

Business- and Working Plan for the Wind Empowerment Maintenance Manual

1. Introduction

The *Hugh Piggot Wind Turbine Recipe Book* is widely known and many wind turbines have been manufactured during workshops and according to this manual. The French organisation Tripalium has modified this construction manual and published their own. Whilst most of the turbines built according to these specifications performed well initially, many broke down after some time due to a lack of appropriate monitoring and maintenance. This is a particular problem for Wind Empowerment (WE) members who implement electrification projects in remote areas of developing countries, where local technical capacity to perform repairs is low and travelling times out to installation sites are particularly long.

Gaël Cesa, the founder of Tripalium and the coordinator of the WE Maintenance Working Group (WG) produced the first version of the WE maintenance manual on a voluntary basis. Whilst this offers people who have built a wind turbine according to Hugh Piggot and Tripalium's specifications basic information on how to maintain their equipment, it currently includes only a few of the failures that might occur during the turbine's lifetime and is missing detailed explanation on how to repair main and sub-components. Therefore there is significant scope for building upon Cesa's work in order to create a more comprehensive second edition. Human resources are the main requirement for this project, so the following document presents a plan for what needs to be done (see *Appendix A.*), how much time would need to be allocated to achieve this (see external spreadsheet *Working_Packages_MaintenanceManual.xlsx*) and variety of possible ways to obtain this time.

2. WE Maintenance WG

Wind Empowerment's Maintenance WG was formed at the association's 2nd global conference, WEAthens2014 with the following group vision:

"To mutually empower people to keep their turbines running"

It was envisaged that this would be achieved by creating a feedback loop (see *Appendix C.*) that gathers experience from existing installations and directly informs maintenance practices, therefore empowering people to deal with failures of equipment that is already in the field more effectively. This feedback loop would encompass both the association's member organisations and participants. The participants are members of the general public with an interest in small for rural development, many of whom may have a small wind turbine installed at their own home. As a consequence, collecting feedback directly from the end-users of the technology themselves offers them agency to declare what is working and what isn't for them and therefore influence the future direction of this constantly evolving open source technology. What is more, it will also enable the rethinking of future projects, so that the technology is designed and implemented in such a way that the major causes of failure are eliminated.

3. Benefits of a maintenance manual

This process capitalises on the collective experience of Wind Empowerment members, as reliability data is notoriously difficult to acquire due to the fact that it requires long-term data collection across a large number of installations. Each member organisation has installed between 1 and 200 small wind turbines, however, together Wind Empowerment members have installed over 1000. What is more, they have been installed in different contexts, which also enables the comparison of the influence of environmental (e.g. lightning strikes), social (e.g. effectiveness of training methods) and economic (e.g. pay as you go vs. donor funded) factors to be determined. In order to collect this data from Wind Empowerment members, two methods have been proposed:

1. A one off survey to capture the experiences of Wind Empowerment members, the contexts in which they work, the delivery models they employ and the most common failures they have experienced.
2. A database that could enable ongoing crowd-sourcing of problems and solutions. The Maintenance WG has proposed a WordPress-based solution on the recently redeveloped digital platform, WindEmpowerment.org. Similar databases have already been created by Wind Empowerment for projects, vendors and products. This will enable Wind Empowerment members to add their experiences of failures that have occurred with the machines that they have installed, together with their proposed solutions. Other members can comment on these entries, creating a database of problems and solutions.

This data would then be fed back into Maintenance Manual, and would provide significant new material for the second edition. In fact, if the database proves successful, it would be able to collect data on a continuous basis, providing material for a third edition and beyond. The detailed working plan (see Appendix A) details a number of other ideas for improving the usability of the manual, as well as additional sources of new content.

Members of the WE Maintenance WG would be recruited to carry out this work and would be paid at the standard WE rate of £100 per day.

4. Advertising and Distribution

- It is intended to provide free access to the maintenance manual. Therefore WE needs to apply for funding, so members of the WE Maintenance WG can be paid.
- If sales of the manual are needed to finance its production and improvement, then digital copies could be sold via WindEmpowerment.org and hard copies sold by WE members alongside the construction manuals commonly sold to practical wind turbine construction course participants.

5. Financial plan

- The estimated time needed for the update of the manual and adding the parts that were described in the beginning of this document can be seen in the external spreadsheet *Working_Packages_MaintenanceManual.xlsx*. The amount of time included in this spreadsheet is just estimated, so deviation is expected and extra time/money for each task should be budgeted
- Importance of providing free access for users (pdf-file or only printing costs) + no commercial interest intended due to background-idea of Hugh Piggot, Tripalium, etc.
- Possible sources of financing the update of the maintenance manual:

Preferred option (listed by preference):

- It is aimed to have the 2nd edition of the maintenance manual ready until the conference in Palestine in 2016. The 2nd edition of the maintenance manual will be financed by using only the available money of WindEmpowerment (1000€ = around 67 working hours, considering the WE standard rate per day = 120€ for 8 hours) as well as voluntary work¹. Furthermore, Jon could use WindEmpowerment time to supervise the work (by Gaël and Jerome) on the maintenance manual.

As discussed during a Skype-call between Jon and Gaël, the 1st edition of the maintenance manual consists out of 14 pages, but should have around 30 pages in the 2nd edition. Due to the limited financial resources, the 2nd edition is considered to be an improvement of the 1st edition. It is intended to further update and improve the maintenance manual (3rd, 4th, 5th... edition) to develop the most comprehensive version in a constant process, based on user feedback (see Appendix C.).

The updated manual will be available on the WE website (pdf) with a suggested

Comment [gC1]:

Gaël:

I rather go for a manual that can be away for free which mean voluntary work (which has already been done on for the first edition) or to find an organisation that is willing to pay. Maybe the fairest thing would be that WE give a bit of money to improve the manual. WE sell it for cheap price 1 or 2 € and get his money back. The crowd funding within WE could also work...

Jerome:

I rearranged this section (5. Financial plan) according to your comment. What do you think of it now?

¹ It should be considered that it took Tripalium 400 hours to set up their construction manual with 112 pages

donation of 2€ per copy. A printed copy might be given away for a donation during construction workshops. All the collected money will be used to further improve the maintenance manual.

- For further editions of the maintenance manual, WE will apply for funding (organisation/company/private person) to finance all the proposed work that is needed to update the manual (see Appendix A). The updated manual will be available on the WE website (pdf) with a suggested donation of 2€ per copy. A printed copy might be given away for a donation during construction workshops and the money will be used to further improve the maintenance manual.

Back up options (all ideas mentioned above and below could also be combined):

- The manual is given away for a donation (disadvantage: only possible with voluntary work beforehand).
- Crowdfunding within WindEmpowerment: Every WE-member purchases a copy in advance and will get a copy as soon as it is updated. Idea Jon: Offer members that support the incentive that they can distribute the manual in order to get money back.
- Or: Crowdfunding within WindEmpowerment: Every member purchases a copy in advance and will get a copy as soon as it is updated. The manual may be freely available as a pdf (no printing costs) or provided during a workshop (charging only printing costs)
- The update of the maintenance manual or a part of it (defining small packages of work) can be the work of a student during an internship or the thesis of a student (cooperation with university). Also: other Pioneer of PiP-program (depending on the skills and background of the person)

1. 6. **Alternative Scenarios & assessment of risk**

| Worst case scenario | Assessment of risk: high / middle / low |
|--|--|
| <i>The update of the maintenance manual is not possible because of a lack of knowledge within Wind Empowerment.</i> | low |
| <i>The feedback from survey is not consistent and meaningful and can not be used for improvement of maintenance manual</i> | middle |
| | |
| | |
| | |
| | |

Comment [gC2]:

Gaël:

What do you mean, what will you put behind this?

Jerome:

We have not yet decided on the content and usefulness of this table, that is why it is still empty. Usually a table like this is used when you apply for funding. You can show the donor that you thought about risks and he/she can assess the risk of funding your project.

I tried to give you an example, check the table on the left...

Comment [Staff/Res3]: Reminder for Jerome: Insert possible faults and display best-case **and** worst-case-scenarios

Appendix A. Essential tasks for the update of the maintenance manual

| Pos. | Description of tasks |
|------|---|
| | FEEDBACK LOOP |
| 1 | Include feedback from experts Including existing feedback from Hugh/Noam etc. (see e-mail) + consult other experts and include their feedback |
| 2 | Conduct a survey & analyse data to draw conclusions for maintenance manual Conduct a survey (within WE-network) on maintenance issues & on problems that occurred in the past on different turbine seize and types (also modifications). <i>Ask all members for:</i> <ol style="list-style-type: none"> every turbine that every WindEmpowerment-member has ever installed, environment in which the turbines had been installed, downtime that was caused by each failure, cost of each failure, most expensive components ("adapting maintenance intervals to the components that are most expensive"). What would you like to see in the updated manual Does your organisation have already a maintenance manual or something comparable? Are you willing to contribute money/working hours/expertise? The survey should show, which components tend to break down most likely so we can put emphasis on the section about parts within the maintenance manual |
| 3 | Create and maintain a "maintenance-database" Create an interactive and simple database where every WE-member will insert a turbine-photo, the site conditions, a technical CV-file, the maintenance intervals, the downtimes, failures that occur, etc . |
| | IMPROVING THE MANUAL |
| 4 | Add a section about environmental/user/component/cost categories Categorising different factors that influence how often maintenance will need to be performed and what kind of solutions will be most appropriate. e.g. <ol style="list-style-type: none"> environment (coastal, humid/desert, forest/urban with high turbulence, hot/ cold) users (experienced with manual work vs inexperienced) budget (premium quality vs low cost) components (e.g. material of blades, fibreglass, carbon-fibre, wood) |
| 5 | Add a tool-section Mention the tools required for each person. Answer questions like: <i>Which tools should be kept on site for repairs by the end user? Which tools should be in the toolkit of a maintenance technician heading out on a field visit?</i> |
| 6 | Include comments that were made on the current version of the maintenance manual Jon and Jerome reviewed the current version of the maintenance manual that was written by Gaël and had some ideas about how it can be improved. These comments can be found within the attached pdf-file. |
| 7 | Insert a section about recommendations on monitoring Draw parallels to big seized wind turbines, explain importance of monitoring and how it can be done on a "low-budget-basis" for LMSWT |
| 8 | Describe problems that might occur more accurately Add diagrams, drawings (exploded CAD) and photographs to describe all problems that might occur within the turbine's life in detail. Intended by Gael (Skype-call): Include a step by step guide (with photos) on how to change the bearings. |
| | TECHNICAL REVIEW OF EXISTING MANUALS |
| 9 | Adapting commercial manuals for our purpose If they are available, review maintenance manuals of commercial manufacturers of SWT. If not available: Contact manufacturers if they provide this information. Transfer ideas from their manual (design as well as content) into WE's manual. |
| 10 | Do a technical review of all existing construction and maintenance manuals Find out and interview the existing groups (Hugh Piggot, Tripalimum, etc.) why they changed their construction manual and if these changes can be considered as improvements. Is it possible to create a single maintenance manual for all the different existing construction manuals? If not: Is it possible to design a manual that has a general part (tools, different site conditions, etc.) and a more specific part that considers all different designs? |
| 11 | Add a section about environmental factors Categorising different factors that influence how often maintenance will need to be performed and what kind of solutions will be most appropriate. e.g. <ol style="list-style-type: none"> environment (coastal, humid/desert, forest/urban with high turbulence, hot/ cold) users (experienced with manual work vs inexperienced) budget (premium quality vs low cost) components (e.g. material of blades, fibreglass, carbon-fibre, wood) |

Comment [gC4]:
Gaël: I will put this in 4 position first thing to do in improving the manual. That can be done in the same time as 1. w

Comment [gC5]:
Gaël: I will put in 8. It's look up and coming but no solution yet...

Jerome: Jon said, that the measurement working group will probably provide this information

Comment [gC6]:
Gaël: That's a good idea. It has been done to work on this edition of the manual (sonkyo, bergey, westwind...). Often maintenance are something that they want to minimize...Maybe in the big wind industry...

Jerome: That sounds very interesting. Did you receive this data (manuals for sonkyo, bergey, westwind...) directly from manufacturers? Or customers that bought a small wind turbine?

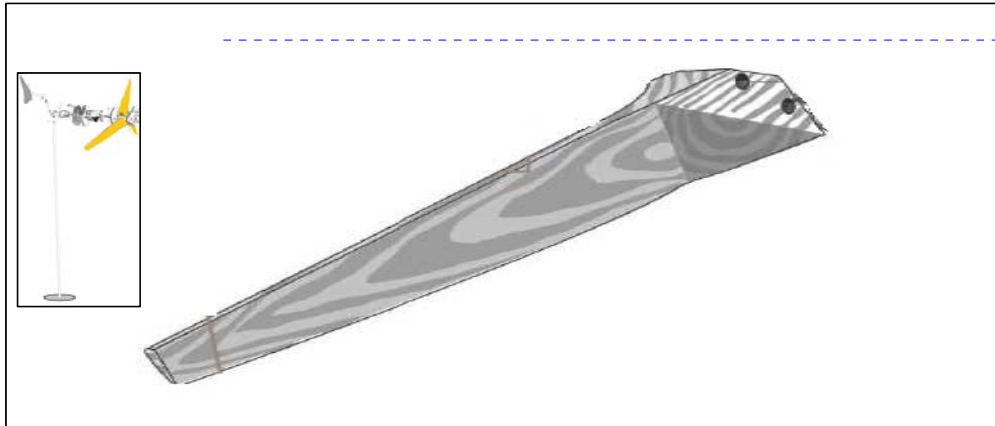
Comment [gC7]: I got no answer in this direction so far but I think comet me got one, bleu energy also ask jon and it hink eolsenegal as well, I will ask them.

Jerome: Great, thanks!

Comment [gC8]:
Gaël: Maybe it can include in the section eg tail vane section humid area you should avoid plywood...

Jerome: Good idea!

Appendix B. Proposal for Layout (example 1. Blades)



Comment [gC9]: I like the idea of having logo for each part of the turbine and installation. It' makes the manual easiest to use. A lots of pictures and/or scheme can be useful even if the manual is not in the right language or for people that can, read. If we have to do to many drawing it can be time consuming...

We can use Tripalium one, piet drawing or on Tripalium website something has be done in this way. Check www.tripalium.org in front page scroll to reach dernières operations.

Jerome: Great! I think it would be very helpful if we could get Piet's CAD drawings.

Leading edge of blade delaminated

Possible cause:

Tools needed:

Description how to fix it:



Paint on hub delaminated

Possible cause: exposure to weather, missing maintenance

Tools needed: ...

Description how to fix it: ...



Blade broken

Possible cause: exposure to storm, missing maintenance

Tools needed: ...

Description how to fix it: Damage cannot be fixed, new blade needed



Blade "exploded"

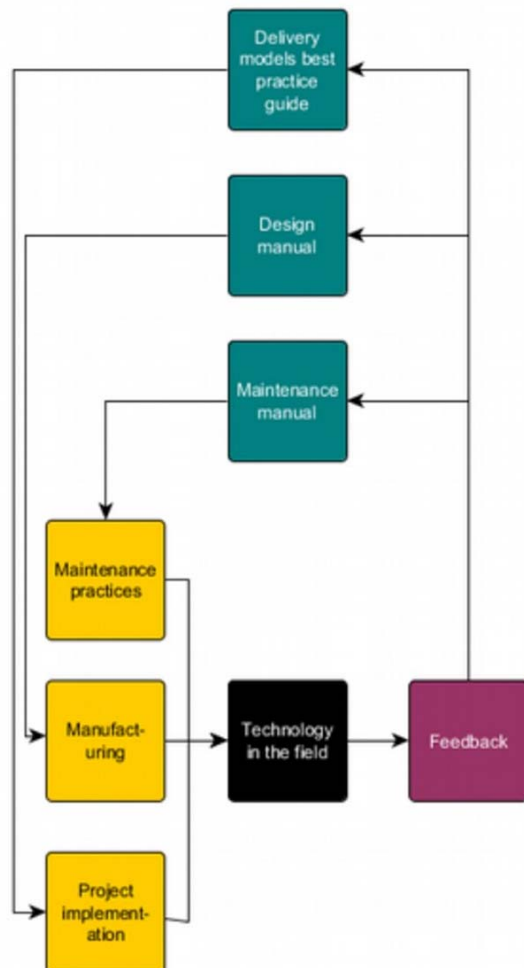
Possible cause: turbine was hit by a lightning

Tools needed: ...

Description how to fix it: Damage cannot be fixed, new set of blades needed



Appendix C. Feedback loop



The role of the maintenance working group was identified as a feedback loop that increases the sustainability of technology in the field by collecting feedback from existing installations to inform maintenance practices, manufacturing and project implementation.