BUILDING A FRAMEWORK FOR INTEGRATED RISK MANAGEMENT OF COMPLEX PROJECTS: THE CASE OF A MAJOR DISTRIBUTION NETWORK INVESTMENT

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ABSTRACT

With the introduction of intermittent renewable generation, distributed energy storage and demand side management, distribution network developments are becoming ever more complex. Northern Isles New Energy Solutions (NINES), led by Scottish and Southern Energy Power Distribution (SSEPD) and supported by Ofgem, aims to incorporate all of these elements into a combined active network management (ANM) scheme. This paper describes a risk management framework that has been developed to assist the managers of the NINES project deal with the multi-faceted challenges presented by large and complex projects. The process combines two parallel but interwoven activities; the first engages a range of stakeholders, using a group decision support system to facilitate the surfacing of risks and their ramifications, in a causal risk mapping process, while the second engages with the SSEPD team to elicit expert judgement regarding specific uncertainties so as to understand the likelihood of particular risks occurring. This in turn allows the consequences of the risks to be evaluated quantitatively and the implications to be more fully assessed by the project management team through a decision tree (DT) approach. While developed here specifically for NINES, the framework has potential across a range of complex project management situations.

INTRODUCTION

The evidence from historical records of project over-runs and projects currently under the media spotlight for cost over-runs, conclusively demonstrates that managing complex projects can be highly risky. Managers are faced with the need to engage and work effectively with many disparate stakeholders, for example suppliers, government, consultants, internal staff and the general public, anticipating and dealing with multiple interlocking uncertainties.

This paper describes a risk management framework that has been developed to assist the managers of the NINES project deal with these multi-faceted challenges. The process engages a range of stakeholders, using a group decision support system to allow greater productivity and equality of view, and a causal mapping process, which facilitates the surfacing of risks along with their ramifications. In this way, the process provides not only a comprehensive appreciation of the totality of the risks identified but also a greater understanding of their subtleties, consequences and inter-relationships. The map of risks and their interdependencies has then been combined with an elicitation process aimed at engaging with experts within SSEPD so as to understand the likelihood of these risks occurring. This in turn allows the consequences of the risks to be evaluated quantitatively and the implications to be more fully assessed by the project management team through a DT analysis. While developed here specifically for NINES, the framework has the potential to be applied across a range of complex project management situations, both within the electricity supply industry and more broadly. The paper begins by providing background on the NINES project before setting out the process that was followed and presenting some of the learning outcomes achieved. It concludes by making an assessment of the implications of the findings before reflecting on areas for future research.

THE NINES PROJECT

The context for the NINES project is the need to replace the thermal power station which supplies the majority of the electricity needs of the Shetland Islands, an archipelago 200km north of the Scottish mainland. The replacement is necessitated by, (i) the age of the plant and (ii) changes to emissions regulations. A proposed ANM scheme aims to allow a greater penetration of renewable generation through domestic demand side management, controllable loads, electro-chemical storage and other technologies, such as dynamic line rating, thereby minimising the use of fossil fuel generation. Reducing dependence on fossil fuels has the triple benefit of reducing generation costs, which are high due to the islands' remote location, lowering exposure to fuel price fluctuations and minimising per unit CO_2 emissions, which are relatively high when compared with the UK as a whole. Currently the connection of new renewables is constrained by the capacity on the existing island distribution grid and the lack of a grid connection to the mainland and the proposed smart grid innovations seek to reduce capacity constraints and increase exploitation of renewable energy resources.

The NINES project seeks to assess the potential for different generation portfolios to meet current and future demand which in turn requires an understanding of the region's electricity demand, the renewable generation potential (which is significant given the high winds and turbulent seas to which the islands are exposed) and network constraints. Moreover, the plant lifetime will be at least 20 years and must be robust against a range of different uncertain and shifting futures. These changes imply the need for significant modifications to the way generation and load is scheduled and brings with it the potential for new risks to supply quality and security.

SSEPD invited academics with competences in engineering, economics, risk analysis and management science to join the NINES project and the authors were involved in the risk identification and risk management element of the project. The objective of this work was to identify, quantify and assess the implications of risks pertaining to the NINES project with regards to the different design options. A key research aim was to integrate the modelling of strategic with operational risk, in order to consider how these could be integrated into a single integrated framework. Finding a manageable process for addressing wicked or complex problems that is not unwieldy is paramount [1] [2] and the authors describe here such a process associated with this major infrastructure project.

DESCRIPTION OF PROCESS

The process pursued is summarised in Fig 1; as can be seen, each of the two risk assessment activities, requiring different analysis tools, has its own development path while exchange between the two paths allowed optimisation of data surfacing and utilisation.

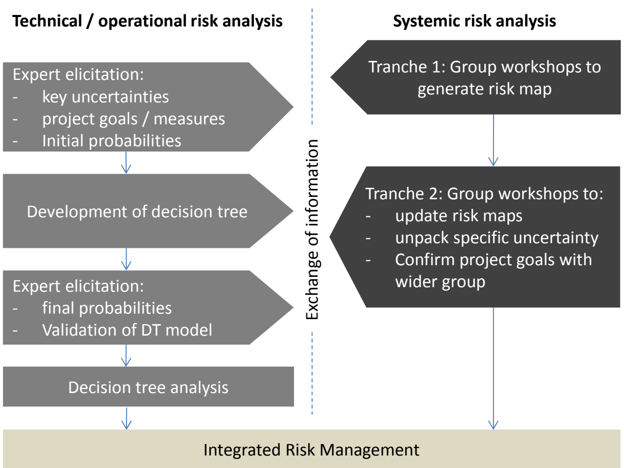

Figure 1: Framework for Integrated Risk Management

Assessment of Systemic Risk

Phase 1 of the project consisted of a series of three risk workshops; the first workshop involving the NINES team, the second Shetland islanders and the last technical staff at SSEPD. The process design was based on an existing body of work focused on the use of Group Support Systems – GSS [3] – which offered greater productivity by allowing simultaneous contributions to group work and by gathering views, causal relationships and preferences. These systems support anonymity and reduce the conformity pressures that participants experience when being identified with specific contributions. Moreover the particular software used – Group Explorer – enables an enhanced understanding of the systemic situation through building a causal model amenable to analysis [4].

The workshops followed mostly the same design, namely the generation of risks, consideration of the relationships between risks (risk systemicity) and the identification of priorities. The key stages in the process were as follows:

(i) The elicitation of risks as perceived by the workshop participants. An objective of the elicitation process was for participants to consider a wide range of risks and inclusion of stakeholders from all parts of the project helped to achieve this objective. Participants were paired, allocated a laptop computer, asked to consider risks that may be associated with the NINES project and type these into GE. Each risk appears both on a participant's console and on the public screen allowing participants to 'piggy back' off each other and trigger as comprehensive a range of risks as possible. To support this activity the facilitator clusters the risks into themes, allowing participants to cognitively manage the growing body of material. The clusters also enabled a quick overview of the themes to be conducted, allowing participants to see what had been generated and prompting further contributions as missing areas became apparent.

(ii) Structuring and linking of the risks. It is often the interaction between risks that can cause most damage to projects [5] [6] [7] and risks can be seen as a network of interrelated possible events. Once participants had exhausted their reservoir of risks, the process moved on to explore how the risks impacted on one another allowing consideration of the systemicity of the risks [8] [9] [6]. This enabled the group to move from a divergent set of views to a more convergent one and also triggered the generation of new material as the rationale for the links was explicated.

(iii) Prioritisation of risks. In each of the workshops, the facilitator identified those risks which are the focal point of links in the map and these risks became the concentrate of the next phase of the workshop. They were asked to prioritise these 'key' risks with respect to likely probability and impact. Participants were encouraged to explain their own reason for prioritisation and were allowed to consider other peoples' views, thus broadening their understanding of the perspectives of other stakeholders. The temporal aspects of risk were explored in a second activity in which participants were asked to prioritise those risks which they believed were most probable to occur in the short term and long-term.

(iv) Enhancing the risk map after the workshop. Participants were given the opportunity to add to or amend the risk map after the workshop. The reason for doing this was partly the limited time available in the workshops but it is also a means to promote the risk map as a dynamic tool which can be updated as new knowledge becomes available.

(v) Feedback on the process. Interviews with individual participants were carried out as a way of gaining further material and also to obtain feedback on the process in order to enhance the process for the tranche 2 workshops.

(vi) Analysis of the resultant material. Once the three workshop maps had been augmented with the material generated during the interviews, the three models were analysed to determine their constituent properties [10]. Each model was considered separately as their idiographic properties provided important insights into managing the messy complex situation. As the workshops

were being conducted to inform the client and there was no demand to integrate the models the insights were kept located with each workshop as the particular mix of participants provided valuable contextual information. However, it was possible to take a more holistic view as insights that emerged across all three workshops gained greater salience.

The tranche 2 workshops, the first of which was carried out in the latter part of 2012, are seen as a means of determining whether the risks identified in the first tranche are still relevant, whether new risks have emerged and whether those risks identified as being particularly key in tranche 1 are still as salient. While these workshops follow broadly the same approach as the tranche 1 workshops, they also aim to integrate the qualitative systemic work with the quantitative modelling efforts and thus included activities relating to the identification of the objectives of the project and the detailing of key uncertainties.

Development of the DT / Bayesian Network

In parallel and in conjunction with the first tranche of workshops, a detailed elicitation process, focused specifically on the repowering decision, was conducted. This consisted of interviewing relevant experts at SSEPD with the aim of developing a quantitative model to explicate the relationship between various decisions concerning repowering, related uncertainties and possible consequences. A natural framework to represent such a decision problem is a DT [11] which can also be represented more succinctly without loss of information as a Bayesian Network (BN) [12]. The outcome of the elicitation process would be to identify the variables, both decisions and uncertainties, define the relevant states that each could be, assess the casual relationship between the variables and quantify these probabilistically as described in [13]. Multiple assessments by different experts can be used to conduct sensitivity analysis and assess robustness of the recommendation. The DT/BN is then used to define the decision policy that optimises the final outcome (principally minimisation of cost and carbon emissions) and allows the value of obtaining information associated with given uncertainties at different stages in the process to be ascertained.

Integration of Workshops with Expert Elicitation

One of the key perceived benefits of the process being described here is the extent to which data can be shared and compared between the workshop-led systemic risk analysis and the expert judgement-informed quantitative analysis. This integration was achieved both implicitly and explicitly as outlined in Table 1.

While the qualitative and quantitative analyses were the responsibility of different members of the Strathclyde risk analysis team, there was a continual sharing of the outcomes from interim stages of the analysis throughout the two processes. This facilitated the informal exchange of information about perceptions of risk and allowed, for example, risks identified in the workshops to be introduced into the DT. Similarly, as described previously, the workshop participants were asked to provide measures of the likelihood of certain risks occurring and where these risks were relevant to the repowering decision that information could be used to corroborate the probabilities elicited from experts. While these would not replace expert judgement, apparent differences might be explored and provide boundaries for sensitivity analysis or highlight the need for further unpacking of the uncertainty in order to revise the elicitation.

Table 1 Forms of process integration

Implicit integration	Explicit integration
• Attendance of wider team of analysts at workshops • Planned observation of elicitation interviews by team leading systemic risk analysis • Internal meetings to discuss correspondence of quantitative and qualitative findings to highlight overlaps / inconsistencies • Integration of information from wider client meetings into both parts of risk analysis	• Session within tranche 2 workshops specifically focused on "unpacking" factors affecting key uncertainties in DT • Session within tranche 2 workshops to identify key outcome measures

As a means to achieve a closer integration of the two parts of the analysis, the tranche 2 workshop was used as an opportunity to ask the participants specific questions regarding aspects of the repowering decision tree. Two facets were explored: Firstly the participants were asked to provide their views on the factors influencing a particular uncertainty identified in the decision tree, namely "What factors might influence whether renewable generator applications will come forward"; secondly, they were asked to put forward the goals or outcomes by which the project's success would be measured, or the decisions judged. Once again, the explicit input provided by the workshop participants was not used to replace but rather to refine and inform the structure and values included in the DT.

LEARNING OUTCOMES

The risk workshops have proved valuable to the client organisation with the interactive process focusing the attention of the participants. They have stimulated active participation, increased understanding of the numerous risks and their ramifications and helped build a more comprehensive view of the project. The process is inclusive, bringing together multiple stakeholders, and this encourages cross disciplinary learning through an appreciation of how risks from each part of the project impact one another. In addition, participants gain a holistic view as the maps demonstrate the systemicity of risk, rather than considering risks in isolation from one another. A key value added for the client has been to extend its risk assessment process beyond the static and proscribed business risk register approach it usually employs. Initial feedback, gathered from participants, confirmed many of the benefits discussed above suggesting that they valued each aspect of the process, as the following quotes suggest:

- *Comprehensive:* "Covered lots of potential risks that we hadn't thought about before."
- *Interaction between risks:* "Given the diversity of group, I was impressed how some of the risks tied

into each other in both the same and other areas. The cross-links were interesting."

- *Inclusive:* "I was very impressed – it got the views of a lot of people and was structured"
- *Holistic:* "Got the big picture… rather than looking only at your own area of responsibility."
- *Improvement on traditional methods:* "The traditional method almost tries to get to answers first, as risks are based on experience and previous knowledge…. However the workshop approach takes a different view by focussing on links and thus picked up on a number of things behind (traditional) risks that wouldn't have been thought about."

The use of a DT to analyse the repowering decision has also proved to be valuable to the SSEPD team, providing useful structure to the discussion. The realisation or not of certain key contingencies could have a dramatic influence on the outcome of the repowering project and the value of resolving these uncertainties before key decisions are made may be considerable. Structuring the problem in this way and using decision support software to visualise the impact of changing parameter values and the timing of contingencies being realised helped the team at SSEPD both in understanding the problem and in presenting different futures in an effective way to all stakeholders.

From a process point of view, the use of the workshop to "unpack" the drivers of a particular uncertainty within the DT and to elicit a more complete range of possible performance measures proved particularly effective. While the use of one-to-one elicitation processes and expert judgement to arrive at the probability and impact of a set of uncertainties being realised has the merit of being focused and reliable, the ability to quickly elicit a wide range of views from a broad group of stakeholders in a short space of time (87 drivers for renewable generation offers were elicited in 8 minutes) was considered extremely useful to the process. The statements gathered provide the basis on which to explore the probability data already elicited in more detail and to challenge and revise it as appropriate.

CONCLUSIONS AND FUTURE RESEARCH

Three tranche 1 and one tranche 2 workshops have already been carried out and a final workshop with Shetland stakeholders is planned for Q1 2013. This has allowed the nature and systemicity of risks to be identified at 2 points in time highlighting, amongst other factors, how risk priorities (or the perception of risk) have evolved over time. In addition, an elicitation process has been carried out in order to develop and populate a DT focused on the repowering project within NINES. Integration of these activities has been achieved both implicitly through dialogue within the team and explicitly through focused elicitation during the workshops. Both the individual processes and the integration of them have proven to be valuable to the client organisation and to the research team in terms of developing and validating the models.

The comparative analysis between tranche 1 and 2 workshops will be completed once the Shetland workshop has been carried out and will enable a more representative comparison. Further work is also required to finalise data within the DT and to perform a wide range of scenario analysis. In addition, the authors will seek to formalise the process followed and to draw conclusions about how it may be replicated as a methodology suitable to a broader range of projects.

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