cutting-edge technologies, as well as contribute to the organisations' development and success (Simonovska and von Estorff, 2012).

The UK supply of STEM graduates in 2009 from disciplines valuable to the nuclear industry:

- 29,081 graduates in engineering and engineering trades or 19.9% of all STEM graduates including 1,871 PhD graduates. Hence, the share of nuclear engineering graduates from all of the engineering graduates in 2009 was less than 1% (259 out of 29,081). Moreover, the fact that 29% of graduates in engineering will be employed by non-engineering sectors is lowering the number of available engineering graduates to 20,647;
- 22,829 graduates in physical science or 15.6% of all STEM graduates;
- 9,324 graduates in mathematics and statistics or 6.4% of STEM graduates.

Figure 3.3.1 Source: Eurostat



The share of STEM graduates that can be potentially employed by the nuclear sector from all the students graduating in the UK is represented in figure 3.3.1. As seen in the above chart STEM disciplines are unpopular fields of study and career paths among young people. More importantly, nuclear engineering is an unpopular choice among these unpopular disciplines.

3.4 Demand for Nuclear Experts in the UK

The main drivers for the rising demand for nuclear experts in the UK are:

- Ageing workforce that requires ongoing replacement;

- Shifting skills into decommissioning due to a high number of scheduled shutdowns for almost all currently operating reactors;
- Construction and operation of the new fleet of nuclear plants.

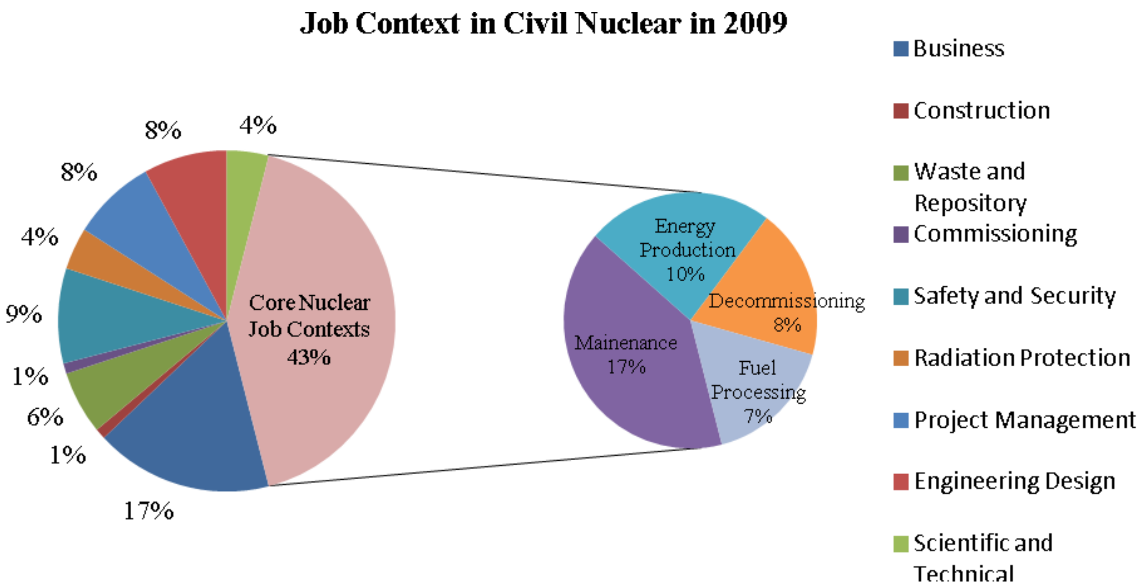
These drivers are going to be analysed in depth below.

According to the Nuclear Energy Skills Alliance (2010), the total number of people currently employed by the UK nuclear sector is 43,667, including 19,735 contractors employed in supply chain and 23,932 directly by the nuclear operating companies. The workforce in nuclear operations is combined of the decommissioning (11,951), electricity generation (7,397) and fuel processing sectors (4,584). However, employment in the fuel processing sector will decline by 63% by 2025 as existing capacity expires and there is no need for reprocessing for the new generation of reactors. Jobs in the decommissioning division will remain at the same level as 15 nuclear reactors are due to phase out in the next 10 years (Department of Energy and Climate Change, 2012a). Employment in electricity generation will be highly affected by the retirement rate and the new nuclear construction demand.

Currently, around 43% (figure 3.4.1) of the nuclear workforce is employed in the 4 core nuclear occupations: energy production operations (10%), decommissioning operations (8%), fuel processing operations (7%) and maintenance operations (17%). Other roles described as supporting, value-adding and regulatory account for approximately 42% of all employees (Cogent[2], 2009).

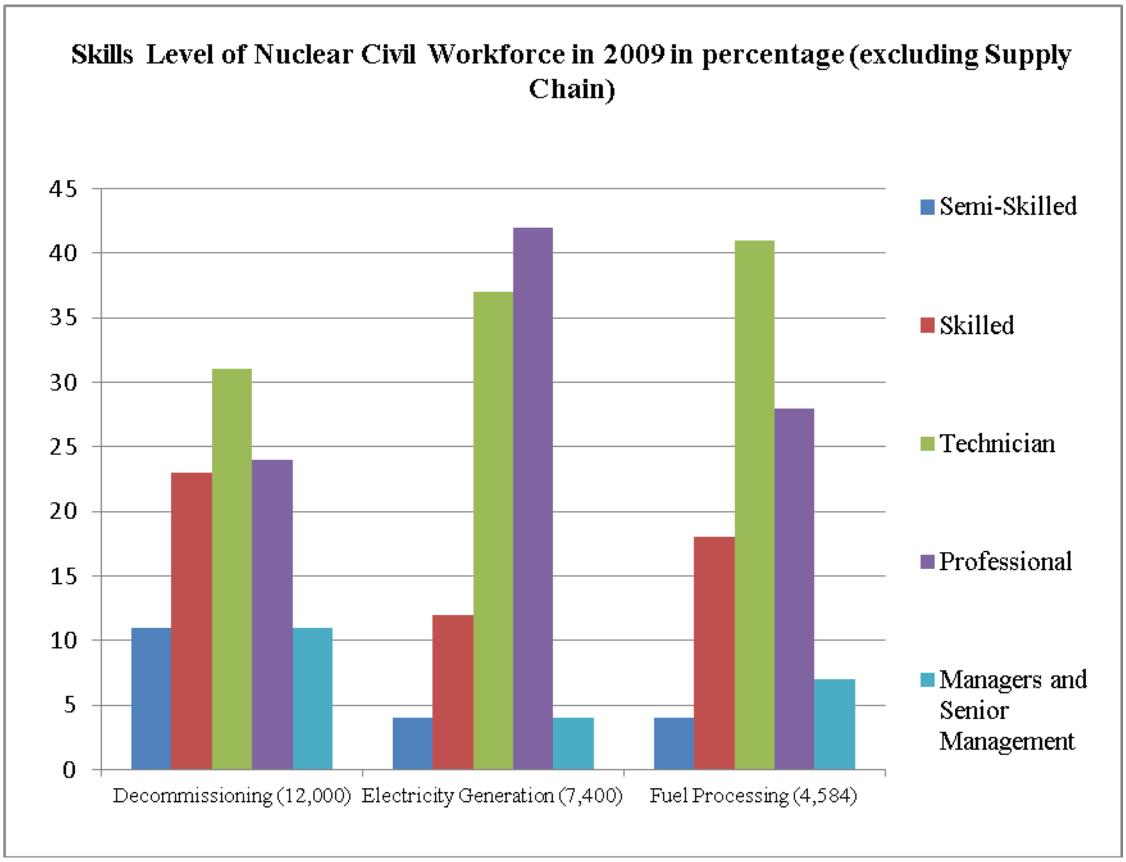
[2] The Sector Skills Council (SSC) for the Chemicals, Pharmaceuticals, Nuclear, Oil and Gas, Petroleum and Polymer Industries that is licensed by the Government to help employers to address their workforce development needs

Figure 3.4.1 Source: Cogent, 2009



Moreover, the proportion of technical workers (the exact definition was not given in the original source) is high throughout the sector and ranges from 30% in the decommissioning sector to 45% in the fuel processing sector (Cogent, 2009). In addition (Figure 3.4.2), the skills level in the industry is very high as its existence and operation is highly dependent on quality, safety and competence. As a result senior management and employees with professional and technical skills make up in total 73% of the current workforce (Cogent, 2009a).

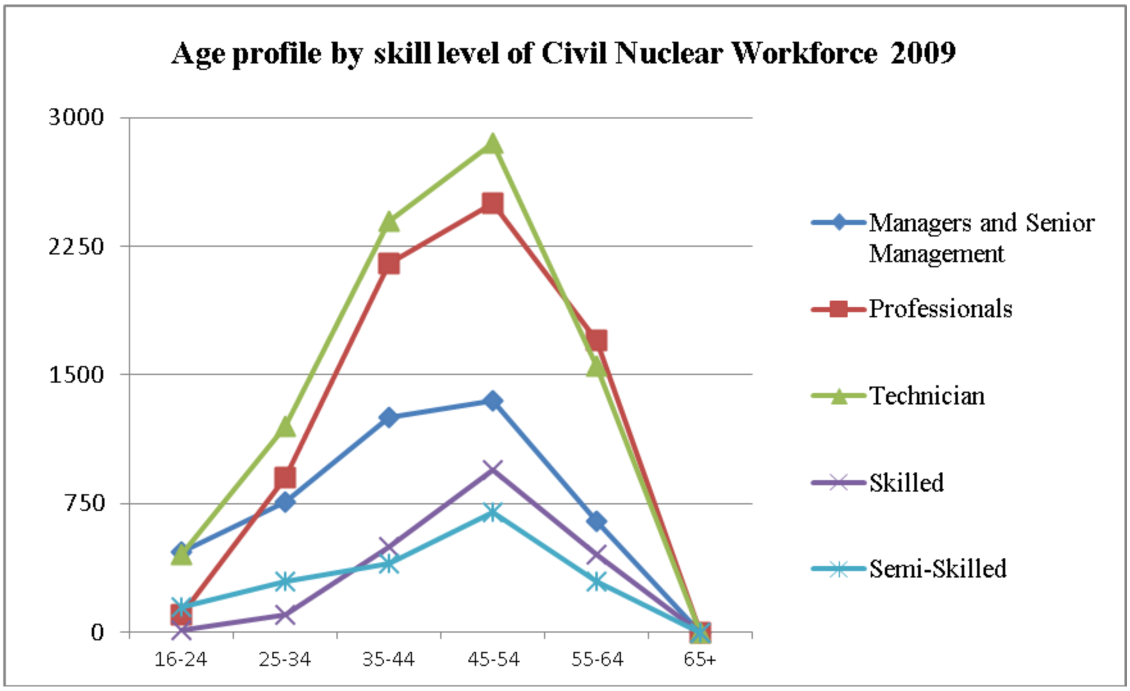
Figure 3.4.2 Source: Cogent, 2009.



On the other hand, Cogent (2009) presents another important issue – the age of the UK nuclear workforce (Figure 3.4.3). The age groups of "45-55" and "35-44" years old are the largest. The age group "below 35" account for less than 20% of the nuclear workforce. This means that by the end of 2025 more than half[3] of the current workforce will leave due to retirement with the erosion rate of 5% every year.

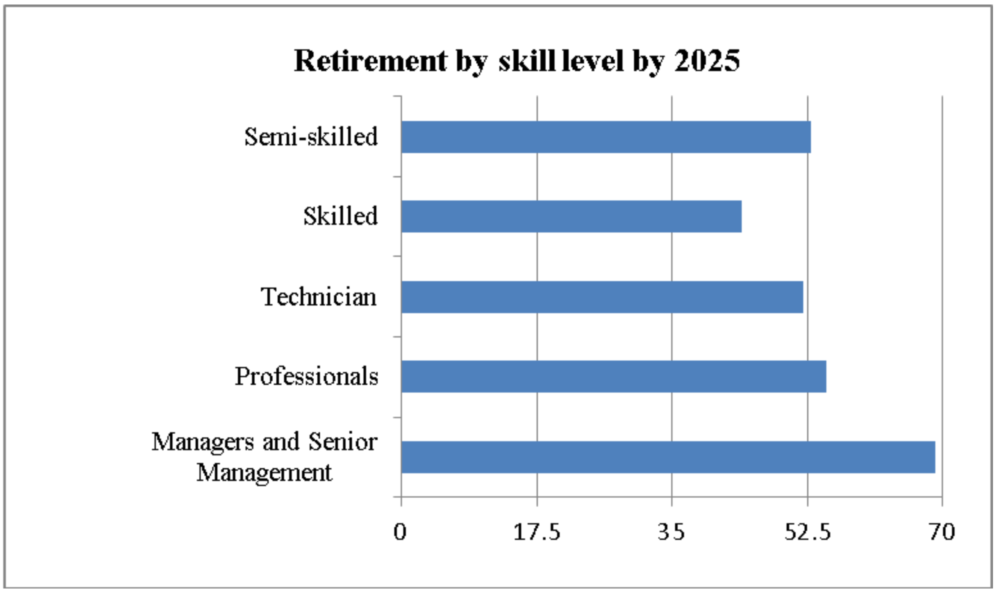
[3] 50-70% of current workforce will be retired by 2025 according to Cogent, 2009

Figure 3.4.3 Source: Cogent, 2009.



The fact that the greatest level of attrition will be among mature skilled employees, such as managers, professionals and technicians, is even more alarming (figure 3.4.4) It is predicted that by the end of 2025 about two thirds of highly skilled workers and professionals will retire (Cogent, 2009). Thus, there is a great need for recruitment and training of new nuclear professionals in the next 10 to 15 years if the new nuclear generating capacity is to be built.

Figure 3.4.4 Source: Cogent, 2009



In summary, more than half of the nuclear workforce employed in the UK today will need to be replaced by 2025. Moreover, safe construction, operation and maintenance of the NPP require a high level of professional and technical skills, so plants can operate safely, efficiently and without disruption 24/7. Currently, the sector employs 73% of highly skilled and experienced workers who carry a vast amount of knowledge. Unfortunately, almost two thirds of these professionals will retire by 2025. Hence, the demand for nuclear expertise in the near future will be extremely high, as there will be a need to replace retired workers and attract new recruits for the construction of new nuclear reactors which is scheduled for 2013.

Predicted demand for new nuclear build requires an average 10,000 jobs per year or 110,000 to 140,000 jobs for the 13 years of the construction programme (The Nuclear Energy Skills Alliance, 2010). Annual employment is expected to peak at 14,000 jobs per year between 2020 and 2022 due to a significant overlap in the programme with 7 reactors being on the different stages of construction simultaneously. The composition of the workforce will be as follows: 60% in construction, 25% in operations and 15% in manufacture and as it was mentioned earlier, not all employees will require a degree or experience in nuclear-related fields to fulfil new jobs. So, for example, only 60% of workforce in operations, 70% of workforce in manufacture and 15% of workforce in construction will have to be nuclear professionals (The Nuclear Energy Skills Alliance, 2010).

Taking into account the retirement rate of 5% per year and expected trends in employment in the core nuclear sectors, it can be calculated that by 2013 there will be a deficit of 2,703 employees in the decommissioning sector, 1,207 in the electricity generation sector and 190 in the fuel processing sector. Moreover, starting from 2013, on average 10,000 people per year will be required to work on the new nuclear build project for the next 13 years. This brings the demand for nuclear workforce working on-site and professionals in construction to approximately 14,100 by 2013. In the next 10 years the demand will be slightly lower as some skills will be transferred from the energy generation sector to the decommissioning sector due to the shutdown of currently operating reactors in 2014 (1), 2016 (4), 2018 (2), 2019 (4) and 2023 (4).

Cogent (2009) predicts that by 2025, there will be a shortage of 14,000 nuclear professionals which will be composed of 8,000 people for direct nuclear operations and 6,000 for supply chain operation. Calculations were made on the earlier established retirement rate, employment trends in the core nuclear sectors and the assumption that the new nuclear build will create 4,600 jobs by 2025. The main conclusion of this research was that the industry will require at least 1,000 new recruits per year to meet the replacement demand and the new project's demand.

Simonovska and von Estorff (2012) established that in 2010, there were approximately 10,000 nuclear experts employed in the UK and estimated that in order to meet new build demand and replace retired employees, the industry will need to recruit approximately 9,000 new nuclear experts by 2020. In other words, at least 900 nuclear experts will have to be employed every year in order to cope with the expected demand in 2020. It is important to note that nuclear experts in this study were defined as employed staff with university degrees in the nuclear field or those with non-nuclear university degrees, but with competences and skills in the nuclear sector acquired through work experience or training. Hence, the above figures did not indicate the need for skills from non-nuclear fields, which will be required during construction, manufacturing and operation stages. This fact is potentially raising the demand from the UK nuclear industry to more than just 900 nuclear experts per year.

The strong demand for nuclear graduates and experts in the future was predicted almost 10 years ago. A nuclear and radiological skills study, performed in 2002, indicated that the UK nuclear industry will need to attract approximately 50,000 new employees during the next 15 years, excluding demand from new build (IAEA, 2004).

Nevertheless, it is important to notice that most of the existing data on the UK nuclear labour market is limited and discrete. The first in-depth survey of the UK nuclear labour market was carried out by Cogent in 2009 which started the Renaissance series, dedicated to the UK nuclear skills and expertise. The main purpose of these series is to ensure that future skills demand can be met by the UK nuclear industry. There are currently three Cogent Nuclear Renaissance reports. Two of them were studied during this research. The first one "Power People: The Civil Nuclear Workforce 2009 – 2025" covers the existing skills in civil nuclear sector; the second report, "Next Generation: Skills for New Build Nuclear", analyses future demand for the skills; the focus of the third report is on the defence sector "Assurance: Skills for Nuclear Defence". However, the figures in these reports are based on the current estimates and depend on the rate of construction, number of units and reactors' design. Hence, these figures are prone to change over time if used variables are inconsistent.

Nevertheless, despite the fact that the figures slightly differ from source to source, they are still consistent in showing that the UK nuclear industry will require a high number of nuclear engineering and technical experts in the near future.

3.5 Analysis of Supply and Demand for the Nuclear Experts in the UK

Current yearly demand for nuclear experts in the UK was estimated between 900 and 1000 experts until 2025 (depending on the source). The supply of nuclear engineering and graduates in related fields can only cover about 26% (259 graduates in 2009) of the yearly demand for nuclear experts under the stipulation that all nuclear graduates will be willing to undertake employment in the nuclear sector.

On the other hand, the rest of the demand (74%) can be directed towards STEM graduates. The number of graduates in engineering, physical science and maths and statistics in total in 2009 was 52,800 (excluding 29% of graduates from engineering who will potentially choose a career path in another sector). The high number of STEM graduates could potentially fulfil the demand of the nuclear sector, if they have been trained to a desired degree of expertise. It is necessary because every job which is related to the nuclear sector requires a high level of competency, health and safety skills and quality assurance, so the highest quality and safety standards can be maintained throughout the whole industry.

However, the above mentioned STEM graduates are in great demand by other sectors. Hence, in order to establish the full extent of potential skill gaps and shortages for the nuclear industry, the supply aspect of the nuclear labour market should be analysed in a wider context, taking into account demand for STEM graduates by other industries and projects. So, for example, by 2017, the UK manufacturing sector will have to employ 587,000 engineers, the UK transport sector will have to look for a further 366,000 engineers and technicians, the construction industry will need an extra 389,000 engineering technicians, the UK electricity, mining, quarrying, gas and water industries will need to recruit an additional 21,000 workers (Engineering UK, 2009). Moreover, 60% of the aerospace and defence workforce will retire by 2030. The latest news on skills shortages revealed that Aberdeen’s oil and gas industry will need to recruit 120,000 professionals by 2022 (The Herald, 2012). This means that the pace of recruitment Aberdeen’s oil and gas industry should be at least 12,000 jobs a year. Obviously, many other UK industries that are looking for well qualified engineers and technicians are facing the same problems: large-scale retirements[4] combined with the need for additional professional workforce in order to meet the requirements of future projects (Engineering UK, 2009; Energy Institute, 2008). Hence, the demand for STEM graduates will be extremely high in the near future, which will result in increased competition between employers.

Not only that, but the fact that from 2013, an average of 10,000 employees will be needed every year to construct, maintain and operate the new nuclear fleet with the peak of employment at 14,000 jobs between 2020-2022, will make competition for STEM graduates, engineering and technician professionals extremely hard. A supply of STEM graduates could potentially meet this demand, as new nuclear build will require diverse skills and expertise. It was already mentioned that 60% of all new jobs will be in construction and only 25% in operations. However, there are several large national construction projects that will run alongside the new nuclear build programme and they will require similar skills and knowledge, which in consequence will increase the competition for STEM graduates. The Nuclear Energy Skills Alliance (2010) defines 6 national projects:

- Crossrail (2010-2017)
- Thames Gateway Regeneration (2010-2017)
- M25 Widening Scheme
- Forth Replacement Crossing (2011-2016)
- High Speed 2 Rail Link
- On-going Defence Programmes

The demand for skills by smaller on-going construction projects and other energy related developments should be considered as well because they can be driven by the same energy security and low-carbon economy trends or/and require similar knowledge and competences as the new nuclear programme. For example, movement towards greener energy and services has made the renewable energy sector very attractive to graduates. It is estimated that this sector will have the highest number of employees in the EU-27 by 2020 with 1.3 million new jobs and will search primarily for construction and energy engineers, installation and maintenance technicians, quality controllers and consultants (Simonovska and von Estorff,

[4] National Skills Academy for Power estimated that 4 out of 5 employees form the energy sector will be retired in 15 years

2012). In comparison to the present, the renewable energy sector only employs 108,000 people across the EU-27 in wind energy generation.

International competition is an important factor as well. It was estimated by Simonovska and von Estorff (2012) that the need for nuclear experts in the EU-27 will be approximately 4,000 per year from 2010 to 2020. France on its own will require around 1,200 of the 4,000 nuclear experts yearly until 2020, which potentially can be very attractive for experts and young graduates from the UK. Other non-EU countries, such as USA, Canada, China, India, Russia, Ukraine and United Arab Emirates, also have large scale nuclear projects and can compete for similar employees.

To summarise, today's supply of UK nuclear graduates does not meet current or future demands of the industry. Hence, in order to fulfil skills gaps and shortages STEM graduates have to be recruited. However, the demand for STEM graduates is very high across other sectors in the UK and internationally[5] (Simonovska and von Estorff, 2012; Hopkins, 2008 and Engineering UK, 2009). The main reasons for this is: an aging workforce across engineering and technician professions, a low number of students entering STEM disciplines and a raising demand created by new projects. This means that the labour market for the skills and expertise required to construct, maintain and operate the new nuclear fleet will be extremely competitive and challenging.

3.6 Conclusion: HR Challenges the UK Nuclear Industry is Currently Facing

A multitude of different factors that have been influencing the UK nuclear industry for decades have made the current situation with existing skills and expertise almost critical. It became more obvious after the government approved the new nuclear build programme. Thousands of professionals will be needed for the next 13 years to make the construction, maintenance and operation of the current and the new nuclear fleet possible. Unfortunately, rapid ageing of the workforce combined with a soaring number of scheduled retirements, low attractiveness of the industry to the younger generation, small numbers of students entering nuclear related disciplines and fierce competition from other high technology industries to

[5] A survey carried out by the Society of Petroleum Engineers showed that nearly 90% of senior human resources executives at top international oil and gas companies consider that their industry faces a major talent shortage and the workforce issue is one of the most critical challenges facing their companies.

recruit young talent jeopardises the new nuclear build programme. Therefore, the main challenges for HR specialists in the UK nuclear industry today are:

- to attract, recruit and retain suitably qualified graduates as well as skilled and experienced workers in a highly competitive environment;
- to secure additional investment for training and development programmes for existing and new employees. So the former can acquire new skills and have a smooth transition from the energy production and fuel processing divisions to the decommissioning division and the latter can develop the required skills for safe operation of new advanced technology;
- to manage a larger workforce, which will require to make structural and functional changes to the organisation.

It is important to understand that the construction of nuclear plants is not only about nuclear skills and experience. A wide range of knowledge is required to deliver the new plants and their operational capabilities including softer skills, such as management, effective communication, leadership and teamwork. This clearly illustrated by the official data, which states that 73% of the UK nuclear industry workforce combined of professionals, technicians or managers. The industry heavily relies on these employees and their knowledge. Most of this important nuclear expertise is acquired through specifically designed in-house training programmes and work experience. The current situation in the UK nuclear industry, where two thirds of these professionals will be lost through retirement by 2025, puts the knowledge and experience accumulated for almost 60 years at the risk of being lost. Therefore, the writer believes that the biggest and the most important HR challenge for the UK nuclear industry today is preserving and transferring existing nuclear knowledge and expertise to the new generation and it has to be addressed promptly and effectively due to the safety-critical nature of the nuclear operations. Success of this process will strongly depend on the industry's ability to attract, recruit and retain suitably qualified graduates and experienced workers, since knowledge transfer is impossible if there is no one to transfer it to[6]. Accomplished successfully it will benefit not only the industry, but the country and its economy. To be more specific, a successful KRT will create a strong base for young employees, thus helping them to avoid the mistakes that previous generations made and saving them from learning well

[6] Refer to tacit nuclear knowledge, which is usually complex and difficult to capture.

known lessons. Hence, the internationally recognised safe, efficient and highly reliable image of the British nuclear industry will be maintained for the next generations. In the future, this step will also help Britain to secure its position as a leading player in the nuclear industry since it will be able to supply world class nuclear-related skills and knowledge on a global scale, help other countries to develop successful KRT strategies and create effective development and training programmes. The next chapter will look into existing theories on managing and transferring knowledge in the HRM literature.

CHAPTER 4 KNOWLEDGE MANAGEMENT THEORIES

4.1 Introduction

The situation around the UK nuclear human resources has been a hot topic of discussion over the past 20 years. Since the future of this industry strongly relies on its knowledge, concern has been raised about shortages of people with the right skills and experience as well as about the ageing profile of the current workforce and a high level of scheduled retirements in the next 15 years. Therefore, there is a high risk that vast amount of critical knowledge accumulated by the first generation of experts since the "Golden Years" of Nuclear Engineering could be lost or not fully transferred (Von Estorff and Debarberis, 2010). Hence, one of the most critical challenges for the UK nuclear industry in the near future will be development of effective KRT strategies. Ignoring this issue will pose a threat to safe, reliable and economically efficient operation of nuclear plants as well as will make it impossible to maintain competitive advantage. This chapter will look into the importance of KM and KRT in particular. It will provide a concise definition of knowledge and KM, and finish off by discussing existing strategies used for KRT.

4.2. The Importance of Knowledge Management and Knowledge Retention and Transfer

"A little knowledge that acts is worth infinitely more than much knowledge that is idle".

Kahlil Gibran (1883-1931)

Modern companies are facing countless challenges brought by the rapid and unpredictable changes evident in the contemporary world. Scholars argue that KM can successfully address some of those challenges, because organisational knowledge is seen by many as a key resource in value creation (DeLong, 2004; Drucker, 2003; Quinn, 1992; Reich, 1992; Teece, 1998; Tsai and Ghoshal, 1999). In other words, organisations believe that knowledge leveraged effectively can help them to increase productivity and efficiency, stay competitive, survive market and economic pressures, satisfy growing customer needs, improve decision making and problem solving processes as well as promote innovations (Gupta at el, 2000; Hahn and Subramani, 2000). Civi (2000) states, that knowledge is the company's most important asset. He also asserts that knowledge can be worth up to 75% of the company's value. Although this statement is just an estimate, it shows that knowledge is an important element of a company. This is the reason why it is vital to manage it effectively. Moreover, many new organisational theories state that organisational knowledge and how it is applied, is the only competitive advantage that company has in the era of the knowledge economy (Gupta at el, 2000; Binney, 2001; Davenport and Prusak, 1997 and Civi, 2000). In order to understand why timely KM is so important to organisations, imagine a situation when a particular skill or talent is lost as a result of employee exit or death. The impact could be disastrous to the organisation depending on the importance of that particular skill in that organisation. Even though sometimes the impact of lost knowledge can be delayed, it still will have a tremendous effect on the organisation in situations where there was no knowledge management strategy in place. Losses could be in terms of finances, efficiency, reduced productivity and reduced competitiveness (DeLong, 2004).

So, for example, during 1990s Boeing workforce was reduced by 50,000 people. Shortly after, the company started to experience more problems with airplanes than usual. Investigation performed by FAA revealed that most errors were in the area of production and engineering. Boeing had made a mistake when it laid-off strategically important employees. As a result, it had to reemploy 9000 people it had made redundant earlier (Leibig, 2001).

A second example comes from the financial sector. One of the Swiss banks encountered major problems after one of its IT systems experts left the company. In order to solve those problems, the bank had to pay $250,000 to this expert to fix the problem since no one else inside the company could find a solution (Probst and Knaese, 1998).

Those examples prove that it is crucial for companies not only to attract talented and experienced people, but to be able to retain them and keep their knowledge inside the firm when they leave or retire. In other words, KRT programmes will save a company’s time and resources from reinventing the wheel and will prevent it from making past mistakes.

4.3. Knowledge

In order to fully understand why departure of some employees can cause significant knowledge loss in a company, it is important to understand the nature of knowledge and its qualities. Since the Classical Greece period, there has been an ongoing debate around the meaning of knowledge. Due to its complex nature and abstract notion (Nonaka, 1994) knowledge has received a broad spectrum of definitions. This research will focus on the most frequently used definitions that can be found in KM related articles and journals. The very first explanation of knowledge stems from the Classical Greece period, where it was described as *"justified true belief"* (Zwass, 2008). In most recent works the definition gained more complexity. Kreiner (1992, p.62) identified knowledge as *"a transient type of resource, as its relevance and credibility are time and context dependent. We cannot regard knowledge as something that we once for all have collected and constructed. Knowledge must constantly be reproduced through execution".* Here it is important to note, that as a resource, knowledge has special qualities that are very different from any other type of resource held by a firm (Adler, 1989; Dalkir, 2005; Sadler, 1988). Firstly, use of knowledge does not consume it. Secondly, you do not loose knowledge if you transfer it. In other words, knowledge will always remain with a sender, even after its transfer to a successor. Thirdly, nowadays people have access to unlimited sources of knowledge. However the ability to use it is scarce. Lastly, organisational knowledge in situations where it is not managed has a tendency of being lost as a result of employee exiting the company.

Another very popular definition of knowledge is given by Davenport and Prusak (1997, p.5) *"fluid mix of framed experience, values, contextual information and expert insight that provide a framework for evaluation and incorporating new experiences and information".* Here it is necessary to distinguish between data, information and knowledge (Nonaka, 1994 and Spender, 1996). Data usually represents raw numbers and words. Information is data that has been structured or organised in a meaningful way. Finally, knowledge is a reflection of information through the prism of individuals' beliefs, values, experience, motivation and action (Nonaka, 1994).

At last, some definitions emphasise close connection of knowledge to action and ability to deliver expected results (Alavi and Leidner, 1999; Brown and Duguid, 2001; Drucker, 2003 Nahapiet and Ghoshal, 1998; Senge, 1999; Tsoukas, 1996 and Zwass, 2008). In other words, they state that doing is inseparable from knowing. So, for example, Senge (1999) and DeLong (2004) define knowledge as *"capacity for effective action or decision making".* From this point of view, knowledge is a prerequisite that helps to achieve desired or expected results.

Summing up, although there are slight differences in the above mentioned definitions, there is a general view of knowledge as dynamic, time specific, strongly related to the organisational context and its value is defined by action.

In order to clarify and unify views on knowledge, and create a systematic approach for its management, scholars made a distinction between two main types of knowledge. Polanyi (1967) was the first to differentiate between tacit and explicit knowledge. This classification still remains the most popular among KM publications (Nonaka and Peltokorpi, 2006). Tacit knowledge usually refers to the personal or intuitive knowledge that is made of individual's experience, skills, values, intuition and judgment. Hence, it is hard to articulate and communicate as well as almost impossible fully convert into explicit knowledge, e.g. papers, files or books. In other words, it has a very low degree of codification. Cooking experience can illustrate the importance of tacit knowledge and difficulties that can be met during its transfer. For a new cook it is almost impossible to make a meal as good as a professional cook, even if detailed instructions are given. Many aspects of cooking might not be mentioned in the guide simply because an expert would do it unconsciously and would not think of it as something important. The difference between professional and novice cooking is rooted in tacit knowledge which, once again proves the accuracy of Polanyi's (1967) statement: *"we can know more than we can tell".* Polanyi (1967) also identified this type of knowledge as crucial to individual's performance. Moreover, he believed that most of our knowledge is tacit or at least originally comes from it.

In contrast, explicit knowledge is defined as articulated knowledge (Hedlund, 1994). It can be easily codified, written down and communicated to others. Therefore, it is generally well documented and readily available. This type of knowledge is presented in form of books, policies, procedures, documents, and other mediums.

In order to avoid confusion, it is worth to mention that different taxonomies for two types of knowledge can be found in academic journals. However, parallels and linkages between mostly all of them can be easily established. So, for example, Polanyi's tacit knowledge can be linked with Boisot's (1987) uncodified knowledge, Bhatt's (2001) background knowledge, positivists' objective knowledge and finally Conner's and Prahalad's (1996), Kogut's and Zander's (1992) know-how. Polanyi's explicit knowledge has some degree of correspondence with Boisot's (1987) codified knowledge, Bhatt's (2001) foreground knowledge, interpretivists' subjective knowledge, Hedlund's (1994) articulate knowledge and Kogut's and Zander's (1992) declarative knowledge.

For this research it is also important to differentiate between different levels of knowledge. It can be organisational and group as well as individual (Bhatt, 2001). Organisational and group knowledge has the same characteristic as individual knowledge and can be tacit or explicit. However, it is more complex than a simple sum of individual's knowledge. It is a product of ongoing interaction between people, technology and processes within an organisation/group influenced by its unique culture, values and history (Bhatt, 2001). According to McGrath and Argote (1993) organisational knowledge is embedded in individuals, tasks and tools. Hence, organisational knowledge has a more complex nature but as individual it is dynamic, time and context specific.

Before moving to the discussion about KM and KRT in particular it is vital to understand how knowledge is created and its flow in the organisation. Mainly because in general it is difficult to understand how something can be managed without understanding how it works. In the context of this research it will be appropriate to know how organisational knowledge is created, developed and maintained. With this knowledge it will be much easier to understand what can have positive or negative impact on the KM processes including KRT process. There are two different perspectives on how knowledge is created. Interpretivists believe that knowledge is derived from personal experience, values and action and hence, subjective (Cohen and Levinthal, 1990; Davenport et al., 1998) whereas positivists argue that knowledge is created and shared through social interaction and shaped by business environment, hence, objective (Brown and Duguid, 2001; Nahapiet and Ghoshal, 1998; Nonaka, 1994; Tsoukas, 1996; Van Krogh, 1998). However, the most recent publications (Nonaka and Toyama, 2005; Nonaka and Peltokorpi, 2006) stated that these two approaches are equally important and complement each other in different ways. In other words, they believe that it will be more beneficial for understanding the contradictory nature of knowledge if both views were studied in combination.

Nonaka and Tokauchi (1995) successfully applied this approach to the process of knowledge creation in organisations. They suggest that tacit and explicit knowledge are not opposing but complementary, because new organisational knowledge is a product of continuous transformation from one type of knowledge to another (Table 4.3.1). In other words, it is a product of subjectivity and objectivity.

They believe that organisational knowledge is formed through four continuous processes: socialisation, externalisation, combination and internalisation. These processes illustrate metamorphosis of knowledge within organisations necessary for its maintenance and development.

Table 4.3.1 Nonaka's knowledge management model (knowledge creation process)

		to Tacit	Explicit
from	Tacit	Socialisation	Externalisation
	Explicit	Internalisation	Combination

Source: McAdam and McCreedy (1999), p. 95

So, socialising transfers tacit knowledge to tacit knowledge into others through everyday communication, workshops, seminars, conferences. Externalisation is responsible for transferring tacit knowledge into explicit knowledge and this is often called formalisation. For example, tacit knowledge that was acquired during conference has to be transferred into a written form (externalised) so that the next step of knowledge transformation could happen. During combination stage explicit knowledge is converted to explicit knowledge in others. In our case formalised knowledge from the conference should be disseminated among other employees who will apply it into practice and combine with personal experience ipso facto finishing the knowledge creation cycle at internalisation stage where explicit knowledge is transferred back to tacit. This model once again, as shown in the table above, demonstrates that organisational knowledge is more compound than just a sum of individuals' knowledge, with the flow moving from organisational to individual and individual back to organisational.

To conclude, the complex nature of knowledge predetermined a plurality of knowledge definitions. However, to some extent they all describe the nature of knowledge as:

- Integration of knowledge and action;
- Personal (unique), as it derived from individual's experience, values and beliefs;
- Dynamic;
- Context and time specific.

To clarify multiple views on knowledge and simplify its management strategies, knowledge was subdivided into two types: tacit and explicit. Polanyi (1967) argued that most knowledge including organisational is tacit that makes its management, especially, transfer and preservation very challenging. Knowledge can exist on different levels: individual, group and organisational. They have the same qualities and characteristics. However, organisational knowledge is a more complex notion than individual since it is a result of an extensive and diverse process of social interactions.

4.4. Knowledge Management and Knowledge Retention and Transfer

"Share your knowledge with others, that's a good opportunity to gain immortality".

Dalai Lama

Knowledge is a foundation used by organisations to create value (Dalkir, 2005). That is why it is seen as a powerful source of competitive advantage. However, knowledge will lose its value if it is not spread and utilised across the organisation (DeLong, 2004). Therefore, in order to survive in the current extremely unstable and unpredictable market environment, a company has to learn how to manage its knowledge effectively.

"Historically, knowledge has always been managed, at least implicitly" (Wiig, in Grey, 1996). Only recently there has been a growing interest in developing more systematic and fundamental approach to it (Gupta at el, 2000). As a result, a new field of study, known as knowledge management, began to emerge. There is still no clarity and consensus on what exactly KM is, due to its emerging state and multidisciplinary nature (Argote et al, 2003; Dalkir, 2005; McAdam and McCreedy, 1999; Nonaka and Peltokorpi, 2006; Quintas at el, 1997). As a result KM has many definitions. There were more than one hundred published definitions of KM found (Dalkir, 2005). They all vary considerably depending on the discipline they are rooted in. However, Wiig (1993) argued that two elements that are crucial for successful KM practices must be stated in it. These elements are knowledge assets and knowledge-related processes. They are clearly reflected in definition found in Dalkir (2005, p.3):

"Knowledge management is the deliberate and systematic coordination of an organization's people, technology, processes, and organizational structure in order to add value through reuse and innovation. This coordination is achieved through creating, sharing, and applying knowledge as well as through feeding the valuable lessons learned and best practices into corporate memory in order to foster continued organizational learning"

In contrast, one of the most popular definitions of KM is very simple and reflecting only on knowledge-related processes. It states that KM is:

"the generation, representation, storage, transfer, transformation, application, embedding and projecting group and organizational knowledge"(Hedlund, 1994, p.76)

Although there is little consensus on KM definitions, there is surprisingly strong agreement on what its goals are. They have been summarised by Nickols (in Dalkir, 2005). He writes that "*the basic aim of KM is to leverage knowledge to organisation's advantage*". However, as it was stated earlier, most of organisational knowledge is tacit. That is why, Davenport (1994) and Gupta at el (2000) argued that main goal of KM is to transfer tacit knowledge into explicit and share it throughout organisation, once again, highlighting the importance of KRT processes in KM.

Furthermore, main KM objectives also have a primarily focus on KRT. Dalkir (2005) identified four of them:

- Ensure secure and effective knowledge transfer between generations;
- Reduce organisational memory loss that can be a result of high retirement level and attrition level;
- Identify critical areas of knowledge and employees who hold it;
- Develop programmes and techniques to reduce tacit knowledge loss.

Relation of these objectives to KRT can be easily explained. So for example, in order to reduce corporate memory loss, retirement has to be carefully planned throughout an organisation (DeLong, 2004). This would help to organise a transfer of accumulated knowledge to the successor in timely manner and prevent its loss. Activities related to identification of business critical knowledge are the first steps of KRT strategies (Stewart, 1997; DeLong, 2004). They are designed to make KRT process more efficient. In the situation where one of the core employees is leaving, they can also help to initiate knowledge transfer programmes immediately. To be more specific, tools used to determine key knowledge areas also identify employees who hold this knowledge. Hence, in the situation where such employees are leaving unexpectedly this could help to transfer most if not all of the requisite critical knowledge on. Moreover, ongoing KRT processes will be more effective because not all, but only important knowledge will be transferred and stored. Strategies for preventing tacit knowledge loss can be focused either on effective techniques for transferring knowledge from one person to another, or on transferring tacit knowledge into explicit and preserving it for future needs (Nonaka and Takeuchi, 1995 and Hansen et al., 1999).

An example of a professional opinion below is used just to stress the importance of knowledge transfer in KM process. Grant (1996), Gupta et al (2000), Wakefield (2004) and Irani et al (2009) all agreed that value of organisational knowledge will diminish if it is not transferred between employees.

To summarise, despite the plurality of KM definitions, it is clear that KRT is a key element of KM. Furthermore, KRT is crucial for development of effective KM programmes, improvement of organisational performance and gaining competitive advantage (Leibowitz at el, 2000). Hence, it is essential to understand what facilitates and what impedes effective KRT. It will be the main point of further discussion, as the focus of this research is KRT in the UK nuclear industry. However, in the next paragraph, effective ways of managing knowledge in general are going to be discussed first. The main reason for that is the close relation of KM and KRT. Consequently, if something is applicable for KM it should be true for KRT. In addition, examination of effective approaches to KM will let the researcher to gain a deeper understanding of KM nature and, thus, KRT processes as they are parts of one.

Some professionals believe that technological advances are the best way to manage knowledge (Bhatt, 2001). Others argue that the most effective way to handle knowledge is learning from other people through coaching, mentoring and training since knowledge resides within the human mind and not within an organisation or technology (Dalkir, 2005; Gupta at el, 2000; Davenport, 1994). To be more specific, some sources state that a vast amount of the most important knowledge is unconscious and only tiny part of it is saved or codified, and therefore, is readily available (Faust, 2007; Chakraborty, 2005). Hence, KM can be effective only if people who carry important knowledge will be willing to share it with others and people who receive this knowledge will be able to capture and reuse it. Bhatt (2001) opposed the above views stating that human and technological component of KM are both equally important. Only the former can transform information into knowledge and make sense of fragmented data whereas the latter is usually used to collect, store and make a huge amount of information easily accessible with minimum human and physical constraints. Therefore, he concluded that KM will be effective only if the right balance between these two elements is found. He suggested that the best way to establish that balance will be analysis of communication patterns between technology, people and processes employed to collect, create and share knowledge. It will reveal how competent people are in using the technology and how effective is the process of information gathering, sharing and exchange in the organisation. Since human interaction is the key process during which different views on the same problem are shared and later accumulated into diverse and important organisational knowledge, Bhatt (2001) strongly recommends reshaping communication patterns in its favour. In other words, the communication patterns should be designed in favour of human interaction, so people can communicate freely and exchange knowledge. However, many authors state that changing people's behaviour, in our case getting them to share information, is a serious challenge for organisation, and it is impossible without a shift in organisational culture, business procedures and commitment at all levels (Bhatt, 2001; Glasser, 1998 and Gupta at el, 2000).

Summing up, successful KM relies on people, technological support and effective information and knowledge flow between individuals. The researcher believes that KRT as being a part of KM is also highly affected by these three variables. Therefore, barriers for successful KRT will be analysed from this perspective.

Firstly, it is important to mention that, while focusing on knowledge transfer more attention will be paid to transfer of tacit knowledge. The main reason for doing this is the fact that most organisational knowledge is tacit or rooted in it (Polanyi, 1967) and its transfer represents the biggest challenge for organisation. The nuclear industry is not an exception to this rule. Substantial amount of knowledge accumulated for the last 60 years can be lost due to the age profile of highly skilled and experienced nuclear workforce. Most of them are due to retire in the next 10-15 years. This would make the transfer of tacit knowledge even more challenging as it defines a certain time frame for its completion.

As it was stated previously the biggest problem that KM and, hence, KRT can face is employees' willingness to share individual knowledge with others. It is seen as a main issue simply because the primary source of knowledge is human interaction and knowledge transfer is impossible without it (Argote and Ingram, 2000; Brown and Duguid, 2001; Nahapiet and Ghoshal, 1998; Nonaka, 1994; Tsoukas, 1996; Van Krogh, 1998). In order to change this, a major shift in **organisational culture** is required (Bhatt, 2001; Glasser, 1998; Gupta at el, 2000; Nonaka and Takeuchi, 1995). Different authors emphasise importance of various aspects of organisational culture necessary for successful KRT (Bhatt, 2001; Glasser, 1998; Gupta at el, 2000; Nonaka and Takeuchi, 1995). Nevertheless, these aspects can be summarised as follows:

- Create and nurture a cooperative/supportive/open organisational climate;

- Support knowledge sharing and transfer;
- Support and develop productive interactions between employees;
- Fully committed employees at all levels.

All the above mentioned characteristics of organisational culture require further changes in organisation's social relations and structure. Firstly, cooperative climate can be highly affected by the level of **trust** between employees as well as between employee and organisation (Kogut and Zander, 1992; McEvily, 2003; von Krogh, 1998). A number of factors may prevent knowledge sharing including: competition for promotion, fear of losing a job, power or own importance, fear of diluting exclusive knowledge and the need to maintain a certain status within the organisation. Therefore, trust has to be established to ensure sustainability of the knowledge. High trust can also minimise the tendency of questioning knowledge accuracy (Argote at el., 2003), hence, accelerating the transfer process. Secondly, knowledge sharing can be more successful if it is incentivised (Argote et al, 2003; Gupta et al, 2000, Hansen et al, 1999; Menon and Pfeffer, 2003). Monetary and non-monetary **rewards** such as recognition are equally important. People more likely will share their knowledge if they directly or indirectly can benefit from it. Finally, the **organisational structure** should support effective communication between employees and ease information flow (Bhatt, 2001). Vertical organisational structure based on total control will minimise opportunities for effective interaction between people, hence, affect quality and speed of knowledge transfer. Whereas horizontal organisational structure with less control will speed up and enrich knowledge flow between different employees and departments, and thus, have a positive effect on KRT process.

Another important factor that can assist or hinder KRT process is the status of an individual, a company or any other body knowledge is transferred from. Argote at el (2003), Borgatti and Cross (2000) and Sine et al (2003) argue that a sender's high status is very important for a successful knowledge transfer. So for example, if there is to be a higher chance of successful knowledge transfer in nuclear physics field, it comes from a professional rather than from a trainee.

Successful KRT is also defined by the qualities of knowledge that has to be transferred. Among them are: the level of its tacitness, its context, distance and importance. The way these four qualities affect knowledge transfer process will be discussed in more detail below.

Success of knowledge transfer is directly proportional to distance: the bigger the physical or psychological distance between involved people the longer and more difficult the process will be (Argote et al, 2003; Kang et al, 2010). The value of knowledge and success of the transfer process has the same dependency: the more important the knowledge is the more efficient will be the transfer (Gupta and Govindarajan, 2000).

Transfer of tacit knowledge is perceived by many researchers as a more complicated process than transfer of codified knowledge (Zander and Kogut, 1995; Inkpen and Dinur, 1998; Lord and Ranft, 1998; Nonaka, 1994). There are two main reasons for it. First, it is almost impossible to acquire it through education, because it is rooted in practice and experience (Polanyi, 1967). Similarly, Nadler at el (2003) argued that it is better transferred through observation and training or, in other words, watching and doing. Therefore, transfer of this type of knowledge requires many hours of extensive practice alongside an expert. In other words, a successful transfer of tacit knowledge strongly depends on the frequency of contact with knowledge source: the higher the rate of interactions – the faster and better the knowledge transfer process is (Inkpen and Dinur, 1998; Kang et al, 2010). Uzzi and Lancaster (2003) concluded that tacit knowledge is best transferred through strong ties relationship since it allows for more intense and rich communication. In addition, Auger and Vendelo (1999) believed that parties connected by strong ties understand each other better as they share the same values, cognitive frames and have social similarities. The same rule applies for transfer of complex knowledge. It means that success of its transfer depends on frequency of contacts, direct interactions and strong connection between involved parties, because as tacit knowledge it is better transferred through strong ties relationship (Kang et al, 2010; Hansen, 1999). It usually takes longer to transfer this type of knowledge than simple one.

The second reason why tacit knowledge is difficult to transfer is because it involves a minimum of two people: a sender and a successor. Therefore, it depends from former's cognitive skills and proficiency to share knowledge effectively as well as from successor's cognitive abilities, including ability to assimilate and apply new knowledge (Cohen and Levinthal, 1990; Argote et al, 2003). In other words, DeLong (2004) concluded that knowledge transfer will bring no results if a successor cannot acquire knowledge and use it to make professional decisions. To be more specific, Szulanski (1996) noted that poor absorptive capacity of the successor can be a barrier for effective knowledge transfer. In addition, it can be challenging to find a suitable person to whom knowledge can be transferred while the knowledge sender is still available.

To conclude, KM is an emerging discipline rooted in different subjects. That is why it is still does not have one and clear definition. It is a complex social process that is impossible without people, technology and effective interaction between individuals. It is generally agreed that KRT is a core of KM. Its success strongly relies on organisational ability to change own philosophy, to support high trust and promote open social interaction. Direct and indirect recognition of knowledge sharing can positively affect knowledge transfer speed and outcomes. Effectiveness of knowledge transfer is also defined by knowledge qualities and the status of knowledge sender. So, for example, tacit and complex knowledge, which are of a main interest to this research, is better transferred through strong ties, from person who has well established reputation and relevant cognitive skills to a person who has high absorptive capacity.

4.5. Knowledge Retention and Transfer as a Part of Knowledge Management Strategy

KM strategy is defined by organisational goals and closely linked to its objectives. In other words, it must be aligned with company's business strategy. Moreover, every KM strategy has to be developed in mind with the size of the company, its operating industry, organisational structure, culture and nature of the business (Dalkir, 2005 and Hansen et al, 1999). That is why every KM strategy differs from one organisation to another. As Robertson (2004) states successful KM strategy should meet organisational objectives as well as be able to identify and address its current needs and issues. Since every company has very specific needs and objectives, most KM strategies mentioned in the literature or by professional bodies are very generic in nature and mainly describe a framework (basic principles and general processes) of an actual KM strategy. Therefore, they do not provide magical ready-made (universal) solution that would immediately provide the company with consistent and effective KM programme. Nevertheless, these models represent fundamental principles for effective KRT that can then be customised or adapted for different contexts. There were also some detailed examples of the best practice of KM strategies found. However, they are all tailored to meet unique needs of a certain company that are not necessary going to match the needs of another company. This means that most of the time companies will have to experiment with different strategies and approaches until the perfect one just for this particular company is found. This process can be time consuming and challenging, especially if very specific and complex knowledge, such as nuclear, is transferred. Moreover, for that particular industry due to the established earlier circumstances it has to be done in a timely manner in order safe and efficient operation of NPP can be maintained throughout its lifecycle.

Robertson (2004) also believes that development of KM strategies usually driven by three main factors:

- retirement level of the key employees;
- need for innovation in order to stay competitive;
- need to stay efficient so organisational costs and effort can be reduced.

Gupta at el (2000) believes that the main goal of KM is to transfer tacit knowledge into explicit and defuse it across the organisation as only then it has real value. In other words, the value of knowledge perishes if it is not accessible and disseminated (Wakefield, 2004; Irani et al, 2009). That is why KRT is the core element of KM.

Success of any KRT strategy is also strongly affected by four main factors: HR practices and policies, methods used to transfer knowledge, technology used to capture, store and share knowledge and knowledge recovery programmes (DeLong, 2004). These factors are going to be analysed in more detail below.

HR practices and policies are a fundamental base of any KRT strategy. The most important among them are: succession planning and career development, building of a retention culture and designing of phased retirements programmes (Delong, 2004; Malone, 2002; White, 2002). However, organisation will never be able to transfer all its knowledge, nor it would need to. As Stewart (1997) noticed the best way to retain critical knowledge is to identify, capture and store it for future needs in the most accessible way as possible. These are three major steps of KRT process (Malone, 2002). Since relationship between employee's input and firm's performance is usually unclear, the first and the most crucial step in KRT is to identify knowledge that is critical to organisation, because only this knowledge has to be retained (Argote and Ingram, 2000; Delong, 2004). Moreover, tasks and processes in which such knowledge is embedded in, as well as those employees who carry the knowledge to perform them should be made visible. At this stage possible future skill gaps are identified and the most appropriate methods of transferring and storing critical organisational knowledge can be chosen. The information gathered during this process also essential for development of attrition profile where the company's latest critical skills and expertise are identified. Different sources have different names for the identification stage of the KRT process. It can vary from knowledge mapping (Vail, 1999; White, 2002) and knowledge audit (Leibowitz et al, 2000) to evaluation of skills and knowledge base (DeLong, 2004). However, despite the variety of names all of them, knowledge maps and databases, have to be updated regularly since knowledge is dynamic in nature. After critical knowledge has been identified, it is important to make sure that people who hold that knowledge are willing to share it (Hansen at el, 1999). Most of the time its success is highly dependent on existing HR practices and ability to create organisational culture that supports retention behaviours and knowledge sharing. In addition, appropriate motivation strategies and reward systems should be put in place to facilitate the process (Nonaka and Takeuchi, 1995; DeLong, 2004).

After the knowledge is identified, the next step of KRT strategy is to choose the appropriate knowledge transfer method. There are many tactics of knowledge transfer exist (Argote and Ingram, 2000; Cummings and Teng, 2003; Formentini and Romano, 2011). However, the most commonly used is usually determined by the type of knowledge. The widely used classification recognises two main approaches to knowledge transfer: personalisation and codification (Hansen et al, 1999). The former is used to transfer tacit knowledge that requires continuous personal interaction and the latter is used to transfer explicit knowledge that can be easily codified and stored. Hansen et al., (1999) also found that in order to transfer knowledge effectively a company should make use of only one approach, which is considered to be the most suitable. Another one should be used as a complimentary option. If both are pursued with the same magnitude, failure is eminent. However, a series of case studies opposed this widely supported view. For example, Fuji Xerox and Boeing used a combination of both strategies for effective KRT (Umemoto et al, 2004; Szymczak and Walker, 2003). Moreover, Scheepers et al (2004) not only proved that KRT is more effective when both strategies are combined. He also found that the predominant use of only one strategy does not result in successful KRT. Nevertheless, this research is going to focus on transfer and retention of tacit knowledge, because most knowledge is tacit (Polanyi, 1967) and a substantial amount of nuclear knowledge accumulated since late 1950s resides within employees who are due to retire. Therefore, the primary goal of the UK nuclear KRT strategy is to establish the best approach to capture tacit knowledge and then transfer it to the next generation.

There are two main ways tacit knowledge can be transferred and preserved. First is elicitation or capture of tacit knowledge (Nonaka and Takeuchi, 1995). That means it has to be transformed into explicit knowledge (Nonaka and Takeuchi, 1995). This is, however, a time consuming process that might take something between six months and seven years (Nonaka and Takeuchi, 1995; Davenport and Prusak, 1998; von Krogh et al, 2000). A second way of transferring and retaining tacit knowledge is to pass it to a successor or in other words, is to apply personalisation strategies (Hansen et al, 1999).

Personalisation strategies are good for sharing scientific and technological expertise, operational know-how and insights about the industry (e.g., business judgements) (Hansen et al, 1999). Since tacit knowledge makes up a core competence in organisation and it is almost impossible to fully capture it, the organisation needs to plan its transfer in advance and to initiate the process in due course after a review of the company's attrition profile. In the situation, where the departure of experienced employee was unpredictable retention activities should be initiated as soon as it became obvious that an employee who holds critical knowledge might leave (DeLong, 2004).

Personalisation strategy is based on extensive personal communication. In general the main goal of personalisation strategy is the development of a network that could connect people to share tacit knowledge effectively (Hansen et al, 1999). Alongside with traditional face-to-face interaction knowledge exchange can be mediated through innovative information technology such as e-mails, video conferencing and knowledge networks (Hansen et al., 1999). However, no matter how extensive the use of IT, the core element of this strategy will remain within the human mind – main storage facility of knowledge, because technology is simply used to help communicate and exchange that knowledge. There are not many instruments of personalisation strategy have been identified in the literature. Nevertheless, since tacit knowledge is acquired through personal experience and practice, they all were focused on providing the opportunity to work close with an expert. Among them often were named communities of practice (Brown and Duguid, 1991; Malone, 2002), knowledge networks (Cross et al, 2001; Malone, 2002), storytelling (DeLong, 2004), tandem, coaching and mentoring, after action reviews and external experts (DeLong, 2004; Hunter et al, 2002; Eraut et al, 1998). One-to-one interviews, brain storming sessions, video conferences, regular meetings, emails also were mentioned as a day to day routine of knowledge transfer process (Hansen et al, 1999).

The main advantages of personalisation strategies are direct interaction and close cooperation between sender of knowledge and its recipient. It provides an opportunity to acquire first-hand experience, receive daily feedback and in depth explanation to any uncertainties. Hence, the expert can shape and tailor the knowledge transfer process according recipient's needs, daily progress and learning abilities.

The main disadvantage of such strategy is its cost (DeLong, 2004; Foray and Hargreaves, 2003; Chai and Nebus, 2010). Tandem, mentoring and coaching at some extent involve two people doing the same job. For many firms in the current economic climate this process can be too expensive. Other disadvantages evolve from the nature of personalisation strategies that require ongoing communication between at least two people. These people might have cultural and generation differences, language barriers, understanding difficulties and poor interpersonal relationships. The individuals may refuse to share or accept certain knowledge because they might value knowledge differently (DeLong, 2004). This can lead to conflicts and make the transfer process difficult. Communities of practice and knowledge networks are cheaper options, but the speed of knowledge flow in such approaches usually depends on the individual's availability which is not acceptable for urgent matters. External experts can be considered for a transfer of non-time critical knowledge. However, they usually have lack of important context knowledge that can limit their capabilities.

The main weakness of personalisation strategies is rooted in its human nature. Transferred knowledge that stored within the human mind can be suddenly lost due to illness or death of an individual. Moreover, very often before a suitable successor can be found an expert will be gone. This means that direct interaction between two parties is not always possible either due to unavailability of an expert/successor or due to financial constraints. That is why sometimes it is necessary to capture tacit knowledge or, in other words, codify it where it is possible and economically viable (Chai and Nebus, 2010). This way it can be used for a development of a suitable training programme, simulation or accessed when it is necessary. The main instruments of codification are documentation/databases, de-briefing, exit interviews, knowledge elicitation (Nonaka and Takeuchi, 1995) and simulations/online training programmes (Hansen at el, 1999). The main strength of this strategy is that knowledge can be easily accessed, applied and reused at no extra cost[7]. Moreover, interviews can be arranged

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[7]This is only true if a common taxonomy and selected technology which provides a 'single search' solution are in place (especially for digital storage/databases)

quickly and at very low cost. This is vital if knowledge has to be transferred in a short time frame and no other way of transferring is available. However, in most cases this process also will be time consuming and expensive. This particularly applies to the development of big databases, to the process of conducting and editing multiple interviews, elicitation of knowledge and design of a simulation. In addition, knowledge stored in documents, databases, captured in de-briefing or exit interviews is usually fragmented as it is taken out of the context, edited by a third party and not personalised. As a result it can be confusing for a non-expert to understand it (DeLong, 2004).

Summing up, the best method of KRT is predetermined by knowledge type, certain context, current situation (e.g. availability of an expert or successor) and a time frame. Only after careful consideration of all the factors the most suitable KRT strategy can be identified. This is especially important for the nuclear industry where KM can face some specific issues and challenges related to the high standards of safety requirements, extended life cycle of the cutting edge nuclear technology and extremely specialised areas of expertise.

The next important element of the retention strategy is technological advances. Technology is used to capture, store and share knowledge. The main goal of using information technology is to improve KRT process. To be more specific, it can accelerate learning and problem solving processes, increase the speed of knowledge flow, improve communication between employees and make KRT cost effective. It can also make knowledge visible and easily accessible. Technology usually used to design and implement advanced documents databases, knowledge mapping systems, e-learning and training programmes, simulations and applications that help to connect people and promote knowledge sharing.

The last step of KRT strategy – knowledge recovery programmes. They are usually applied when organisation has lost critical knowledge. Sometimes it is enough to outsource some capabilities or hire recently retired employee as a consultant or a contractor. However, if knowledge is completely lost and unavailable from external source, it has to be regenerated internally. This process is time consuming and expensive (DeLong, 2004). That is why it is sensible to have a KRT strategy in place.

To conclude, KRT is a core element of KM strategy. The choice of KRT programme is predetermined by knowledge type, knowledge retention goals, organisational context, the urgency of the transfer and availability of the expert and the successor. There are two main tactics of knowledge transfer: personalisation and codification. They are used to transfer tacit and explicit knowledge respectively. However, some tacit knowledge can be codified if it is possible to convert it into explicit knowledge and if this process justifies the effort. This is especially useful in the situation where successor is unavailable, a key employee is leaving unexpectedly or knowledge has to be transferred quickly. In addition, identification of critical organisational knowledge, nurture of the knowledge sharing culture, development of programmes that motivate employees to share knowledge are fundamental for successful KRT. On the other hand, KRT also can be improved if suitable information technology applications are developed and applied. In some cases, phased retirement programmes and practices for retention of older workers' can be developed to meet knowledge retention goals. The next chapter will look at the existing practices of KRT in the UK nuclear industry and analyse its relation to the theory.

Chapter 5 Knowledge Retention and Transfer in the UK Nuclear Industry

As it was discussed in chapter three, the UK nuclear industry will require significant number of new highly skilled and qualified workers in the near future. It will have not only to attract new professionals to meet future demand and replace retirees but also develop new skills to meet the requirements of a new build programme. In addition, due to the age profile of the nuclear workforce, industry should focus on the retention of existing employees in order to transfer tacit knowledge successfully to the next generation. This is important condition for successful KRT process because knowledge is created and shared through social networks and requires extensive social interaction between predecessor and successor. Due to industry specific factors, context and complex expertise, KRT strategies can differ from the one discussed in the literature. Nuclear industry even has its own definition of knowledge and KM that better reflects the industry nature, needs and requirements.

5.1 Why Knowledge Management is Important for the UK Nuclear Industry

The loss of important nuclear knowledge due to the retirement of the first generation of workers will pose a significant threat to safe and economically effective operation of nuclear plants, as well as affect the positive public perception and trust (Faust, 2007). Therefore, KRT in the most critical areas such as design, construction, operation, maintenance and decommissioning of the plant is a vital part of the UK nuclear KM strategy (IAEA, 2011). It is interesting to note that the nuclear industry understanding of KM importance differs significantly from the one defined in the theory. The main accent in the reviewed literature was made on economic and financial factors (DeLong, 2004; Drucker, 2003; Quinn, 1992; Reich, 1992; Teece, 1998; Tsai, Gupta at el, 2000, Hahn and Subramani, 2000; Ghoshal, 1999). The industry, on the other hand, while taking the above factors into consideration, places safety issues above everything.

Researcher believes that due to the current situation around nuclear workforce, growth of the decommissioning sector and ambitious new nuclear build projects worldwide, the main goal of nuclear KM is defined differently from the one found in the academic literature (Nickols, in Dalkir, 2005). The focus is not on the knowledge-related processes and their effectiveness, but on the people who works in the industry and people who hold relevant knowledge. IAEA defines effective management of nuclear knowledge as *"ensuring the continued availability of qualified personnel"* (IAEA, 2011, p. 49) because only then it will be safe, efficient and secure to operate NPP, innovation will prosper and the benefits of nuclear energy will be available for future generations. Moreover, the Convention of Nuclear Safety (article 11.2, in IAEA, 2006, p. 22) states that each Member State is responsible for providing the sufficient number of highly skilled workers with relevant experience and skills for all safety-related processes for every NPP throughout its life.

Mohamed Elbaradei, the Director General of the IAEA, stated that:

"Whether or not nuclear power witnesses an expansion in the coming decades, it is essential that we preserve nuclear scientific and technical competence for the safe operation of existing facilities and applications. Effective management of nuclear knowledge should include succession planning for the nuclear work force, the maintenance of the 'nuclear safety case' for operational reactors, and retention of the nuclear knowledge accumulated over the past six decades".

To sum up, the main difference between reviewed literature and reality is that the idea of safe and secure operation of nuclear plants runs through the entire industry which is also reflected as one of the imperatives in its KM strategy whereas in theory such matters as competitive advantage and efficiency have a higher priority. Therefore, the main goal of nuclear KM strategy and its effectiveness are achieved through continuous supply of suitably qualified personal. This might be due to the fact that operation of nuclear industry is impossible if safety has been jeopardised.

5.2. Nuclear Knowledge Management

Nuclear industry operation and safety is heavily regulated on an international level due to the nature of this business and the danger it can pose to the whole world when just a single plant is not operated properly. In order to establish safe, reliable and cost-effective operation of nuclear plants worldwide, the International Atomic Energy Agency (IAEA) developed recommendations and guidelines on KM which also applies to the UK nuclear industry. Hence, analysis of some international norms will provide us with general information about methods and tools used to manage nuclear knowledge across the world as well as in the UK.

Nuclear KM defined in IAEA (2006, p.3) as:

“an integrated, systematic approach to identifying, managing and sharing an organisation’s knowledge, and enabling persons to create new knowledge collectively in order to help achieve the objectives of that organisation”.

KM definition used by the nuclear industry is simple and clear. It specifies only knowledge-related processes without mentioning knowledge assets which is similar to Hedlund (1994) definition but runs counter with Wiig (1993) views on it who argued that both elements: knowledge assets and knowledge-related processes are crucial for successful KM and, for that reason, has to be stated in its definition.

The main objectives of Nuclear KM were announced at the International Conference:

- “*Safety – achieve safe operation and maintenance of all nuclear facilities by sharing of operational experience.*
- *Economic – achieve gains in economics and operational performance through effective management of the resource knowledge.*
- *Security – achieve responsible use by properly identifying and protecting nuclear knowledge from improper use.*
- *Innovation – facilitate innovation to achieve significant improvements in the safe, economical operation of all new nuclear projects.*
- *Sustainability – maximise the flow of nuclear knowledge from one generation to the next*.” (IAEA, 2007)

The core difference between KM objectives found in academic literature and stated by the nuclear industry is in the areas they are focused on. Objectives described in the literature are general and focused on the KM assets and processes (Dalkir, 2005) whereas the industry’s objectives are very specific and focused on the outcomes of KM strategy. They reflect current goals and needs of the nuclear industry: safety, effectiveness, security, innovation and sustainability. Such a difference might be explained by the fact that every KM strategy has to meet organisational goals and objectives as well as address existing organisational issues which is impossible in theory where KM strategies usually do not relate to any specific company (Dalkir, 2005; Hansen et al, 1999; Robertson, 2004).

Nuclear KM recognises three main elements: people, processes and technology which are all important for its success (IAEA, 2008). To be more specific, people hold knowledge, that is why, it is crucial for organisation to create and promote culture of trust and fairness where people can communicate freely, share knowledge, resources and experience as well as reuse and apply knowledge (IAEA, 2006; IAEA, 2004; IAEA, 2008; IAEA, 2007). Processes refer to methods used to find, create, capture and share knowledge whereas technology is a vital tool to connect people, store and share knowledge and make it easily accessible. Human factor is considered as the main component of KM by the nuclear industry, because success of this process strongly depends upon an employee's willingness to share and their ability to reuse accumulated knowledge (IAEA, 2006). Theory and nuclear industry goes hand in hand with their views on KM components. However, theory places the main emphasis on two of them: people and technology (Bhatt, 2001; Dalkir, 2005; Gupta at el, 2000; Davenport, 1994). Nevertheless, the final conclusion that theory came to derives from the human element of KM and is similar to the nuclear industry conclusion. To be more specific, theory also admits that it is very challenging to change people's behaviour in terms of sharing information and knowledge, hence, a shift in organisational culture, business procedures and commitment is required and has to come first when transferring knowledge (Bhatt, 2001; Glasser, 1998; Gupta at el, 2000).

Nowadays many NPP have adopted a strategic approach to human resource planning so that the successful transfer and retention of crucial knowledge can be achieved (IAEA, 2004). It usually includes analysis of current and future workforce requirements and organisation's development plans, creation of attrition profile and design of succession planning programmes. So, for example, expected retirements are usually planned 10 years or more in advance (IAEA, 2004).

Due to the age profile of the nuclear workforce the main focus of KRT practices is to attract a new talent to the industry and to retain existing expertise since it is simply impossible to preserve tacit knowledge if there is no one to transfer it to. Activities aimed to improve collaboration between industry, schools, universities and research institutions; develop and sponsor new educational and training programmes based on industry needs; provide scholarships and funding for students interested in nuclear studies and promote networking of institutes of higher education are usually used by the industry to attract young employees (IAEA, 2004; IAEA, 2006). The well known international initiatives in this field are European Nuclear Education Network (ENEN), World Nuclear University (WNU), which was opened in 2003, Young Generation Network and Asian Network for Education in

Nuclear Technology (ANENT). In addition to international projects in order to attract young generation, some countries (Canada and UK) developed the internship programmes for nuclear industry (IAEA, 2006).

Another main concern of nuclear KRT strategy is the retention of existing employees, since there is a high demand for skilled and experienced engineers and technicians across different sectors (based on findings of Third Chapter). Different approaches are used by the industry for this purpose. There are five methods that are commonly practiced (IAEA, 2006). The first one is creating possibilities for career growth, personnel and professional development. The second is promotion of long term perspectives with organisation through financial and non-monetary incentives. Establishing regular communication with employees with regard to their job satisfaction is third. The next one is monitoring the external job market in order to maintain competitive wages, benefits and job conditions and the last is applying KM tools correctly during downsizing and outsourcing so critical skills and knowledge can be retained.

Summing up at this point, three main drivers for the development of KM strategies stated by Robertson (2004) can be found behind nuclear KM strategy. One of the biggest reasons for the development of KM programmes for the nuclear industry is the retirement level of key employees. As it was discussed above many initiatives took place in order to address this issue. Another two drivers – a need for innovation and efficiency were stated in the nuclear KM objectives during the international conference on Knowledge Management in Nuclear Facilities in 2007 (see p.53 for more details). However, safe operation of nuclear facilities and global security (peaceful use of nuclear energy) are another two extremely important and industry specific drivers for the development of nuclear KM programmes, which are missing from the literature review.

Having established the nuclear view on KM, the main reasons behind the nuclear KM strategy and its current objectives, the main approaches to the transfer of tacit knowledge can be discussed. Nuclear industry is consistent with the theory on that matter and utilises two main approaches when transferring tacit knowledge (IAEA, 2004). The first one is coaching and mentoring (i.e. personalisation) and the second one is elicitation of tacit knowledge where it is possible (Hansen et al, 1999; Nonaka and Takeuchi, 1995). The last approach is very popular for capturing "operating experience" (for example in forms of operating manuals). A lot of such work has been done on an international level. Many "operating experience" databases were developed by different professional bodies, such as the Institute of Nuclear Power Operations (INPO), the World Association of Nuclear Operators (WANO) and IAEA. In addition to what was previously known as tacit knowledge, such databases usually keep records of systematically updated explicit knowledge. This information (explicit and codified tacit knowledge) is captured regularly, because it is vital for the safe and smooth operation of NPP. In addition to such databases, tacit knowledge very often converted into explicit using such tools as development of simulations, creation of 3-D models and video recording of interviews, conferences, presentations and other activities held by an expert (IAEA, 2011a). That is why nuclear industry generally has a higher ratio of explicit to tacit knowledge in comparison to other sectors.

The high volume of codified nuclear knowledge is more difficult to manage. Special technology and information management systems were designed to capture and share nuclear knowledge effectively. These technological advances are playing an important role in nuclear KM processes, including its transfer and preservation. Official databases store critical organisational knowledge and information. The main advantage of such facilities is that every authorised employee can search its content quickly, easily and accurately even if large volumes of information are stored there (IAEA, 2004). These databases are updated frequently, because operating processes are improving continuously and new mission critical knowledge emerges. Moreover, technology is widely used to support collaboration and cooperation in the nuclear industry worldwide. This is a crucial part of the nuclear KRT strategy. As a result, the International Nuclear Information System (INIS) grew into one of the most successful and comprehensive systems, that stores the largest collection of information in the nuclear field available today. Another important condition of successful KM established in the literature (DeLong, 2004) is fulfilled by the nuclear industry. It is clear that technology is playing an important role in the nuclear KM process and it is widely used to capture, store and share existing knowledge as well as improve and accelerate the knowledge flow between individuals.

Nuclear KRT process is consistent with the theory part of this research and starts from identifying business critical knowledge for the plant operation and maintenance, known as knowledge or concept mapping (IAEA, 2004). Since knowledge transfer is a time consuming and expensive process, nuclear industry experts agree with the statement made by Argote and Ingram (2000) and Delong (2004) and believe that it is imperative for the business to transfer only critical to the organisation knowledge. Moreover, the importance of organisational culture for successful transfer of tacit knowledge is also addressed in strategies developed by nuclear operating organisations. Industry and theory (Bhatt, 2001; Glasser, 1998; Gupta at el, 2000; Hansen at el, 1999; Nonaka and Takeuchi, 1995) have similar views on this aspect of the KRT process as they both state that even the best methods and approaches will fail if people are not willing to share their knowledge. Therefore, it is imperative to support a cooperative and collaborative culture within the organisation for successful KRT. This is especially true when transferring tacit knowledge, because it is usually done on a person-to-person basis. Succession planning (internal successors preferred), mutual trust and respect, open communication and close cooperation between all levels are widely practiced to promote and support a knowledge sharing culture in the nuclear industry (IAEA, 2004). Hence, almost all variables (except for reward) that have been stated in theory as fundamental for the development of a strong cooperative and collaborative organisational culture (Bhatt, 2001; Delong, 2004; Glasser, 1998; Gupta at el, 2000; Kogut and Zander, 1992; McEvily, 2003; Nonaka and Takeuchi, 1995; von Krogh, 1998) and, therefore, essential for successful knowledge transfer currently present in the nuclear KRT process.

In order to use tacit knowledge effectively and transfer it smoothly to the next generation of employees, nuclear operating organisations had to adjust their daily operations accordingly. Many of them established communities of practice, safety communities and working teams where a mix of different expertise is usually present (IAEA, 2004). In addition, such practices as job rotation, conferences, meetings, storytelling and various reviews are taking place regularly. Moreover, it is NPP common practice to free employees close to the retirement age from their routine tasks at least one year before the departure so that they can document critical knowledge and work closely with their successors, in other words coach or mentor them (IAEA, 2004). Alongside a traditional technique of exit interviews for departing employees, the nuclear industry practice new preservation tools such as learning audits and oral histories (IAEA, 2011).

On-the-job training is a key part of the nuclear KRT process, because much of the nuclear expertise is acquired through it. Coaching and mentoring are widely used in knowledge transfer, especially for new employees or when a job position is changed (IAEA, 2004). There are also many training courses in place, including e-learning, where more experienced employees share their knowledge with young experts. They are usually designed to improve certain skills or to distribute new important information among employees.

To conclude at this point, a mix of personalisation and codification instruments that has been discussed in Chapter Four (Brown and Duguid, 1991; Cross et al, 2001; DeLong, 2004; Hansen et al, 1999; Hunter et al, 2002; Eraut et al, 1998; Malone, 2002; Nonaka and Takeuchi, 1995) are widely used by the nuclear industry to transfer tacit knowledge.

The international collaboration is also seen by nuclear industry as a crucial part of KRT strategy. As it was mentioned earlier the International Nuclear Information System (INIS) is one of the biggest, most successful and comprehensive developments in this field. Another example of global initiative is the International Youth Nuclear Congress, which was formed to promote nuclear related disciplines among younger generation and enable knowledge transfer and preservation processes (IAEA, 2006). In order to nurture a knowledge sharing culture on an international level, it was proposed to create an integrated social network of nuclear knowledge, where all skills and expertise will be mapped (IAEA, 2006). It will provide not only details of individual experts and ease communication and knowledge exchange, but also will help to create and support communities of practice. The first step towards this project has already been made.

In conclusion, there are many similarities between theory and nuclear industry views on KM and KRT strategies. Both have a more or less similar definition of KM and refer to the same three elements of KM: people, processes and technology. They recognise the same personalisation and codification techniques when transferring knowledge. As a result, methods and instruments they are using are also the same since they are related to certain techniques. All the main factors of successful KRT process mentioned in the theory are also addressed by the industry. To be more specific, among those factors are the importance of cooperative and collaborative organisational culture, use and application of advance technology and identification of business critical knowledge. However, due to the nature of this industry and its specific business goals and objectives, there were some major differences found in relation to KM drivers, objectives and goals. Although they have some similarities with the theory, the main emphasis by the industry is placed on the safe operation of nuclear facilities and global security which can only be achieved if people with the right skills and experience are in place.

5.3. The UK Experience and Perspective on Knowledge Retention and Transfer

For the same reasons as for the whole nuclear industry, the UK's KRT strategy is focused on the attraction of young employees to the industry. For that purpose in 2004 the Nuclear Technology Education Consortium (NTEC) was formed. It brought together eleven Higher education organisations which developed more than twenty new different modules for Master level courses (Nuclear Industry Association, 2012). They provided students with real projects that let them gain some insights into the nuclear industry. The success of new Master courses and interest expressed by the younger generation to the nuclear subjects led to the development of new undergraduate courses in 2006. In addition, two PhD programmes were developed where more than twenty students are trained every year (Nuclear Industry Association, 2012). To make the inflow of young employees to the industry even higher in the future, visits of nuclear experts to schools are taking place regularly. They are advising about challenges, opportunities and secure career paths within the sector.

In addition, in 2008 in order to maintain the sufficient supply of skilled workers, meet future demands of the rapidly growing industry and address current workforce challenges the National Skills Academy for Nuclear was launched (The National Skills Academy Nuclear, 2008). Along with providing a workforce that can safely and efficiently build, operate and decommission the UK nuclear plants, the National Skills Academy could be a first step in the development of an educational platform for training overseas students.

Clearly, the retirement level of key employees in the UK nuclear industry is one of the main drivers for the development of a comprehensive KM strategy. Other motivating factors such as innovation, efficiency, safety and security identified earlier in the nuclear KM objectives are also applicable for the UK since the nuclear industry is highly regulated on an international level. This means that some drivers are consistent with the theory (Robertson, 2004) whereas others, such as safety and security are specific for the UK nuclear industry.

A lot of attention is also paid to the development of a knowledge sharing culture, opportunities to exchange good practices and effective information flow across the UK nuclear industry. For that reason the Nuclear Industry Association was established in 1993. Moreover, the UK's National Nuclear Archive (NNA) is currently under development and NDA is planning to complete it by 2014 (NDA, 2008). The scale of this project for the nuclear industry can only be compared to the British Library. Nuclear knowledge accumulated since the 1940s will be preserved and presented there in the best possible way in the paper, digital or photographic form. It will hold between 20 and 30 million records. Construction of this world-class internationally renowned facility will also improve the nuclear KM process across the UK.

Again, similarly to the nuclear industry in general, the UK nuclear industry pays a lot of attention and effort to the development and support of a collaborative organisational culture across the sector. According to the theory (Bhatt, 2001; Glasser, 1998; Gupta at el, 2000; Hansen at el, 1999; Nonaka and Takeuchi, 1995) this is imperative for the successful KRT.

Currently the main focus of nuclear knowledge management in the UK is on a clean-up and decommissioning since many existing nuclear reactors are at the end of their lifecycle and due to retire (IAEA, 2007; IAEA, 2006). That is why the decision was made to analyse nuclear KM practices established at Sellafield Ltd. This company is responsible for safe delivery of decommissioning, reprocessing, nuclear waste management and fuel manufacturing activities across Sellafield site, including Calder Hall, Windscale and Capenhurst, on behalf of the Nuclear Decommissioning Authority (NDA). Sellafield is the largest nuclear site in Europe where almost half of the UK's nuclear workforce is based (Sellafield Ltd, 2012). Its 10,000 employees operate over 1,000 nuclear facilities. Sellafield Ltd has one of the most comprehensive KM processes, including knowledge retention and transfer, which represents the best practice for the UK nuclear industry (John A. Day, Head of Knowledge Management and Intellectual Property at Sellafield Ltd). That is why all nuclear sites that belong to the UK Government, to be more specific run by NDA, will adopt the same approach. There are currently 19 different nuclear sites owned by the UK Government and only 8 power generation sites are owned by private company EDF Energy (NDA, 2012 and EDF Energy, 2012). Moreover, as John A. Day, specified, most likely new nuclear power stations that are planned to be built by private companies will implement the same approach too: *"They might do slightly different things, but fundamentally they will be based on similar approach, as it represents the best practice"*. This means that Sellafield Ltd practice in KM will be adopted by most UK nuclear operating organisations. This makes the research even more valuable because its findings should be valid across almost the whole UK nuclear industry.

In 2006 the NDA stated that every licensed nuclear site in the UK (including Sellafield Ltd) must have a robust and effective programme in place to manage its knowledge and intellectual property (NDA, 2006; NDA, 2006a). However, since 2001 the Government body known as British Nuclear Fuels plc (BNFL) until 2005 and later reorganised and now known as NDA, has been already working on the development of the knowledge retention programme for the UK nuclear industry. The main focus of that programme was to capture individual tacit knowledge associated with key technologies and core plant processes and later align it with already existing explicit knowledge. During the first stage of this programme a sophisticated computerised knowledge database where all existing explicit knowledge is stored was developed. It was named Corporate Memory (IAEA, 2004a). It contains over 250,000 scientific and technical reports dating back 60 years. It covers not only knowledge related to the company's plants and projects (here means Government owned sites), but also includes explicit knowledge captured by United Kingdom Atomic Energy Authority (UKAEA) and Atomic Energy Authority Technology (AEAT) as well as materials, such as conference notes and journal articles, available from the public domain. The main reason behind this process was the need to develop a core knowledge that can be used to support plants and processes at the nuclear reprocessing facility Sellafield Ltd because the business focus for the nuclear industry was changing towards decommissioning (IAEA, with no date).

The above example shows that the UK nuclear industry uses codification techniques to capture and store explicit and tacit knowledge (Hansen et al, 1999; Nonaka and Takeuchi, 1995). Moreover, in this case it is also clear that the UK nuclear industry is using and applying the latest technology to capture, store and retrieve knowledge, which was stated in the literature as one of the fundamental factors for successful KM and KRT (DeLong, 2004). The importance of this factor is predetermined by its features: it helps to connect employees, make knowledge easily accessible and improve information flow within the industry.

During the second stage of this knowledge management programme, explicit knowledge stored in the Corporate Memory was linked to the existing tacit knowledge (IAEA, 2004a). This process began with the identification of the key specialists who hold knowledge about the nuclear plants or certain technology. In order to capture tacit knowledge detailed interviews at least one hour long were conducted. Employees who had 20-30 years of experience within the industry usually were selected for these interviews. This method helped to identify and permanently highlight the most important knowledge in each particular field. Moreover, during the interview process other sources of relevant to the subject knowledge were established.

To sum up at this point, critical organisational knowledge, employees who hold it and processes it is embedded in were identified at this stage, hence, the process established in the literature review (Argote and Ingram, 2000; Delong, 2004) as critical for KRT is followed by the industry.

Furthermore, all knowledge that has been extracted during the interview and later aligned with appropriate explicit knowledge was always supplemented by knowledge package that had links to the additional sources of knowledge identified during the interview. These sources usually refer to existing literature, including external reports; seminars, presentations and conferences captured on video; internal information systems or external web-sites that can contain information either about key individuals in the field or specialist organisations. Therefore, it is clear that knowledge captured during this programme has a very complex structure. Within 3 years of this programme 300 interviews were conducted during which 2,500 key documents were identified. This resulted in the development of 45 knowledge packages which are continuously updated (IAEA, 2004a). Another, important observation which can be made at this stage is that the UK nuclear industry often adopts codification techniques when transferring and preserving tacit knowledge. So for example, knowledge elicitation was used during interviews and knowledge codification when capturing seminars, presentations and conferences on video, creating reports, websites and information systems. As a result, the final product (knowledge database and knowledge packages) of this knowledge retention programme is also fully codified and well documented. The preference towards this approach might be explained by the nature of the business where knowledge gets documented on a regular basis so that the safe and secure operation of nuclear plants can be maintained. Moreover, according to Chai and Nebus, 2010 this approach is also economically viable since codified knowledge can be easily accessed, applied and reused at no extra cost, which is important for a big organisation that operates more than just one facility and involve at least three generations of employees throughout its life cycle.

So that this complex knowledge could be utilised effectively, it was made available throughout the whole BNFL using modern technology. This step is essential for success of KRT because knowledge is losing its value if it is not assimilated across the organisation, applied and accessible (Gupta at el, 2000; Irani et al, 2009; Wakefield, 2004). Moreover, universities with the relevant knowledge and expertise also had access to the knowledge packages and were encouraged to contribute their own materials and findings so that it could be developed further. This is another example of successful application of technological advances which helped to maintain access to this comprehensive knowledge base throughout the whole industry (Bhatt, 2001; DeLong, 2004). What is more, the importance of knowledge sharing was also acknowledged during this programme, which is imperative for successful knowledge transfer according to DeLong (2004). Further steps were taken to promote a knowledge sharing culture on the industry level. BNFL looked into the possibilities of installing the UK nuclear knowledge portal which would help to promote a greater sharing of nuclear knowledge across different organisations in this field.

During this programme BNFL also address issues related to the aging workforce and lack of young graduates entering the UK nuclear industry (IAEA, with no data). The first steps were made towards making the industry more attractive. Firstly, the key areas of expertise within selected universities started to receive funding to develop new up-to-date programmes or to support research projects. Secondly, the national nuclear centre for research and education – the Dalton Nuclear Institute – was established in 2005 in order to support the government programme on nuclear decommissioning. Originally it was mainly focused on the supply of young experts who have experience and knowledge of the UK nuclear industry and, therefore, would not require many hours of additional training.

The change in KM took place not only on the industry level, but on the organisational level too. Soon after the NDA announced its request in 2006, specialists at Sellafield Ltd started to work on the development of a new KM strategy. Today, the company's approach to KM is considered to be the best practice in the sector[8]. It is not focused on knowledge of individuals or a particular group of people anymore. It is comprehensive and applies to the whole organisation. Knowledge at every level: individuals, groups, teams, departments and even certain disciplines are taken into consideration. It is also supplemented by an integrated documentation system and by the social collaboration tools to help people share knowledge more informally and effectively. That is why this approach can be called holistic.

Current focus of Sellafield Ltd KM strategy is on the KRT of nuclear knowledge that can be lost to attrition. In order to transfer/preserve this knowledge effectively Sellafield Ltd follows well-established procedures. To be more specific, there are three main processes of knowledge transfer that run simultaneously. First is consolidation of explicit knowledge. At

[8] All information with regard to a Sellafield Ltd KM practices was obtained via primary contact during the interview with John A. Day, Head of Knowledge Management and Intellectual Property at Sellafield Ltd.

this point all explicit knowledge is reviewed by experts and then it is reorganised, corrected and validated. Its main focus is on procedures, plant configuration and safety case. The second process is capturing (codifying) implicit or tacit knowledge using special knowledge modelling techniques. At this stage implicit/tacit knowledge is being elicited as far as possible. Finally, the last knowledge transfer process is tacit transfer. It is designed to transfer knowledge between the expert and other people when elicitation is impossible. During this process personalisation technique applies.

A more detailed overview of a KRT process at Sellafield Ltd is presented below. The first step of their KRT process is the same as it was stated in the literature review (Argote and Ingram, 2000; Delong, 2004) and focused on the identification of experts who hold critical knowledge and are close to the retirement age. At the same time, since knowledge transfer is a time consuming and costly process, knowledge importance is also analysed. So only business critical knowledge that is at risk of being lost or not widely available is captured and transferred using appropriate instruments. One of the most common techniques used by Sellafield Ltd to prioritise and identify important knowledge is knowledge mapping (Vail, 1999; White, 2002). However, for the safe and efficient operation of the nuclear plant, John A. Day noticed, *"Ideally you should never be in the position where you rely only on one individual, leaving or not leaving. You should have duplication of skills so anybody could be replaced by another person who is suitably qualified".*

The second important step of KRT process at Sellafield Ltd is either identification of the recipients who can successfully acquire, reuse and reapply transferred knowledge or storage facility for captured knowledge so it can be easily retrieved. Obviously this step is defined by knowledge type to be transferred. The significance of this stage is also reflected in literature review, where Cohen and Levinthal (1990) and Argote et al (2003) state that success of tacit knowledge transfer is highly dependent on the cognitive abilities of the recipient, who has to be able to acquire knowledge and use it to make professional decisions. Szulanski (1996) confirms the importance of absorptive capacity of the successor and believes that if it is poor it can be a barrier for effective knowledge transfer. For the UK nuclear industry, including Sellafield Ltd, suitability of a successor for a knowledge transfer is usually assessed through SQEP, which means that every selected person has to be suitably qualified and experienced.

In addition, it is important to note that the KRT process at Sellafield Ltd is an integral part of the daily operations with tools and techniques which facilitate this approach. People's careers are planned well in advance to make sure there is no emergency needs for additional transfer work. Routine transfer is having successors in place and it seems to work efficiently and smoothly. This type of transfer normally would happen without any additional interventions. However, risks will always emerge because business environment is constantly changing: people can retire earlier or nuclear regulations can change. Therefore, Sellafield Ltd has made a provision in their KRT programme for dealing with personnel who for a variety of reasons may elect to leave the company sooner than originally anticipated.

According to the primary source another vital point in relation to how the process operates at Sellafield Ltd is the importance of trust and sharing culture which are essential for successful KRT (Bhatt, 2001; Glasser, 1998; Gupta at el, 2000; Hansen at el, 1999; Nonaka and Takeuchi, 1995). However, at Sellafield Ltd it is not only about the culture, it is about the environment. In other words, this organisation seeks to encourage an environment conducive to easy learning and sharing which facilitate innovation and collaboration through collective interaction. Currently, this is achieved by providing the infrastructure, tools and opportunity for people to cooperate, collaborate and share knowledge. There are two main tools that are used at Sellafield Ltd to help employees to share their knowledge. The first one is online facilities, e.g. social networking or collaboration tools. So, for example, experts are encouraged to have a blog where they can share their daily experiences and have followers. The second tool is legitimate (managerially approved/set up) communities of practice – both face to face and virtual, with their own internal web space including a discussion forum or blog. The main advantage of such knowledge sharing communities is that every one of them has a senior management sponsor and this is helping people to legitimise face-to-face meetings when necessary, even during busy times. These are the main tools that are used by Sellafield Ltd to sustain and nurture a cooperative and collaborative culture. There are also simple tools that Sellafield Ltd employs to maintain a knowledge sharing environment. Among them are special network events, forums, seminars, lectures, "lunch and learn" events. All of these events provide a good opportunity to share knowledge and experience, ask specific questions, or get information on the particular topic. Another important condition of effective knowledge flow and sharing at Sellafield Ltd is security. The nuclear knowledge can be dangerous in the wrong hands. Hence, certain precautions should be taken when sharing it. All Sellafield Ltd employees are aware that all organisational knowledge is located within the secure environment, so that people can trust who they talk to. Sellafield Ltd has a secure firewall, internal yellow pages, contact lists, and other online collaboration tools.

These secure online facilities help people to find others with similar issues or interests within the industry who they feel safe to talk to. Thus, technological advances are widely used to sustain sharing culture and build trust at Sellafield Ltd. In other words, the knowledge sharing culture is always supplemented by online collaboration tools to help people share and spread knowledge more widely. The only discrepancy found with the theory is that financial reward, established in the literature review as a tool that can be used to promote knowledge sharing, is not currently employed at Sellafield Ltd (Argote et al, 2003; Gupta et al, 2000; Hansen et al, 1999; Menon and Pfeffer, 2003).

Another specific characteristic of KRT process at Sellafield Ltd is its preferred knowledge transfer technique. The main knowledge transfer technique that has been utilised within the organisation is codification. To be more specific, where it is possible, knowledge is always captured and stored securely for future use at Sellafield Ltd. Knowledge modelling techniques are usually used for this purpose. Personalisation strategies are applied only for very difficult expertise that is impossible to capture. The most typical examples of personalisation tools are mentoring, coaching or shadowing, seminars and lectures, Q&A sessions, and all those approaches that help people to pick up tacit knowledge that the experts gained over many years of experience. The success of such tactics has been discussed in the literature, where Hansen et al., (1999) stated that knowledge transfer can only be effective if the company utilises one approach (personalisation or codification) that is best suited to the company needs, and the other is just used as a complimentary. The preference to use codification strategy in most knowledge transfer cases is also conditional to the industry and organisation needs to stay safe and reliable. Documented knowledge is certain, precise, easier to audit and share throughout the organisation. *"So wherever anything can be reduced to a written system of work or written decision tree, we try and do that, because this is all certain".*

The main challenges of knowledge transfer that Sellafield Ltd is currently facing are aging workforce and complexity of the transferred knowledge. Since this is a highly technical field, knowledge transfer process can be very difficult and time consuming (Kang et al, 2010; Hansen, 1999). In other words, it takes much longer to transfer this type of knowledge. So the big challenge for Sellafield Ltd is to transfer all that important knowledge that resides within a human mind in a certain time frame (before employees retire).

To conclude, there are many similarities between the KRT approach used by the UK nuclear industry and the one discussed in the literature. First, they both employ the same personalisation and codification techniques, tools and instruments when transferring knowledge. Second, they recognise and address the importance of trust, collaborative and knowledge sharing culture. Third, advanced technology in both cases is a vital tool in KRT process since it is widely used to capture, store and share existing knowledge, improve the knowledge flow between individuals and sustain the knowledge sharing culture. And, finally, in practice and in theory before the transfer takes place knowledge is prioritised, so only critical for organisation knowledge is captured. However, due to the nature of nuclear business and its specific business goals and objectives the UK nuclear KRT process has some unique characteristics. So, for example, the idea of safe and secure operation of nuclear plants is one of the imperatives of its KM strategy. This idea also influenced the KRT programme. However, in theory such matters as competitive advantage and efficiency have a higher priority. Therefore, the main goal of nuclear KM strategy and its effectiveness are also different from the theory and achieved through the continuous supply of suitably qualified personal. Another, distinctive characteristic of the UK nuclear KRT is its preference to codification techniques. Again, it is all about the safe and secure operation of nuclear plants, since documented knowledge can be easily accessed, applied and reused. Moreover, it is certain, precise, easier to audit and share throughout the organisation which is important for a big geographically dispersed organisation that operates more than just one facility and involves at least three generations of employees throughout the plant life. The last and unique characteristic of nuclear KM and KRT process in comparison not only to the theory, but to the business reality is its universal application. To be more specific, many industries trying to keep their achievements in KM as a secret, know-how, so they can stay competitive and prosper, whereas nuclear industry shares its successful experience in KM on the industry level (Sellafield Ltd practice is going to be applied across all Government owned sites) and internationally (e.g. conferences, forums). The main reason for doing this might be also hidden in the nature of the business: operation of nuclear industry is impossible if safety is jeopardised. Even if one single plant will have issues, it will affect the future of the industry worldwide as well as can cause irretrievable damaged to the environment and consequences might be fatal.

CHAPTER 6 CONCLUSION

The ***aim*** of this dissertation was to look at the HR challenges that the UK nuclear industry is currently facing and to analyse in depth one of them – knowledge retention and transfer. The focus was on knowledge because the safe and reliable operation of nuclear plants is the primary concern of all times. It strongly relies on skilled people who have the right knowledge and experience. However, there is a shortage of qualified people in the UK nuclear industry, given the ageing workforce and very little fresh blood entering the industry (Knight, 2008). Most of the people who are due to retire have been working in the industry since the first plants have been commissioned. They carry a vast amount of tacit knowledge that can be only acquired over time through work experience. This knowledge is the hardest to manage and it can be challenging to transfer it into any formal storage facility. Thus, it was decided to look at how this issue is addressed by theory and by the UK nuclear industry.

In support of this aim, three research ***objectives*** were identified:

- to analyse the current labour market issues around the UK nuclear industry and look closely at the supply and demand side of it, focusing on expert workers such as engineers, technicians and scientists;
- to examine the key concept about theories and ideas of knowledge management and KRT in particular;
- to explore the relationship between theories on KRT and practices currently established in the UK nuclear industry and analyse the effectiveness of these practices in the context of the theories.

In relation to the first objective it was established that thousands of professionals will be needed for the next 13 years to make construction, maintenance and operation of the current and the new UK nuclear fleet possible. The main characteristics of the nuclear labour market that can negatively impact the future of the industry are rapid ageing of the workforce, a soaring number of scheduled retirements, low attractiveness of the industry to the younger generation, small numbers of students entering nuclear related disciplines and aggressive competition from other high technology industries to recruit young talented employees.

Analysis of the current labour market trends helped to identify the main challenges that HR specialists in the UK nuclear industry are facing. They are as follows:

- to attract, recruit and retain suitably qualified graduates as well as skilled and experienced workers in a highly competitive environment;
- to secure additional investment for training and development programmes for existing and new employees. This would let employees to acquire new skills required for safe operation of new advanced technology and for a smooth transition from the energy production and fuel processing divisions to the decommissioning division;
- to manage a larger workforce, which will require to make structural and functional changes to the organisation;
- to preserve and transfer existing nuclear knowledge and expertise to the new generation of employees.

Operation of nuclear plants is impossible without experienced and qualified employees. The current situation in the UK nuclear industry, where two thirds of these professionals will be lost through retirement by 2025, puts the knowledge and experience accumulated for almost 60 years at the risk of being lost. Therefore, the last challenge was considered by the researcher as the biggest and the most important HR challenge due to the safety-critical nature of the nuclear operations. This challenge received all the attention when the two following objectives were discussed.

In relation to the second research objective, the literature review showed that KRT is a crucial element of every KM strategy. There were two main tactics of knowledge transfer identified: personalisation and codification. They are used to transfer tacit and explicit knowledge respectively. However, some tacit knowledge can be codified if this process justifies the effort. This is especially useful in the situation where successor is unavailable, critical employee is leaving unexpectedly or knowledge has to be transferred quickly. In addition, identification of critical organisational knowledge, nurture of the knowledge sharing culture, development of programmes that motivate employees to share knowledge are fundamental for successful knowledge transfer. On the other hand, process of KRT also can be improved if suitable information technology applications are developed and applied. However, the choice of KRT strategy is predetermined by knowledge type, knowledge retention goals, organisational context, the urgency of the transfer and availability of the expert and the successor. Only after careful consideration of all the factors the most suitable KRT strategy can be identified. This is especially important for the nuclear industry where KM can face some specific issues and challenges related to the high standards of safety requirements, extended life cycle of the cutting edge nuclear technology and extremely specialised areas of expertise.

Finally, with regard to the last objective many similarities were established between KRT approach used by the UK nuclear industry and the one discussed in the literature. First, they both employ the same personalisation and codification techniques, tools and instruments when transferring knowledge. Second, they recognise and address the importance of trust, collaborative and knowledge sharing culture. Third, advanced technology in both cases is a vital tool in knowledge transfer process since it is widely used to capture, store and share existing knowledge, improve the knowledge flow between individuals and sustain the knowledge sharing culture. And, finally, in practice and in theory before the transfer takes place knowledge is prioritised, so only critical for organisation knowledge is captured. However, due to the nature of nuclear business and its specific business goals and objectives the UK nuclear KRT process has some unique characteristics. So, for example, the idea of safe and secure operation of nuclear plants is one of the imperatives of its KM strategy whereas in theory such matters as competitive advantage and efficiency have a higher priority. Therefore, the main goal of the UK nuclear KM strategy and its effectiveness are also different from the theory and achieved through continuous supply of suitably qualified personal. Moreover, this fact also influenced the way UK nuclear KRT programmes are designed and implemented[9]. Another, distinctive characteristic of the UK nuclear KRT process is its preference to codification techniques. Again, it is all about the safe and secure operation of nuclear plants. This technique provides opportunity to capture knowledge which can be easily accessed, applied and reused at any time. Moreover, it is certain, precise, easier to audit and share throughout the organisation. This is important in the situation where big geographically dispersed organisation operates more than just one complex facility that involves a few generations of employees. The last and unique characteristic of nuclear KM and KRT process is its universal application. To be more specific, many industries trying to keep their achievements in KM just for themselves, so they can stay competitive and prosper, whereas nuclear industry shares its successful experience in KM on the industry level and

[9] More details about it in the next characteristic.

internationally. The main reason for doing this might be also hidden in the nature of the business: operation of nuclear industry is impossible if safety is jeopardised.

The aim and objectives of the dissertation have been met despite the difficulties that the researcher faced while obtaining necessary information from secondary sources. If this research had to be carried out again the approach used would be different. Interviewing or questionnaires would provide more detailed and specific to the topic information faster, than it was done through secondary research. Another important conclusion carried out from this research, is that the UK nuclear industry currently facing more than just one HR challenge, therefore, a lot of opportunities for further research are exist. The main areas that can be explored further are:

- Practices that are employed by the UK nuclear industry to attract, recruit and retain necessary skilled and experienced personal. The effectiveness of these practices has to be analysed. Firstly, in a highly competitive labour market climate with aging workforce, skills gaps, experience and skills shortage. Secondly, in meeting increasing demand for the workforce in the near future. For example, retention of employees for the duration of the new project is vital, but can be challenging due to churn and constant up skilling of more than a marginal level;
- Challenges the UK nuclear industry is facing in relation to management, training and retaining increased workforce for the new nuclear build. It will obviously require organisational and structural changes, introduction of new communication mechanisms between different units so they can cooperate and coordinate effectively throughout the whole process. It will also need more resources to train workers, keep them motivated and engaged;
- New nuclear build and its influence over the current training and development programmes utilised by the UK nuclear industry. The introduction of new technology and how to operate it safely and efficiently will require people with the new sets of skills. Even those who have existing skills will have to be re-trained in the correct procedures for management and operation of the plants. It will require additional investment in training and development programmes for people who is already on board and new recruits. So, for example, the construction of the new European Pressurised Reactor (EPR) plants in Somerset will require development and practice of the necessary new skills before any operational responsibility is assumed. Therefore, provision of training with recognised qualifications and accredited

certification has to be fully integrated into the HR strategy to provide people with the right skills and responsible in their approach to quality and health and safety so that the plant can operate safely, efficiently and without disruption.

- The workforce demand for the new nuclear build can be analysed again, since the scheduled timeframe for the new build has been moved and some stakeholders withdrawn.

All these topics are very challenging, cover key HR issues that the UK nuclear industry is currently facing and address the most important industry needs in safety, security, innovation, economic and sustainability.

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