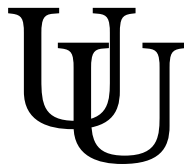# EXAMPLE DOCUMENT USING THE MODERNTHESIS TEMPLATE

Claudio Mattera

Department of L-Space Studies
Magical Faculty
Unseen University

UU

February 2019

SUPERVISION

Principal supervisor: Mustrum Ridcully, UU, Archchancellor
Co-supervisor: Horace Worblehat, UU, Librarian

EVALUATION COMMITTEE

Ponder Stibbons (chair), UU, Head of Inadvisably Applied Magic
Rincewind, UU, Egregious Professor of Cruel and Unusual Geography
Ipslore the Red

COLOPHON

ABSTRACT

This is a template for a Ph. D. thesis created by myself, Claudio Mattera. The cited publications used as examples are from my own thesis.

RESUMÉ

Dette er en template til en Ph. D. afhandling oprettet af mig selv, Claudio Mattera. De citater, der bruges som eksempler, er fra min egen afhandling.

PUBLICATIONS

MAIN AUTHOR PUBLICATIONS

The following are the publications, written as first author, included in this thesis.

[1] **Claudio Giovanni Mattera**, Sanja Lazarova-Molnar, Hamid Reza Shaker and Bo Nørregaard Jørgensen. 'A Practical Approach to Validation of Buildings' Sensor Data: a Commissioning Experience Report'. In: *Third International Conference on Big Data Computing Service and Applications (BigDataService)* (San Francisco, CA, USA, 6th–9th Apr. 2017). IEEE. 12th June 2017, pp. 287–292. DOI: 10.1109/BigDataService.2017.48.

[2] **Claudio Giovanni Mattera**, Muhyiddine Jradi and Hamid Reza Shaker. 'Online Energy Simulator for Building Fault Detection and Diagnostics Using Dynamic Energy Performance Model'. In: *International Journal of Low-Carbon Technologies* 13.3 (1st Sept. 2018), pp. 231–239. ISSN: 1748-1325. DOI: 10.1093/ijlct/cty019.

[3] **Claudio Giovanni Mattera**, Joseba Quevedo, Teresa Escobet, Hamid Reza Shaker and Muhyiddine Jradi. 'Fault Detection and Diagnostics in Ventilation Units Using Linear Regression Virtual Sensors'. In: *International Symposium on Advanced Electrical and Communication Technologies (ISAECT)* (Kenitra, Morocco, 21st–23rd Nov. 2018). IEEE. 24th Jan. 2019. DOI: 10.1109/ISAECT.2018.8618755.

[4] **Claudio Giovanni Mattera**, Joseba Quevedo, Teresa Escobet, Hamid Reza Shaker and Muhyiddine Jradi. 'A Method for Fault Detection and Diagnostics in Ventilation Units Using Virtual Sensors'. In: *Sensors* 18.11 (14th Nov. 2018). ISSN: 1424-8220. DOI: `10.3390/s18113931`.

[5] **Claudio Giovanni Mattera**, Hamid Reza Shaker and Muhyiddine Jradi. 'Consensus-based Method for Anomaly Detection in VAV Units'. In: *Energies* 12.3 (1st Feb. 2019). ISSN: 1996-1073. DOI: `10.3390/en12030468`.

[6] **Claudio Giovanni Mattera**, Hamid Reza Shaker, Muhyiddine Jradi, Mathis Riber Skydt and Sebastian Skals Engelsgaard. 'Fault Detection in Ventilation Units using Dynamic Energy Performance Models'. In: *Sustainable Cities and Society* (2019). ISSN: 2210-6707. **Submitted**.

CO-AUTHOR PUBLICATIONS

The following are secondary publications, contributed as co-author during the Ph. D. project. They are not included in this thesis.

[7] Muhyiddine Jradi, Fisayo Caleb Sangogboye, **Claudio Giovanni Mattera**, Mikkel Baun Kjærgaard, Christian T. Veje and Bo Nørregaard Jørgensen. 'A World Class Energy Efficient University Building by Danish 2020 Standards'. In: *Energy Procedia* 132 (Oct. 2017): *11th Nordic Symposium on Building Physics*, pp. 21–26. ISSN: 1876-6102. DOI: `10.1016/j.egypro.2017.09.625`.

[8] Muhyiddine Jradi, Krzysztof Arendt, Fisayo Caleb Sangogboye, **Claudio Giovanni Mattera**, Elena Markoska, Mikkel Baun Kjærgaard, Christian T. Veje and Bo Nørregaard Jørgensen. 'ObepME: An Online Building Energy Performance Monitoring and Evaluation Tool to Reduce Energy Performance Gaps'. In: *Energy and Buildings* 166 (1st May 2018), pp. 196–209. ISSN: 0378-7788. DOI: `10.1016/j.enbuild.2018.02.005`.

[9] Krzysztof Arendt, Aslak Johansen, Bo Nørregaard Jørgensen, Mikkel Baun Kjærgaard, **Claudio Giovanni Mattera**, Fisayo Caleb Sangogboye, Jens Hjort Schwee and Christian T. Veje. 'Room-level Occupant Counts, Airflow and CO2 Data from an Office Building'. In: *The 16th ACM Conference on Embedded Networked Sensor Systems*. Proceedings of the First Workshop on Data Acquisition To Analysis (Shenzhen, China, 4th–7th Nov. 2018). ACM. New York, NY, USA, 2018, pp. 13–14. DOI: 10.1145/3277868.3277875.

[10] Muhyiddine Jradi, Na Liu, Aslak Johansen, Krzysztof Arendt, **Claudio Giovanni Mattera**, Mikkel Baun Kjærgaard, Christian T. Veje and Bo Nørregaard Jørgensen. 'Dynamic Energy Model-Based Automatic Building Performance Testing for Continuous Commissioning'. In: *Proceedings of the 16th IBPSA International Conference Building Simulation 2019* (Rome, Italy, 2nd–4th Sept. 2019). International Building Performance Simulation Association. URL: http://buildingsimulation2019.org/. **Submitted**.

[11] Krzysztof Arendt, Anders Clausen, **Claudio Giovanni Mattera**, Muhyiddine Jradi, Aslak Johansen, Christian T. Veje, Mikkel Baun Kjægaard and Bo Nørregaard Jørgensen. 'Controleum: Multi-Objective Model Predictive Control Framework for Buildings'. In: *Proceedings of the 16th IBPSA International Conference Building Simulation 2019* (Rome, Italy, 2nd–4th Sept. 2019). International Building Performance Simulation Association. URL: http://buildingsimulation2019.org/. **Submitted**.

Light thinks it travels faster than anything but it is wrong. No matter how fast light travels, it finds the darkness has always got there first, and is waiting for it.

SIR TERRY PRATCHETT

ACKNOWLEDGMENTS

This document was typeset using the `modernthesis` template for Ph. D. thesis created by Claudio Mattera.

CONTENTS

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LIST OF FIGURES

LIST OF TABLES

LIST OF LISTINGS

ACRONYMS

BMS building management system.

GLOSSARY

CO$_2$ Carbon dioxide, gas produced by breathing and by several industrial processes. 12

STRUCTURE OF THE THESIS

This thesis follows the format of a collection of publications, i.e. it includes the publications produced during the Ph. D. project. It is divided into three separate parts.

Part I serves as a general introduction to the work carried out during the Ph. D. project. Chapter 1 introduces the context of this thesis and presents the motivation, the research questions and the methodology. The current state of the art of the field is reviewed in Chapter 2, where its gap is highlighted, and the contribution of the thesis is presented.

Part II contains the individual publications, both published and under review, included in this thesis. In Chapter 3, the first publication is reported. In Chapter 4, the second publication is reported. In Chapter 5, the third publication is reported.

Part III concludes the thesis. In Chapter 6, future research directions are suggested in the context of the thesis. The findings of the thesis are summarized and elaborated in Chapter 7.

Part I

Background

This part serves as a general introduction to the work carried out during the Ph. D. project. Chapter 1 introduces the context of this thesis and presents the motivation, the research questions and the methodology. The current state of the art of the field is reviewed in Chapter 2, where its gap is highlighted, and the contribution of the thesis is presented.

INTRODUCTION

In this chapter, the template for Ph. D. thesis is introduced and instructions are provided.

1.1 INSTRUCTIONS

In this section, instructions to use this template are provided. Moreover, this document itself uses this template, and can be also used as documentation.

In general, this template assumes the author has at least some knowledge of LaTeX. The minimal-effort approach is to take this document and replace the text and chapters with new content. The majority of customizations are available through arguments to the document class. However, some customizations might require to change the class itself or to the document structure.

This template is based on class 'scrbook' from the 'KOMA Script' bundle, therefore, it can be customized using the related commands. Note that some packages are not compatible with KOMA Script, and they will probably not work with this template.

This template was designed to be used with LuaLaTeX. While most of it should work with pdfLaTeX, there might be something missing. E.g. the icons for contact information in the colophon require a LaTeX processor that can use OTF fonts, or are otherwise replaced by textual labels.

1.1.1 FONTS INSTALLATION

The fonts used in this template are available in the directory `fonts`. They need to be installed in your operating system before they can be used by LuaLaTeX. In alternative, it is possible to specify a directory when loading the fonts in the document class.

1.1.2 CONFIGURATION

This template consists of two elements: a custom LaTeX class 'modernthesis' and a certain document structure. The class defines the minimal document layout, i.e. the fonts, the page size, the heading styles and some of the most important commands. The document structure complements the class with the content suitable to a Ph. D. thesis.

The bare minimum requirement for using this template is, therefore, to load its class, and run the command **\modernthesissetup**. As shown in Listing 1.1, this command is used to set most of the custom parameters necessary for generated content and customizations.

Some of the arguments, such as 'title', 'email', 'orcid' should be obvious, the others are documented in the following.

mainauthorpublications Contains the citation identifiers of the publications included in thesis written as main author. They will be printed at the beginning of the thesis.
coauthorpublications Contains the citation identifiers of the publications not included in thesis and contributed as co-author. They will be printed at the beginning of the thesis.
showprinter Enables the text 'Printed by …' in the colophon.
printer Overrides the default printer name in the colophon.
additionalcolophon Adds content to the colophon. It should start with a newline ****.
acronyms Enables acronyms using package 'glossaries'.
glossariy Enables the glossary using package 'glossaries'.
cfivepaper Sets the paper size to C5. It also sets to true the toggle 'c5', which can be used in the document to conditionally execute

Listing 1.1: Example template setup.

```
\documentclass{modernthesis}
\modernthesissetup{
    title={Software Tools and Methods for Buildings
            Fault Detection and Diagnostics},
    author={Claudio Giovanni Mattera},
    email={fake@email.com},
    linkedin={linkedin},
    orcid={0000-0002-3801-5617},
    googlescholar={Rw6VmLsAAAAJ},
    researcherid={P-3517-2018},
    year=2019,
    month=2,
    mainauthorpublications={
        doi:10.1109/BigDataService.2017.48,
        doi:10.1093/ijlct/cty019,
        doi:10.1109/ISAECT.2018.8618755,
        doi:10.3390/s18113931,
        doi:10.3390/en12030468,
    },
    coauthorpublications={
        doi:10.1016/j.egypro.2017.09.625,
        doi:10.1016/j.enbuild.2018.02.005,
        doi:10.1145/3277868.3277875,
    },
    showprinter,
    acronyms,
    glossary,
    cfivepaper,
    highlightannotatedauthors,
    highlightpubstate,
    rotatesidewaysfloats,
}
\begin{document}
...
\end{document}
```

different parts. If this argument is missing, or set to false, the page size is set to A4.

paper Explicitly sets the 'paper' argument to the KOMA script class. This allows to use other formats than A4 and C5. It is overridden by 'cfivepaper' if present.

DIV Explicitly sets the 'DIV' argument to the KOMA script class. This allows to use other formats than A4 and C5. It is overridden by 'cfivepaper' if present.

highlightannotatedauthors Highlights in boldface specific authors in the bibliography. E.g. to highlight the third author in a reference, add `author+an = {3=highlight}` in the bibliography file.

highlightpubstate Highlights in boldface the publication state, such as 'submitted' or 'in preparation'.

separatebibliography Sets to true the toggle 'separatebibliography', which can be used to repeat local bibliographies at the end of each publication included in the thesis.

rotatesidewaysfloats Redefines the command `rotatesidewayslabel` so that it rotates the page for landscape floating environments. The default implementation does nothing.

highlightunderfullvboxes Highlights in red paragraphs corresponding to underfull vboxes. It requires LuaLATEX, and it might suffer from false positives.

openaccess Prints the Open Access logo next to each bibliographic reference. It requires LuaLATEX. The Open Access information is taken from the bibliography file.

doiapi Takes the Open Access information from an online service. It requires LuaLATEX and it uses the specified email to query the service.

BCOR Absolute value for binding correction (must be a length, default: `0cm`). This is passed directly to the underlying KOMA-Script class.

1.1.3 DOCUMENT STRUCTURE

Listing 1.2 shows the document structure of this template. The actual document is slightly longer, here it is trimmed to fit the page layout,

but all the core concepts are kept.

At first, the title page is included. The title page is created with the command **\modernthesisfrontpage**. On the first recto, it typesets the title, author, departments and the rest of the expected information. On the first verso, it typesets the names of the supervisors, the names of the evaluation committee members, and the colophon, which contains also the author's contact information.

After the title, the abstract, the lists of the included publications and the acknowledgement are included. The lists of publications are generated inside two refsegments, see the documentation of package 'biblatex' for more details.

Next, the table of contents, and all the specific lists of floats, acronyms and glossaries, are printed and, at the end of the front matter, the structure of the thesis is summarized. In the front matter, all pages are numbered using Roman numerals, with the exception of the title pages, recto and verso, which are unnumbered. At the beginning of the main matter, the page numbering is set to Arabic numerals and it restarts from 1.

The main matter is organized in three parts, i.e.

Background Contains the introduction to the thesis, the review of the state of the art, and other optional chapters.
Publications Contains the publications included in the thesis, preceded by a short introduction and a bibliography.
Conclusion Contains the future research and conclusion chapters.

Finally, the back matter contains a common bibliography.

1.1.4 COMPILATION

This template is configured to be compiled using 'latexmk'. The file `latexmkrc` already contains the required commands, so the compilation literally consists of the single command `latexmk`.

By default the document is compiled with LuaLaTeX. In order to switch to pdfLaTeX it is enough to set the PDF mode to 1 by changing the first line in the file `latexmkrc` to `$pdf_mode = 1;`.

Listing 1.2: Example document structure.

```latex
\begin{document}
\frontmatter
\include{front-back-matter/title}
\include{front-back-matter/abstract}
\include{front-back-matter/publications}
\include{front-back-matter/acknowledgments}
\include{front-back-matter/contents}
\include{front-back-matter/structure}

\cleardoublepage
\mainmatter

\part{Background}
\include{chapters/introduction}
\include{chapters/state-of-art}

\part{Publications}
In this part, are reported, one per chapter, the
following publications.
\printbibliography[segment=1, heading=none]

\include{publications/first-publication/publication}
\include{publications/second-publication/publication}
\include{publications/third-publication/publication}

\part{Conclusions}
\include{chapters/future-research}
\include{chapters/conclusions}

\appendix
\backmatter
\addchap{Bibliography}
\printbibliography[heading=none, prenote=openaccess]
\end{document}
```

1.1.5 CONVENTIONS AND REQUIREMENTS

This template mandates or, at least, suggests certain conventions. The reason behind this is to maintain a consistent style over the document. E.g. if dates are typeset manually, the author might use different formats in different chapters. Using commands, instead, prevents this issue.

First of all, this template should be used with LuaLATEX. LuaLATEX allows to access fonts in True Type and Open Type formats. Moreover, it allows to extend LATEX functionality using Lua programming language. Some of the packages included in this template require LuaLATEX, however, most of it should work with other distributions as well, provided fonts are loaded in an alternative way.

Therefore, dates should always be typeset using the command **\DTMdisplaydate**{2016}{9}{1}{3}, which renders 'Thursday 1 September 2016'. The last field is the weekday, starting from 0 for Monday. In case the weekday is not important, setting it to –1 removes it, as in **\DTMdisplaydate**{2016}{9}{1}{-1}, which renders '1 September 2016'. The names of weekdays and months should be typeset with **\DTMWeekdayname**{3} and **\DTMMonthname**{3}, which render, respectively, 'Thursday' and 'March'. Similarly, times should be typeset using the command **\DTMdisplaytime**{8}{10}{0}, which renders '8:10am'.

Words and sentences should be quoted using package 'csquotes', which uses the correct convention according to the language, e.g. **\enquote**{A quoted sentence}, which renders 'A quoted sentence'.

A few common abbreviations are defined. E.g. **\Eg**, **\eg**, **\Ie**, **\ie** and **\phd**, which render 'E.g., e.g., I.e., i.e. and Ph. D. '. Do not add a comma after them, it is already typeset automatically depending on the language convention.

Numbers and units should be typeset using the package 'siunitx'. E.g. thirty-two kilowatt hour should be typeset using the command **\SI**{32}{**\kilo\watt\hour**}, which renders '32 kW h'. Raw numbers should be typeset with **\num**{244}, which renders '244'. Ranges and lists should be typeset with **\SIrange**{10}{15}{**\celsius**}

and **\SIlist**{400;500;600}{**\ppm**}, which render '10 °C to 15 °C and 400 ppm, 500 ppm and 600 ppm'. If necessary, additional units can be created.

Chemical formulas should *not* be typeset exploiting mathematical mode. Instead, the package 'mhchem' should be used. **\ce**{CO2} renders 'CO_2'.

Acronyms and glossaries should be created with package 'glossaries'. Acronyms should be typeset with **\ac**{bms}, or **\Ac**{bms} if the initial letter must be capitalized, e.g. at the beginning of a sentence[1]. Plural forms can be typeset with **\acp**{bms}. On first use, both long and short version will be shown, later only the short one. First use is reset at the beginning of each part and chapter. The previous examples render, respectively, 'building management system (BMS)', 'BMS' and 'BMSs'. To force the long version, use the command **\acl**{bms}, which always renders 'building management system'.

Glossary entries should be typeset with **\gls**{co2}, which render 'CO_2'. In some cases, the command **\glsadd**{co2} can be used when the text is about the entry, but it is not named exactly as in the glossary. It will record the usage of the entry, but it will not render anything.

Bibliographic references use the 'biblatex' package, and citations should be typeset with **\autocite**{eu:32018L0844}, and should be separated by the previous word with a non-breaking space ~, which renders the following [12]. Few commands are available for typesetting specific fields such as **\citetitle**{eu:32018L0844}, **\citeauthor**{eu:32018L0844}, **\citeyear**{eu:32018L0844} or **\citejournal**{eu:32018L0844}. The examples render, respectively, 'Second Energy Performance of Buildings Directive', European Parliament and Council of the European Union, 2018 or *Official Journal of the European Union*. Another useful command for bibliographic citations is **\longfullcite**{eu:32018L0844}, which replicates the citation as it is typeset in the bibliography, and renders the following.

European Parliament and Council of the European Union. 'Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 Amending Directive 2010/31/EU on the Energy Performance of

---

[1]Often, this only affects the first use.

Buildings and Directive 2012/27/EU on Energy Efficiency'. In: *Official Journal of the European Union* L156 (19th June 2018), pp. 75–91. EU DIRECTIVE: 2018/844.

Cross-references should be typeset using the 'cleveref' package. The command **\cref**{chap:introduction} renders 'Chapter 1'.

Figures are typeset as usual in LaTeX, which renders as shown in Figure 1.1. Figures (and other floats such as tables) should be smaller than the page size, which is 12.72676 cm by 18.25574 cm. Figures can be typeset in landscape mode using the environment 'sidewaysfigure', which renders as shown in Figure 1.2. Tables can also typeset in landscape mode using the environment 'sidewaystable'. The command **\rotatesidewayslabel** can be used inside the floating environment and, if the class option 'rotatesidewaysfloats' was specified, it will rotate the relative page in the PDF document, as shown in Figure 1.3. Note that landscape figures cannot be put in the front matter, i.e. where pages are numbered with Roman numerals.

The command **\caption**[short]{long} can be used to create captions inside floating environments. The normal caption is specified between braces, and it must *not* be terminated by a period, because one will be added automatically. An optional short caption can be specified between square brackets, and it will be used in the table of contents and in the running headers.

1.2 CUSTOMIZATION

1.2.1 CUSTOM FLOATS

LaTeX offers by default floating environments for figures and tables. Other packages add more environments, e.g. 'minted' adds listings. Sometimes it is nice to add additional ones, e.g. 'rules' or 'examples'.

The following example adds a new floating environment for rules. The environment is first defined in Listing 1.3, and the names of references are defined in Listing 1.4. Both these snippets must be in the preamble.

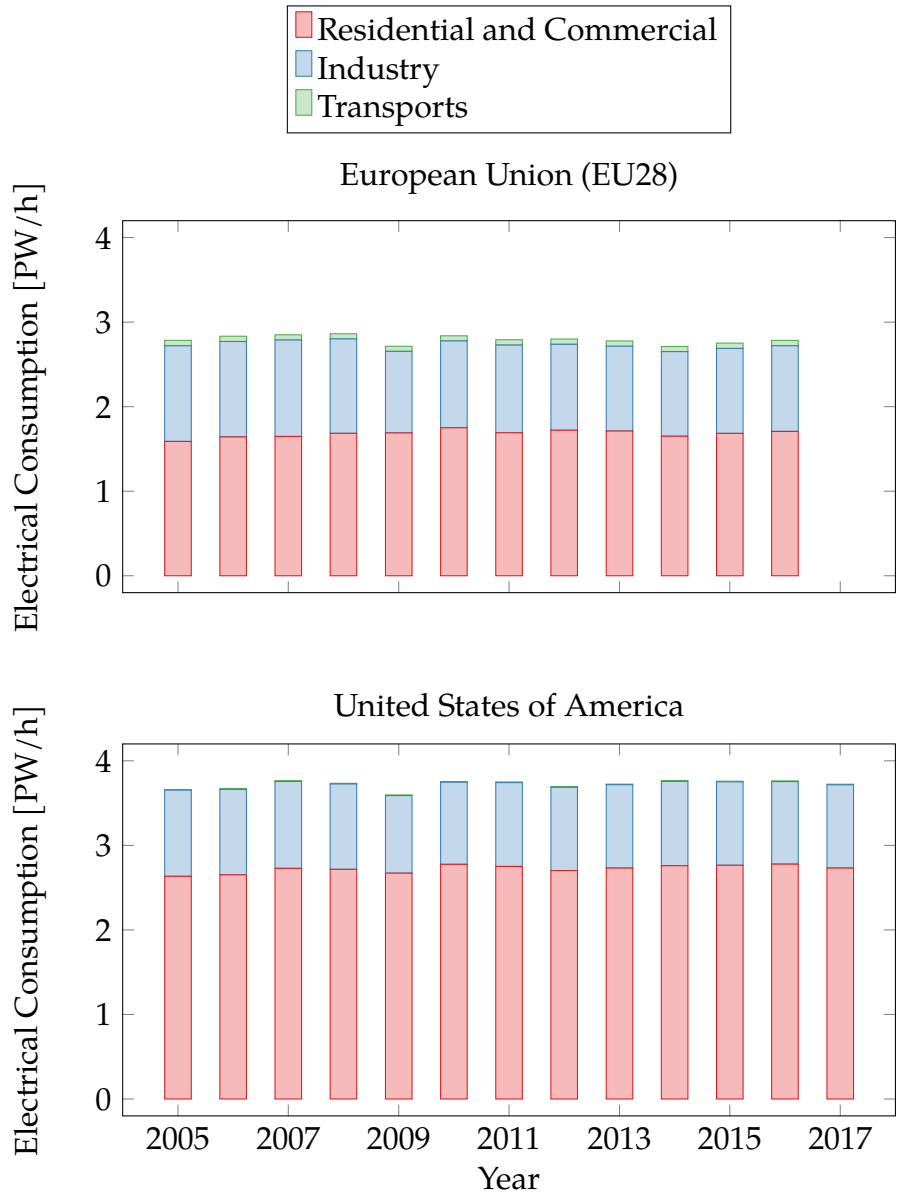The list of new floating environments can be added after the table

Figure 1.1: Electricity consumption due to buildings in Europe and the United States of America.
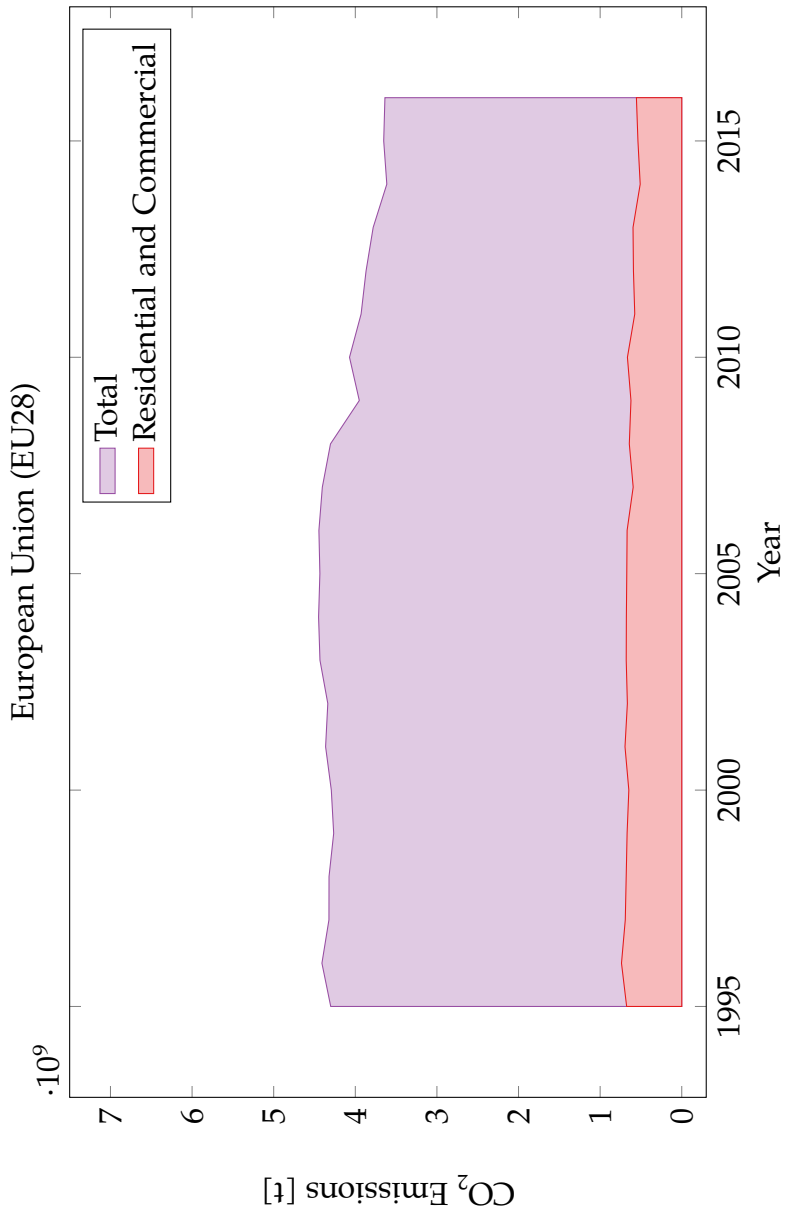
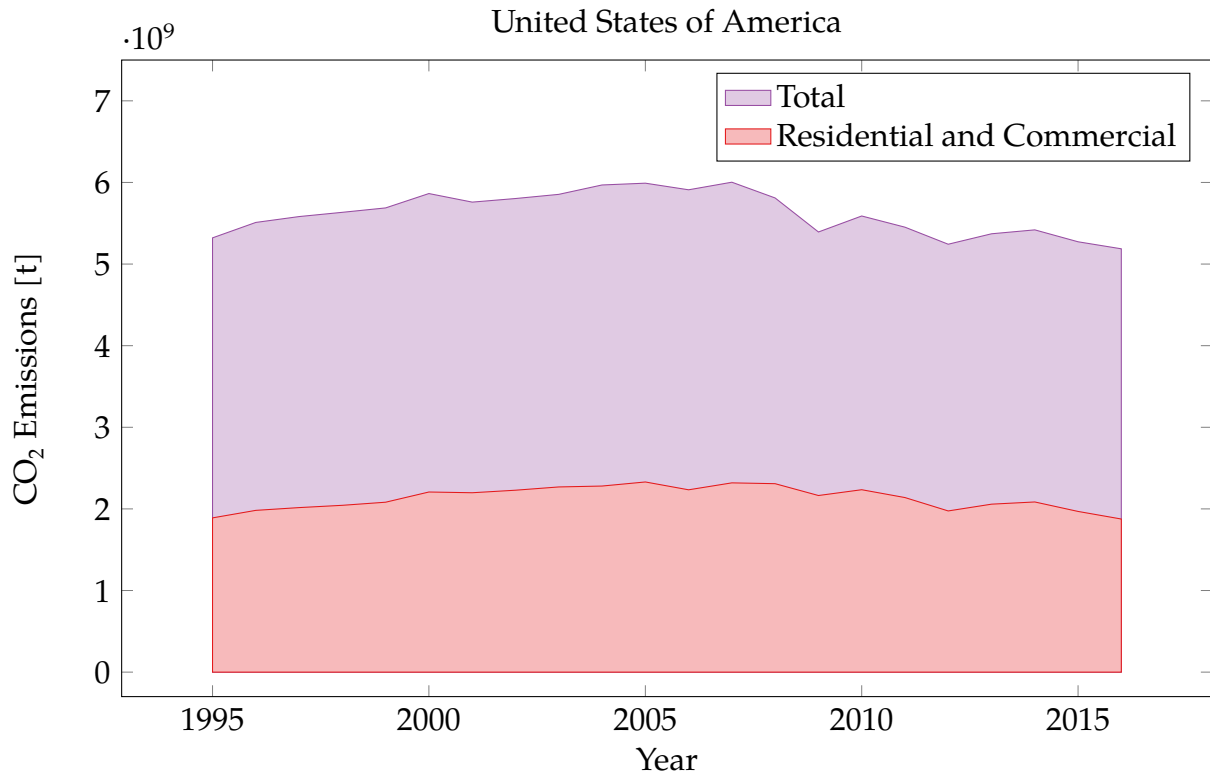**Figure 1.2:** Carbon emissions due to buildings in Europe.

Figure 1.3: Carbon emissions due to buildings in the United States of America.

Listing 1.3: Definition of a new floating environment.

```
\DeclareNewTOC[%
    type=algorithmrule, % This is the name of the
                        % floating environment
    float,
    floatpos=tbph,
    counterwithin=chapter,
    name=Rule,
    listname={List of Rules},
    tocentryindent=1.5em, % default is 1em, figure
                          % uses 1.5em
    tocentrynumwidth=2.3em, % default is 1.5em,
                            % figure uses 2.3em
]{listofrules}

\setuptoc{listofrules}{chapteratlist}
```

Listing 1.4: References customization of a new floating environment.

```
% This sets up the names for package cleveref
\if@cref@capitalise
    \crefname{algorithmrule}{Rule}{Rules}
\else
    \crefname{algorithmrule}{rule}{rules}
\fi

\Crefname{algorithmrule}{Rule}{Rules}
```

Listing 1.5: Printing the list of new floating environments.

```
\cleardoublepage\listofalgorithmrules
\addcontentsline{toc}{chapter}{\listalgorithmrulename}
```

Listing 1.6: Usage of new floating environments.

```
\begin{algorithmrule}[h]
\caption{My rule}
\label{rule:my-rule}
\begin{algorithmic}
\IF{$a > b$}
    \IF{$a > c $}
        \STATE $a$ is the largest
    \ENDIF
\ENDIF
\end{algorithmic}
\end{algorithmrule}
```

of contents, as shown in Listing 1.5.

Finally, the new floating environment is used in the document as shown in Listing 1.6.

1.3 TERMS OF USE

There are no particular restrictions on the use of this template. It would be nice of you to keep the text 'using […] the modernthesis template created by Claudio Mattera' in the colophon, but it is not a requirement. Feel also free to modify the template if it suits you better. The fonts included in this template have free-software licenses, and they are available in the same directory.

1.4 STRUCTURE OF THE THESIS

The rest of the thesis is structured as it follows. The current state of the art of the field is reviewed in Chapter 2, where its gap is highlighted, and the contribution of the thesis is presented.

Part II contains the individual publications, both published and under review, included in this thesis. In Chapter 3, the first publication is reported. In Chapter 4, the second publication is reported. In Chapter 5, the third publication is reported.

Part III concludes the thesis. In Chapter 6, future research directions are suggested in the context of the thesis. The findings of the thesis are summarized and elaborated in Chapter 7.

STATE OF THE ART

2

In this chapter, the state of the art is reviewed. Finally, the gap in the state of the art is identified, and the contributions of this thesis—and of the individual publications included—are summarized.

Part II

Publications

In this part, are reported, one per chapter, the following publications.

[1] **Claudio Giovanni Mattera**, Sanja Lazarova-Molnar, Hamid Reza Shaker and Bo Nørregaard Jørgensen. 'A Practical Approach to Validation of Buildings' Sensor Data: a Commissioning Experience Report'. In: *Third International Conference on Big Data Computing Service and Applications (BigDataService)* (San Francisco, CA, USA, 6th–9th Apr. 2017). IEEE. 12th June 2017, pp. 287–292. DOI: `10.1109/BigDataService.2017.48`.

[2] **Claudio Giovanni Mattera**, Muhyiddine Jradi and Hamid Reza Shaker. 'Online Energy Simulator for Building Fault Detection and Diagnostics Using Dynamic Energy Performance Model'. In: *International Journal of Low-Carbon Technologies* 13.3 (1st Sept. 2018), pp. 231–239. ISSN: 1748-1325. DOI: `10.1093/ijlct/cty019`.

[3] **Claudio Giovanni Mattera**, Joseba Quevedo, Teresa Escobet, Hamid Reza Shaker and Muhyiddine Jradi. 'Fault Detection and Diagnostics in Ventilation Units Using Linear Regression Virtual Sensors'. In: *International Symposium on Advanced Electrical and Communication Technologies (ISAECT)* (Kenitra, Morocco, 21st–23rd Nov. 2018). IEEE. 24th Jan. 2019. DOI: `10.1109/ISAECT.2018.8618755`.

[4] **Claudio Giovanni Mattera**, Joseba Quevedo, Teresa Escobet, Hamid Reza Shaker and Muhyiddine Jradi. 'A Method for Fault Detection and Diagnostics in Ventilation Units Using Virtual Sensors'. In: *Sensors* 18.11 (14th Nov. 2018). ISSN: 1424-8220. DOI: `10.3390/s18113931`.

[5] **Claudio Giovanni Mattera**, Hamid Reza Shaker and Muhyiddine Jradi. 'Consensus-based Method for Anomaly Detection in VAV Units'. In: *Energies* 12.3 (1st Feb. 2019). ISSN: 1996-1073. DOI: `10.3390/en12030468`.

[6] **Claudio Giovanni Mattera**, Hamid Reza Shaker, Muhyiddine Jradi, Mathis Riber Skydt and Sebastian Skals Engelsgaard. 'Fault Detection in Ventilation Units using Dynamic Energy Perform-

ance Models'. In: *Sustainable Cities and Society* (2019). ɪssɴ: 2210-6707. **Submitted**.

Figures and tables were minimally edited to fit the layout of this thesis, and they are otherwise identical to the ones in aforementioned publications. Text was copied verbatim, except for bibliography reference numbers and styles which are kept uniform for the entire thesis, and for minor spelling adaptations and corrections.

A local bibliography is reported at the end of each chapter, listing all references cited in the corresponding publication. All references are also repeated in the global bibliography at the end of this thesis, on page 41.

SENSORS VALIDATION: A PRECONDITION TO ANY BUILDING APPLICATION

This chapter is a cosmetic adaptation of the following conference paper.

Claudio Giovanni Mattera, Sanja Lazarova-Molnar, Hamid Reza Shaker and Bo Nørregaard Jørgensen. 'A Practical Approach to Validation of Buildings' Sensor Data: a Commissioning Experience Report'. In: *Third International Conference on Big Data Computing Service and Applications (BigDataService)* (San Francisco, CA, USA, 6th–9th Apr. 2017). IEEE. 12th June 2017, pp. 287–292. DOI: `10.1109/BigDataService.2017.48`

The paper was presented at the IEEE Third International Conference on Big Data Computing Service and Applications in San Francisco, USA, on Sunday 9 April 2017.

ABSTRACT

An abstract

3.1 INTRODUCTION

In the bibliography at the end of this chapter, if enabled at all, only references cited in this chapter are reported, such as 'Second Energy Performance of Buildings Directive' [12] and 'Room-level Occupant Counts, Airflow and CO2 Data from an Office Building' [9].

REFERENCES

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IDENTIFYING FAULTY SUBSYSTEMS WITH ONLINE ENERGY SIMULATOR

4

This chapter is a cosmetic adaptation of the following journal paper.

Claudio Giovanni Mattera, Muhyiddine Jradi and Hamid Reza Shaker. 'Online Energy Simulator for Building Fault Detection and Diagnostics Using Dynamic Energy Performance Model'. In: *International Journal of Low-Carbon Technologies* 13.3 (1st Sept. 2018), pp. 231–239. ISSN: 1748-1325. DOI: 10.1093/ijlct/cty019

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INTRODUCING REDUNDANCY THROUGH LINEAR REGRESSION VIRTUAL SENSORS

This chapter is a cosmetic adaptation of the following conference paper.

Claudio Giovanni Mattera, Joseba Quevedo, Teresa Escobet, Hamid Reza Shaker and Muhyiddine Jradi. 'Fault Detection and Diagnostics in Ventilation Units Using Linear Regression Virtual Sensors'. In: *International Symposium on Advanced Electrical and Communication Technologies (ISAECT)* (Kenitra, Morocco, 21st–23rd Nov. 2018). IEEE. 24th Jan. 2019. DOI: `10.1109/ISAECT.2018.8618755`

This work was the result of a collaboration with the Center for Supervision, Security and Automatic Control (CS^2AC), at the Polytechnic University of Catalonia (UPC), Barcelona, Spain.

The paper was presented at the IEEE International Symposium on Advanced Electrical and Communication Technologies in Kenitra, Morocco, on Wednesday 21 November 2018.

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PART III

CONCLUSIONS

This part concludes the thesis. In Chapter 6, future research directions are suggested in the context of the thesis. The findings of the thesis are summarized and elaborated in Chapter 7.

FUTURE RESEARCH | 6

In this chapter, future research directions are discussed. At first, a brief recap of the individual publications is reported and, afterwards, a general summary is presented for the whole thesis.

CONCLUSION 7

In this chapter, conclusions about the thesis work are drawn.

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