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Managing social challenges in the nuclear decommissioning industry: a responsible approach towards better performance

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Abstract

At the end of their lifecycle, several large infrastructure will have to be dismantled, presenting unfamiliar challenges. Therefore, project management will need to focus extensively on the delivery of successful decommissioning projects to meet stakeholders' expectations and funding constraints. While there is an extensive literature that investigates the techno-economic aspects of decommissioning, social aspects remains remarkably under-investigated. Even if stakeholder communication, involvement and engagement are widely believed to be key enablers for the success of a project, often the needs and preferences of local communities are neglected and a participatory-based form of dialogue averted. Consequently, decommissioning projects fail to meet their intended objectives. Focusing on the nuclear decommissioning industry, this paper addresses the literature gap concerning social responsibility. A deductive method to formulate and validate theories regarding the social challenges for decommissioning is developed through a review and analysis of salient case studies.

Highlights:

- Project management knowledge in construction is far greater that decommissioning
- Decommissioning projects have to be managed in a socially-responsible way
- Nuclear decommissioning projects are complex, long, risky and expensive
- This paper presents a socio-economic review of nuclear decommissioning projects
- Timely engagement, early planning and siting results to be key success factors

Keywords: Stakeholders management; Decommissioning; Social Responsibility; Participatory decision making; NIMBY syndrome.

1. Introduction

Project management has, until now, mainly focused on new built. However, at the end of their lifecycle, most of infrastructures and industrial plants have to be dismantled. Therefore, in the future, project management will need to focus more and more extensively on the challenges imposed by decommissioning projects.

In particular, the decommissioning of mines (Nehring & Cheng 2015; Franklin & Fernandes 2013) and energy infrastructures such as large dams (Agoramoorthy 2015; Oldham 2009; Pacca 2007), Oil&Gas platforms (Oil&Gas UK 2015; Lakhal et al. 2009) and nuclear facilities (IAEA 2016c; OECD/NEA 2016; Laraia 2012a), are likely to raise the biggest challenges not only from the economic perspective, but also from the socio-environmental one. Within these, the nuclear decommissioning industry is the most affected by decommissioning costs and socio-environmental impact, because of the activities connected with decommissioning and the complex regulations that establish the correct disposal of radioactive material. In fact, nuclear infrastructures are extremely complex and various encompassing numerous types of facilities, such as Nuclear Power Plants (NPP), fuel fabrications facilities and research centres.

Depending on their function, nuclear facilities' life cycle widely varies, normally lasting several decades. Primarily, the end of nuclear infrastructure's operational phase is due to uneconomical operation, technical obsolescence, safety consideration, or to the conclusion of the research programme (Laraia 2012b).

Globally, costs' estimates for Nuclear Decommissioning Projects and Programmes (NDPs) lie in the range of hundreds of billions of pounds, reaching for instance £ 55 billion in France (WNA 2015c) and almost £ 70 billion (discounted) in the UK (NDA 2016a) [1]. NDPs have huge uncertainties that hinders the reliability of their forecasts. NDPs schedules can last decades, so several stakeholders are involved throughout their development. Consequently, it is important to evaluate the success of a project taking different stakeholders' point of view, according to a number of success criteria, in different timescales, as suggested by (Turner & Zolin 2012; Müller & Turner 2007).

From the socio-economic perspective, some of the key enablers for the success of a project recognised in the literature are (Ruuska et al. 2011; Greiman 2013; Zeng et al. 2015; NDA et al. 2015a):

- the local economy promotion, through allocation of benefits
- poverty alleviation through careful job repositioning, and

[1] £ 53.2 billion for the decommissioning of Sellafield site alone, that is expected to last 120 years (NDA 2016b).

- effective stakeholder communication involvement and engagement.

However, as it happened in the construction of a waste repository in Scanzano Jonico (Bentivenga et al. 2004; Zinn 2007), the needs and preferences of the local community are often still neglected and a participatory-based form of dialogue averted. NDPs fail to meet their scope and they are considerably delayed or even cancelled.

NDPs are morally troublesome also from an intergenerational perspective, as the benefits of nuclear power production are mainly for the present generation, while burdens (such as the remaining of long-living radiotoxic waste) could be transferred to the future generation (Taebi et al. 2012). In several countries the last generations (from the 50s to early 2000) enjoyed the creation of job positions and the availability of electricity, while the present and future generation will carry only the burden and costs of the compulsory nuclear sites clean-up and waste management.

This paper addresses the topic of social responsibility in decommissioning/dismantling projects. A deductive approach is adopted to formulate and validate theories regarding the social challenges that affect NDPs, and following the social constructionism approach, take account of what people think and feel, both individually and collectively. This promotes a better understanding of the situation, incorporating the stakeholder perspective into theories. This analysis is based on a systematic collection of quantitative and qualitative data, so that theories can be critically framed into more formally defined constructs.

More specifically, this paper addresses two research questions:

- Which are the main social challenges that arise during the development of a NDP, and how do they affect NDPs?
- Which are the best practices to socially and ethically manage these challenges, and successfully meet the scope of the project?

NDPs are analysed because of their economical relevance, urgency to deal with radioactive waste and the availability of public information. Nevertheless, lessons learned gained from NDPs are applicable to a number of decommissioning/dismantling projects in other industrial sectors, such as oil & gas, water infrastructures etc.

Since NDPs are characterized by extremely high budgets and have a high level of innovation and complexity, they can be addressed as megaprojects. Therefore, this paper is organised as follows: the literature review of section 2 starts with the analysis of social responsibility of major infrastructures, focusing on NDPs, and answers the first research question and identifies the main social challenges of NDPs and their consequences. Section 3 describes the research methodology for the collection and selection of the NDPs. Section 4 addresses the second research question and highlights the key factors to manage the risks for social responsibilities in order to successfully and ethically meet the scope of the project. Section 5 presents a deep reflection on the importance of stakeholder management and social responsibility in NDPs, highlighting best practices from international case studies.

2. Literature Review

2.1. Social Responsibility of Major Infrastructures

There is not a single accepted definition of major and mega project in the literature: usually, megaprojects are characterized by budgets above $1 billion with an high level of innovation and complexity (Flyvbjerg et al. 2003; Locatelli et al. 2014a; Merrow 2011; Van Wee 2007). However, already in 1985, Warrack (1985) argued that $1 billion is not a constraint in defining megaprojects, since sometimes a relative approach is needed. In fact, in some contexts, a much smaller project (such as one with a $100 million budget), could constitute a megaproject. Similarly, Hu et al. (2013) claim that a deterministic cost threshold is not appropriate for all countries, and a relative threshold such as the GDP should be used instead.

Existing studies on social responsibility of major infrastructures are still scattered and fragmented (Zeng et al. 2015) and concerns about social responsibility have grown significantly only during the last two decades. Craddock (2013) defines "*project social responsibility*" as "*the process to achieve the projects' objectives and balance the needs of all the stakeholders is an ethical manner to ensure that financial resources, human resources and environmental resources are utilized in a way that sustains all three*" and focuses on the business excellence models contribute to project sustainability and project success. Wang (2014) adopts the stakeholders' perspective and investigates the relationship between megaproject crisis management and social responsibility: the author's conclusion suggests that a dynamic megaproject network governance mode can promote stakeholders engagement in collaborative actions and improve the effectiveness and efficiency of the delivery of the megaproject. Shen et al. (2010) highlight the importance of incorporating sustainable development principles during the feasibility study of a project, considering not only the economical perspective, but also the social and environmental one, emphasizing the pivotal role that the Government, clients, architects & engineers, contractors and suppliers.

Focusing on nuclear sites in the UK, Whitton et al. (2015) highlights an increase in dialogue with stakeholders, concluding that fairness and justice are necessary to promote a community and institutional awareness of social sustainability. In fact, businesses and organizations do not operate in a vacuum and "*their relationship to the society and environment in which they operate is a critical factor in their ability to continue to operate effectively*" (ISO 2010). The nuclear industry, and the nuclear decommissioning industry in particular, suffers from the so-called "complex project environment" (Locatelli et al. 2014).

Therefore, since NDPs usually involve large numbers of partners and stakeholders and are (1) characterized by activities that range from small projects to major national multibillion projects; (2)

at least partially commissioned by governments; (3) uncertain, complex and politically sensitive projects without fixing a deterministic threshold, this paper addresses NDPs as megaprojects (Turner 2009; Flyvbjerg 2014; G. Locatelli et al. 2014; Brookes & Locatelli 2015).

2.2. The relevance of nuclear decommissioning & its social implications

Nuclear decommissioning is a long, expensive and complex set of processes with a multidisciplinary nature. Its scope is defined by the International Atomic Energy Agency (IAEA) as "*the administrative and technical actions taken to allow the removal of some or all the regulatory controls from a facility, except a repository which is* closed *and not* decommissioned […]*"* and can *"be concluded without dismantling, if the existing structures are for another use"* (IAEA 2016b). Decommissioning, waste management and site remediation, are the main phases to restore the nuclear site to new use, which is not necessarily identical to its original state. However, in the nuclear decommissioning industry, the boundaries between "decommissioning projects" and "waste management projects" are blurry and hard to distinct. Therefore experts often refer to them as "waste-lead decommissioning projects" and the literature includes the management of radioactive wastes within the NDPs costs estimate (OECD/NEA 2012). This causes a scope definition and management issue due to the lack of a clear description of what a "decommissioning project" and "waste management project" is. This can also create confusion regarding the differences of a NDPs (with a clear end, e.g. the removal of a certain amount of radioactive material or the construction of a waste repository) and nuclear decommissioning operations (the continuous process of handling radioactive material, both legacy and continuously generated). This paper focuses on the NDPs highlighted in Fig 1 (see the red circle), i.e. with the NDPs that deal with the existing legacy (i.e. the decontamination, de-energizing, dismantling and demolition of existing infrastructure) and the construction of new facilities (i.e. for the management, storage and disposal of radioactive material). Site restoration projects and the operations concerning the management of radioactive material that arise from nuclear decommissioning activities (see the red arrows) and the normal operation of nuclear facilities will be the topic of following researches.

Radioactive Material

Post-Operational Activities	**Nuclear Decommissioning Projects and Programmes**	**Site Restoration Projects**	**Operations of existing and new facilities**
Dealing with **existing legacy:** • Decontamination • De-energizing • Dismantling • Demolition of existing infrastructure	X		
Construction of **new facilities** for the: • Management • Storage • Disposal of radioactive material	X		
Site radiological assessment & environmental remediation		X	
Radioactive material management: e.g. material sorting, fuel management, waste processing, conditioning & passivation; transport, storage and/or disposal; post clean-up surveys			X

Fig 1. Nuclear post-operational activities, adapted from (UK T&I 2013)**: the red circle highlights NDPs, i.e. the focus of this research.**

Scope management significatly impacts on the NDP. In fact, the inclusion or exclusion of work packages, such as the fuel removal (NRC 2016) or the complete dismantling of the plant (IAEA 2016b), have an impact both in terms of budget and schedule and of social implications, e.g. the balance between the money spent vs the money to be spent, and the legacy left to future generations. Radioactive material (e.g. high-level-waste) are dangerous for thousand/hundreds of thousands of years, representing a relevant intergenerational equity issue. Future generation will have to deal with this waste for thousand/millions of years, without gaining any benefit and even bearing the risk of terroristic attack (POST 2004). Indeed, this occurs not only when the facilities are operating but also when the facility is shut down, and the radioactive material has to be handled, reprocessed, transported, stored and disposed.

In contrast to the construction of a NPP, which is not compulsory since another type of power plant (e.g. Gas power plant) could be potentially be built instead, NDPs are mandatory both for safety, ethical and regulatory reasons. Remarkably, at the end of the construction of a NPP, new job positions are created, and the local community could take advantage from other benefits, such as the reduction of the electricity prices. Conversely, at the end of a NDP, there is no direct cash in-flows and the surrounding community is likely to be left with the legacy of radioactive waste.

Moreover, compared to other decommissioning projects, NDPs present unique characteristics. Firstly, several Oil&Gas facilities have already been safely removed (more than 100 only over the past decade in Golf of Mexico (Lakhal et al. 2009)), while the number of completed NDPs is negligible, being the fully completed decommissioned civil nuclear power reactors only 16 of the 150 that ceased operations (OECD/NEA 2016). This hinders the process of applying lessons learned from past experience and increases the challenge to create trust within the local community, as it is impossible to demonstrate that the same NDP has been already performed safely before. Furthermore, the time scale for other decommissioning projects lays in the range of months-years, while decommissioning nuclear facilities can take decades, which requires a continuous and strenuous involvement of stakeholders. Furthermore, the possibility of recycling materials during the decommissioning of non-nuclear facilities is an established practice (e.g. the metal and concreate of civil infrastructure such as dams and long bridges) and could be a source of revenues for cost models that are based on the weight of material removed (Lakhal et al. 2009). Conversely, the recycling of nuclear material is hindered by extremely strict policies and technical constraints. Only few "win-win" shipment agreement exists, as highlighted by the swap deal between the UK and the US, where 700kg of enriched uranium were shipped from Sellafield, UK, to the US in exchange of American nuclear material that will be used in the treatment of cancer patients across Europe (The Independent 2016).

On the basis of the aforementioned literature and of interviews with experts, two major challenges that undermine the development of the NDPs stands out, i.e.:

1) personnel transition;
2) public unacceptance.

These two challenges directly affect the employees and the local community surrounding the NDPs, described as the "*the group of personal actors potentially concerned by, or who may become involved in, deliberations about radioactive waste management facility siting and operations*" (OECD/NEA 2015a). The first major social concern is the so-called "personnel transition". Indeed, the transaction from the operations of a nuclear facility to its decommissioning requires major organizational changes. Personnel transition concerns retraining of the employees, restructuring of the management, creation of alternative employment and development of compensation strategies to dismiss employees (Negin & Szilagyi 2012). This transition affects staff morale and commitment, as employees have to deal with new and unfamiliar, technical and organizational problems (Negin & Szilagyi 2012). Moreover, the downsizing of the workforce socially affects the citizens surrounding the nuclear site, mostly because some workers cannot find a new employment in the community and are forced to relocate. Real concern also exists regarding the willingness of individuals to change from operators to decommissioning workers and to accelerate work that would result in more rapidly putting them out of a job (ITRC 2008).

The second main social concern is the limited public acceptance of the local community facing the decision of building new nuclear facilities during the development of NDPs, such as a nuclear waste repository. Public unacceptance is generated by factors such as fear, lack of knowledge and low public participation (Devine-Wright et al. 2010), and is likely to cause the rejection of a project before it begins, or its interruption during its development. In the case of Japan, this "Not In My Back Yard (NIMBY) syndrome" has proved to cause an acceptance drop to less than 20%, if the repository is to be installed near the respondents' residency (Gallardo et al. 2014). Gallardo et al. (2014) also underlines the split between the general and the local interest, where the benefits of having a repository are widespread at national level but the costs are absorbed by small local communities. Radioactive waste management is one of the main challenges connected to decommissioning. It includes sorting nuclear waste by degree of contamination, its deployment in apposite containers and its monitoring over an extended period of time in a long-term storage repository. Radioactive waste management issues are embedded in broader societal issues, i.e. environment, risk, sustainability, and energy and health policy (OECD/NEA 2015b) and it is recognized as a complex decision-making-process that embraces social aspects as well as techno-economical ones. Early engagement with stakeholders and high level of communication maximizes the chances to receive higher degree of acceptance and reduce the unexpected complaints that would prevent the development of the NDPs from proceeding smoothly (McIntyre 2012).

Due to personnel transition and public unacceptance, the socio-economic impacts of the implementation of NDPs has to be carefully evaluated, and the optimum decommissioning strategy have to be determined not only focusing on policy, safety, financial and technological constraints, but also involving employees and the local community surrounding the nuclear facility.

2.3. Stakeholder management to tackle the social challenges of NDPs

Project stakeholder management includes the processes that "*required to identify the people, groups, or organizations that could impact or be impacted by the project, to analyse stakeholder expectations and their impact on the project, and to develop appropriate management strategies for effectively engaging stakeholders in project decisions and execution*" (PMBOK 2013). Stakeholder management has been vastly investigated in the literature, as shown by Mok et al. (2015) in their review of publications on mega construction projects published from 1997 to 2014.

In the decommissioning industry, the IAEA (IAEA 2009) lists technical, economic, social and environmental stakeholders, while Love (2012) suggests classifying stakeholders into statuary consultees (government, health and safety regulators, environmental regulators, local authorities,

#legal representatives) and non-statuary consultees (direct employees, contractors, non-government organization, local communities, local residents).

Concerning the ways to meet stakeholders expectations and request, the three "pillars of trust", i.e. safety, participation, and local development could be implemented (NEA/RWM/WPDD 2007). This is explained by the fact that (NEA/RWM/WPDD 2007):

- safety is paramount and it is necessary for any individual to be able to act, take decisions and make use of his freedom;
- participation is fundamental to involve local politicians or community leaders, providing them with transparent information about plans and programmes and being constantly available to answer their questions;
- local development is needed to ensure high quality of life in the host community.

Whitton et al. (2015) highlight the importance of embracing the move towards a participatory-based form of dialogue in decisions rather than an expert-led form of consultation. Innes & Booher (2004) state that legally required participation methods can be counterproductive, but that key elements are authentic dialogue, networks and institutional capacity. LaGuardia & Murphy (2012) affirm that *"a lack of consideration of social needs can create political problems within the local population and significantly hinder the acceptance of a project".* Also future generations are significantly affected by the development of NDPs, and the concept of intergenerational equity originates from the idea that the benefits of nuclear power production are mainly for the present generations, while the burdens of nuclear waste are transferred to the future (Taebi 2012). In addition, energy policy institutions have operated out of the public eye and with minimal public involvement, and now face new challenges as the public becomes more attentive and responsive to energy choices (Miller et al. 2014).

In the nuclear decommissioning industry, stakeholders' management is also hindered by the peculiar characteristics of NDPs and the complicated interrelationships among various stakeholders. Indeed, nuclear facilities are usually built in remote areas and the local community strongly relies on the activities of the nuclear facility and benefits from lower energy costs and compensation from the government. One prime example is represented by Dounreay nuclear site in Northern Scotland, where the decommissioning programme accounts for one in every three local jobs (Beckitt 2012) and the compensation from the government reaches £ 2 million to boost the workforce skills (Dounreay News 2011). In the UK, the Nuclear Decommissioning Authority (NDA) sets three methods of supporting socio-economic activities, i.e. direct NDA funding, support through NDA operations, and funding Dounreay Site Restoration Ltd to deliver Socio Economic activities (NDA et al. 2015b). The remoteness of the facilities is typical of the nuclear industry, as several nuclear sites were selected mainly according to the orography of the area, the distance to major population centre and the overall lower population density.

Consequently, during the lifecycle of a nuclear facility several hundreds of people are engaged in the operations of the nuclear facility. The local community heavily relies on the operations of the nuclear site. When the nuclear facility has to shut down, the personnel transition is a complicated task, and affects not only the employees, but also their families and all the local community surrounding the nuclear site. In particular, when the nuclear facility stops operation, decommissioning experts are needed to help the transition, so the numbers of employees firstly slightly increases and then starts decreasing with the progress of decommissioning, as exemplified in (IAEA 2011b). If this transition is not carefully managed, it would cause personnel dissatisfaction and widespread discontent.

The central feature of social responsibility is the willingness of an organization to incorporate social and environmental considerations in its decision-making process (ISO 2010). Therefore, since the local community is likely to affect the outcome of a NDP, a systemic and sustainable approach and a societal dialogue is needed to inform and engage the stakeholders (Whitton 2011), stakeholders' needs and preference have to be carefully addressed.

3. Method

Embracing the principle that the reality is determined by people, and willing to take into account what people think and feel, both individually and collectively, the social constructionist approach has been adopted in this research. This approach increases the general understanding of the situation incorporating the stakeholder perspective into theories (Easterby-Smith et al. 2012). To add authenticity and reliability to the research methodology, we address social responsibility challenges in NDPs through the cross-cases analysis (i.e. NDPs delivered in different countries). The approach adopted in this paper is based on the seminal work of Eisenhardt (1989) who derived a process where theoretical generalizations could be generated from reviewing a set of cases of a particular phenomenon. She also discusses "*reaching closure*," i.e., "wh*en to stop adding cases, and when to stop iterating between theory and data*". Eisenhardt (1989) advises researchers to stop adding cases upon reaching theoretical saturation and/or when the incremental improvement to quality is minimal. Four to ten cases usually work well because too few cases will be insufficient for empirical grounding and generalization and too many cases will be overly complex in terms of data management. In our effort to generate evidence, we reached 10 NDPs.
In particular, the criteria for the NDPs selection were:

- The project is a NDP, either dealing with legacy (to be decontaminated and dismantled) and construction of new facilities (for the storage and disposal of radioactive material), as highlighted in Fig 1;
- The project faces social risks during its development;
- The project is recent as possible;
- The projects show international experiences, and the different ways in which the social challenges on NDPs have been addressed in different countries;
- There is enough officially, reliable, and publically available information regarding the NDP.

Considering that the nuclear decommissioning industry is at its early stage of development, our collection of case studies virtually represent all the recent NDPs where public information are available in the European context.
The data and information collected, selected and analysed are mostly qualitative, since quantitative indicators are not fully practical and suitable for this kind of research (Labuschagne & Brent 2008). Factors that have been evaluated are:

- stakeholder reactions to the communication of the NDP;

- protests arisen and the participation of the local community to these event;
- the percentage of workers employed in the nuclear facility prior shutdown compared to the number of relocated jobs after the shutdown;
- re-training activities that have been planned and performed;
- activities to inform and educate the local community;
- society and compensation mechanism developed for workers & the local community

Clear sign of aversion to nuclear power is also investigated, and is highlighted by factors such as the outcome of referendum (e.g. the one hold in Italy, respectively after Chernobyl and Fukushima accidents).

4. Results

4.1. NDPs social challenges & their consequences

Personnel transition and public unacceptance are the major social challenges that are likely to arise during the development NDPs, as explained in section 2. Following the methodology described in section 3, a purposive sample of the NDPs has been collected, selected and summarized in Table 1 and Table 2, to highlight that personnel transition and public unacceptance have respectively the following consequences, i.e.:

1) Underestimated socio-economic personnel costs;
2) abandonment of the project.

NDP	Country	Site		Scope	Stakeholders reactions and NDPs progress	Key reference
		Pre-project	Post-project			
Kozloduy – 1 & 2	Bulgaria	Brownfield (6 units on site)	Brownfield (Unit 1, 2 ,3, 4 were shut down before 2006. Unit 5 and 6 are still operating)	Decommissioning of unit 1 & 2 of Kozloduy NPP	Disputed BUT progressed	(WNA 2016a), (WNN 2016), (EU 2015), (EU 2013a), (Öko-Institut 2013), (IAEA 2009), (Kozloduy NPP Plc 2008), (IAEA 2008b)
Ignalina – 1 & 2	Lithuania	Brownfield (2 units on site)	Brownfield (buildings that can be re-used will be preserved (INPP 2016))	Decommissioning of unit 1 & 2 Ignalina NPP	Disputed BUT progressed	(WNA 2016b), (EU 2013a), (EU 2013b), (Öko-Institut 2013), (Ministry of Energy 2011), (IAEA 2009)
Superphénix	France	Brownfield (NPP in operation)	Brownfield	Decommissioning Superphénix NPP	Disputed BUT progressed	(EDF 2014), (Tompkins 2011), (IAEA 2008b)
Greifswald – 8 units	Germany	Brownfield (NPP in operation)	Brownfield (The site will distrubute natural gas, process renewable raw material, produce large components for shipbuilding..)	Decommissioning Greifswald NPP	Disputed BUT progressed	(Backer 2012b), (Bäcker 2012), (Backer 2012a), (IAEA 2011a), (IAEA 2008b), (IAEA 2008a)
Vandellós-I	Spain	Brownfield (NPP in operation)	Brownfield (the reactor building will ramain in a "dormancy" for 25 years)	Decommissioning Vandellós-I NPP	Accepted AND progressed	(WNA 2016c), (NEA/RWM/WPDD 2007), (ENRESA 2007), (Bond et al. 2004)
Barsebäck – 1 & 2	Sweden	Brownfield (NPP in operation)	Brownfield (The demolition of the facility will await the construction of a storage facility, scheduled to be ready in the 2020s)	Decommissioning of unit 1 & 2 Barsebäck NPP	Accepted AND progressed	(Lorentz 2014), (Lorentz 2009), (IAEA 2008b)
José Cabrera	Spain	Brownfield (NPP in operation)	Greenfield	Decommissioning José Cabrera NPP	Accepted AND progressed	(OECD/NEA 2016),(IAEA 2016a), (WNA 2016c), (IAEA 2011a)

			(Waste stored waiting for the repository)			
Trawsfynydd	UK	Brownfield (NPP in operation)	Brownfield (NPP buildings in "care & maintencance")	Decommissioning Trawsfynydd NPP	Accepted AND progressed	(Hyder Consulting Limited 2010), (NDA 2009), (Bond et al. 2004), (Jones 1993)
Scanzanio Ionico	Italy	Greenfield (No nuclear site)	Brownfield (Nuclear waste repository would operate)	Construction of national waste repository	Disputed AND abbandoned	(IAEA 2009), (Zinn 2007), (Bentivenga et al. 2004)
Onkalo, Olkiluoto	Finland	Brownfield (NPP in operation)	Brownfield (NPP in operation and waste repository)	Construction of national waste repository	Accepted AND progressed	(WNN 2015b), (WNN 2015a), (WNN 2013), (EU Committee 2006)

Table 1. Selected NDPs

4.2. Underestimated socio-economic personnel costs

The first NDPs social challenge is the risk of underestimating personnel transition costs, mainly caused by the need of staff retraining (Negin & Szilagyi 2012), redeployment (NDA 2012), the employment of new specialized staff (Devgun 2012), and organizational changes.

The abrupt shutdown of the two units of Kozloduy NPP in Bulgaria exemplifies this challenge. In Bulgaria, the shutdown caused an unexpected reduction in the need of personnel and led to a decline in motivation due to frustration, fear of change and a loss of confidence in management. To tackle this, a training centre for the employees was established, but more absenteeism and increase in stress were still reported (IAEA 2009). Since Kozloduy NPP was affected by early shut down and it is a heavy financial burden for these countries, the EU provided financial support (IAEA 2009), and received the decommissioning licence in 2014 (WNN 2014). Ignalina NPP in Lithuania is another example of geographically and socially isolated NPP. Its closest town, Visaginas, has been hardly hit by the closure of Ignalina NPP, and has suffered not only by the decline in staffing and prestige of its largest employer and the loss of the original reason for the town's existence, but also from a near 5-fold rise in heating prices and similar trends in electricity prices (Ministry of Energy 2011). The European Union has accepted to bear the economic and social impact of Ignalina NPP closure (Öko-Institut 2013), since without sufficient funding the whole NDP would require even greater financial resources and longer time, staff expertise is likely to be lost and social tensions will exacerbate in the region. Also, in Greifswald, Germany, activities such as re-training for the employees, education for new jobs for and the adoption of retirement scheme have been undertaken (Backer 2012b). However, there was a the decrease of working moral and productivity, Increase of unemployment, decrease of tax yields and less opportunities for investments, and one of the substantial problem was ensuring the acceptance of the public (Backer 2012b).

Conversely, the Barsebäck NPP case, in Sweden, is a meaningful example of positive outcome of a sensible management of staff to maintain the feeling of personnel security: this was achieved through 3 to 5 years of employment guarantee before the reactor was closed and several initiatives such as individual supportive discussion (Lorentz 2009; IAEA 2008b). Similarly, at Vandellós-I, in Spain, the ENRESA[2] mitigated the negative socio-economic impact of the NPP shutdown hiring local and provincial companies (65% of the employees) and implementing a complete training plan to provide the workers the necessary knowledge (NEA/RWM/WPDD 2007; ENRESA 2007). Here, employment was perceived to be the main local concern, especially as staff numbers have dropped from 350 when the plant was operational to about 100, and would reduce to 50 during the latency period (Bond et al. 2004).

A similar approach had already been taken in the UK during the transition from operation to defueling (and subsequent decommissioning) of the Trawsfynydd nuclear site (Jones 1993). In Trawsfynydd, the consultation strategy started with the identification of three groups on whom the decommissioning was likely to have an environmental and socio-economic impact, i.e. employees, people living within 25-30 km radium from the nuclear site, and the locally elected council. These groups were separately consulted, they were handed information material, and a questionnaire. The questionnaire results pointed out that the major concern regarding the decommissioning phase was the job creation for local people. All the staff were counselled regarding their personnel preferences, and they were offered the following choices:

- relocate to a different site within the company;
- leave the company on selective voluntary severance, an approach that give mutual benefit to the company and the employee;
- remain at Trawsfynydd for defueling work and eventually subsequent decommissioning.

Even if social groups within communities have different priorities (Whitton et al. 2015), the Trawsfynydd staff management proved to be efficient, with 75% of people allocated to their first choice, and only 10 employees of the original workforce of 487 employees affirmed to be "*significantly dissatisfied*" of their final allocation (Jones 1993).

4.3. Abandonment of the project

The second NDP social challenge is the abandonment of the project, which can be caused by public unacceptance and local opposition. A radioactive waste repository has to be "hosted" by the local community for a very long time, so a collaborative and sustainable relationship must be established

[2] The National Enterprise of Radioactive Waste, in Spanish is called Empresa Nacional de Residuos Radiactivos (ENRESA)

with the residents from the early stage of the development of the NDP. This improves both the ongoing quality of life of the host community and future societal capacity to contribute to the oversight of the facility (OECD/NEA 2015a).

One negative case is the siting of the waste repository that was planned to be built in Scanzano Jonico, in Southern Italy. The choice of the Italian Government to identify in Scanzano Jonico the site for nuclear repository arises from the need to unlock a ten-year temporary situation in the management of radioactive waste. This waste was a legacy of the work done by the first Italian NPPs (shut down after the referendum of 1987 after Chernobyl accident), research activities, industrial and medical use. The routine activities of research centres and hospitals. The Italian population already expressed clear sing of aversion to the nuclear industry through the referendum against nuclear power, and the communication of the site selection came totally unforeseen for the citizens of Scanzano Jonico, who were totally unprepared and uninformed of the topic. This completely unexpected communication was made through Law Decree 314 of the 14th of November 2003 and caused the rise of critics and protests form the local community that lasted several days (Bentivenga et al. 2004; Zinn 2007). The main reasons that led to the failure of the initiative of Scanzano Jonico were the lack of early and timely involvement of the local community, exemplified by the complete absence of initiatives of communication to the public prior to the choice, and the general lack of trust in the institutions, strengthened by the procedure of the site selection. The arisen protests caused not only a delay in the project, but also the total removal of the assignment to Scanzano Jonico and the withdrawal of the whole project. A similar matter occurred during the search for the siting of the Japanese geological disposal facility for spent nuclear fuel, where surreptitious deals not open to public produced surprise, anger and unacceptance when discovered by the local community (Lawless et al. 2014). On the contrary, the scoping project regarding the geological disposal in Finland (the Onkalo NDP) (WNN 2015a; WNN 2015b) shows how the dialogue with stakeholders improves the decision-making process and that the search of public consent through public engagement is essential to proceed with construction. Onkalo NDP is, in fact, a positive example of successful search for the repository of spent nuclear fuel and nuclear waste, and a repository is currently under construction at Olkiluoto nuclear site. Due to the Finnish open and transparent policy and the overall trust in the public authorities, no major protests of the local community have arisen (EU Committee 2006). In May 1991 the government approved plans for a geologic repository; then, after twenty years of consultation, the repository has been sited at Olkiluoto (EU Committee 2006), in February 2015 the regulators approved the waste repository plan (WNN 2015a), and the construction licence was granted in November 2015 (WNN 2015b). Also in Sweden, the engagement of the local community resulted fruitful for the siting of a high-level-waste repository and two municipalities voted to candidate for the deep geological repository and received the support of more than the 75% of the population (WNA 2015b).

4.4. Guidelines to address the social challenges of NDPs

The aforementioned consequences of NDPs social challenges can cause the delayed or abandonment of the NDP. However, relevant considerations can be drawn to build guidelines and develop future public participation strategies. In particular, it is worthwhile to highlight the following NDPs' promoting factors, i.e.:

- Engage and involve early and timely the local community;
- Start the planning of the NDP as soon as possible, possibly when the facility is still operating;
- Privilege the siting of a waste storage/repository where a nuclear licence has been already provided (e.g. for nuclear power production).

These considerations are supported by the NDPs analysis that shows that:

- avoiding the engagement with the local community causes demonstrations and protests from the local community and can lead to the rejection of the project; and
- starting the planning of NDP after the end of the operations of nuclear facilities does not facilitate the acceptability of the NDP, both if it is related to the dismantlement of a nuclear facility (e.g. Ingalina and Kozloduy) and the siting of a waste repository (e.g. Scanzano Jonico).

NDP		NDPs' promoting factors			Stakehdolers reaction	
		Early and timely engagement with the local community	Start the NDP planning soon as possible, even better, when the facility is still operating	Privilege the siting of a waste storage/repository where a nuclear licence has been already provided	Positive	Negative
Transition from operation to decommissioning	Kozloduy – 1 & 2	-	-	X There is a low and intermediate level radioactive waste treatment and storage facility on site (WNA 2016a)		X
	Ignalina – 1 & 2	-	-	X There is a final repository for low- and intermediate-level waste near to Ignalina NPP (WNA 2016b)		X
	Superphénix	-	-	X France has along history of nuclear power production and the country benefits from low and intermediate level waste repositories and high level waste storage systems (EDF 2014)		X
	Greifswald – 8 units	-	-	X The need to build an integrated interim storage facility for waste and fuel on-site is recognized as a cornerstone fro decommissioning (IAEA 2008b)		X
	Vandellós-I	X As highligthed in (ENRESA 2007), (NEA/RWM/WPDD 2007), (Bond et al. 2004)	Vandellos-I was shut down on July 31, 1990, following a fire in one of its two turbogenerator in October 1989. The decommissioning plan was submitted by ENRESA to the Ministry in 1994 (Bond et al. 2004).	X Vandellos-I is now in "latency" and works as temporary storage facility for the graphite of the NPP (ENRESA 2007)	X	
	Barsebäck – 1 & 2	X As highligthed in (Lorentz 2009), (IAEA 2008b)	X As highlighted in (Lorentz 2009), (IAEA 2008b)	X Some low-level waste is disposed of at reactor sites, and some is incinerated at the Studsvik RadWaste incineration facility in Nyköping (WNA 2016d)	X	
	José Cabrera	X As highligthed in (IAEA 2016a), (IAEA 2011a)	X As highlighted in (WNA 2016c), (IAEA 2016a)	X Low and intermediate level waste is sent to El-Cabril. High level waste is stored on site (WNA 2016c)	X	
	Trawsfynydd	X As highligthed in (Jones 1993), (NDA 2009)	X As highlighted in (WNA 2015d), (NDA 2009)	X UK has along history of nuclear power production and the country benefits from low and intermediate level waste repositories and high level waste storage systems (WNA 2015d)	X	
Search for the siting of a nuclear waste repository	Scanzanio Ionico	-	-	The selected site has not previously been granted any nuclear licence (Bentivenga et al. 2004)		X
	Onkalo, Olkiluoto	X As highlighted in (WNN 2015b), (WNN 2015a), (WNN 2013)	X	X Finland benefits from low and intermediate level waste repositories that have been operating sincemore than two decades (WNA 2015a)	X	

Table 2. NDPs characteristics and their impact on the project outcome

These findings are consistent and complement the principles of best practice public participation, and this analysis corroborates existing theoretical best practices, confirming that "*only when nuclear experts can withstand public challenges, they will gain and keep public trust in their judgement*" (Lawless et al. 2014). Consistently with Bond et al. (2004), this research also shows that if the decision-making process is transparent, the public feel that their legitimate concerns have been addressed. Moreover, in order to tackle the social challenges of personnel transition and public unacceptance while still maintaining a broad overview, the empirical evidence collected in this research fosters:

- Firstly, to consider the stakeholders logistically closer to the nuclear facility and cluster them into the following groups, i.e. direct employees (e.g. staff involved in daily operations), indirect employees (e.g. suppliers), associate (e.g. unplanned maintenance), workers at the local community (e.g. school teachers), and others (e.g. retired people) (IAEA 2008a; IAEA 2009);
- Secondly, to engage with stakeholders in institutionalized dialogue, and timely involve the local community, to avoid surprise prevent reluctance in accepting the NDPs;
- Thirdly, manage the decrease of staff needed during the decommissioning phase also according to the individual needs and preferences, and engage the remaining staff in the decommissioning activities, both through economic incentives and psychological help. as suggested by Campbell (2007).

These considerations regarding a socially-responsible management of all the major stakeholders are likely to reduce both the risk of local opposition and the risks of incurring on higher personnel transition costs. The empirical evidence validates and updates the earlier findings regarding the need to increase the public acceptance and satisfaction in the attempt to avoid social issues to arise. This is congruent with human resources management, that has traditionally had two roles: a "management support role", i.e. providing the organization with competent people to undertake the work processes, and an "employee support role", i.e. caring for the well-being of employees (Turner et al. 2008).

The organizational design during of NDPs is extremely relevant and is a dynamic entity that continuously evolves depending on the progress of the work. The management team should focus on the alignment of the number and skills of people necessary during the decommissioning phase to accomplish the decommissioning tasks, and the employees' necessity and preferences in terms of possible relocation. In particular, the decrease in the number of required staff for the decommissioning activities should be as aligned as possible with the numbers of people that leave. On one side, older people should be provided with the opportunity to benefit from early retirement, while on the other side, according to their preferences, younger and more employable people should be given the possibility to relocate or to decide to remain so that their experience is retained. The decrease of employee during the transition from operations to decommissioning should be as gradual as possible, and a long-term government financing scheme should be put in place to guarantee the lowest possible impact on the local community: in some cases, early decommissioning could be preferred to maximize jobs and local income after the end of operations. Additionally, the management board need to address the fact that workers are not just "industrial assets" but human being with a complex mix of feelings and aspiration, and should be treated according to their needs and necessities in every stage of the development of the NDP. Even if the implementation of these principles is likely to slightly increase the estimates for overall decommissioning costs, it will put the companies involved in the NDP into a stronger position, and the NDPs is more likely to receive consensus. These guidelines can be incorporated by the project management team during the decision making process to improve the planning and delivery of NDPs.

5. Discussion and conclusions

Historically, project management has focused mainly on construction projects. However, at the end of their lifecycle, several industrial plants and energy infrastructures in particular, have to be dismantled. Therefore, project management needs to learn how to face the unfamiliar challenges arising from decommissioning projects, both technical and socio-economic ones.
NDPs are the most likely to be heavily affected by decommissioning costs, due to the imperative safety regulation, the long schedule and the number of stakeholders involved. Moreover, due to the large variety of both their design and purpose, nuclear facilities are characterized by an extreme complexity and variety, therefore their decommissioning presents huge challenges.
This paper, embracing the principle that the reality is determined by people and willing to take into account what people think and feel both individually and collectively, applies the social constructionist approach. This empirically-based cross-case analysis highlights the major NDPs social challenges, i.e. personnel transition and public unacceptance. Personnel transition concerns the re-training for part of the workforce, the development of compensation strategies to dismiss the rest of the workforce, the creation of alternative employment, and restructuring the management. Public unacceptance is generated by factors such as fear, lack of knowledge, low public participation and is one of the causes of the so-called NIMBY syndrome, where fear caused by a perception of risk is likely to cause a significant acceptance drop.
The literature review, interviews with experts and the analysis of the 10 NDPs showed how the personnel transition and public unacceptance can hinder the smooth progress of NDPs. These two major social challenges have dramatic consequences on the development of a NDP and can respectively cause higher personnel costs and the abandonment of the project. From this analysis, the following project management considerations can be made, i.e.:

1) Engage and involve early and timely the local community;
2) Start the planning of the NDP as soon as possible, and even better when the facility is still operating; and
3) Privilege the siting of a waste repository where a nuclear licence has been already provided

These are the NDPs' promoting factors from the social and ethical perspective.
These three factors, can be generalized to non-nuclear industrial sectors entering the decommissioning stage, as it is essential to supply to the employees, the local community and their political representatives prompt, accurate and reliable information. In addition, it is pivotal to provide stakeholders with ancillary support (in the form both of economic compensation and

psychological help), and to make sure that the number of employees needed to accomplish the decommissioning project reduces together with the increase of retirement.

Strictly related to the early engagement of stakeholders, is also the early start of planning a decommissioning project: early planning promote a gradual change of culture within the company and reduce the impact of the transition between operation and decommissioning.

Lastly, the use of an already licensed site to locate the waste repository or a landfill is likely to be better accepted by the community. This is particularly relevant for the nuclear industry where the waste produced can be only partially recycled, but it is also relevant for other decommissioning projects, where the early selection of where to place the waste generated during the decommissioning activities can reduce future costs.

In conclusion, along with NDPs, also the decommissioning of Oil&Gas, dams and mines accounts for a budget in the range of thousands of billions. To this extremely high budget are associated an even higher social responsibility: project management, traditionally focused on construction, needs to learn as soon as possible how to manage decommissioning projects in a socially-responsible way, and to broaden its focus including future generations.

Appendix

NDP	Name and Country	Social Challenge Analysed and Its consequesnces	Stakehodlers reaction
Transition from operation to decommissioning	**Kozloduy – 1 & 2, Bulgaria**	Kozloduy NPP, Bulgaria, is one example where the shutdown of the facility caused an abrupt reduction in personnel, and led to a decline in motivation due to frustration, fear of change and a loss of confidence in management. To tackle this issue, a training centre for the employees was established, but more absenteeism and increase in stress is still highlighted (IAEA 2008b). Since Kozloduy NPP was affected by early closure and it is a heavy financial burden for these countries, the EU provided financial support (Öko-Institut 2013; IAEA 2009).	**Disputed NDP**
	Ignalina – 1 & 2, Lithuania	Ignalina NPP, Lithuania, is an example of a socially and geographically isolated NPP. Its closest town, Visaginas, has been hardly hit by the closure of Ignalina NPP, and has suffered not only by the decline in staffing and prestige of its largest employer and the loss of the original reason for the town's existence, but also from a near 5-fold rise in heating prices (Ministry of Energy 2011). The European Union has accepted to bear the economic and social impact of Ignalina NPP closure (IAEA 2009),(Öko-Institut 2013) , because without sufficient funding, the whole decommissioning process will require even greater financial resources, staff expertise is likely to be lost and social tensions will exacerbate in the region.	**Disputed NDP**
	Superphénix, France	At Superphénix, France, the relocation process progressed easily at the beginning, but it became more difficult with each passing year. This last period of staff reduction (2003–2004) was a difficult one, as most people did not want to relocate, there was lack of motivationamong personnel, it was too early to recruit new young people (IAEA 2008b).	**Disputed NDP**
	Greifswald – 8 units, Germany	At Greifswald, Germany, activities such as re-training for some employees, education for new jobs for and the adoption of retirement scheme have been undertaken, together with a scoring system has been adopted to categorize employees and decide who to re-train and who to re-deploy (Backer 2012b; IAEA 2008b). However, there was a the decrease of working moral and productivity, Increase of unemployment, decrease of tax yields and less opportunities for investments, and one of the substantial problem was ensuring the acceptance of the public (Backer 2012b). Also, of the staff that was working in Greifswald, one third needed to get a new job, and one third remained either jobless or retired (Backer 2012b). Additionally, the IAEA highlights that the shutdown caused a degree of local uncertainty (IAEA 2008b).	**Disputed NDP**
	Vandellós-I, Spain	At Vandellós-I, Spain, the ENRESA mitigated the negative socio-economic impact of the NPP shutdown hiring local and provincial companies (65% of the employees) and implementing a complete training plan to provide the workers the necessary knowledge (NEA/RWM/WPDD 2007; ENRESA 2007). Here, employment was perceived to be the main local concern, especially as staff numbers have dropped from 350 when the plant was operational to about 100, and would have reduced to 50 during the latency period (Bond et al. 2004).	**Accepted NDP**
	Barsebäck, Sweden	The Barsebäck NPP, in Sweden, is a meaningful example of positive outcome of a sensible management of staff to maintain the feeling of personnel security: this was achieved, for example, through 3 to 5 years of employment guarantee before the reactor was closed and several initiatives, such as individual supportive discussion (Lorentz 2009; IAEA 2008b).	**Accepted NDP**
	José Cabrera, Spain	José Cabrera, Spain, is an example of early and timely stakeholders involvement, that promoted the successful progress of the NDP (IAEA 2016a).	**Accepted NDP**
	Trawsfynydd, UK	In Trawsfynydd, UK, the consultation strategy started with the identification of three groups on whom the decommissioning was likely to have a socio-economic adn environmental impact, i.e. (1) employees, (2) people living within 25-30 km radium from the nuclear site, (3) locally elected council. In fact, even if social groups within communities have different priorities (Whitton et al. 2015), the Trawsfynydd staff management proved to be efficient, with 75-85% of people allocated to their first choice, and only a very small number of employees who defined themselves as "*significantly dissatisfied*" of their final allocation and of the management approach (Jones 1993). NDA's stakeholders consultation (NDA 2009) also shows the NDA ongoing commitment towards the stakeholder (Bond et al. 2004).	**Accepted NDP**

Search for the siting of a nuclear waste repository	**Scanzano Jonico, Italy**	Scanzano Jonico, Italy, was chosen as a nuclear waste repository to unlock a ten-year temporary situation in the management of radioactive waste (IAEA 2009). This waste was a legacy of the work done by the first Italian nuclear power plants (turned off after the referendum of 1987) and from the routine activities of research centres and hospital. However, the communication to the population regarding the site selection came completely unexpected (through Decree Lawn.314 of 14 November 2003) and the citizens of Scanzano Jonico were totally unprepared and uninformed of the topic. This caused the rise of critics and protests form the local community that lasted several days (Bentivenga et al. 2004; Zinn 2007). The arisen protests caused not only a delay in the project, but also the total removal of the assignment to Scanzano Jonico and the withdrawal of the whole project.	**Disputed AND abandoned NDP**
	Onkalo, Finland	Onkalo, Finland, is an extremely good example of successful search for the repository of spent nuclear fuel and nuclear waste where a repository which is currently under construction at the Olkiluoto NPP site in Finland. Due to the Finnish open and transparent policy and the overall trust in the public authorities, no major protests of the local community have arisen (EU Committee 2006): in May 1991 the government approved plans for a geologic repository, and after twenty years of consultation and research investigation the repository is to be sited at Olkiluoto (EU Committee 2006); in February 2015 the regulators approved the waste repository plan (WNN 2015a), and the construction licence was granted in November 2015 (WNN 2015b).	**Accepted NDP**

Table 3. Social Challenges of decommissioning projects

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