READING GUIDE

Thesis

**Topic:** Energy Storage

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**Date:** 02-07-2013
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# PREFACE

## Content of this paper

This Master Thesis is part of the Master Hydraulic Engineering with the specialization Hydraulic Structures at the faculty of Civil Engineering and Geosciences of Delft University of Technology and consists of the following three documents:

<table>
<thead>
<tr>
<th>Part</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Reading</td>
<td>Reading Guide</td>
</tr>
<tr>
<td>(2) Part one</td>
<td>Energy storage It’s Inevitable</td>
</tr>
<tr>
<td>(3) Part two</td>
<td>Gravity power: A preliminary feasibility study</td>
</tr>
</tbody>
</table>

The thesis covers the subject of energy storage and has been divided into two parts: *part one* (non-technical) and *part two* (technical). These can be described with the following keywords (Figure I).

![Figure I (non)-technical part of thesis](image)

This paper has been written for everyone that is interested in the topic of energy. Attempted has been to write this paper in such a way so that it’s easy to follow for everyone.

Part one, the non-technical part, should be an easy read for everyone. Part two, on the other hand, is a technical report, nonetheless, most basic concepts are explained so that everyone should be able to understand, except for a few parts where technical pre-knowledge is required.

*Part two*, can be understand without reading *part one* of this paper. However, it is highly recommended to read part one prior to part two as *part two* continues, where *part one* finishes. Besides, often is referred to part one of this paper. What follows is a brief summation of what can be found in each part.

**Part one** (non-technical)

*Part one* explains what energy storage is, and why energy storage is necessary. This has been done by first taking a peek into the energy grid and assessing the demand and supply of energy which is done in *Chapter 1*. There are different methods of energy storage, which has been discussed and compared in *Chapter 2*. *Chapter 3* describes the complications one could expect when applying an energy storage project and
discusses a case study for the application of a storage device. The Appendix of part one, explains how different forms of energy is converted to electricity which is used in the electrical grid.

**Part two (technical)**

Part two is a technical design study to the feasibility of one of the (hydraulic) energy storage concepts: gravity power. In Chapter 4, the concept of gravity power is analyzed and compared with other hydraulic energy storage methods regarding functionality and storage capacity. In Chapter 5, an initial design will be made. In Chapter 6, this design will be assessed regarding stability, construction and costs, and is further optimized in Chapter 7. Chapter 8, provides conclusions, recommendations and a final evaluation.

**Acknowledgement**

This thesis wouldn't be possible without the assistance of many people who I'd like to thank.

First of all, I would like to thank my graduation committee Prof. dr. ir. S.N. Jonkman, Ir. A. van der Toorn and Dr. ir. drs. C.R. Braam for their guidance and feedback during the project. In addition I would like to thank Ir. dr. Anton van Beek for his help regarding the mechanical challenges. Finally I want to thank my parents and friends for their support throughout my studies.
MISCELLANEOUS

Internal references [1]

Often is referred to a chapter, paragraph, section or sub-section. What these references mean has been visualized in Figure II.

![Diagram showing internal references]

Internal references [2]

Internal references to the appendix or parts that are not within the same paragraph, has been shown with “[ ]” brackets. [Appendix Z: This is a test, p98], for example, means that it refers to “Appendix Z: This is a test”, which can be found on “page 98”. Note these are hyperlinked and on a computer redirects directly to this page when clicking on it.

External references

External references are shown with “()” bracket. (R. Booker, 2013), for example, refers to the author and year of publication of that piece of information. Note that sometimes one can see “n.d.” between those brackets, that either means that the author is unknown or that multiple authors have written it.

Software

During the course of this paper, the following software packages have been used:

<table>
<thead>
<tr>
<th>Software package</th>
<th>for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word 2013</td>
<td>Documenting</td>
</tr>
<tr>
<td>Excel 2013</td>
<td>Technical calculations &amp; cost</td>
</tr>
<tr>
<td>AutoCAD 2013</td>
<td>Technical drawings</td>
</tr>
<tr>
<td>Photoshop CS6</td>
<td>Coloring &amp; Improving technical drawings</td>
</tr>
<tr>
<td>Visio 2013</td>
<td>Simple graph/objects</td>
</tr>
<tr>
<td>Maple 17</td>
<td>Design calculation &amp; Plots</td>
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<tr>
<td>Matlab 2013</td>
<td>Design calculation &amp; Plots</td>
</tr>
<tr>
<td>Solid works 2013</td>
<td>3D drawings</td>
</tr>
<tr>
<td>Matrix-frame</td>
<td>Technical Modelling</td>
</tr>
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