Durham University
School of Engineering and Computing Sciences

Requirements Document 2009/2010

Windfarm Planner

airnegy

Development By:
SEG 2

Document Information

Project Name:	Wind Farm Planner		
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1.2	25/10/2009	Prathna Singh	Draft Section 5
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2.0	14/11/2009	Eloise Stancombe	First Draft Complete
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3.0	17/11/2009	Eloise Stancombe	Final Draft
3.1	18/11/2009	Eloise Stancombe	Partial Edit
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3.5	20/11/2009	Eloise Stancombe	Updated Section 6
3.6	24/11/2009	Seg 2	Final

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Purpose (Executive summary)

Airnegy have been approached to develop an application to aid regional development agencies in the planning, preparation and maintenance of wind farms in the UK. At a high level, the software will maintain information on planned and existing wind farms, electrical substations and other relevant data to support the Regional Development Agencies (RDAs), decision-making process in relation to where and when to place wind farms.

This document will detail the project justification, requirements, constraints, stakeholders and dependencies as well as the project plan to demonstrate that Airnegy has the resources and the time to develop the application. Airnegy also includes research into the environmental, scientific, financial and political issues involved.

1. Domain Analysis

1.1. Analysis Process

In order to clarify exactly what the system needs to do, the data and environment in which the system will work in must first be looked at. The system will operate within the RDA. However, the RDA does not create or manages wind-farms nor do they research wind-speeds in random locations, thus the system must also create, and input reports and, statements from third-party hired companies. Additionally all outputs from the system have to be approved by the management before any action regarding them is to commence. Categorising these forms and requests as input and output we get:

Inputs

- Users input data concerning power consumption and production figures for the region in question. This data is given to the RDA by a third-party.
- Users input data concerning wind-turbines from companies which associate with the RDA including generic models for use when requesting quotation from companies which are not directly associated with the RDA.
- Users input wind speed data which are then converted into wind-maps. This data is given in standard form by a third-party.
- Users also initially input data regarding existing wind-farms and electrical infrastructure.

Outputs

- A report presenting possible locations for wind-farms including creation and running costs along with data which concern the electrical infrastructure and operation of the turbines such as up-time and power production.
- A report presenting areas in which require extra power but there is insufficient wind-map information in order for the system to suggest wind-farm location.
- A report determining specifications of wind-farm to be build which is sent to third-party associated company which will create and manage wind-farm.

1.2. Analysis

This system will run on a standalone computer within a business. Thinking about where this system could be used helps to identify different type of stakeholders who will have an interest in the building of such a system.

Stakeholders

End Consumers and Energy Suppliers
The consumers are more likely to choose their electricity supplier based on price but some choose based on their ability to supply greener energy. It is therefore important for Energy suppliers to have cheaper greener electricity on offer for current and future customers.

Local Communities
The local area where a prospective wind farm is to be placed must also be considered. This is especially important as wind farms are met with different levels of enthusiasm in different areas. Some like the greener aspects of having one while others communities consider them eyesore and also disagree on the noise pollution that may occur. Therefore they have to be a big consideration when planning a wind farm.

Planning and Development Agencies
This involves all the companies that will be incorporated in the building and planning of the prospective wind farms. They will want to know the semantics like turbine models and grid connections.

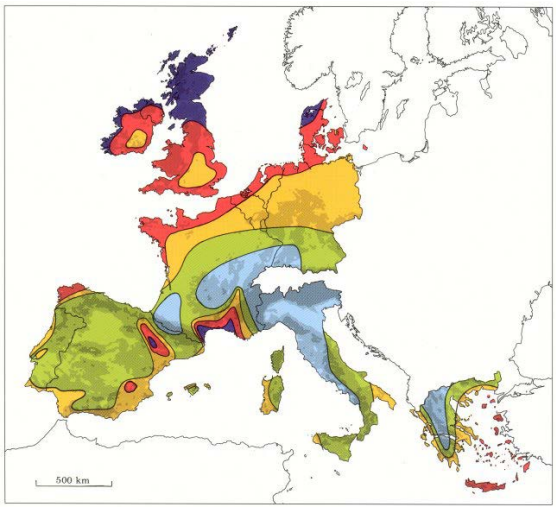
Government
This covers the main parliament in London to all the local councils. Different authorities will have different interests and different levels of power. The Government will be more interested in how much green power is being produced whereas the RDA will more interested in their regional performance.

Due to the current economic climate and with fossil fuels running out, renewable energy is becoming more important. This software will be able to help with the aim of using more wind power, as it is considered possible that the whole of the UK can be powered using just wind power according to the European Union.

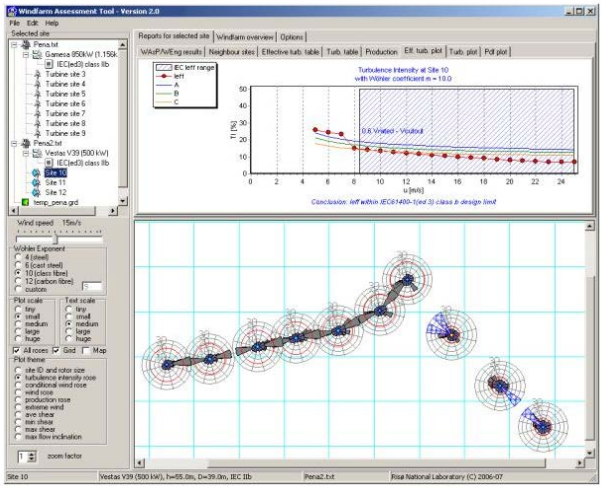
However wind power is not the only renewable energy source available. There is also solar power, bio fuels and hydropower. Therefore with competition from other sources, planning and producing also has to be cost effective and not just ‘green’.

Competitor's Software

WAsP



Example of a Wind Atlas produced by WAsP software at 50 metres above ground level



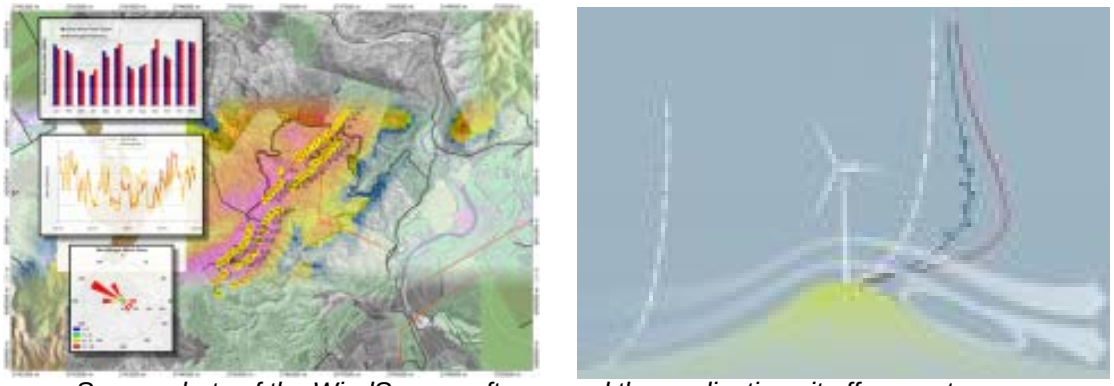
Screen Shot of the WaSP Software

WAsP, Wind Atlas Analysis and Application Program is used for predicting wind climate, wind resource and power production from wind turbines and wind farms. The predictions are based on wind data measured at stations in the same region. This software is also used for wind farm production and efficiency, wind climate estimation, wind resource mapping and positioning of wind turbines. Its main function however is for Wind Atlas generation. Wind Atlases are used to try and identify places and countries that are suitable for the production of Wind energy. It contains information on wind speed and wind direction in a region. The required data includes 10-minute averaged wind speeds at heights between 30 and 100 meters over a 10 to 20 year period to produce a Wind Atlas.

WAsP 9 will run on a computer with a minimum 133 MHz processor, 32 MB RAM and 80 MB of free hard disk space. However, at least 800 MHz processor and 128 MB RAM are recommended, especially if for a large projects. Windows XP or later is recommended as an Operating System. The cost for the system is £3,000 for the standard

This system is very similar to our proposed solution, although we will not want to produce wind maps as this will not be a way in which wind farms will be selected. Different types of terrain and wind flow will also not be included as the system will be a guide to where to place a wind farm and will therefore not include detailed wind information on what happens if a wind farm will be placed there.

WindScape

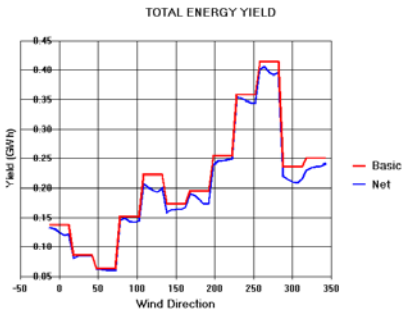


Screen shots of the WindScape software and the applications it offers customers.

WindScape is software, developed by WinLab, that is used to locate potential wind farm sites which is both cost effective and quick to use, a global energy development company. It outputs maps with annual wind speed and annual energy yield. At any point within the area of interest, it is possible to extract a time-series of wind speed and direction. When in operation, it takes synoptic weather data gathered by the World Meteorological Organisation (WMO). This dataset is made up of the collection and processing of wind speed, wind direction, temperature, moisture, pressure and other atmospheric parameters over the entire globe. This raw data is collected and interpolated onto a global latitude/longitude grid. The High Resolution Model takes into account friction from various types of land cover (forests, crops, streams) and acceleration over and around smaller-scale topography. The result is a model of wind conditions within the area of interest. Parameters such as average wind speed and directional information can then be extracted for any point.

This is a useful system to look at as it is similar to the proposed solution. Except for the map section, which is more detailed than we are planning to implement. The information collected on which to base the wind farm is more specialised than the data used in our system which will be based on wind speed only and not on terrain, climate or wind direction. However it does not take into account the national grid system to which the wind farms must be joined.

WindFarm



Example of energy yield report produced by the software

Example of the 3d-visualisation available to users.

WindFarm, by reSoft is used once the site for a wind farm has been decided and it will help bring the user to a decision on whether the land is suitable or not. It has a Graphical User Interface (GUI) that enables the user to produce an efficient, optimised wind farm design. This software will also calculate the energy yield of the proposed wind farm as well as how to optimise it. It will calculate the level of noise pollution and the wind flow across the terrain of the chosen ground so that the user can see the wind flow as well as the wind speed. It will also build a 3dimensional-visualisation of the wind farm so that the user will have an idea of what it will look like when completed. It will also display the radar ceiling height based on the line of sight analysis to ensure that the disturbance is minimal. It also provides the option of data conversion like contour and grid information.

The software runs on Windows 2000/XP/Vista and does not require any external software packages. Self-guided tutorials are included on the software CD with additional support provided by email to inexperienced computer users. This software us used by E.ON UK plc. The price for the entire system is between £3,000 and £4,000.

This system was useful to look at due to the act that helps the user come to a decision about whether the location is appropriate for building a wind farm or not. However many of the calculations it uses are useful and similar to the ones that our proposed solution will require.

2. Project Purpose

The purpose of the Airnegy Wind Farm planner is to provide proof-of-concept software that will be used by England's Regional Development Agencies (RDAs); a group of 9 organizations that where launched in 1999 in order to improve economic development, social and physical regeneration. As such each RDA has been tasked with contributing to the UK's targets on renewable energy. In support of this, each RDA is examining the potential for their region to contribute wind-powered energy to the national grid infrastructure.

Proof-of-concept software aims to aid the RDA for the North East (although it should also prove beneficial to the other 8 RDAs) in planning for wind farms. This will be done by providing software that will aid in planning for wind farms by allowing an RDA to associate wind speed information with electricity infrastructure information. Thus enabling the user to add, view and edit information such as name, location (Latitude/Longitude), date online (dates in the past are existing, dates in the future are planned), number of turbines, turbine model name and power output (MW) about existing or planned wind farms. Also the user should be able to add, view and edit information based on the Long Term Development Statements that Network Distribution Operators (NDOs), information such as name, location (Latitude/Longitude), size in kilovolts (33kV, 66kV, 132kV), maximum capacity (megawatts) and current capacity (megawatts) concerning electrical substations. All this information will be able to be queried by the user giving them information such as the average wind speed for different heights above sea level, at different locations of interest as well as allowing the user to specify a region around that centre location for which wind data should be displayed e.g. "show me the wind speeds at 20m above ground for NZ276415 and the surrounding 5km".

The Airnegy Wind Farm Planner project will aim to use the above information to allow the user to:

- Find potential wind farm sites by finding windy areas and then determines the distance away from electrical infrastructure (e.g. electrical substations).
- Search on a need to provide electricity to a particular substation and then determine the nearest windy area to that substation.
- Model the addition of a new wind farm by changing several variables associated with a potential wind farm which include name, location, number of turbines, maximum power output (MW), connected sub-station and distance from sub-station as well as allowing the user to enter a cost per km for connecting the wind farm.
- Project cost and model typical yearly yields as well as the typical yearly revenue based on the variation of, maximum power output of the wind farm, hours per year of operation (based on a percentage of total year in operation), wholesale price of electricity, revenue price for renewable energy certificates, average wind speed and if adding the proposed wind farm will exceed the maximum capability of the connected substation with the modelled maximum power output.

Our proof-of-concept software can be broken down into 3 sections; the user interface, the database and the java code that will connect the aforementioned 2 sections.

3. Roles and Deliverables

3.1. Roles

Airnegy has a democratic structure. Each team member has equal say in decision making. Whilst the heads of sections are responsible for the collation, it will be a group effort in the content. All decisions will be made by the whole group, with the majority verdict dictating the outcome.

All Heads of their sections mentioned below are responsible for all team members work to be handed in by the soft deadlines set.

Daniel Allsop
Daniel is joint head of implementation with Alexandros. This is one of the subsections of the final Design Document. He has good experience in the programming language Java due to a logical mind. For the requirements he has had several sub sections to do, this can be viewed on the Gantt chart.

Danny King
Danny is the head of Testing. He has prior experience of testing. He has a very methodical way of working and he has a reasonable knowledge of the Java API. Other work from other sections shall be also done by him can be viewed on the Gantt chart.

Prathna Singh
Prathna is the head of Design. This means that she will be collating the sub section of the design document as well as the joint head of the whole Design Document with Eloise. Her skill set consists of good mathematical skills to analysis functions, good eye for detail and a systematic approach.

Eloise Stancombe
Eloise is the head of the Requirements Document as well as joint head of collating the Design Document. Her skill set includes a good command of the English Language as well as thinking as a user as if she was not a programmer. Other work will be set in the Gantt chart.

Alexandros Zachariades
Alexandros is joint head of the Implementation with Daniel. As mentioned previously it is a sub section of the Design Document. He has a lot of experience in programming and is very good at problem solving. Other work on the Gantt Chart.

3.2 Deliverables

We have all agreed soft deadlines for all deliverables in a complete form to be ready one week before the final deadline. This way we have time to look through the document as a group as well as allow the heads of each section to make any changes and format. Hopefully this will minimise mistakes.

User Acceptance Testing (draft)- 3rd November 2009, 17:15.
Also known as "end user testing," this is the phase of the project where the client, tests the system in a "real world" environment. We have specially designated tests which we have created to test the usability and functionality of the system.

Requirements Specification and User Acceptance Testing- 24th November, 17:15.
The Requirements Specification is a detailed statement of the exact results we and the customer want to get from a project. This is a condition or capability that must be met or possessed by the system to satisfy the mandate. Requirements include the quantified and documented needs, wants and expectations of the sponsor, customer and other stakeholders. The document is a defined goal that details the desired end result of a project. This helps project managers to ensure that they are delivering exactly what their customers want, because it is specified and communicated clearly to those involved in the project.

Prototype Demonstration- 26th January 2010, 14:15.
This is where we hope to have a rudimentary working system built as a part of the development process. A basic version of the system is built, tested, and then reworked as necessary until an acceptable prototype is finally achieved. Then from this the complete system can now be developed.

Implementation Demonstration- 25th February 2010, 14:15
This is the demonstration in which the system is tested using the tests mentioned in the User Acceptance Document. The high priority requirements have to be implemented.

Design Document- 29th April, 17:15
This document consists of four distinct but interrelated activities – data design, architectural design, interface design, and procedural design. This document will help implement the requirements of the user in a way that a programmer can interpret and therefore implement accurately.

4. Project Plan

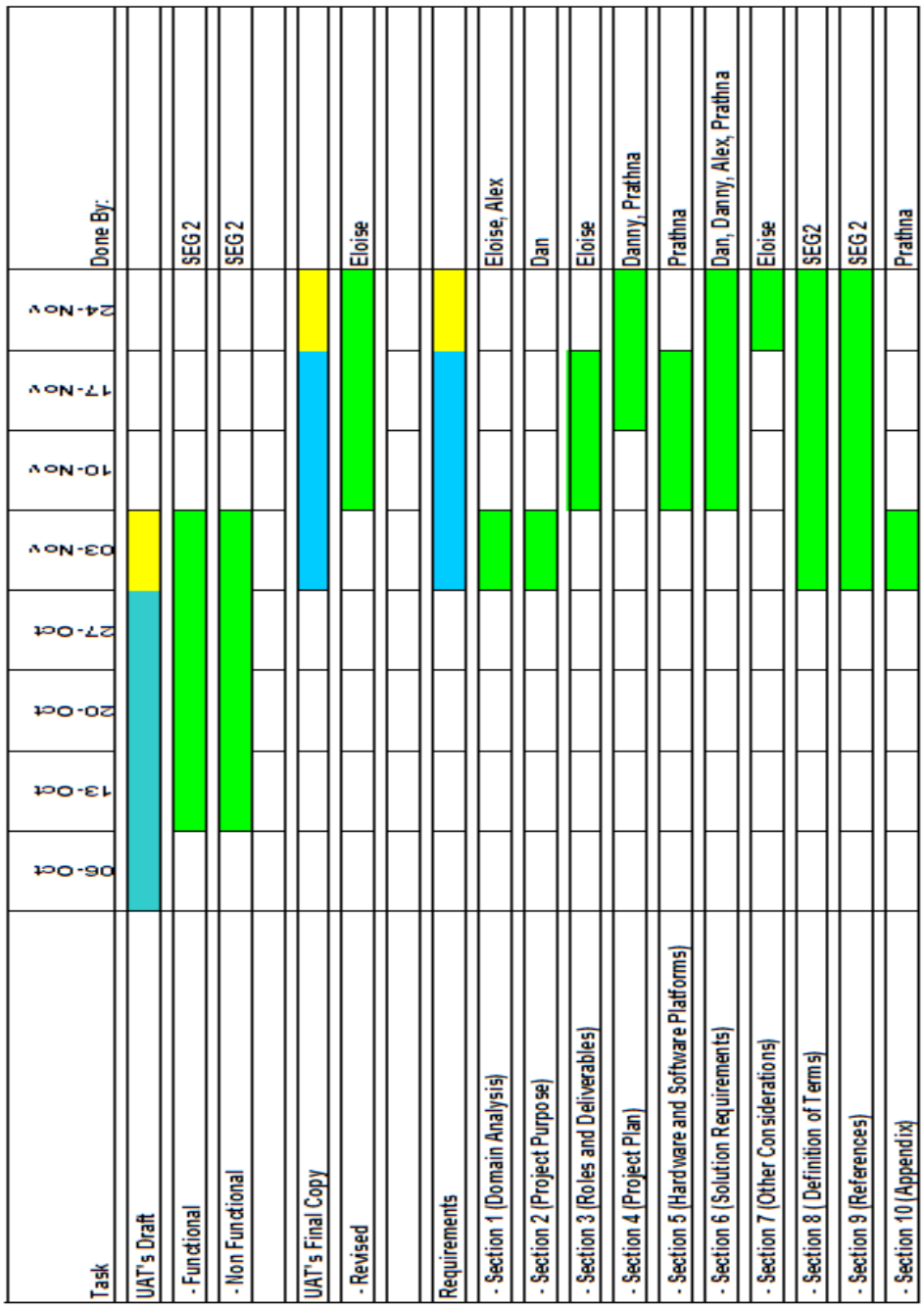
Below is a Gantt chart to show the project schedule that our team will be working to. The first Gantt chart is an indication of the work we are currently doing, in more detail because we know what work is needed from us, from the template of the requirements that we have been given. The later Gantt chart is our future deliverables and what we will be working on.

Key:

- This is the week of the final deadline
- This is the duration of the time allocated until our soft deadline
- This is the planned time we have for each part of the section; some sections are dependent on others so they have to be finished first in order to start the next section.

Dependencies

- Solution requirements can only be started on when the UATs have been complete.
- UATs can only be completely finished once they have been handed back with feedback.
- The implementation demo is a continuation of the prototype demo.
- Maps interface can only be started once most of the system is functional because it is one of our low requirements.
- The user guide can only be done when the implementation has been done.
- The rest of the work can be started once the end of the requirements document has been completed, hence a lot of work can be started from the 1st of December.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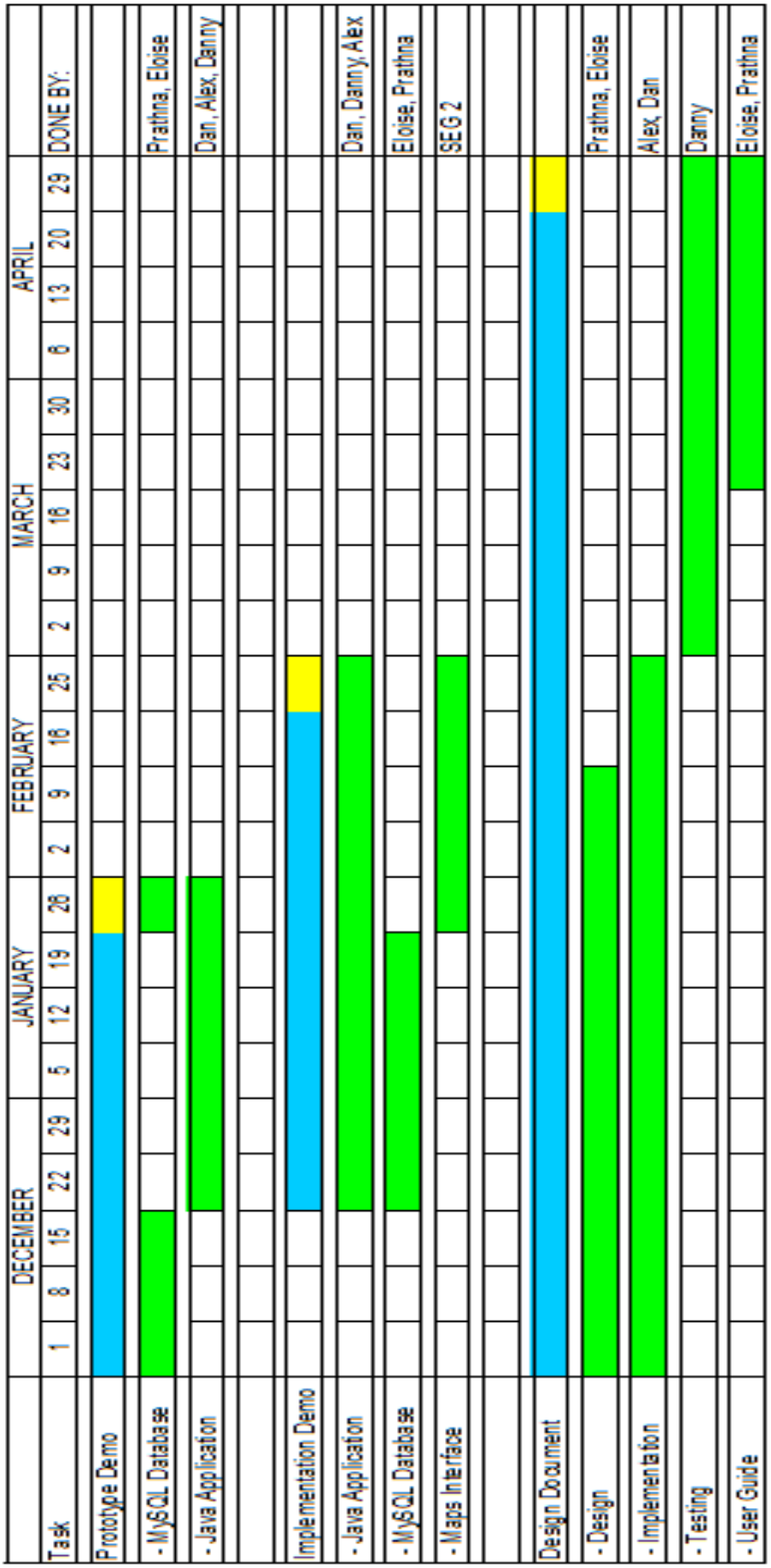
Done By:
06-Oct
13-Oct
20-Oct
27-Oct
03-Nov
10-Nov
17-Nov
24-Nov
UAT's Draft
- Functional
SEG 2
- Non Functional
SEG 2
UAT's Final Copy
- Revised
Eloise
Requirements
- Section 1 (Domain Analysis)
Eloise, Alex
- Section 2 (Project Purpose)
Dan
- Section 3 (Roles and Deliverables)
Eloise
- Section 4 (Project Plan)
Danny, Prathna
- Section 5 (Hardware and Software Platforms)
Prathna
- Section 6 (Solution Requirements)
Dan, Danny, Alex, Prathna
- Section 7 (Other Considerations)
Eloise
- Section 8 (Definition of Terms)
SEG2
- Section 9 (References)
SEG 2
- Section 10 (Appendix)
Prathna


Task
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
1
8
15
22
29
5
12
19
26
2
9
16
25
2
9
16
23
30
6
13
20
29
DONE BY:
Prototype Demo
- MySQL Database
- Java Application
Implementation Demo
- Java Application
- MySQL Database
- Maps Interface
Design Document
- Design
- Implementation
- Testing
- User Guide
Prathna, Eloise
Dan, Alex, Danny
Dan, Danny, Alex
Eloise, Prathna
SEG 2
Prathna, Eloise
Alex, Dan
Danny
Eloise, Prathna

5. Hardware and software platforms to be used

In this section we will be discussing which hardware and software platforms we are using to produce the Wind farm planner software.

5.1 Software

- Java 1.5.0_08 – this is the software platform that that is going to be used, which has been created by Sun Microsystems which provides a system for programmers to develop application software.

- Eclipse –This software is being used to develop the Wind Planner's Java backend write our java source code into. This software is an environment used by several languages to develop new software. This is where the programmers write the source code to create the software, where they have checked that is correct and get rid of bugs if necessary.

- MySQL - is a relational database management system where it stores data in separate tables rather than putting all the data in one big storeroom. This adds speed and flexibility. For the use of MySQL the language SQL has to be used. This is the Structured Query Language used to query the Database. This is one also one of the most popular languages for databases.

- Microsoft Windows – is the operating system that we are using to create the software on.

- SVN is a repository that we will be using to store our work that we are collaborating on. This will make sure that we are using the most up to date version of the software we have created as well as using this repository online as a safe and secure place to back up the information.

In order to use some of these pieces of software we need to use certain programming languages. For instance in Eclipse the use of the language Java. Java is also needed for the runtime environment and the virtual machine. The reason why we are using Java is that there is a rich API which can be used to enhance the software. It is one of the most used languages and therefore it is popular as well as it is simple to use.

5.2 Hardware

- Required peripherals will be a mouse, keyboard, USB Stick and a printer. The printer is needed to test if the software we are developing will print out reports with specified information for the user.
- We will be using USB sticks as back up devices. Although the data will be centralised in the database. A back-up will also be kept on a subversion repository, although another will be kept in case of subversion failure.
- We will be using a commodity computer running Microsoft Windows XP Professional.

5.3 Hardware and software that the user may need

- The Java Runtime Environment (JRE) need to be installed on the client's computer in order for the user to run the Wind Farm Planner.
- As for the client's computer, any operating system which can install the java JRE can be used because Java applications can be run on any supported environment.
- For storage of a backup of the Wind Farm Planner data, a USB with a minimum storage of 4GB should be enough to store the data files and software.
- A printer is optional, if the user requires printing of reports.

6. Solution requirements

6.1. Functional Requirements

6.1.1. System Functional Requirements

6.1.1.1. Electrical Infrastructure information

Requirement	6.1.1.1.1 - Add Electrical Substation
Priority	High
Description	The system will allow new electrical substation records to be entered into the database: The system checks that the inputted name and location are unique before the new electrical substation will be added. If the inputted name is not unique then the recorded will not be added to the database and the system will require the user enters a different name for the electrical substation If the inputted location is not unique then the recorded will not be added to the database and the system will require the user enters a different location for the electrical substation The system will check that the values entered for the fields: **Size** **Current capacity** **Maximum capacity** do not precede or exceed predetermined values. The system will notify the use if the operation was successful or not.
Supplier Comment	
Supplier Compliance	

Requirement	6.1.1.1.2 - Delete Electrical Substation
Priority	High
Description	The system will allow electrical substation records to be removed from the database: The system will check that the inputted name or location match that of a previously entered electrical substation If the substation exists, the user will be required to confirm that they wish to delete it and upon confirmation the record will be deleted. If the substation does not exist then no records will be deleted and the system will require the user enter different values for the value that didn't match. The system will notify the user if this operation was successful or not.
Supplier Comment	
Supplier Compliance	

6.1.1.2. Wind Turbine Model Information

Requirement	6.1.1.2.1 - Add Wind Turbine Model Information
Priority	High
Description	The system will allow new wind turbine model records to be entered into the database: System checks that the inputted name is unique before the new wind turbine model will be added. If the inputted name is not unique then the recorded will not be added to the database and the system will require the user enters a different name for the wind turbine model. After the completion of this, the user **must** define a power output curve (T-FR2). The system will check that the values entered for the fields: **Maximum Power output** **Power output curve** information (T-FR2) in the form of: **Cut-in wind speed** **Rated wind speed** **Cut-out wind speed** And any wind turbine model information included from **WTMI-SFR2.1.2: Store More Wind Turbine Model Information** do not precede or exceed predetermined values. The system will notify the use if the operation was successful or not.
Supplier Comment	
Supplier Compliance	

Requirement	6.1.1.2.2 - Delete Wind Turbine Model Information
Priority	High
Description	The system will allow wind turbine model records to be removed from the database: The system will check that the inputted name or location match that of a previously entered wind turbine model. If the wind turbine model exists, the user will be required to confirm that they wish to delete it and upon confirmation the record will be deleted. If the wind turbine model does not exist then no records will be deleted and the system will require the user enter different values for the value that didn't match. The system will notify the user if this operation was successful or not.
Supplier Comment	
Supplier Compliance	

6.1.1.3. Wind-Farm Information

Requirement	6.1.1.3.1 - Add Existing Wind-Farms Information
Priority	High
Description	The system will allow new existing wind turbine records to be entered into the database: System checks that the inputted name and location are unique before the new existing wind farm will be added. If the inputted name is not unique then the recorded will not be added to the database and the system will require the user enters a different name for the existing wind far. If the inputted location is not unique then the recorded will not be added to the database and the system will require the user enters a different location for the existing wind farm. The system will check that the value entered **Number of turbines** does not exceed a predetermined value and that the value given for **Online Date** does not precede a predetermined date. The system will notify the use if the operation was successful or not.
Supplier Comment	
Supplier Compliance	

Requirement	6.1.1.3.2 - Delete Existing Wind-Farms Information
Priority	High
Description	The system will allow existing wind farm records to be removed from the database: The system will check that the inputted name or location match that of a previously entered existing wind farm. If the existing wind farm exists, the user will be required to confirm that they wish to delete it and upon confirmation the record will be deleted. If the existing wind farm does not exist then no records will be deleted and the system will require the user enter different values for the value that didn't match. The system will notify the user if this operation was successful or not.
Supplier Comment	
Supplier Compliance	

6.1.1.4. Proposed Wind Farms Information

Requirement	6.1.1.4.1 - Add Proposed Wind-Farms Information
Priority	High
Description	The system will allow new electrical substation records to be entered into the database: The system checks that the inputted name and location are unique and that the substation name refers to an existing substation before the proposed wind farm will be added. If the inputted name is not unique then the recorded will not be added to the database and the system will require the user enters a different name for the proposed wind farm If the inputted location is not unique then the recorded will not be added to the database and the system will require the user enters a different location for the proposed wind farm If the inputted connected substation name does not match any of the names in the electrical substation information database then they user will be required to enter a different name that does match one of the names in the electrical substation information database. The system will check that the values entered for the fields: **Number of turbines** **Turbine model** **Connection Cost Rate** **Hours per year of projected operation**: **Output factor** **Wind speed** do not precede or exceed predetermined values. The system will notify the user if this operation was successful or not. If a new record is successfully entered into the database then: The **distance between the substation and the potential wind farm** will be calculated to give a connection cost based on the connection cost rate. **Energy yield** (MWh) will be calculated as the product of: **Power output** **Output factor** **Hours per year of projected operation**.
Supplier Comment	
Supplier Compliance	

Requirement	6.1.1.4.2 - Delete Proposed Wind-Farm Information
Priority	High
Description	The system will allow proposed wind farm records to be removed from the database: The system will check that the inputted name or location match that of a previously entered proposed wind farm. If the proposed wind farm, the user will be required to confirm that they wish to delete it and upon confirmation the record will be deleted. If the proposed wind farm does not exist then no records will be deleted and the system will require the user enter different values for the value that didn't match. The system will notify the user if this operation was successful or not.
Supplier Comment	
Supplier Compliance	

6.1.1.5. Ease of Use

Requirement	6.1.1.5.1 - Smart Input Forms
Priority	LOW
Description	The system will temporarily remember any information that the user entered when trying to create a record so that if a mistake is made then they don't have to re-enter all of the entered information.
Supplier Comment	
Supplier Compliance	

6.1.1.6. Wind Speed Data

Requirement	6.1.1.6.1 - Store Wind Speed Data
Priority	High
Description	The system will store the following information for wind speed data: **Easting Value** **Northing Value** **Wind speed** (m/s)
Supplier Comment	
Supplier Compliance	

Requirement	6.1.1.6.2 - Add Wind Speed Data
Priority	High
Description	The system will allow new wind speed data to be entered into the database: The input to the system will be one or more files in the agreed format, as defined in the README.TXT file of the supplied wind speed data. For each of the supplied data files, the system will report whether import was successful or not.
Supplier Comment	
Supplier Compliance	

Requirement	6.1.1.6.3 - Replace Wind Speed Data
Priority	High
Description	The system will allow new wind speed data to replace old wind data already in the database: The input to the system will be one or more files in the agreed format, as defined in the README.TXT file of the supplied wind speed data. The system will ask the user to confirm that they wish to replace the data. For each of the supplied data files, the system will report whether import was successful or not.
Supplier Comment	
Supplier Compliance	

Requirement	6.1.1.6.4 - Query Wind Speed Data
Priority	High
Description	User can query the wind speed data to determine wind speeds at different heights for a location. The user will supply: Location: The user will supply all of the following: • Name: this should be unique • Height range: minimum height and maximum height in meters. Default will be all heights. • Area: user will define an area by supplying a distance (d) around the supplied location, in kilometres (km) or miles (mi). Default, will be 0. If the supplied area is 0, then the system should return wind speeds for the nearest data-point to the supplied location. If the supplied area is >0 then the system should return wind speeds for a square area around the supplied location. The square will have side length of twice the distance “d”. The area will be $(2d)^2$. One of: • Message to indicate that the user supplied data that results in no information. • Wind speeds at different heights for a single location. • Wind speeds at different heights for an area.
Supplier Comment	
Supplier Compliance	

6.1.1.7. Modelling Potential Wind-Farm Sites

Requirement	6.1.1.7.1 - Find Potential Wind-Farm Site by Substation
Priority	High
Description	The system will require the following information as input: **Substation name**: this must refer to an existing electrical substation. **Range**: the distance from the electrical substation the search will be limited by; real number in kilometres (km). Default: 20km. **Height range:** minimum height (m) and maximum height(m). Default: all heights. **Number of locations** (n): how many search results to return; integer value. Default: 1. **Allowed wind-farm proximity:** real number distance in km Upon receiving and verifying the required input to ensure that the substation name refers to an existing substation and that the distance is valid: A search will be performed to find the n locations that have the highest average wind speed within the range specified. If a location is found that contains a wind farm nearby (defined by 'allowed wind-farm proximity') then this result will be flagged. If m locations have the same average wind speed and m > n, then m results will be returned. Resulting in the system outputting a set of locations, where each location will have an associated average wind speed taken from the highest wind speed found in the height range defined along with the distance away from the substation. A flag will identify those locations that have a wind farm nearby.
Supplier Comment	
Supplier Compliance	

Requirement	6.1.1.7.2 - Model Potential Wind-Farm Revenue Yield
Priority	High
Description	When modelling potential wind farms to calculate revenue yield the system should take as input: **Name:** must be unique (of a stored Potential Wind Farm). **Revenue price for renewable energy certificates** **Pence per kilowatt hour**. **Average wind speed** And then use these in the energy yield calculation with the selected average wind speed, and calculate the projected revenue yield per year.
Supplier Comment	
Supplier Compliance	

6.2. Non-Functional Requirements

6.2.1. Non Functional System Requirements

6.2.1.1. Platform related

Requirement	6.2.1.1.1 - O/s compatibility
Description	The program should work on the client's operating system
Priority	High
Supplier Comment	
Supplier Compliance	

Requirement	6.2.1.1.2 - Client development
Description	Client software should be written in J2SE for desktop computers
Priority	High
Supplier Comment	
Supplier Compliance	

Requirement	6.2.1.1.3 – Database
Description	Database should be correctly designed and all query's fully functional
Priority	High
Supplier Comment	
Supplier Compliance	

6.2.1.2. Input/output Related

Requirement	6.2.1.2.1 - Input validation
Description	Data input from the user should be validated in order to ensure smooth operation and avoid incorrect input.
Priority	High
Supplier Comment	
Supplier Compliance	

Requirement	6.2.1.2.2 - Input verification
Description	User verification should occur every time the user create, delete or modifies data to ensure that he/she does not do anything he/she does not wish to do.
Priority	High
Supplier Comment	
Supplier Compliance	

Requirement	6.2.1.2.3 – Quality
Description	Formula results and all quantitative figures returned from the system should meet desired accuracy.
Priority	High
Supplier Comment	
Supplier Compliance	

6.2.1.3. Security & robustness of software

Requirement	6.2.1.3.1 – Backup
Description	System must be able to be backed-up and restored to ensure no data loss incase of hardware crash
Priority	Medium
Supplier Comment	

Supplier Compliance	

Requirement	6.2.1.3.2 – Reliability
Description	All functions should present expected results and should not crash system.
Priority	High
Supplier Comment	
Supplier Compliance	

6.2.1.4. Documentation:

Requirement	6.2.1.4.1 – Documentation
Description	The development (design and implementation e.g. java comments) of the system shall be documented.
Priority	High
Supplier Comment	
Supplier Compliance	

Requirement	6.2.1.4.2 - User guide
Description	Clear and comprehensive user guide
Priority	Medium
Supplier Comment	
Supplier Compliance	

Requirement	6.2.1.4.3 - User tooltips
Description	Clear, easy to understand help embedded in the application
Priority	Low
Supplier Comment	
Supplier Compliance	

6.2.2. Non Functional User Requirements

Requirement	6.2.2.1 - Colour blindness
Description	The program's user interface should use non-contrasting colours from the perspective of the colour blind.
Priority	Low
Supplier Comment	
Supplier Compliance	

Requirement	6.2.2.2 – Usability
Description	The customer should be able to enter a new wind farm, turbine and substation in less than two minutes after training.
Priority	Medium
Supplier Comment	
Supplier Compliance	

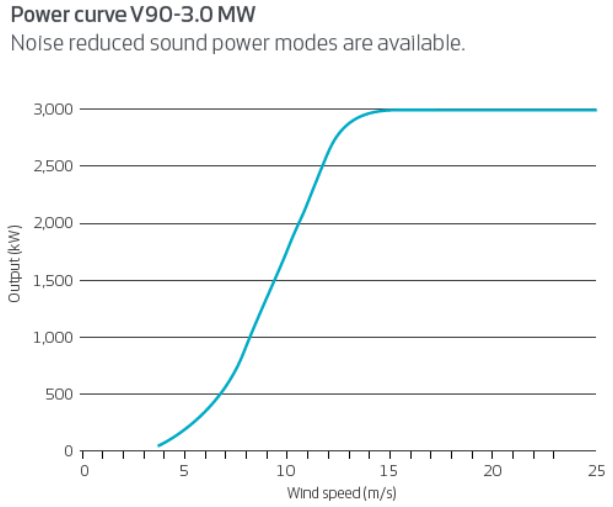
Requirement	6.2.2.3 – Accessibility
Description	The user interface should be designed with accessibility in mind.
Priority	Low
Supplier Comment	
Supplier Compliance	

6.3. Domain Requirements

This section lists all the formulae required by the system to function accurately.

6.3.1. Turbine Power Output Curve

This graph represents the power output of a wind turbine in relation to the wind-speed driving the turbine.



We are only interested in values of output when the wind speed is 10, 25 and 45 mph.

Total power generated by the wind-farm is calculated by the formula:

Total Power output = number of turbines * power output at specified speed

6.3.2. Area of a Location

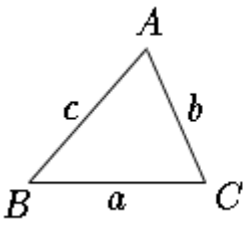
Area = $(2 * d)^2$

Where “d” is the distance (in kilometres or miles) around a specified location. This equation is used to find an area around a specified point for the wind speeds around a point. The user has to input the distance.

6.3.3. Distance between two coordinates

Distance (Km) = cos(((sinLat1 * sinLat2) + (cosLat1 * cosLat2)) * cos(long2 – long1)) * 6371

This equation is the cosine law, which is:



$$a^2 = b^2 + c^2 - 2bc\cos A$$
$$b^2 = c^2 + a^2 - 2ca\cos B$$
$$c^2 = a^2 + b^2 - 2ab\cos C$$

This equation needs the input of two longitude and latitude coordinates, therefore the equation is slightly harder.

6371 is the mean radius of the earth's surface (in kilometres) which needs to be included because the earth is curved and the distance has to be more accurate.

Once the variables are entered into the equation it will return the distance in kilometres.

6.3.4. Cost of the connection to a substation

Using the outcome from the last equation (calling it D) then multiplying it by the cost of the connection per kilometre will give the total connection cost.

Total Connection Cost = D* Connection Cost

6.3.5. Yield Equation

Yield (MWh) = Max power output (MW) * Output factor * hours per year

Max power output (MW): The power output will be derived from the turbine's power output curve against the modelled wind speed.

Output Factor: Is a percentage of the wind turbines being in operation for the year. Default will be 30%.

Hours per year: Is a constant of how many hours there are in a year (365 * 24 = 8760)

6.3.6. Wholesale Price

The wholesale price of energy per Kilowatt hour is 2p.

Wholesale (£) = 0.02* yield * 1000

Yield is measured in Megawatt Hours so it must be converted into Kilowatt-hours.
1MWh = 1000 KWh

6.3.7. Renewable Energy Certificate Revenue

The amount of money given per Kilowatt-hour is worth 4p.

Renewable Energy Revenue(£) = 0.04 * yield * 1000

Yield is measured in Megawatt Hours so it has to be converted into Kilowatt hours.
1MWh = 1000 KWh

6.3.8. Revenue

Revenue(£) = Wholesale + Renewable Energy Revenue

This is derived from the two equations above to get the total Revenue.

6.3.9. Mile to, and from, Kilometre conversion

1 mile = 1.6093 kilometres

Thus:
Miles=kilometres/1.6093
Kilometres=miles*1.6093

6.3.10. Calculating power deficit of Electrical infrastructures

deficit=maxCap – curUsage

Where maxCap (in KW) is the maximum capacity of the specific infrastructure taken from the database and curUsage (in KW) is the current power stored in the infrastructure taken from the database.

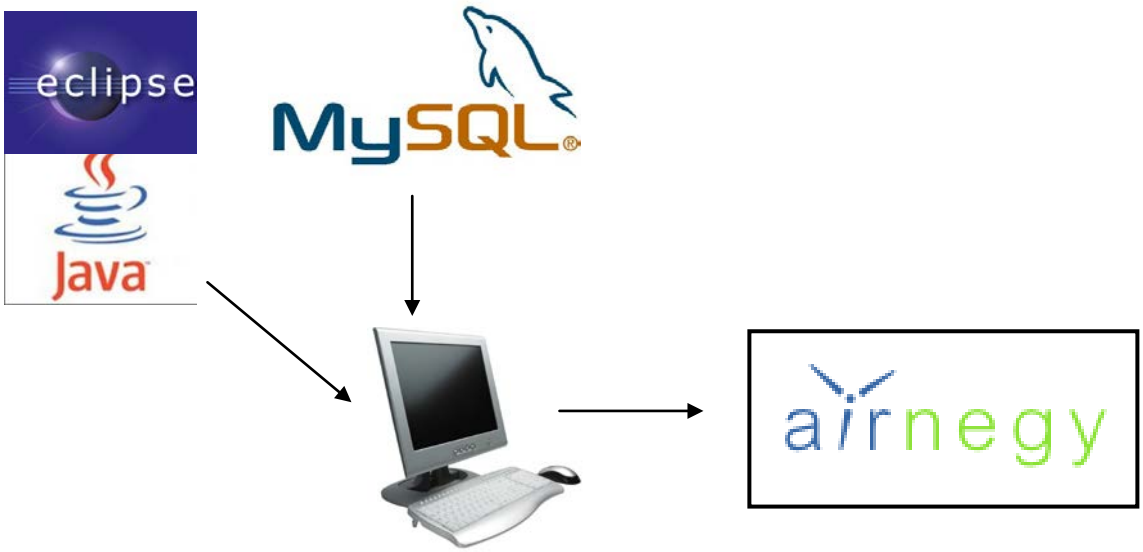
6.3.11. Calculating how many wind-turbines can be connected to a Electrical Infrastructure

turbines=deficit / (maxTurOut * noOfTurb)

Where deficit is the calculated deficit of a given Electrical Infrastructure (see 6.3.10), noOfTurb is the number of turbines used and maxTurOut is the maximum power output (in KW) of the specific model of turbine.

6.4 Interface Requirements

This section describes how the new system will co exist with existing sub sysems



This is a diagram that shows how other pieces of software and the internet being connected to a computer which we will then manipulate to create our system of the Wind Planner. This describes the data structure. This is consisting of the database and java application.

Procedural Interfaces

This is an explanation of how the pieces of software above provide certain services that we can use.

- Java has a rich list of Application Program Interfaces (API's). These are features that are already built in, pre written code that that can be used within our software. This means that sometimes do not have to try and provide a solution from scratch because it has already been implemented and can be re used in a different context.
- Plugins can also be used which are computer programs which adds an additional function to a program. In this case we can use plugins to set up a communication between our programs. This makes it easier for stand alone programs to be used together. If we could not use plugins then we would not be able to use different pieces of software to develop the Wind Planner system.

7. Other considerations

7.1. Assumptions

To develop the system we have made a series of assumptions were made:

- It has been presumed that the users are English speaking.
- The system will be used by British legislated companies.
- There will only be one type of user and that any batch input for example the wind speed data, is standardized.
- The RDA will not be using a server but stand alone computer.
- The employees using the completed system will under go training before they use the program and are therefore aware of its limitations.
- The customers minimum requirements were correct.

7.2. Constraints and Dependencies

There are a number of factors that will restrict the development of the Wind Farm system:

- Money
- Time
- Government regulations relating to the building of wind farms (noise, radar).
- The Data Protection Act (1998) must be adhered to that we only use the data for the purpose intended and not for any other reason.
- The system is limited by the Java and MySQL dependant on the fact that the client's computer has java runtime environment as well as a MySQL server.

7.3 Risk Analysis

Risk	Risk Type	Description	Probability	Effects
Failure of SVN	Technology	All our documentation and coding and implementation of the software cannot be access due to SVN not working	Low	Tolerably
Incompatibility of Software	Technology	Two separate pieces of software not being able to communicate with each fully causing the system to malfunction.	Moderate	Catastrophic
Software Failure	Technology	Any software used in the development of the system failing to operate correctly.	Low	Serious
Hardware Failure	Technology	The chosen terminal has a mechanical fault e.g. hard drive overheating.	Low	Insignificant
Loss of Team Member	People	Member of the team leaves during project duration e.g. becomes ill.	Moderate	Serious
Incomplete skill set	People	Members of the team unable to contribute to all sections due to their lack of knowledge e.g. not proficient in Java.	Moderate	Tolerable
Missing deadlines	People	Team member fails to hand in completed work to the section head on time.	Moderate	Tolerable
Human Errors	People	Programmer forgets to convert between KM and miles, causing a hard to detect bug.	High	Serious
Back-up	People	If a member of the team forgets to make a viable, current back-up of the system, which is then needed.	Moderate	Tolerable
Management Change	Organisational	If a there is a change in section head during the project e.g. a person refuses to do their job.	Low	Serious
Change of Requirements	Requirements	If the specification of the project changes causing a change in requirements leading us to have to re-do documentation and implementation.	Low	Serious
Redundancy	Requirements	Team have developed a function for the system that is not required for the system.	Moderate	Insignificant

Time management	Estimation	Team does not estimate the correct time to complete a section of the system e.g. java coding takes 2 weeks instead of the 1 week planned.	High	Serious

8. Definition of terms

Domain Analysis

Interpolate
- To introduce (something additional or extraneous) between other things or parts, interject.

Topography
- Detailed, precise description of a place or region

Line of sight analysis
- Provide point-to-point information on visibility by means of: (a) mapped lines -variable colouring of a line drawn on the map between the source and target points; (b) tabulated data for the selected transect; and (c) profiles. Lines of sight may be computed from a single point to multiple destinations at regular angular intervals, providing a simplified picture of overall visibility from an observation point.

Project Purpose

Proof-of-concept software
- Wind farm - is a group of wind turbines in the same location used for production of electric power [1].

Wind turbine
-A rotating machine which converts the kinetic energy of wind into mechanical energy [2].

Electrical substation
- A subsidiary station of an electricity generation, transmission and distribution system where voltage is transformed from high to low [3], our project focuses on electrical substations of size 33kV, 66kV, and132kV.

Regional Development Agencies (RDAs)
- A non-departmental public body established for the purpose of development, primarily economic, of one of England's Government Office regions [4].

Network Distribution Operators (NDOs/ Distribution network operators (DNOs))
- Are companies licensed to distribute electricity in Great Britain by the Office of Gas and Electricity Markets [5].

Database
- An integrated collection of logically related records or files consolidated into a common pool that provides data for one or more uses.

Hardware and software platforms to be used

Java Language
– A high-level programming language developed by Sun Microsystems. Java is an object-oriented language similar to C++, but simplified to eliminate language features that cause common programming errors.

Java Virtual Machine
– This converts the high level language code written by the programmer into code that is understandable to the computer.

Java Runtime Environment
– Enables java programs to run on top of the Operating System.

MySQL
- A relational database management system.

Eclipse
- A multi-language software development environment.

API
- An application programming interface (API) is an interface that a software program implements in order to allow other software to interact with it, much in the same way that software might implement a user interface in order to allow humans to interact with it. It provides a list of extra functionalities for the programs to use.

Application Software
- Application software is computer software designed to help the user perform a particular task.

Platform
- A framework on which applications may be run.

Commodity computer
- Computer systems manufactured by multiple vendors, incorporating components based on open standards.

Solution Requirements

System
– Our proof of concept software as a whole.

Unique
– It cannot contain data that is duplicated as it must be able to be used as a primary key.

Predetermined values
– The values entered while creating the database that set the character limit of data entered, and also the values used to set the range which any data entered into that places has to be between.

Record
– A full set of data relating to a wind turbine model, wind turbine (either proposed of existing), electrical substation or wind speed data that has entries in all “not null” fields.

Area
- The surface of a specified region. Given a length normally, a radius for a circle and the length and with for squares and rectangles.

Cosine Law
- A trigonometric formula that was invented by the Greek mathematician Euclid. Normally it is used to find the unknown side of a triangle, not only right angled ones.

Longitude
- Latitude is measured from the equator, with positive values going north and negative values going south.

Latitude
- Longitude is measured from the Prime Meridian (which is the longitude that runs through Greenwich, England), with positive values going east and negative values going west.

Power curve
- Defines the maximum power output according to specific heights in our case. When reading a power curve read the x axis first to find what wind speed you would like to find out the power output for and move up the y axis until the point on the curve is reached.

Renewable energy certificate (ROCs)
- Only when the wind farm is fully operational and starts delivering electricity to the grid, it qualifies for ROCs for each megawatt unit of electricity produced. The ROC payments are fixed by the electricity market, not by the Government, and serve to protect and encourage investment in low-carbon energy technologies.

Revenue
- For a company, this is the total amount of money received by the company for goods sold or services provided during a certain time period.

Wholesale
- In commerce, a wholesaler buys goods in large quantities from their manufacturers or importers, and then sells smaller quantities to retailers, who in turn sell to the general public.

Yield
- A function of the maximum power output and time in operation per year.

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