Technische Universität Berlin
Faculty III – Process Sciences
Institute of Energy Engineering
Chair of Energy Process Engineering and Conversion Technologies for Renewable Energies

Master's thesis

Thesis using Overleaf/LaTeX

Subtitle

Jane Doe
Energy Engineering and Process Engineering
Student-ID 111213

Berlin, July 1st, 2025

Supervised by Prof. Dr. Katharina Herkendell and Dr.-Ing Mathias Hofmann
as well as John Doe (Import Export GmbH)

Eigenständigkeitserklärung

Hiermit versichere ich, dass ich die vorliegende Arbeit ohne Hilfe Dritter und ausschließlich unter Verwendung der aufgeführten Quellen und Hilfsmittel angefertigt habe. Alle Stellen die den benutzten Quellen und Hilfsmitteln wörtlich oder inhaltlich entnommen sind, habe ich als solche kenntlich gemacht.

Sofern KI-Tools verwendet wurden, habe ich Produktnamen, Hersteller, die jeweils verwendete Softwareversion und die Art der Nutzung (z.B. sprachliche Überprüfung und Verbesserung der Texte, systematische Recherche) benannt. Ich verantworte die Auswahl, die Übernahme und sämtliche Ergebnisse des von mir verwendeten KI-generierten Outputs vollumfänglich selbst.

Die Satzung zur Sicherung guter wissenschaftlicher Praxis an der TU Berlin vom 15. Februar 2023 habe ich zur Kenntnis genommen.[1]

Ich erkläre weiterhin, dass ich die Arbeit in gleicher oder ähnlicher Form noch keiner anderen Prüfungsbehörde vorgelegt habe.

Berlin, den 1. Juli 2025

Jane Doe

1 https://www.static.tu.berlin/.../Amtliches_Mitteilungsblatt_Nr._16_vom_30.05.2023.pdf

Angaben zur Nutzung von künstlicher Intelligenz (KI)

Bereich	Ja/Nein	Tool/Plattform	Kurzbeschreibung
Themenfindung, Ideensammlung			
Textarbeit (Formulierung, Stil)			
Übersetzung, Sprachkorrektur			
Programmierung, Datenanalyse			
Sonstiges: [BITTE EINTRAGEN]			

Reflexion zur Eigenständigkeit

Wie haben Sie sichergestellt, dass die inhaltliche Verantwortung Ihrer Arbeit bei Ihnen liegt? [ANTWORT]

Wie wurden Inhalte, die durch KI-Tools erzeugt wurden, kritisch überprüft und ggf. angepasst? [ANTWORT]

Welche Abschnitte der Arbeit spiegeln besonders Ihre eigene wissenschaftliche Leistung wider? [ANTWORT]

Abstract

English

Zusammenfassung

German

Contents

1. Introduction

1.1. Motivation

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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1.2. Aim of the work

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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1.3. Outline and notes

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2. Useful information for theses with Overleaf/LaTeX

Here are some tips for writing academic papers with LaTeX, especially theses. LaTeX markup describes the content and layout of the document, in contrast to formatted text in WYSIWYG word processors such as Google Docs, LibreOffice Writer, and Microsoft Word. The writer uses markup tagging conventions to define the general structure of a document, style text throughout the document (e.g., bold and italics), and add citations and cross-references. LaTeX is particularly powerful when it comes to typesetting formulas, tables, and automatically generating lists (bibliography, table of contents), references, and numbering.

2.1. Working with LaTeX

The easiest way to edit LaTeX documents is to use online LaTeX editors such as Overleaf. This is a cloud-based online platform for creating, editing, and collaborating on text documents. A key feature of Overleaf is its real-time preview: changes to the source text are immediately displayed in a PDF document. This makes the work process very transparent, which is particularly helpful for beginners. In addition, several people can work on a document at the same time, making Overleaf ideal for team projects, joint scientific work, publications, or student research projects. The integrated version management allows you to restore previous editing states and track changes. In addition, Overleaf offers a variety of templates, for example for theses, articles in scientific journals, presentations, or resumes. Many of these already comply with the formatting requirements of universities or publishers. The platform also supports connection to GitHub, Dropbox, or Git, which means that Overleaf can also be easily integrated into existing workflows.

To work with LaTeX on a Windows computer, you need a distribution such as texlive. You also need a powerful LaTeX editor, such as TeXstudio. Both can be downloaded from the Internet and installed. Mac and Linux users may be interested in other programs.

Extensions for LaTeX, such as embedding formulas, setting tables, and creating figures and diagrams, are organized on the basis of so-called packages. When using the packages presented below and included in the template, you should always consult the corresponding package documentation. These can be found on the CTAN server, example package siunitx.[1]

2.2. References within the document

Text with reference to Table 2.1 or Fig. 2.5 to Page 9. With the cleveref package, the prefixes are set automatically. The reference to Eq. (2.4) also works with `\cref`. The parentheses are included automatically.

1 https://ctan.org/pkg/siunitx

Command	Output	Example output
`\cref{Label}`	Object/Type and Number/Value	Section 2.2
`\crefrange{Label1}{Label2}`	Object/Type from to	Sections 2.2 to 2.9
`\cpageref{Label}`	Pagenumber incl. prefix Page	Page 4
`\cpagerefrange{Label1}{Label2}`	Range of pages	Pages 4 to 10
`\namecref{Label}`	Object/Type	Section
`\labelcref{Label}`	Number/Value	2.2
`\labelcpageref{Label}`	Pagenumber only	4

2.3. Equations

LaTeX is ideal for displaying formulas. The amsmath package makes LaTeX even more powerful. Numerous complex representations can be easily implemented. Here are a few examples:

Isentropic efficiency

$$\dot{W}_{\mathrm{el}} = \dot{m} \cdot \Delta h_s \left(\eta_{\mathrm{m,el}} \cdot \eta_s\right)^{\alpha} \qquad \alpha = \begin{cases} 1 & \text{Turbines} \\ -1 & \text{Pumps, compressors} \end{cases} \tag{2.1}$$

Physical exergy of an ideal gas

$$\frac{e^{\mathrm{PH}}}{c_{\mathrm{p}} T_0} = \left[\frac{T}{T_0} - 1 - \ln\frac{T}{T_0}\right] + \ln\left(\frac{p}{p_0}\right)^{\frac{(\kappa-1)}{\kappa}} \tag{2.2}$$

Exergy destruction rate for isobaric heat transfer

$$\dot{E}_{\mathrm{D}} = \sum_j \left[\int_{\mathrm{i}}^{\mathrm{e}} \left(1 - \frac{T_0}{T}\right) \mathrm{d}\dot{Q}\right]_j \tag{2.3}$$

A cost balance

$$\sum_i \left(c_i \dot{E}_i\right)_k + \underbrace{\frac{\left(CC_\ell + OMC_\ell\right) BMC_k}{\tau \sum_k BMC_k}}_{\dot{Z}_k = \dot{Z}_k^{\mathrm{CI}} + \dot{Z}_k^{\mathrm{OM}}} = \sum_e \left(c_e \dot{E}_e\right)_k + c_{\mathrm{w},k} \dot{W}_k + c_{\mathrm{q},k} \dot{E}_{\mathrm{q},k} \tag{2.4}$$

2.4. Numbers and units

With the siunitx package, numbers and units can be easily set in both continuous text and mathematical environments. Commands or abbreviations exist for all SI units and units derived from them; see the package documentation.

Command	Output
`\num{3,5}`	3.5
`\si{\meter}`	m
`\SI{3,5}{\meter}`	3.5 m
`\numlist{3;3,5;4,2}`	3, 3.5 and 4.2
`\numrange{3,5}{4,2}`	3.5 to 4.2
`\SIlist{3;3,5;4,2}{\meter}`	3 m, 3.5 m and 4.2 m
`\SIrange{3,5}{4,2}{\meter}`	3.5 m to 4.2 m

2.5. Chemical formulas

The powerful mhchem package should be used here. Simple reaction equations can be written directly.

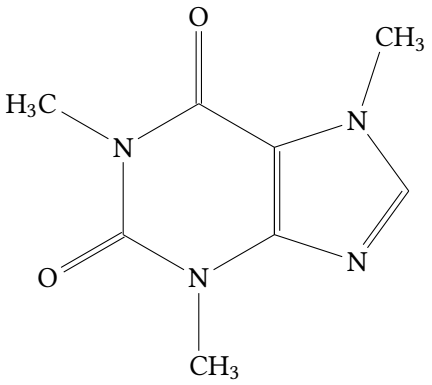
$$\mathrm{CH_4 + 2\,O_2 \longrightarrow 2\,H_2O + CO_2} \tag{2.5}$$

But more complex relationships and combinations with formulas are also possible.

$$\overbrace{(c^*\cdot \mathrm{C} + h^*\cdot \mathrm{H} + o^*\cdot \mathrm{O} + n^*\cdot \mathrm{N} + s^*\cdot \mathrm{S})}^{m_{\mathrm{waf}}=1\,\mathrm{kg}} + \nu_{\mathrm{O_2}}\cdot \mathrm{O_2} \longrightarrow \nu_{\mathrm{CO_2}}\cdot \mathrm{CO_2} + \nu_{\mathrm{H_2O}}\cdot \mathrm{H_2O_{(l)}} + \nu_{\mathrm{N_2}}\cdot \mathrm{N_2} + \nu_{\mathrm{SO_2}}\cdot \mathrm{SO_2} \tag{2.6}$$

2.6. Molecular structures

The chemfig package can be used to set simple two-dimensional chemical structures and diagrams in LaTeX. TikZ is used to draw the molecules and structures. Below is an example of the molecular structure of caffeine, a common component in the preparation of theses.



(2.7)

2.7. Illustrations

In principle, vector graphics (*.pdf, *.eps, *.svg) are preferable to bitmap images (*.jpg, *.png, *.tif). The use of images without the copyright holder's permission constitutes a copyright infringement. Create your own images, obtain permission if necessary, or use images with the appropriate approvals.

2.7.1. Diagrams

Diagrams can be created quickly and easily with TikZ. Here is an example optimized for black-and-white printing and copying, see Fig. 2.1. Below that, in Fig. 2.2, is a diagram that can be used for electronic submission. The diagram was created with TikZ using external data; for example, *.dat or *.csv files can be used.

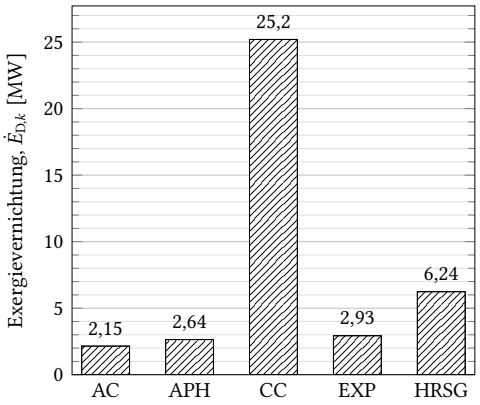


Fig. 2.1.: Long caption, with reference to source if required

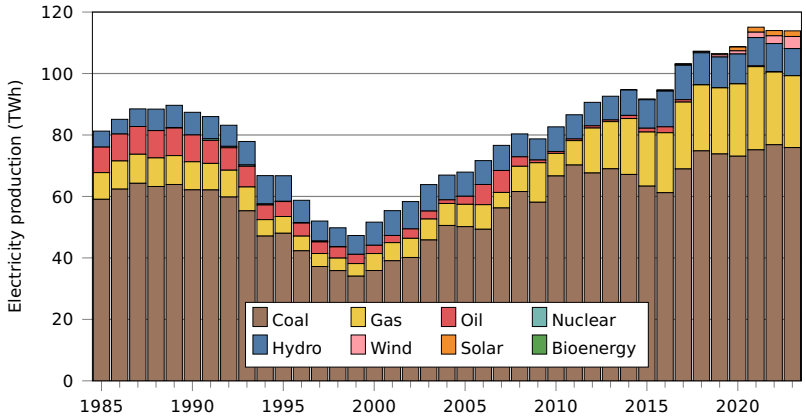


Fig. 2.2.: Electricity production by source, Kazakhstan, 1985–2023, transferred from [1]

2.7.2. Flow charts

Can be created directly within Latex using the chemplants package or the chemplants-tub[2] version (including extensions for ISO component representations) or freehand with Inkscape. The Libertine document font or the sans serif Arev or Roboto fonts are suitable fonts.

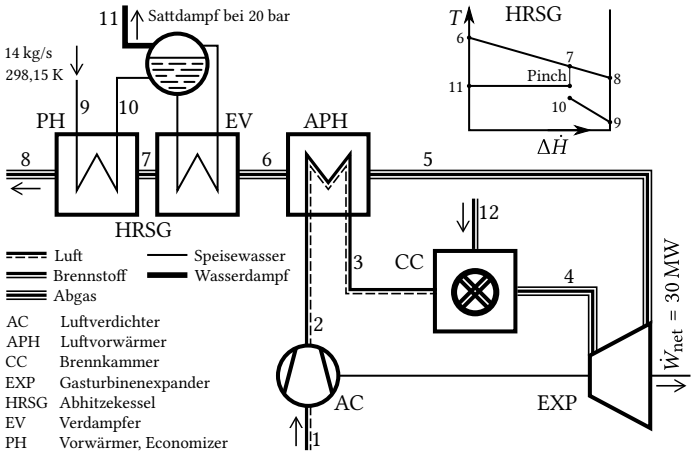


Fig. 2.3.: Flow chart CGAM process, including legend and labels, created in Inkscape (using the Libertine document font and the tex-to-text plugin)

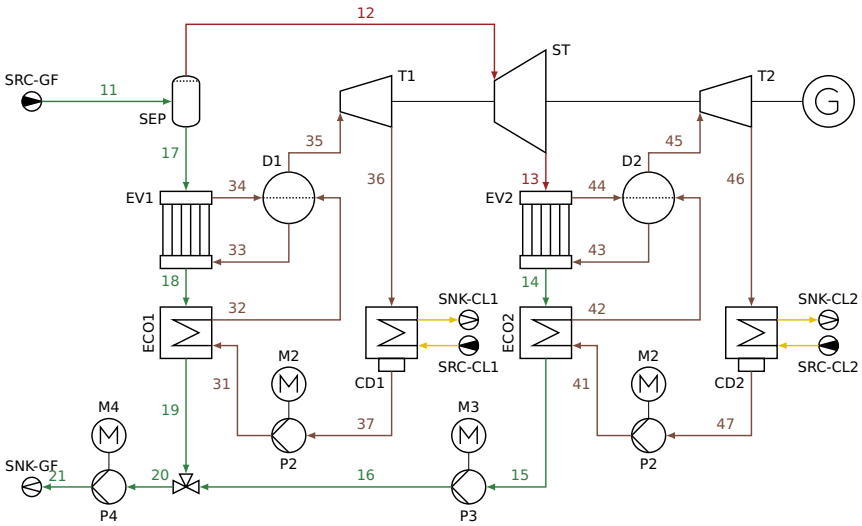


Fig. 2.4.: Flow chart of a geothermal process with complete electrical extraction using two downstream ORC processes, created with chemplants-tub

2 https://github.com/tub-hofmann/chemplants-tub/

2.7.3. Pictures, photos

If *.jpg or similar files need to be included, ensure that the resolution is as high as possible. Always consider whether a schematic representation or a black-and-white illustration would be more suitable.

Fig. 2.5.: Miniature funnel, French, 18th century (Image cropped)

2.8. Tables

The booktabs package is used to create tables. Vertical lines in tables should be avoided. Here is an example including table footnotes.

Table 2.1.: Parameter of the economic analysis

Parameter	Symbol	Unit	Value
Plant economic lifetime, see [2]	n	a	40
Avg. nom. escalation rate, universal[a]	$r_{\mathrm{n,uni}}$	%/a	1,5
Fixed operating and maint. costs, see [3]	omc_{fix}	%/a	1,5
Variable operating and maint. costs	omc_{var}	€/$\mathrm{MWh_{el}}$	1,3[b]
Specific emission cost[a]	ec	€/$\mathrm{tCO_2}$	20
Emission factor[c]	$k_{\mathrm{CO_2}}$	$\mathrm{tCO_2/MWh_{fuel}}$	0,34
Annual equivalent full-load hours	τ	h/a	4500
Annual effective rate of return	i_{eff}	%/a	5
Specific fuel cost	fc	€/GJ	1,9
Avg. nom. escalation rate, fuel	$r_{\mathrm{n,fuel}}$	%/a	2

[a] Assumption
[b] see [3]
[c] Based on own calculation; for methodology, see [4]

2.9. Literature references

With biblatex and biber, you can quickly and easily create bibliographic references. The options for biblatex are specified in the preamble. Biber is used as the backend. Sources are entered in a *.bib file. Reference management programs such as jabref (open source) or Citavi (fee-based, license via TU Berlin) can also be used for this purpose.

2.9.1. An example with a quote

The mathematical description of the stationary power plant simulation corresponds to an implicit system of equations. Instead of $y = f(x)$,

$$F(x, y) = 0 \tag{2.8}$$

is used.[3] This may even be necessary, since according to [6, p. 260] (translated from German), "the determining equation is difficult or impossible to solve explicitly for $y = f(x)$." Even a simple substance property polynomial such as the representation of entropy at reference pressure according to Knacke et al., [7],

$$s^0 = \mathrm{S}^+ + \mathrm{a}\,\ln(T/\mathrm{K}) + \mathrm{b}\,y - \frac{\mathrm{c}}{2}\,y^{-2} + \frac{\mathrm{d}}{2}\,y^2 \qquad \text{with} \quad y = 10^{-3}\,T/\mathrm{K} \tag{2.9}$$

i.e., only dependent on temperature, cannot be analytically resolved to T.

2.9.2. Simple references to literature

In their scientific article, Zoder et al. [8] conclude that the use of exergy-based methods is helpful in the analysis of energy conversion plants. When citing scientific articles in the bibliography, a DOI should always be provided if possible.

Other authors also present interesting results in their comprehensive publications, cf. [9–13]. However, so-called *lumped references* should be avoided. Each reference should be acknowledged individually and it should be described what has been taken from this source or which approaches, ideas, findings, etc. are worth mentioning.

Some authors have written books that are well worth reading, including Baehr and Kabelac [14], Szargut [15], and Moran et al. [16]. Not to be forgotten are Müller [17] and the current compilation by the IEA [18].

In addition to books and scientific articles, it is also possible to refer to book contributions [13], conference proceedings [19], contributions in conference proceedings [20, 21], dissertations [22, 23], scientific reports [24, 25], internet sources [26–29], and much more.

2.9.3. Literature reference with page number

Müller notes the thermal equation of state according to van der Waals, see [17, p. 100].

3 cf. [5, p. 147]

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Nomenclature

Abbreviation

AC	Air Compressor
APH	Air Preheater
CC	Combustion Chamber
EXP	Expander
HRSG	Heat Recovery Steam Generator

Latin symbols

$\dot{C}$	Cost flow rate, €/h
c	Specific cost per unit of exergy, €/J_{ex}
CC	Kapitalgebundene Kosten, €
cf	Capacity factor, –
$\dot{E}$	Exergy flow rate, W
e	Mass-specific exergy, J/kg
$\bar{e}$	Mol-specific exergy, J/mol
f	Exergoeconomic factor, –
FC	Fuel cost, €
fc	Specific fuel cost, €/J
$\dot{H}$	Enthalpy flow rate, W
h	Mass-specific enthalpy, J/kg
HHV	Higher heating value, J/kg

Greek symbols

ε	Exergy efficiency, –
η_s	Isentropic efficiency, –
κ	Isentropic exponent, –
λ	Air-fuel ratio, –
ν	Stoichiometric coefficient, –

Operators

Δ	Difference

Subscripts

0	Reference point, ambient conditions
a	Average
D	Destruction
F	Fuel
net	Net value

Superscripts

CI	Capital invest
OM	Operation and maintenance
PH	Physical

List of Figures

List of Tables

Appendix

A. Simulations – Flow charts and parameters

A.1. Case 1

Fig. A.1.: Caption

B. Cost analysis

C. Results