

Assessing Challenges to Nuclear Power Plant Management in Five European Countries: Methods, Results and Lessons Learned

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Abstract

The main purpose of this paper is to highlight some of the most important challenges to nuclear power plant management in Europe. Both qualitative and quantitative methods were used to analyse the data. The analysis saw two challenges emerging as the most important: human resource management and issues within the operating environment of the utilities.

1 Introduction

Over the past decade managers of utilities and nuclear power plants (NPPs) have been confronted with an increasing number of new challenges. These challenges have recently accelerated e.g. as a result of ageing plants and equipment [1], deregulation of the electricity market [2], and the ongoing generation turnover in the nuclear power industry [3]. However, there are also significant differences between countries. For example, while Sweden has decided to phase out nuclear power, a Finnish power company TVO is proceeding with its plan to build further nuclear capacity (www.tvo.fi). This paper will consider how the European funded research project LearnSafe¹ has attempted to address the management of such challenges in five European countries: Finland, Germany, Spain, Sweden and United Kingdom. The objective of this paper will thus be to present an overview of the most important challenges to NPP management in these five countries and to highlight their major similarities and differences. A further objective will be to evaluate their applicability of the applied methods to studying organisation and management issues in the context of nuclear power.

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2 Methods

Data was generated in response to the research question ‘What are the perceived emerging challenges in the management of nuclear power plants in the context of safety?’ using Metaplan sessions and semi-structured interviews. Metaplan sessions were designed to create an opportunity for mapping the challenges. Metaplan is an active method of data collection during which the researcher acts as a moderator to the process and guides participants through the discussion.

A total of 19 Metaplan sessions were conducted with senior and medium-level NPP managers, of which 18 sessions were held at ten NPPs in the five LearnSafe countries. One session was held at the World Association of Nuclear Operators (WANO) in Paris. During each session participants are asked to individually identify four to five key challenges in response to the research question. Challenges were then grouped into larger thematic clusters by the whole group. Semi-structured interviews were utilised to gather data from ten top utility managers from five utilities. Prior to analysis, data from the interview transcripts was reduced to form short summary statements of perceived challenges, which were integrated with the data collected during the Metaplan sessions.

The researchers selected both qualitative (Content analysis) and quantitative (MetaFuzz) methods to analyse the data as described below.

2.1 Content Analysis

Content analysis was selected to analyse the data that was collected during phase 1 of LearnSafe. "Content analysis is a phase of information processing in which communication content is transformed, through the objective and systematic application of categorisation rules, into data that can be summarised and compared [4]." Content analysis enables hypotheses to be tested by comparing the messages produced by two or more different sources. The benefit of content analysis is that it allows researchers to generate frequencies from qualitative data, whilst also maintaining its richness. The method involves the generation of key words and phrases being listed, categorised and counted.

Data was analysed by LearnSafe researchers using computer assisted qualitative data analysis software. N-Vivo 2.0 was selected for use by the research team, as it is more attuned to supporting social science research compared to other packages available. N-Vivo 2.0 encourages an exploratory approach to data analysis and is better at fine-grained analysis than other data analysis software. The researcher began the qualitative analysis of the data by importing the Metaplan and interview transcripts into the computer package; using N-Vivo 2.0 the researcher is then able to browse and explore the documents to identify challenges. The researcher uses tree nodes as a container whilst coding; each of the nodes are named by the researcher to reflect the challenges contained within. As the researcher codes the data, the references to the text are stored within specific nodes. When the analysis is complete the coded data can be retrieved and reported.

2.2 Fuzzy sets and cluster analysis (MetaFuzz)

The MetaFuzz method involved three main phases. Phase 1 started with the definition of a common classification model. The original clusters formulated as part of the Metaplan sessions were very heterogeneous which made comparisons between particular plants and countries difficult. Therefore a common classification model was developed. The model was based on the Competing Values Framework [5] and recent work conducted within the context of LearnSafe [6]. The model consisted on five dimensions that were assumed to cover the general characteristics of a NPP manager's job: 1) Economic and financial, 2) Workforce and competence, 3) Technology, 4) Systems and procedures, and 5) Environment. These dimensions were interpreted as fuzzy sets. The concept of fuzzy set was utilised in this instance because the identified challenges related to each other in different ways and did not therefore easily fit into mutually exclusive categories.

In phase 2 identified challenges were classified. The identified challenges were stored in an Excel-file and presented in random order. All references to particular countries, plants and sessions were concealed. The challenges were then classified on the basis of their assessed degree of membership to each dimension using a scale of 0 to 100, 0 denoting no membership and 100 very strong membership. Thus each challenge was assigned with an array of five integers. The classification was conducted by three researchers representing three different organisations in three countries. Data from three Metaplan sessions was omitted due to its late arrival. Coding was therefore conducted for a total of 593 challenges collected from 16 Metaplan sessions and ten top manager interviews.

In phase 3 the classified data was analysed. The average values of assigned membership coefficients (i.e. the assessed degrees of membership) were subjected to a series of cluster analyses. Cluster analysis was regarded as an efficient way of structuring the classified management challenges. A hierarchical cluster analysis was conducted to determine the optimal number of clusters. On the basis of the clustering (agglomeration) coefficient a nine-cluster solution was selected. K-means cluster procedure was used to create nine clusters. These nine new clusters were named by emphasising challenges located close to the cluster centres. Associations between the new clusters and selected background variables (Country, Organisation and Management level) were studied by means of cross-tabulation and Chi-square tests. All statistical tests were conducted using SPSS.

3 Results

3.1 Content Analysis

The preliminary analyses using content analysis suggests that the data can be categorised using the five dimensions of the common classification model (discussed earlier): 1) Economic and financial, 2) Workforce and competence, 3) Technology, 4) Systems and procedures, and 5) Environment. The first four categories correspond to Strategic financial management, Human resource management, Technology

management and Quality management, respectively. Further analysis of the data uncovered sub-categories within each of the five categories.

Overall, two areas emerged as to be the most important and influential: Human resource management and Environment (Table 1). Issues related to human resource management appear to be among the most important challenges to NPP and top utility managers across Europe; an example of the challenges that continuously appeared within the data set was the ageing of personnel at NPPs, the generation turnover and skills renewal. Issues within the environment, over which the NPP management have little or no control, were also regarded as being a huge challenge for NPP and for top utility managers. Public opinion pressures and globalisation of events were considered to be the most pressing issues within the environment.

Table 1. Data generated from the content analysis (% within Country, rounded).

DATA CATEGORIES	FIN	GER	WANO	SP	SWE	UK
1. Strategic financial management	4	13	27	15	13	13
2. Human resource management	32	25	27	35	33	38
3. Technology management	22	10	13	6	11	9
4. Quality management	13	22	5	11	13	13
5. Environment	30	30	27	33	30	27
TOTAL	101	100	99	100	100	100

Managers at nuclear power plants within four of the participating countries (Finland, UK, Sweden and Spain) considered issues related to human resource management to be the most important challenges. Issues within the environment were seen as being the most important for senior managers at German NPPs. Technology management (UK, Sweden and Spain) and strategic and financial management (Finland and Germany) were not considered to be pressing challenges within the management of a NPP.

The data generated from each of the participating plants indicates that the most pressing issues for NPP managers are related to the workforce and levels of competence as well as to operating environment. Within the UK site of Oldbury and at the German site of Krümmel challenges related to systems and procedures were frequently identified as important issues for managers to overcome. At Olkiluoto NPP in Finland the analysis of the data highlighted that issues related to technology are particularly challenging for the management team.

Further analysis of the data revealed that senior plant managers and functional managers believed the most pressing challenges were related to human resource management, while top utility managers and mixed groups (senior and functional managers) believed issues occurring within the outside environment to be the most challenging. The least challenging issues were related to technology management (senior and functional managers and mixed groups) and quality management (top utility managers).

3.2 Fuzzy sets and cluster analysis (MetaFuzz)

The nine new clusters proposed by the cluster analysis were named as follows: 1) Economic pressures, 2) Human resource (HR) management, 3) Nuclear know-how,

4) Rules and regulation, 5) Focus and priorities, 6) Aging, modernisation and new technologies, 7) Public confidence and trust, 8) Climate and culture, and 9) Miscellaneous (a number of challenges without a common denominator). These clusters provide an overview of today's challenges to the management of nuclear power plants in Finland, Germany, Spain, Sweden and United Kingdom. The largest clusters, and consequently the most challenging areas of management activity, were HR management (22.3 %), Climate and culture (17.4 %) and Public confidence and trust (12.8 %). The main results are shown in Table 2.

Table 2. Cross-tabulation of Cluster and Country (% within Country, rounded). INT refers to WANO and to a group of top utility managers from two countries.

CHALLENGE CLUSTERS	FIN	GER	INT	SP	SWE	UK	ALL
1. Economic pressures	0	16	19	11	12	4	10
2. HR management	21	18	8	19	29	26	22
3. Nuclear know-how	5	11	4	8	11	4	8
4. Rules and regulation	2	5	2	8	6	7	6
5. Focus and priorities	16	8	15	3	11	16	10
6. Ageing, modernisation, ...	18	13	8	3	9	12	9
7. Public confidence and trust	11	5	19	21	11	1	13
8. Climate and culture	21	16	6	24	8	27	17
9. Miscellaneous	5	8	19	3	3	4	5
TOTAL	99	100	100	100	100	101	100

The results of the Chi-square tests indicated that both Cluster and Country ($\chi^2 = 127.38$, $df = 40$, $p < 0.001$) and Cluster and Organisation ($\chi^2 = 181.45$, $df = 88$, $p < 0.001$) were significantly related. This suggests that different challenges tend to be emphasised in different countries and in different organisations. For example, Climate and culture-related challenges were emphasized in Finland, Spain and the UK, while the Swedish NPP managers did not appear to be particularly concerned about this area. On the other hand, Cluster and Management level were not statistically related ($\chi^2 = 24.18$, $df = 16$, $p \approx 0.086$). These findings suggest that managers appear to worry about the same things irrespective of their relative rank (top, senior or functional) in their organisations. Notable differences were identified only with respect to Economic pressures: the higher the rank, the more attention was paid to economic issues.

4 Discussion

The analysis of the data collected by the researchers via Metaplan sessions and semi-structured interviews has uncovered some interesting findings for the European nuclear industry. The most important challenges across Europe have been highlighted during the analysis of the data using both qualitative and quantitative methods. Overall, it was found that challenges related to human resource management and challenges occurring within the operating environment were recognised as having the greatest impact. On the other hand, the least challenging issues to NPP management teams across Europe was recognised as being technology

management and quality management.

However, there were a number of differences uncovered from the analysis of the data. For example, data gathered from Finland highlighted that issues related to technology are particularly challenging for the management team. A further difference between the data sets was that issues related to climate and culture were not considered to be an important challenge to NPP managers at Swedish plants. There were also large variations in the importance attributed to challenges of public confidence and trust within each of the European countries. Finally, the analysis also highlighted that there were a number of differences in the perceived influence that economic pressures are believed to have upon safety.

The differences that have been uncovered during the analysis of the data may in part be explained by the political situation within each of the participating countries. The national culture within each of the European countries participating in the study appears to impact the way in which individuals define each of the challenges.

5 Conclusion

Overall, the two methods produced similar results highlighting the situation within the nuclear power industry across Europe. The findings from the content analysis seem to produce a generic structure of the challenges which is comparable to many industrial organisations; while the cluster analysis highlights more nuclear specific issues. The use of the two methods described in this paper enables researchers to identify unique challenges to specific organizations, countries and industries and to generate a holistic view of such challenges.

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