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Proposed Methodology for Technical Due Diligence Assessment of Wind Farm Projects

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Academic Supervisor: Mr Richard Koehler
Academic Examiner: Dr Bahri Uzunoglu

Keith Lynch
Master of Science Programme in Wind Power Project Management,
Department of Wind Energy, Gotland University / Högskolan på Gotland,
Sweden.
Abstract

Technical Due Diligence (TDD) is an extensive document review process in which a complete assessment is made of all potential risks to the realisation or successful operation of a wind farm project. The goal of this assessment is to determine the commercial feasibility of the proposed project.

TDD assessments are extensive undertakings, and potentially subject to the bias of the individual reviewer. This aim of this research project is to develop a methodology to assist in the completion of TDD reviews at the host company for this research project, Mecal Wind Farm Services B.V., which will reduce the subjectivity of the TDD analysis and allow for objective comparison between different projects.

A methodology was developed which assists the TDD assessment process. This methodology uses the combined judgements of individual reviewer and project manager to apply a weighting to the risk assessments carried out as part of the review. A spreadsheet tool was created, based on this methodology, to assist the completion of TDD assessments at Mecal.

The spreadsheet tool was validated by reference to historic project data at Mecal. The output of the tool compared well with the outcome of the project, proving that the concept and methodology of the tool is sound.

Key Words

Due diligence, Technical Due Diligence, wind farm, risk assessment.

Key Terminology

Technical Due Diligence: Technical Due Diligence (TDD) is an extensive document review process in which a complete assessment is made of all potential risks to the realisation or successful operation of a wind farm project. The goal of this assessment is to determine the commercial feasibility of the proposed project.
Abbreviations

ECTS European Credit Transfer and Accumulation System
EWEC European Wind Energy Conference
FMEA Failure Mode and Effect Analysis
HAZOP Hazard and Operability Studies
TDD Technical Due Diligence
VBA Visual Basic for Applications

Acknowledgements

I would like to acknowledge the support and assistance of the academic staff in the Department of Wind Energy at Gotland University, particularly my thesis supervisor Richard Koehler.

I am grateful for the assistance of Mecal Wind Farm Services; in particular Eric Kamphues for his invitation to participate in this research and Fergal O’Mahony for his assistance in the development of this research project.
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1. Introduction

This document Thesis report document was prepared in partial fulfilment of the requirements of the Thesis Module (15 ECTS) of the Master of Science Programme in Wind Power Project Management at Gotland University (Visby, Sweden), for the academic year 2010-2011.

This report describes the research project undertaken with and on behalf of the host company for this project, Mecal Wind Farm Services B.V. (Enschede, The Netherlands) and describes the scope, objectives, methodology & results of the research undertaken.

In addition, it also describes the software tools created as part of this research and should be read in conjunction with the software “User Guide” submitted as part of the Thesis.

A number of confidentiality constraints apply to this research, as described in Section 6.

2. Problem Statement

This research aims to propose and validate a methodology for conducting Technical Due Diligence (TDD) assessments of wind farm projects, using specifically-developed analytical tools to assist successful completion of the TDD assessment and increase the objectivity of the results.

3. Background & Context

Technical Due Diligence (TDD) is a detailed document review process carried out by, or on behalf of, a prospective investor in advance of arriving at a formal decision to invest in a wind farm project. This investment can be made - and hence the TDD carried out - at any stage in the life-cycle of a wind farm project.

The TDD process is a multi-discipline analysis, in which risk assessments are made for all individual elements of the wind farm project. The goal of the TDD process is to give an overall assessment of the commercial viability of the specific project by identifying risks to the realisation or operational success of the project; this information is a key guide to both the technical - and hence financial - uncertainties inherent in the project.

The TDD is, therefore, fundamentally a risk assessment process. An effective TDD review requires detailed technical knowledge of all the engineering and technical disciplines involved in the planning, design, construction and operation of a wind farm.

A TDD review is an extensive undertaking, requiring a significant investment of both time and resources. Current methods for completing this work rely on the judgement, expertise and experience of individual engineers who assess specific elements of the
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project and provide an assessment of the project status based on their findings. Unless these findings and opinions are harnessed effectively – and the risks quantified in as scientific a manner as possible – a TDD can be an overly subjective process, the results of which are not necessarily repeatable or readily comparable against other projects.

4. Key Stakeholders

4.1 Gotland University

Gotland University (Högskolan på Gotland, Visby, Sweden) is the awarding body for the degree of “Master of Science in Energy Technology with Specialisation in Wind Power Management” (60 ECTS), for which this thesis report is submitted. The Department of Wind Energy at Gotland University is a centre of wind energy research in the Baltic Sea region and is currently hosting a number of research programmes in collaboration with universities and industry partners throughout the Nordic countries.

Further information on the Department and its current areas of research is available at the University website, http://www.hgo.se/wpmaster. This research was supervised on behalf of Gotland University by Mr Richard Koehler, Project Manager/Lecturer, Master Programme (MSc) in Wind Power Project Management.

4.2 Mecal Wind Farm Services B.V.

Mecal Wind Farm Services B.V. (hereafter referred to as Mecal) is the host company for this research. Mecal is a medium-sized (approx 100 employees) independent engineering company headquartered in Enschede, The Netherlands. It operates in a number of sectors – including the wind energy sector - and offers engineering expertise and consultancy services to a global client base with main markets in Europe, Asia and North America. Further information is available at the company website, http://www.mecal.eu.

This research project was made possible by the invitation of Mecal and the assistance of a number of their key staff, particularly Mr Eric Kamphues, Business Unit Manager, and Mr Fergal O’Mahony, Project Manager.
5. Scope of Work

As a Technical Due Diligence review is predominantly a risk assessment process, it was necessary to conduct some background research to gain a basic understanding of risk assessment.

Mecal’s current methodology for completing TDD assessments was reviewed. A methodology was developed which, it is believed, will be applicable to all TDD reviews conducted at Mecal and allow for increased confidence in the TDD review process at Mecal. A Microsoft Excel spreadsheet tool, based on this methodology, was developed to assist the TDD review process.

This spreadsheet tool was validated by trial on a sample scope of works from one of Mecal’s recent projects. This required that the output of the TDD spreadsheet tool was compared with the findings of the review originally carried out on this project.

A “User Guide” was written for the spreadsheet tool, to assist Mecal in training staff on its use.

6. Research Constraints

6.1 Confidentiality

A significant portion of the literature reviewed during this research remains the property of Mecal or their clients and much of this information is commercially sensitive. The author has signed a non-disclosure agreement with Mecal, to safeguard the confidentiality of this information.

6.2 Time and Scope

The time available for this research did not permit a detailed analysis of an actual TDD assessment and it was therefore not possible to thoroughly examine a complete multi-discipline wind farm project of significant size. (For example, one of Mecal’s most recent TDD assessments was conducted as part of a multi-company partnership, in which Mecal spent over 300 person-days evaluating the technical content of the project.) The available time allowed only for a brief review of one such project at Mecal; this was carried out in order to gain an understanding of the TDD process within the company.

6.3 Travel, Costs and Logistics

To protect confidentiality, it was necessary to conduct much of the research for this work at the offices of Mecal in Enschede, Netherlands. This time available for this work was limited due to cost and logistics constraints.
7. **Key Drivers of the Research**

7.1 **Business Need**

The key driver of this research is an identified business need. Mecal have carried out a number of TDD reviews in recent years and have developed an expertise in the area. However, they believe that their TDD methodology could be refined to improve its efficiency and have identified requirements to reduce the time taken to complete TDD reviews and to reduce the subjectivity of TDD assessments. Following in-house reviews and client feedback, Mecal would also like to move away from detailed in-depth summarising and analysis documents to a more concise format (with more emphasis on tabular and graphical data rather than text) to make their reports more readable and digestible for the client.

These requirements are driven by a commercial motivation – namely the reduction of costs associated with completing a TDD assessment – and by an aim to improve the quality of the end-product delivered to the client. It is believed that an increased objectivity in the TDD process would enhance the quality of the TDD assessment by increasing the repeatability of the TDD process and allowing for more meaningful comparisons to be made between assessed projects.

7.2 **Client Requirements**

Mecal clients have requested concise, simple statements of risk – much shorter than the necessarily detailed TDD reports typically delivered by Mecal and other consultants. It is believed that the findings of this research project - in particular the specifically-developed Microsoft Excel spreadsheet tool - will contribute to a more concise TDD reporting methodology.

7.3 **Personal Interest**

Technical Due Diligence is a personal interest of the author and research into this area has greatly enhanced the authors’ understanding of the risks and practical considerations of business-driven wind farm project development.
8. Current Industry Practice

There is very limited information readily available on TDD assessment methods used in the wind industry. It is believed that the practices used within individual engineering or consulting companies have been developed within those companies and accordingly details of their methodologies remain confidential. Consequently, there is limited published material on this subject and most of that material uncovered during this research and published by these engineering or consulting companies is marketing material only. This is not surprising, given that wind farm Technical Due Diligence is a relatively new field of work – particularly in the growing offshore sector.

8.1 Mecal Wind Farm Services

The TDD review method currently employed at Mecal requires expert engineers from each relevant discipline to review, summarise and report on project documentation supplied by the client. This documentation typically includes drawings, specifications, schedules, contracts, and reports under a diverse category of headings including permitting/environmental, engineering design and construction, operation and maintenance and wind resources (etc.). On a large project, many thousands of individual documents will be reviewed and many thousands of hours are required to complete this work (note the example referred to in Section 6, where Mecal expended over 300 person-days on one TDD assessment project).

An overall report is then drawn up by the project manager, which summarises all the individual findings of the members of the review team into one report which is then presented to the client. This report seeks to identify all the project risks and propose mitigation measures where appropriate. It will also make recommendations to the client, based on the findings of the review team.

A key criticism of this method is that each individual element of a project assessment is subject to “personal or discipline bias” – i.e. each individual reviewer is sufficiently expert in his/her own field to recognise individual technical risks, but these risks are not independently weighted or adequately assessed in terms of potential real impact to the realisation of the overall project.

It has been found through experience that many engineers conducting these reviews can be overly conservative in identifying risks within their own disciplines (perhaps believing that their own technical discipline is the one with the most important ramifications to the project) and that the actual impact to the overall project of many of the identified risks can be less than initially estimated. This can result in an overly conservative set of recommendations being presented to the client.

8.2 Competitor Companies

Without access to TDD assessments in any company other than Mecal, it is difficult to generalise on methods that competitors may be using for TDD appraisals (although it seems reasonable to assume that similar methods to those at Mecal must be employed).
It is not known if any of these competitor companies have developed any specific in-house spreadsheet - or similar - tools to assist them with the TDD assessment process, although it seems reasonable to speculate that they have.

A number of engineering or consultancy companies have presented papers on Technical Due Diligence at wind energy conferences. Among them is a paper presented by Garrad Hassan (Offshore Wind Due Diligence – How Country and Life-Cycle Stage Impacts What To Look For) at the European Wind Energy Conference (EWEC) in Marseille, France, in 2009. This paper summarises general risks under various headings and specific risks associated with offshore development in individual countries. This paper does not propose or explain any TDD assessment methodology as proposed in this research.

### 8.3 Additional Research

Additional research was carried out into risk assessment methods used in industry, with a view to finding existing methods which could be applied to the Technical Due Diligence process. This did not produce any results strictly relevant to the TDD assessment needs at Mecal.

Standard methods of risk assessment such as Failure Mode and Effect Analysis (FMEA) and Hazard and Operability studies (HAZOP) were briefly reviewed and determined to be unsuitable as they focus on purely technical issues. The HAZOP technique, which uses standard key-words and prompting questions, could potentially be adapted to develop a comprehensive TDD assessment checklist based on a similar strategy, although it is not relevant to the core goal of this research.
9. Previous Research at Mecal

In 2010 Pedro Peña Gama, an MSc student at the Institute of Physics at the University of Oldenburg (Germany), conducted research into Technical Due Diligence on behalf of Mecal. The scope of this work was limited to the front end study stage of the wind farm development process, and specifically focussed on the following areas:

- Preliminary surveys,
- Foundations,
- Wind turbine technology selection,
- Wind farm layout,
- Electrical infrastructure and cabling,
- Installation methods.

The output of this research included a Microsoft Excel spreadsheet which functions as a checklist of items to review as part of a TDD assessment. It was developed from the existing project database at Mecal.

This tool is not currently used in the TDD assessment process at Mecal as it does not assist Mecal in assessing the level of risk. However, its checklist serves as a useful “starting point” for the purposes of developing a new tool which can assist Mecal in evaluating risk.
10. Research Objectives

The key objective of this research is to develop a working Technical Due Diligence methodology that satisfies a key business need at Mecal. This research aims to improve Mecal’s Technical Due Diligence assessment process by developing an appropriate methodology for completion of these assessments. It is anticipated that this methodology will increase the objectivity of the TDD assessment results and aid the TDD reporting process within Mecal. It may also facilitate direct comparison of TDD assessments carried out on different wind power projects at Mecal.

This research also aims to analyse existing TDD assessment methods at Mecal and develop an appropriate spreadsheet tool to assist Mecal in completion of TDD assessments.

A secondary goal of this research is to learn more about the real risks and practical considerations of wind farm project development for the personal benefit of the author, which will be achieved by investigation of existing projects at Mecal.

11. Research Methodology

This research originated in response to an invitation from Mecal to assist them in enhancing their Technical Due Diligence (TDD) assessment methods. Consequently, Mecal’s business need was examined to define the problem and devise a method of solving it.

Some background research was initially carried out into risk assessment and Technical Due Diligence to develop a sufficient understanding of the principles involved.

Mecal’s existing TDD assessment process was examined, with particular reference to a large offshore project, for which Mecal have recently completed a TDD assessment. This particular project was studied to gain an understanding of the scope and complexities of the TDD assessment. Some detailed conversations with Mecal staff members contributed to a greater understanding of the project. This work was carried out at the offices of Mecal in Enschede, The Netherlands, in order to protect the confidentiality and security of the project documentation. It was necessary to spend several weeks in-situ at the Mecal offices to complete this work in sufficient detail.

An original spreadsheet tool was created, based on a specifically-developed methodology (this tool and the theory behind it are described in detail in Section 12), to assist completion of the TDD assessment process. This spreadsheet was then tested and validated by reference to an historic project at Mecal. Following this, a “User Guide” for the tool was written to aid Mecal in training their staff on its use.
12. The Microsoft Excel Tool

12.1 General

A Microsoft Excel spreadsheet tool was created to assist the Technical Due Diligence review process. The tool is based on the principle that whilst the individual engineers are experts in their own technical disciplines, the project manager (who does not carry out assessments on individual client-issued project documents) has a better understanding of the goals and risks of the overall project and is therefore in a better position to assess the real risks to the realisation of the project.

Optimum use of the tool therefore combines the independent judgements (inputs) of both the project manager and the individual engineer responsible for reviewing a specific technical discipline of the project, from which a weighted risk assessment based on their inputs is produced.

The tool also produces a unique score for the overall project, based on the number and types of risks identified during the TDD assessment. It is anticipated that this function, in particular, may allow future comparison between wind farm projects.

It is not the intent of the tool to act simply as a checklist, although it fulfils this function via a number of sample checklists included under a number of headings which have been developed from previous projects at Mecal.

The tool uses a number of macros – written with Microsoft Visual Basic for Applications (VBA) code – to automatically select specific worksheets based on user selections of project type (i.e. onshore or offshore, etc.).

12.2 Format

The spreadsheet tool consists of a number of worksheets, as follows:

- Project Front Page – in which the user enters basic data about the project and runs a macro to select the relevant module worksheets for the project.
- Project Summary - which graphically summarises the quantities and types of risks identified during the TDD assessment and gives an overall project score based on these risks.
- Individual modules (worksheets, each representing a typical contract package or technical discipline on a large windfarm project and containing a checklist of items), as follows:
  - Planning, Project Management
  - Permits
  - Leases, Agreements
  - Onshore Investigations
  - Offshore Investigations
  - FEED Studies
  - Procurement
  - Decommissioning
  - Certifications, QA
  - HSE
  - Insurance
  - Asset Management
  - Technical Operation
  - Logistics O&M
  - Service & Maintenance
12.3 Definitions

The Microsoft Excel tool uses a number of terms which have specific meanings in this context, as follows:

**General:**

**USER**

The person(s) who carries out due diligence assessments, and who reviews client documentation as part of this process. This is typically expected to be the engineer responsible for reviewing an individual technical discipline.

**EXPERT**

The person(s) who oversees and manages the work of the USERSs and with overall responsibility for the project. This is typically expected to be the Project Manager or someone sufficiently experienced and with the authority to decide on the relative importance, to the project as a whole, of each of the individual elements of the project.

**USER Inputs:**

**YES**

The USER agrees that the document under review is of acceptable scope & quality and that it is sufficiently complete, to provide meaningful input to the TDD tool.

**NO**

The USER does not agree that the document under review is of acceptable scope & quality and that it is sufficiently complete, to provide meaningful input to the TDD tool.

**LOW CONSEQUENCE**

The USER considers that the information presented in the document under review is likely to be of low consequence to the project.

**ACCEPTABLE CONSEQUENCE**

The USER considers that the information presented in the document under review is likely to be of acceptable consequence to the project.

**UNACCEPTABLE CONSEQUENCE**

The USER considers that the information presented in the document under review is likely to be of unacceptable consequence to the project.
EXPERT Inputs:

LOW IMPORTANCE
The EXPERT considers that the particular subject (or line item) is likely to be of low importance to the realisation of the overall project.

MODERATE IMPORTANCE
The EXPERT considers that the particular subject (or line item) is likely to be of moderate importance to the realisation of the overall project.

CRITICAL IMPORTANCE
The EXPERT considers that the particular subject (or line item) is likely to be of critical importance to the realisation of the overall project.

TDD Tool Outputs:

LOW RISK
This indicates that, considering the weighted judgements of both the EXPET and the USER, the particular subject or line item is likely to be of low risk to the realisation of the overall project.

MEDIUM RISK
This indicates that, considering the weighted judgements of both the EXPET and the USER, the particular subject or line item is likely to be of medium risk to the realisation of the overall project.

HIGH RISK
This indicates that, considering the weighted judgements of both the EXPET and the USER, the particular subject or line item is likely to be of high risk to the realisation of the overall project.

12.4 Use of the Tool

Inputs by EXPERT:

The EXPERT is required to assess the relative significance of every subject line item to the goals of the overall project. In doing so, the EXPERT is responsible for assigning a weighting to that item, which will contribute to determining the level of risk that item poses to the project as a whole.

The EXPERT is required to answer the following question for each item:

- What is the PREDEFINED IMPORTANCE CATEGORY? - i.e. how important is this item to the whole project?

The EXPERT is to choose from the following possible answers only (to be selected from the drop-down menu):
The selected answer is the EXPERT’s view on the relative importance of that particular line item to the overall project. This view should be informed by his/her own previous experience and the unique factors of the particular project.

**Inputs by USER:**

The USER is required to answer two questions for each subject line item investigated, the first of which is:

- Is the Document of Acceptable Scope, Quality & Completeness?

Possible answers (to be chosen from the drop-down menu) are:

- YES
- NO

The second question to be answered is:

- What are the Consequences of the Document Findings?

Possible answers (to be selected from the drop-down menu) are:

- LOW CONSEQUENCE
- ACCEPTABLE CONSEQUENCE
- UNACCEPTABLE CONSEQUENCE

In making the above judgements, the USER is responsible for assigning a weighting to that item, which will contribute to determining the level of risk that item poses to the project as a whole. The USER should exercise appropriate professional judgement at all times using the Excel Tool.
12.5 Scoring System

For the purposes of assessing individual risk items, two scoring systems have been developed, one for each scenario of either “Acceptable” or “Unacceptable” quality documentation, as determined by the USER. In either case, the selection is limited (by deliberate design) to a choice of three items. Mecal requested that the scoring system be simple, and that the USER and EXPERT be limited to choosing from no more than three options on any drop-down menu.

A key approach of this research is the development of weighted risk assessments. The selections made by the EXPERT and the USER are each assigned a numerical value (Table 1) corresponding to their assessments of consequence. The corresponding risk categories are shown in Table 2. Note that the scoring assigned by the EXPERT is different to that assigned by the USER, reflecting the additional weighting given to the EXPERT’s judgement in the case of items considered by the EXPERT to be of “Critical Importance”. This is intended to reflect the experience of the project manager and reduce the “discipline bias” of the USER which may otherwise occur.

<table>
<thead>
<tr>
<th>SCORE VALUES, ACCEPTABLE DOCUMENTATION QUALITY</th>
<th>EXPERT INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>USER INPUT</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1 - Numerical Score Values, Acceptable Documentation Quality (by author)

<table>
<thead>
<tr>
<th>RISK CATEGORIES, ACCEPTABLE DOCUMENTATION QUALITY</th>
<th>EXPERT INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW CONSEQUENCE</td>
<td>LOW IMPORTANCE</td>
</tr>
<tr>
<td>LOW RISK</td>
<td>LOW RISK</td>
</tr>
<tr>
<td>ACCEPTABLE CONSEQUENCE</td>
<td>LOW RISK</td>
</tr>
<tr>
<td>UNACCEPTABLE CONSEQUENCE</td>
<td>LOW RISK</td>
</tr>
</tbody>
</table>

Table 2 - Risk Categories, Acceptable Documentation Quality (by author)
Where the USER has determined that the scope & quality of the reviewed documentation is inadequate (given by a “NO” answer to the question: “Is the Document of Acceptable Scope, Quality & Completeness?”), the following score values (Table 3) & risk categories (Table 4) apply:

<table>
<thead>
<tr>
<th>USER INPUT</th>
<th>SCORE VALUES, UNACCEPTABLE DOCUMENTATION QUALITY</th>
<th>EXPERT INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3 - Numerical Score Values, Unacceptable Documentation Quality (by author)

<table>
<thead>
<tr>
<th>USER INPUT</th>
<th>RISK CATEGORIES, UNACCEPTABLE DOCUMENTATION QUALITY</th>
<th>EXPERT INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW CONSEQUENCE</td>
<td>LOW IMPORTANCE</td>
<td>LOW RISK</td>
</tr>
<tr>
<td>ACCEPTABLE CONSEQUENCE</td>
<td>MODERATE IMPORTANCE</td>
<td>MEDIUM RISK</td>
</tr>
<tr>
<td>UNACCEPTABLE CONSEQUENCE</td>
<td>CRITICAL IMPORTANCE</td>
<td>HIGH RISK</td>
</tr>
</tbody>
</table>

Table 4 - Risk Categories, Unacceptable Documentation Quality (by author)

The judgement of the EXPERT is given a greater weighting than that of the USER, as can be seen in the above tables. Note also that the absence of acceptable quality documentation – as determined by the USER - elevates the risk level, highlighting the additional potential risk that this scenario brings to the project. This has the effect of producing a greater number of “High Risk” items, which in the opinion of Mecal, is desirable in cases where insufficient information is available to make a sound assessment. This can also prompt Mecal to issue a request to the client for further information for absent documentation.

A function has been developed for the spreadsheet tool which can express the risk profile of the entire project as a single numerical value. The intent of this is to indicate, in simple terms, the level of risk uncovered during the TDD. A “Points Risk” ratio has been developed for this purpose, which is calculated from both the quantity and types of risk uncovered during the TDD assessment.
An arbitrary points system was established, which awards a fixed number of points to each category of risk, as follows:

<table>
<thead>
<tr>
<th>RISK LEVEL</th>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>POINTS AWARDED</td>
<td>10</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 5 - Points Awarded per Risk Level (by author)**

The Total Points Scored for the project is calculated by multiplying the total quantity of risks identified at each Risk Level by the corresponding points, shown in the table above. This value is then divided by the quantity of all risk items identified in the TDD assessment, to give the “Points Risk” Ratio for the project. This is, in effect, the average “risk” per item and has no upper or lower restrictions on its value.

This number has no particular significance for any individual project or TDD assessment; however, it does allow simple comparisons to be made between projects. If this ratio was not applied, it would be impossible to compare projects using “Total Points Scored” only, as the size of the project (i.e. the quantity of items reviewed) would be the determining factor in the calculated result. The application of this ratio will reduce the impact of differences of scale between two projects.

The Total Points Scored and Points Risk Ratio values for the project are presented on the Project Summary page of the Microsoft Excel spreadsheet tool.

### 12.6 Outputs

The tool produces a number of outputs. Three levels of risk are possible for any given line item, shown on the individual module worksheets as follows:

- LOW RISK
- MEDIUM RISK
- HIGH RISK

Each of these reflects the combined judgements of both the EXPERT and the USER and is a combined view on the risk of that particular line item to the realisation of the overall project.
In addition, the tool produces, via the Project Summary page, a numerical and graphical summary of the quantity and type of risks identified during the TDD assessment. It also calculates Total Points Scored and Points Risk Ratio values for the project, which may be used for the purposes of comparison with future TDD projects. This page can also be used as an aid to the reporting process.

12.7 Interpretation of Outputs

It is obvious but important to state that use of the spreadsheet tool does not and cannot replace professional engineering judgement. It is purely a tool to aid in the identification of risk items. The tool simply evaluates the combined judgements of the EXPERT and the USER to produce a weighted risk assessment based on their inputs.

Output from the Excel Tool should be checked against previous project experience and must be confirmed by an experienced project manager familiar with the development of wind power projects.

12.8 Limitations

The spreadsheet tool has a number of limitations, as follows:

- It is only as good as the professional judgements provided as inputs.
- Cannot replace the professional judgement of experienced personnel.
- Expert knowledge is required to determine the “Consequence Categories” of individual risk items; this expertise is generally limited to experienced project managers. (It is arguable that this is actually a benefit to the tool, in that it offers a more controlled approach to risk assessment by reducing the “discipline bias”.)

12.9 Benefits

The key benefits of the spreadsheet tool are considered to be:

- Can aid identification of risk items in the TDD.
- Can reduce subjectivity in risk assessment, by considering the judgements of both the USER and the EXPERT with appropriate weightings.
- Reduces the “discipline bias” of an individual reviewer.
- The tool can be used to help manage the technical work of others (a key role of a project manager).
- Can aid formal TDD reporting via the Project Summary Page.
- The checklists included in the tool can prompt additional questions to the client, the information from which may then contribute to a more comprehensive TDD assessment.
13. Results

A methodology has been developed which will contribute to more objective completion of Technical Due Diligence assessments. This methodology combines the independent judgements (inputs) of both the project manager and the individual engineer responsible for reviewing a specific technical discipline of the project, to produce a weighted risk assessment.

A spreadsheet tool, based on the above methodology, was developed to assist the TDD assessment process.

This spreadsheet tool uses weighted scoring systems to apply numerical values to the inputs of the tool users. These scores are then summarised and presented in numerical and graphical which can then be used as an aid to project reporting.

The spreadsheet tool has been tested on a historic project at Mecal and shown to produce results which agree with the practical experience of that project. It should be noted that the tool does not replace professional engineering judgement, but acts as an aid to the Technical Due Diligence assessment process. It is therefore expected that the tool can be reliably used as an aid to conducting future Technical Due Diligence assessments within Mecal.

14. Validation

At early stages of development of the Technical Due Diligence assessment tool, the concept of separate inputs by USER and EXPERT was proposed to – and accepted by - Mecal. Development of the tool continued based on this principle, which, it is believed, substantially reduces the subjectivity of a TDD assessment.

Upon creation of the basic structure of the tool, a validation exercise was carried out to prove the concept of the tool and to determine if it produced reasonable and reliable answers.

An historic project was examined, for which Mecal had previously completed project management services. The spreadsheet tool was used to complete a simple assessment (similar to a TDD assessment, but on a smaller scale) on the original project documentation, and the output was compared to the original assessments of those projects. The output of the tool compared well with the outcome of the project, proving that the concept and methodology of the tool is sound and that it produces reasonable results.

Following this, minor changes to format of the tool were made and a number of additional checklists were added. It is intended that these checklists will be developed in Mecal on an on-going basis.
15. Conclusions

This research sought to develop a methodology to improve on existing methods of Technical Due Diligence assessments at Mecal Wind Farm Services B.V.

The objectives of the research have been accomplished: a new methodology has been developed and this concept has been used to create a specifically-developed spreadsheet tool for use at Mecal. This tool assists the completion of TDD assessment at Mecal, will facilitate future comparison between TDD projects assessed and can assist the reporting methodology at Mecal.

During this research, the author has learned a great deal of new information on the development of offshore wind farm projects in general and on the process of Technical Due Diligence in particular.

Mecal now have a functional spreadsheet tool which they can use in the completion of TDD assessments on behalf of their clients. It is anticipated that this tool will result in a higher quality of TDD assessment – by achieving a less subjective output – which should add value to the final product delivered to the client.
References


Bibliography

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In addition, a number of Mecal projects were used as research material, in order to gain an understanding of the TDD process and to facilitate development of the Microsoft Excel TDD assessment tool.

Existing checklists at Mecal (sourced from Peña Gama, Pedro; Improvements to Offshore Wind Farm Technical Due Diligence Assessments, University of Oldenburg, Institute of Physics, 2010) were added to some worksheets in the TDD spreadsheet.

Due Diligence literature from selected companies:

Appendix A: Microsoft Excel Tool - Technical Notes

The spreadsheet tool was created using Microsoft Excel 2010 (Version 14.0.5128.5000, 32-bit), on a personal laptop running the Microsoft Windows 7 Operating System (Version 6.1.7600 Build 7600).

The finished version of the tool was subjected to a number of validation exercises (described in Section 14) at Mecal headquarters, using an older version of Excel (Microsoft Excel 2003, Version 11.8328.8329, SP3) installed on a PC running Windows XP Professional (Version 5.1.2600 Service Pack 3 Build 2600).

Preliminary research suggests that any relevant compatibility problems between different versions of Microsoft Excel will be limited to a “minor loss of fidelity” rather than a “significant loss of functionality”. These are described in “ActiveX control compatibility issues” section of the Help function in Microsoft Excel 2010.

It has been assumed, for the purposes of this research, that future versions of Microsoft Excel will maintain, as a minimum, the functionality of Version 14.0.5128.5000.