

Operation optimization of an ATES system for a High-Tech industrial building

Confidential Report



Master of Science Thesis on
Operation optimization of an ATES system for a
High-Tech industrial building

Alexandros Papageorgiou, BSc.
Eindhoven, The Netherlands
May, 2019

Colophon

This report is treated under "confidentiality restrictions" by the Education Office which means that:

- The report is stored only digitally in a special section of the digital archive
- Only the program management has access to the digitally stored report

Title: Operation optimization of an ATES system for a High-Tech industrial building

Master: Sustainable Energy Technology (SET)

Department: Built Environment

Research Group: Building Performance

Student: Alexandros Papageorgiou

Identity Number: 1071878

TU/e supervisors: prof.dr.ir Jan Hensen
 dr.ir. Pieter-Jan Hoes
 Luyi Xu, MSc
 Evangelos Kyrou, MSc

Engie External Supervisor: Joep Berghs

Date: 08/05/2019

Table of Contents

Colophon	iii
Abstract	vi
Acknowledgements	vii
1 Introduction	1
1.1 Background of the project	1
1.2 Problem definition and research questions	1
1.3 Project objectives and Research questions	3
2 Literature review	4
2.1 ATES systems	4
2.2 Demand prediction	5
3 Methodology	6
3.1 Simulation and calculation tools	8
4 Case study building and modelling assumptions	9
4.1 Case study	9
4.1.1 Building envelope	9
4.1.2 Internal heat gains.....	10
4.2 Assumptions	10
4.3 Settings for HVAC system	10
5 System models and modelling assumptions	11
5.1 Cleanroom model	11
5.1.1 MAU submodel.....	11
5.1.2 Main cleanroom model	11
5.1.3 Cleanroom modelling assumptions	12
5.1.4 Modelling summary.....	13
5.2 Demand Scenarios	13
5.3 ATES integrated heating and cooling system	14
5.3.1 ATES operation	14
5.3.2 ATES integrated heating and cooling system modelling.....	16
5.4 Process cooling system	20
5.4.1 Process cooling operation	20
5.4.2 Process cooling system modelling.....	20
6 Demand prediction results	22
6.1 Building energy simulations	22
6.2 Cleanroom demand results	23
6.3 Demand scenarios results	24
6.3.1 Heating, cooling and process cooling demand for demand scenario 1	24
6.3.2 Heating, cooling and process cooling demand for demand scenario 2	25

6.3.3	Heating, cooling and process cooling demand for demand scenario 3	26
6.3.4	Summary of results for heating, cooling and process cooling demand	28
6.4	Process cooling model results	28
6.5	ATES model results	30
6.5.1	Aquifer temperature results	31
6.6	Model validation	33
6.6.1	Building energy simulation model validation	33
6.6.2	Cleanroom model validation	33
6.6.3	ATES integrated heating and cooling model validation	36
7	Assessment of operational strategies	39
7.1	Initial operation strategy	39
7.2	Operation scenarios results	41
7.2.1	First operation strategy	42
7.2.2	Second operation strategy	43
8	Conclusions	45
8.1	Conclusions	45
8.2	Limitations and recommendations for future work	45
9	References	47
10	Appendices	50

Abstract

Buildings in Europe are responsible for the 40% of the total energy consumption and one third of the total CO₂ emissions. Following this worrying trend, European Union has issued the Energy Performance of Buildings Directive in an effort to reduce the energy consumption in the built environment and increase the share of renewable energy. The Netherlands adopted these measures and have enforced the "Energy Agenda" under which they want to stop using gas and replace it by other more sustainable sources like thermal energy storage (TES) in combination with a sustainable energy supply.

Different operation strategies in order to reduce the energy consumption of a high tech industrial building are investigated in this research. The Brainport Industries Campus (BIC) built in the area of Eindhoven is used as a study case. BIC aims to be an energy neutral 'gas-free' campus and for this reason uses an ATES system for heating and cooling, and a process cooling system to supply the cleanrooms which are located in the main building.

Due to lack of metered heating, cooling and process cooling data, simulation software tools (IES VE, Dymola) are used to create demand scenarios in order to be used as input to the models of ATES and process cooling system. These systems are modelled using the object oriented modelling interface of Dymola. Two operation strategies, one addressed only to the operation of the ATES system and one combining ATES and process cooling systems, are evaluated based on the achieved energy savings compared to the initial operation strategy.

The obtained results showed that energy savings from 11 MWh to 41MWh can be achieved from the operation of the ATES system by applying strategies to thermally balance the cold and warm wells. Also, applying operation strategies which combine the systems of ATES and process cooling can be preferable only when there is enough process cooling demand, otherwise it can lead to little or no energy savings. In general, for both strategies the energy savings increase as heating, cooling and process cooling demand increase.

Acknowledgements

I would like to thank my TU/E supervisors Luyi, Evangelos, Pieter-Jan and Jan Hensen for their support during this project. Prof. Hensen, who was also my academic mentor, was always very helpful during my studies. Luyi, even though she is very busy being a PhD student, always had time to provide feedback and support.

Also, I would like to express my gratitude for his time, support through good and bad times during the project, willingness to share information and especially the walks during the lunch break to my daily supervisor from ENGIE Zuid Services BV, Joep Berghs.

Last but not least, I would like to thank my parents for all their support. Without them I would not be the person I am today.