

DANIEL JAKOB

HYBRID HEAT PUMP ANALYSIS

HYBRID HEAT PUMP ANALYSIS

THE OPTIMISATION OF A HEAT PUMP–GAS BOILER COMBINATION IN A
RESIDENTIAL HOME

DANIEL JAKOB
(18409686)



Mechanical Engineering Master's (MEng.)
School of Mechanical and Materials Engineering
College of Engineering & Architecture
University College Dublin

11th October 2022 – v0.1

Daniel Jakob: *Hybrid Heat Pump Analysis*, The optimisation of
a heat pump–gas boiler combination in a residential home, ©
May 2023

SUPERVISOR:

Prof. Donal Finn

COLLABORATOR:

Dr. Mohammad Saffari

EXAMINER:

Dr. Joe Bloggs

HEAD OF SCHOOL:

Prof. Kenneth Stanton

Mechanical Engineering Master's (MEng.) Thesis 2023:XX
School of Mechanical and Materials Engineering
College of Engineering & Architecture
University College Dublin
Belfield, Dublin 4, Ireland

Typeset in L^AT_EX, with LuaL^AT_EX and the classicthesis v4.6

Printed by XXX, 15th May 2023, Ballsbridge, Dublin 6, Ireland

FONTS:

main text font: TeX Gyre Pagella, math font: TeX Gyre Pagella

Math, monospace font: Bera Mono

SOURCE AVAILABLE AT:

<https://github.com/daniel-jakob/Thesis>.

CONTENTS

I Preamble

- 1 Introduction 3
- 2 Literature Review 5

II Model and Results

- 3 Methodology 9
- 4 Model 11
- 5 Sensitivity Analysis 13
- 6 Techno-Economic Assessment 15
- 7 Conclusions 17

Bibliography 19

III Appendix

- A Appendix Test 23
 - A.1 Appendix Section Test 23
 - A.2 Another Appendix Section Test 24

LIST OF FIGURES

LIST OF TABLES

Table A.1 Autem usu id 23

LISTINGS

Listing A.1 A floating example (listings manual) 24

ACRONYMS

HHS Hybrid heating system

ABSTRACT

Short summary of the contents in English... a great guide by Kent Beck how to write good abstracts can be found here:

<https://plg.uwaterloo.ca/~migod/research/beck00PSLA.html>

Keywords: Hybrid heat pumps.

DECLARATION

I hereby certify that the submitted work is my own work, was completed while registered as a candidate for the degree stated on the Title Page, and I have not obtained a degree elsewhere on the basis of the research presented in this submitted work.

Belfield, Dublin 4, May 2023

Daniel Jakob

*We have seen that computer programming is an art,
because it applies accumulated knowledge to the world,
because it requires skill and ingenuity, and especially
because it produces objects of beauty.*

— knuth:1974 [knuth:1974]

ACKNOWLEDGMENTS

Put your acknowledgments here.

Many thanks to everybody who already sent me a postcard!

Regarding the typography and other help, many thanks go to Marco Kuhlmann, Philipp Lehman, Lothar Schlesier, Jim Young, Lorenzo Pantieri and Enrico Gregorio¹, Jörg Sommer, Joachim Köstler, Daniel Gottschlag, Denis Aydin, Paride Legovini, Stefan Prochnow, Nicolas Repp, Hinrich Harms, Roland Winkler, Jörg Weber, Henri Menke, Claus Lahiri, Clemens Niederberger, Stefano Bragaglia, Jörn Hees, Scott Lowe, Dave Howcroft, José M. Alcaide, David Carlisle, Ulrike Fischer, Hugues de Lassus, Csaba Hajdu, Dave Howcroft, and the whole L^AT_EX-community for support, ideas and some great software.

Regarding L_YX: The L_YX port was initially done by *Nicholas Mariette* in March 2009 and continued by *Ivo Pletikosić* in 2011. Thank you very much for your work and for the contributions to the original style.

¹ Members of GuIT (Gruppo Italiano Utilizzatori di T_EX e L^AT_EX)

Ohana means family.
Family means nobody gets left behind, or forgotten.
— Lilo & Stitch

Dedicated to the loving memory of Rudolf Miede.
1939 – 2005

NOMENCLATURE

Physics Constants

c	Speed of light in a vacuum	$299\,792\,458\,\text{m s}^{-1}$
G	Gravitational constant	$6.674\,30\times 10^{-11}\,\text{m}^3\,\text{kg}^{-1}\,\text{s}^{-2}$
h	Planck constant	$6.626\,070\,15\times 10^{-34}\,\text{J Hz}^{-1}$

Number Sets

\mathbb{C}	Complex numbers
\mathbb{H}	Quaternions
\mathbb{R}	Real numbers

Other Symbols

ρ	Friction index
V	Constant volume

Part I

PREAMBLE

INTRODUCTION

LITERATURE REVIEW

Hybrid heating system ([HHS](#))

Part II

MODEL AND RESULTS

METHODOLOGY

HHS

MODEL

HHS

SENSITIVITY ANALYSIS

[1]

TECHNO-ECONOMIC ASSESSMENT

[1]

CONCLUSIONS

BIBLIOGRAPHY

- [1] Gang Li. 'Parallel loop configuration for hybrid heat pump – gas fired water heater system with smart control strategy'. In: *Applied Thermal Engineering* 138 (25th June 2018), pp. 807–818. ISSN: 1359-4311. DOI: [10.1016/j.applthermaleng.2018.04.087](https://doi.org/10.1016/j.applthermaleng.2018.04.087). URL: <https://www.sciencedirect.com/science/article/pii/S1359431118302886>. (13, 15).

Part III

APPENDIX

APPENDIX TEST

Lorem ipsum at nusquam appellantur his, ut eos erant homero concludaturque. Albucius appellantur deterruisset id eam, vivendum partiendo dissentiet ei ius. Vis melius facilisis ea, sea id convenire referrentur, takimata adolescens ex duo. Ei harum argumentum per. Eam vidit exerci appetere ad, ut vel zzril intellegam interpretaris.

More dummy text.

A.1 APPENDIX SECTION TEST

Test: [Tbl. A.1](#) (This reference should have a lowercase, small caps A if the option `floatperchapter` is activated, just as in the table itself → however, this does not work at the moment.)

Table A.1: Autem usu id.

LABITUR BONORUM PRI NO	QUE VISTA	HUMAN
fastidii ea ius	germano	demonstratea
suscipit instructor	titulo	personas
quaestio philosophia	facto	demonstrated

$$V = \frac{4}{3}\pi r^3 \quad (\text{A.1})$$

$$= \eta_{\text{s, turbine}} \quad (\text{A.2})$$

$$\text{ch}(f_! \mathcal{F}^\bullet) \text{td}(Y) = f_*(\text{ch}(\mathcal{F}^\bullet) \text{td}(X)) \quad (\text{A.3})$$

Eq. A.1 Eqs. A.1 to A.3 Eqs. A.1 and A.3

A.2 ANOTHER APPENDIX SECTION TEST

Equidem detraxit cu nam, vix eu delenit periculis. Eos ut vero constituto, no vidit propriae complectitur sea. Diceret nonummy in has, no qui eligendi recteque consetetur. Mel eu dictas suscipiantur, et sed placerat oporteat. At ipsum electram mei, ad aequae atomorum mea. There is also a useless Pascal listing below:

*More dummy
textss.*

List. A.1.

Listing A.1: A floating example (listings manual)

```

1 for i:=maxint downto 0 do
2 begin
3 { do nothing }
4 end;
```

COLOPHON

This document was typeset using the typographical look-and-feel `classicthesis` developed by André Miede and Ivo Pletikosić. The style was inspired by Robert Bringhurst’s seminal book on typography “*The Elements of Typographic Style*”. `classicthesis` is available for both \LaTeX and \LyX :

<https://bitbucket.org/amiede/classicthesis/>

Happy users of `classicthesis` usually send a real postcard to the author, a collection of postcards received so far is featured here:

<http://postcards.miede.de/>

Thank you very much for your feedback and contribution.