Ermiyas Dessalegne and Anil Bhattarai

Renovation of a historical building

Hotel Agricola

Helsinki Metropolia University of Applied Sciences

Bachelor of Engineering

Sustainable Building Engineering

Thesis

08 May 2018

Helsinki Metropolia University of Applied Sciences

Authors Title Number of Pages Date	Ermiyas Dessalegne and Anil Bhattarai Renovation of a Historical Building: Hotel Agricola 87 pages + 12 appendices 08 May 2018
Degree	Bachelor of Engineering
Degree Programme	Civil Engineering
Specialisation option	Sustainable Building Engineering
Instructors	Sunil Suwal, Senior Lecturer Eric Pollock, Principal Lecturer, Architect SAFA

The purpose of this thesis was to study the feasibility of renovating a historical building to a hotel. The energy renovation and strategies of turning an old building into a modern one were studied. The advantage of repurposing a building can be felt at the building level in terms of indoor environment comfort and aesthetics as well as job creation, and decreased carbon foot print on the environment.

To answer the main question of the project, how to change the purpose of the building, a literature review was carried out. Various published articles and books on renovation topics were studied. The findings were verified with simulation software, such as IDA ICE. Furthermore, some people in the field of historical buildings were interviewed.

Through the analysis of the data from the simulation of the building and through the calculation of the payback time, the project established that it is possible to change the purpose of the building in question to a four star hotel.

Therefore it is recommended that this aesthetically pleasing historical building is transformed into a hotel.

Keywords	energy renovation, historical building, Agricola Hotel

Contents

Abbreviations

AC/DC	Alternating Current/ Direct Current
AHU	Air Handling Unit
BIM	Building Information Modelling
CAD	Computer Aided Design
C4	National building code on Thermal Insulation of Buildings
D3	National building code on Energy Efficiency of Buildings
DHW	District Hot Water
E1/E2	National building code on Fire Safety of Buildings
EI-M	Integrity Insulation – Mechanical Resistance
HVAC	Heating Ventilation and Air Conditioning
IDA ICE	IDA Indoor Climate and Energy
IFC	Industry Foundation Classes
PV	Photo Voltaic
U-Value	Thermal Transmittance
UAS	University of Applied Sciences
UFH	Under Floor Heating
UV	Ultraviolet
Wufi	Wärme Und Feuchte Instationär (Heat and Moisture Transiency)
XPS	Extruded Polystyrene

Acknowledgment

The compilation of this thesis project would not have been possible without the assistance of so many people whose names might not all be mentioned. We sincerely appreciate and acknowledge their contributions to this work.

We would like to express our special gratitude to Sunil Suwal for his guidance, encouragement and patience throughout the project. Thank you so much for making us work on the project to the best of our abilities and opening up our eyes to the different possibilities. Your guidance was essential to the success of this paper.

We would also like to thank Eric Pollock for imparting his expertise on this project and providing information and advice on different aspects of the project. We would also like to thank Jorma Lehtinen for providing architectural insights on historical buildings.
We are highly indebted to our school Metropolia UAS for providing the opportunity for all of this to happen.

To our families, friends and others who shared their support morally, thank you.
Above all, to the author of knowledge and wisdom, to the Great Almighty, we thank you for your countless blessings.

1 Introduction

Buildings are one of the biggest untapped energy saving and CO_2 reduction potential across the EU. 40% of the total energy consumption across the EU is from buildings. *(*EPBD 2010*).* Energy efficiency in general is one of the most effective ways of reducing greenhouse gases. The cost of living and the quality of life are better in energy efficient buildings.

Historical buildings are important to the society. They tell the story of an earlier time and promote the respect for those who lived in that society. These buildings cultivate the sense of pride of our past and bring character to the society. They have intrinsic value and are symbols of a city's culture and complexity. However, these buildings were seldom constructed with good insulation materials and for that reason they are high energy consuming 'eco-monsters'.

The concept of energy renovation is undervalued as it is believed that the only benefit from the renovation is energy saving. However, there are many direct and indirect benefits to the community. The benefits can be economic, social, environmental and energy system benefits. The thesis aims to show that it is possible to lower the energy demand of historic buildings while keeping their structural integrity and aesthetics. The renovation of such buildings is important in keeping the cultural heritage of Helsinki.

The Agricola building, built in 1920s, currently serves as a school campus for Metropolia University of Applied Sciences and is moving out in 2019. The focus of the thesis is to convert the purpose of the Agricola building in to a four-star hotel. The thesis also studies the feasibility of transforming the Agricola building to a four-star hotel by developing methods and concepts of sustainable renovation. However, the aim is to improve the energy performance of the building for a hotel purpose.

Building codes of Finland related to planning, fire safety, acoustics, energy efficiency and accessibility are focused in the thesis. Improvements on the walls, window and roof has been done. The building is simulated with IDA ICE to determine the space heating needs. The excess energy consumption of the building is offset using renewable energy sources. Analysis from business perspective is done mainly using SWOT analysis, competition analysis, market needs, marketing plan and payback period calculation.

This thesis discusses the building at Agricola 1-3 in Helsinki. Unfortunately, exact data on the construction of the building is not available. Therefore, assumptions had to be made estimating the thickness of the external wall based on the characteristics for buildings of the same era. The component materials of the wall, on the other hand, were available.

The climate file and weather profiles used in the IDA ICE simulations represent a pattern for a typical year. Therefore, the actual heating and cooling demand of the building might vary depending on the weather condition.

2 Importance of Renovation

It is important to establish the benefits that can be achieved through building energy renovation before studying the ways to do it. It is usually thought that the only benefit from the energy renovation is energy saving. However, this undervalues the whole concept. From the investors' perspective, the energy saving is what motivates the energy renovation of a building, but for the society there are also other benefits. Energy renovation brings both direct and indirect benefits to the community. The benefits are economic, social, environmental and energy systems. (BPIE 2013, 6.) The benefits are discussed further below.

The economic benefits that can be reached with energy renovation across Finland and the EU can be trillions of euros per annum. An average household spends about €1400 per year on energy expenses. (Economidou 2011.) Improved energy savings results in economic gain for the investor.

The renovation activities cannot happen without an initial investment. An investment in sustainable building stock affects a wide range of professionals, from construction workers to financial institutions. This means it has an impact on the overall GDP of the country, as well as on property values.

There are several societal benefits associated with the renovation of a building. First, renovation can ensure better health for the occupant through better indoor environment quality. Renovation may help to avoid the sick building syndrome, allergy and asthma, and the transmission of infectious diseases. Secondly, renovation increases comfort, satisfaction and well-being, generated through perceptual and sensory processes. The psychological interpretation of the environment has an effect on the work performance and productivity of occupants. Finally, renovation has safety and security benefits. Improved building safety and improved energy efficiency can be complimentary if designed well. (BPIE 2013, 10.)

Building renovation has environmental benefits as well. If done properly and extensively, it can result in carbon savings and reduced pollution. Buildings hold the greatest potential in carbon reductions. Deep renovation scenarios can lead to a significant reduction of carbon emission between 71 and 90%. (BPIE 2013, 12.) The decrease in demand for energy production results in a reduced use of fossil fuels which results in decreased amount of pollutants such as SO_2, NO_x and other dangerous pollutants in the air. (BPIE 2013, 12.)

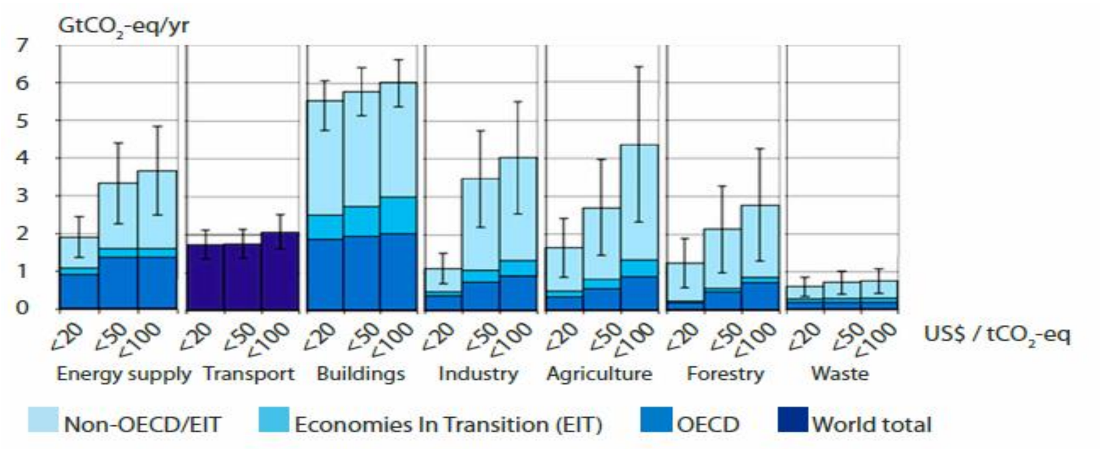


Figure 1. Buildings' CO_2 reduction potential (Reprinted from BPIE 2013)

Figure 1 shows the comparisons of cost effective CO_2 reduction potentials. According to the analysis, carbon emissions from the building sector can be reduced significantly up to 90 %. Buildings hold the greatest potential for cost effective carbon emission reductions.

Energy renovation results in the decrease of the building's energy demand. This has a huge impact on the local energy grid. First, renovations are beneficial for energy security. Less energy demand on the grid means there will be more chance to store the remaining energy for future use, meaning there will be a better security. Renovation also reduces peak loads. The most expensive generation capacity is at peak loads. By avoiding this, it is possible to the operational costs of energy systems. Furthermore, renovated buildings help when avoiding to build new production capacity, and thus decrease the construction of new power stations. As small an energy use reduction as 20 % can result in the avoidance of 1000 coal powered stations or 500,000 wind turbine installations (assuming 4MW capacity and operating 2300 hours/year). (BPIE 2013.)

3 The Agricola Building

The building at Agricolankatu 1-3 in Helsinki, referred to as the Agricola hotel in this thesis, was built in the 1920s to house a technical school, which through several stages has become part of Metropolia University of Applied Sciences.

The main reason for our renovation case study is the fact that the school will move out of the building in 2019. It provides an opportunity of reuse for this historically important building.

The objective of the project is to study the feasibility of transforming the Agricola building to a four-star hotel by developing methods and concepts of sustainable renovation. The aim is to create

- optimal energy renovation concepts for historical buildings without distraction of the original building materials
- sustainable renovation strategies for buildings of the same era
- an understanding of energy renovation in terms of economic, social and environmental gains
- introduction of a very simple yet effective renovation method
- improvement in the aesthetics of the building
- increased the use of renewable energy in the building
- decreased short and long term costs

The focus of the thesis is on the improvement of the energy performance of the building for a hotel purpose.

Figure 2. The Agricola Building (ArchiCAD Rendered)

Figure 2 shows the rendered look of the Agricola hotel building in ArchiCAD. Built in the 1920s, Agricola building is one of the architectural marvels of the city of Helsinki. Its location and topographic setting makes it ideal for a hotel purpose.

4 Finnish Building Code

A building code is a set of rules that specifies the minimum standard for constructed objects such as buildings or non-building structures. (Banerjee 2015.) Building codes aim at ensuring the health, safety and welfare of the population. They are used by architects, engineers, contractors and regulators. However, their use is not limited only to these personnel. They are also used by safety inspectors, real-estate developers, insurance companies, facility managers and many more. (Banerjee 2015.)

The Finnish building code regulates the technical requirements concerning the stability and strength of the structure, as well as safety issues. It also specifies the different authorities responsible for the different tasks associated with the building. According to the Finnish Ministry of Environment’s website, the Finnish building code has 10 subsections that deal with matters related to

- Planning
- Strength and stability
- Fire safety
- Health
- Safety of use
- Accessibility
- Noise conditions
- Energy efficiency
- Use and maintenance manual
- Housing design (MOE 2018.)

Structural renovation works needs to be done on the foundation as well as the load bearing components of the building (walls, columns and load bearing walls that are not going to be demolished). This is useful to further strengthen the structural components of the building.

Upon inspection of the Agricola building, it was established that the building has cracks on the foundation and some structures. These cracks contribute to air leakage and need to be repaired. The exterior walls are to be repainted with the exact same paint color the building has now due to heritage building protection law of Finland. According to the law, it is not possible to change the paint colors of protected buildings. (Lehtinen 2018.) Only new lightings will be added to the façade to highlight the aesthetics of the building.

The thesis focuses on the design regulations concerning planning, fire safety, acoustics, accessibility and energy efficiency.

4.1 Planning

The planning section of the building code focuses on ensuring that the design and construction of a building is in accordance with regulations and the permit granted. Here, it is important to prove to the city of Helsinki that the project is feasible and meets the statutory requirements of the law. The thesis assumes that a building permit is granted for the renovation. This assumption is based on an interview with an architect who is familiar with heritage buildings. It was suggested for the project assumes the necessary permits granted for all requirements except parking. (Lehtinen 2018.)

The city of Helsinki has a minimum parking space requirement for accommodation spaces. (Lehtinen 2018.) This is based on assumption of the demand generated by the use of the building. It ensures the convenience of the accommodation service.

The current backyard of the Agricola building has the capacity to park 15 cars. The space near the backyard entrance is left open for service vehicles to go in and out of the building’s premises easily. In addition to that, an underground parking space, with a capacity of accommodating 20 cars, is to be constructed. This construction brings the total parking spaces to 35. The underground parking space is connected to the Agricola building through walk ways, and to the building’s floors through an elevator.

An alternative would have been to rent parking in an existing facility. There is a parking facility 400 m from the Agricola building. However, there are two problems with this alternative. First, it is not convenient. 400 m is a considerable walking distance. Second, the rental price per square meter area is expensive in the Kallio district.

The price of residential space in Kallio, where the Agricola building is located, is between €4500 and €8100 per m^2. This averages about €6500 per m^2. The price of garage spaces in Kallio was not available at the time of writing this paper. However, a garage space located in Ullanlinna district of Helsinki, which has comparable real-estate value, is sold at an average of €4500 per m^2. (Habita 2018, Etuovi 2018.) Considering this price tag for Kallio, it is expensive to buy parking spaces for 35 cars for these prices. It is cheaper to build the additional underground parking space on the property.

4.2 Fire Safety

The fire safety regulations of the building code should be a major focus for any renovation project. The building must be designed in a way that is fire safe for the intended use. The load bearing structures must be designed to endure fire for a minimum required time taking into account the possible collapse of the building, evacuation routes, rescue operations and fire extinguishing. It must also be possible to limit the spreading of fire and smoke to the surrounding rooms.

The E1 and E2 parts of the Finnish building code regulate fire safety of buildings. According to E2 (E2 2005), the Agricola building is categorized as ‘Fire hazard class 2’ because of the operations performed in the building. This means large scale fire or explosion is possible. The building is classified in this category because of the big kitchen and saunas in the building.

The E2 further specifies the level of protection of the building. There are three levels. In level 1, only first aid fire-extinguishing equipment is present. In level 2, there is a fire alarm system which automatically calls the local fire stations and emergency response centers. Level 1 extinguishing equipment is also present. In level 3, there are automatic fire extinguishing systems and also first-aid extinguishing systems (E2 2005, 3.) Protection level 3 with a sprinkler system was chosen for the fire safety of the building. However, if this system is too expensive, it is also possible to choose protection level 2 because the local fire station is only 600 m away.

The building is further classified in fire class P1. Buildings in this class are multi-storey buildings with day to day operations. (E2 2005.)

Table 1: Class of fire separating building elements (Reprinted from E2 2005)

	P1	P2	P3
Fire hazard class 1			
– protection level 1 and 2	EI-M 90	EI-M 90	
– protection level 3	EI-M 60	EI-M 60	EI-M 60
Fire hazard class 2			
– protection level 1 and 2	EI-M 120	EI-M 120	*not permitted*
– protection level 3	EI-M 60	EI-M 60	EI-M 60
Indication in the table:	(oval)	= Class A1 material required	

As can be seen in table 1, the building material elements used in the renovation of the Agricola building should be EI-M 60. All building components used in the renovation design satisfy this requirement. In the table, ‘E’ stands for the integrity of a building component to prevent the passage of flames and hot gases to the unexposed side when exposed to fire on one side. The ‘I’ stands for Insulation. It measures the ability of the building component to restrict temperature rise on the unexposed side. The ‘60’ represents the time in minutes the building component can withstand such conditions. (E1 2011)

In addition to implementing the statutory fire protection requirements, the renovation design also improves the interior of the building to perform well during fire emergencies. First of all, two stair cases on the opposite sides of the building are added to serve as additional fire escapes. So, in case of fire emergency, the hotel guests can use their nearest exit to evacuate the building.

Another fire safety improvement is to add fire resistant glass doors on both sides of the corridors. These doors serve as an additional barrier to the spread of smoke or fire to the other parts of the building. Figure 3 below shows the position of one of the glass doors. The whole floor layout can be seen in figure 4.

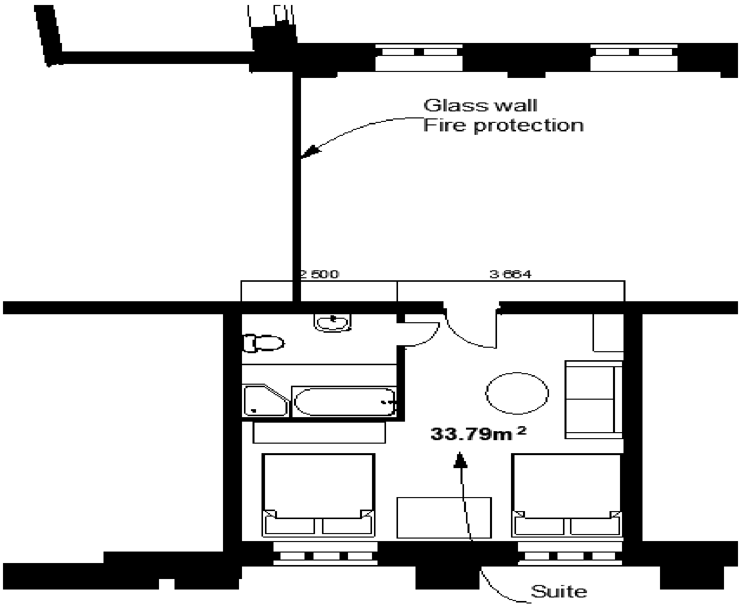


Figure 3. Design of glass wall on the hotel floor

Figure 3 shows the design of glass door for fire protection in the corridors. This fire resistant glass door limits the spread of fire and other fumes to the other parts of the building in case of fire.

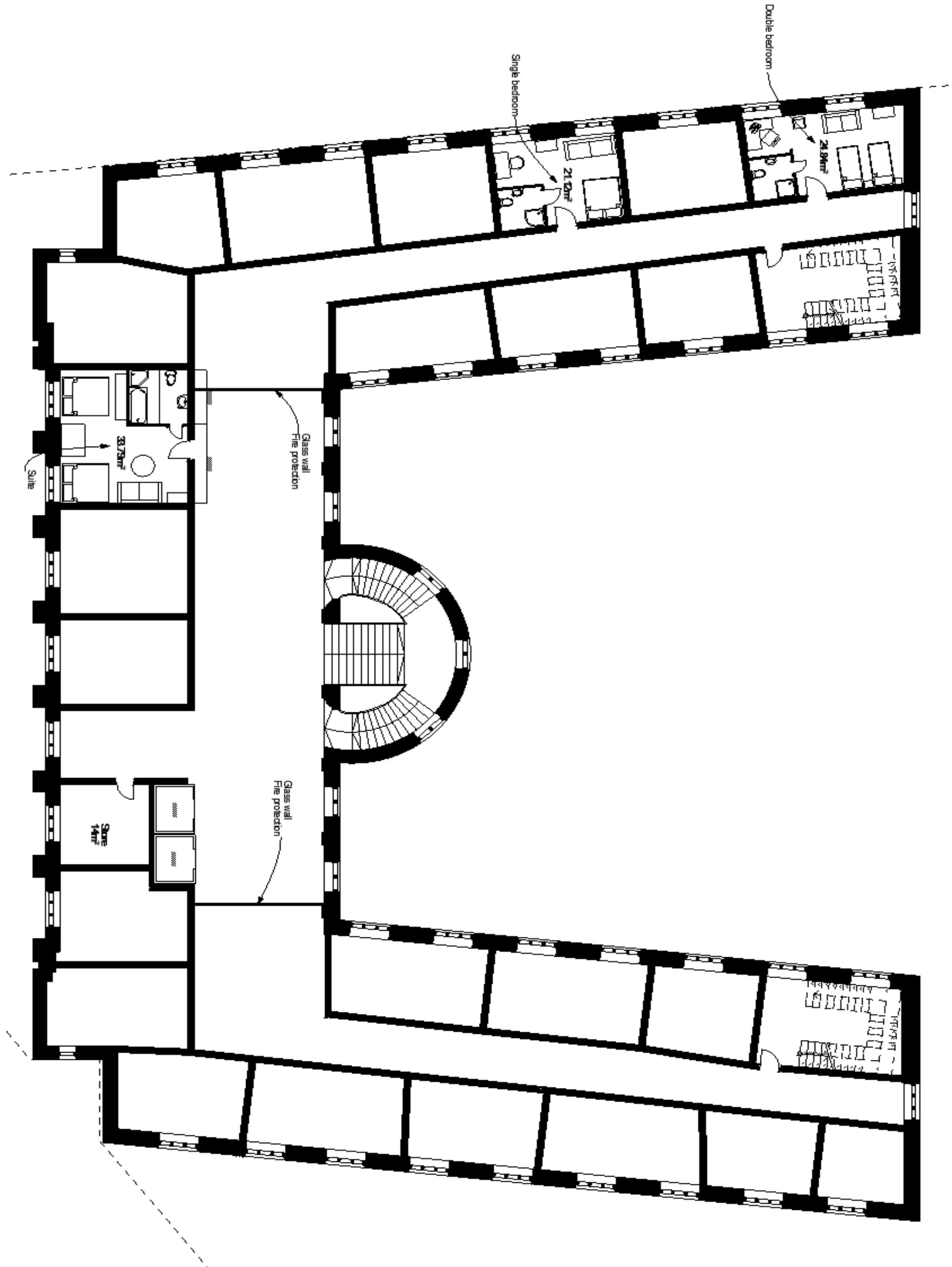


Figure 4. Layout of the hotel floors

Figure 4 shows a sample layout of a hotel floor. The two stair cases that are added for fire safety can be seen in the figure. It is also possible to see the total number of rooms per floor and their general designs.

4.3 Acoustics

The Finnish building code requires for a building to have a noise level limit. The sound insulation material used in the building must be good enough for people in the building not to be disturbed from their state of rest and sleep. (Decree 796 2017.)

The noise can be voices from adjoining rooms, music, footsteps or doors closing. The path of the noise can be directly through walls or floors or indirectly through the surrounding structure, which is known as flanking transmission where sound goes over or around rather than directly through the element. (Gyprock 2010.)

Methods of noise control in a building can focus on systems, structures and component materials. The building code has a minimum requirement for walls and floors that must be satisfied. Generally, the acoustic performance is further analyzed in terms of airborne sound, impact sound and flank transmission. (Gyprock 2010.) The main performance measure in this paper is airborne sound.

Airborne sound is expressed in terms of R_w and R_w+C_{tr}. R_w is the weighted sound reduction index and it represents the reduction of sound from one part of the element to the other. C_{tr} is a value used to modify the sound performance rating of the building element. It is important when calculating low frequency noises. C_{tr} is a negative number, and R_w+C_{tr} is always less than R_w. These values are obtained under laboratory testing so there will be a variation in real application. (Gyprock 2010.)

The analysis of impact sound and flanking transmission are not covered in this thesis because they require further investigation of the structural integrity of the building. They would require specific components and structural load paths to be taken into consideration. The performance measuring system in this project is the airborne index.

The building, as mentioned above, is from the 1920s. At that time, due to lack of good insulating materials, the components were built to be as thick as possible for better thermal performance. The external walls of the Agricola building are made of three brick layers and the internal slabs (floors) are made of 50 cm thick concrete. Thick building components are great sound insulators. (NZCMA 2013.) The exact sound insulation properties and values are further determined in laboratory tests. However, since the interior is redesigned, the internal partition walls are to have proper sound insulation. The values for the internal wall design are R_w=52dB and R_w+C_{tr}= 43dB.

4.4 Energy Efficiency

Energy efficiency is a major aspect in new construction and renovation projects. Due to the availability of new and improved insulation materials, the thermal performance of buildings has increased. Improved energy performance in already existing buildings is achieved through energy renovation. In energy renovation, building component materials are usually replaced with materials of better energy performance. (Häkkinen 2012.)

The building code is not very strict on the energy performance of historical buildings. To improve the overall energy performance of the Agricola building, the envelope materials would have to be changed, which would cause a significant change in the structural components of the building, and this would, in a way, destroy the original building.

In the renovation design for the Agricola building, no alteration is done to the existing exterior walls so that the structural integrity of the building is kept. The excess energy consumption due to the original building materials is remedied with renewable sources of energy production such as solar thermal and solar photovoltaic system. These choices are discussed in detail in chapter 9.

4.5 Accessibility

Accessibility is another important aspect in hotel design. It is essential to ensure that the building and its premises are constructed according to the intended use. As a hotel, the building must be accessible to people of all age groups including children and the elderly, as well as people with various disabilities.

According to the Finnish building code (F1 2005, Decree 231 2017.), there must be routes suitable for wheelchairs or wheeled frames from the building plots to the building facilities. The different levels of the Agricola building are linked together by internal routes suitable for wheelchair users and blind people. Various groups with special accessibility need are discussed below.

Non-Ambulatory Disability (Wheelchair users)

The Agricola building is designed to be wheel chair accessible from all the entrances as well as from the underground parking spaces. Both entrances to the lobby have an inclined ramp with an inclination of 4.76° that guests with wheelchairs can use. There is also an elevator from the underground parking space that goes to all floors. The toilets and elevators are designed to be spacious enough for wheelchair users with adequate space to transfer to the toilets seats from the wheelchair. (F1 2005, Decree 231 2017.)

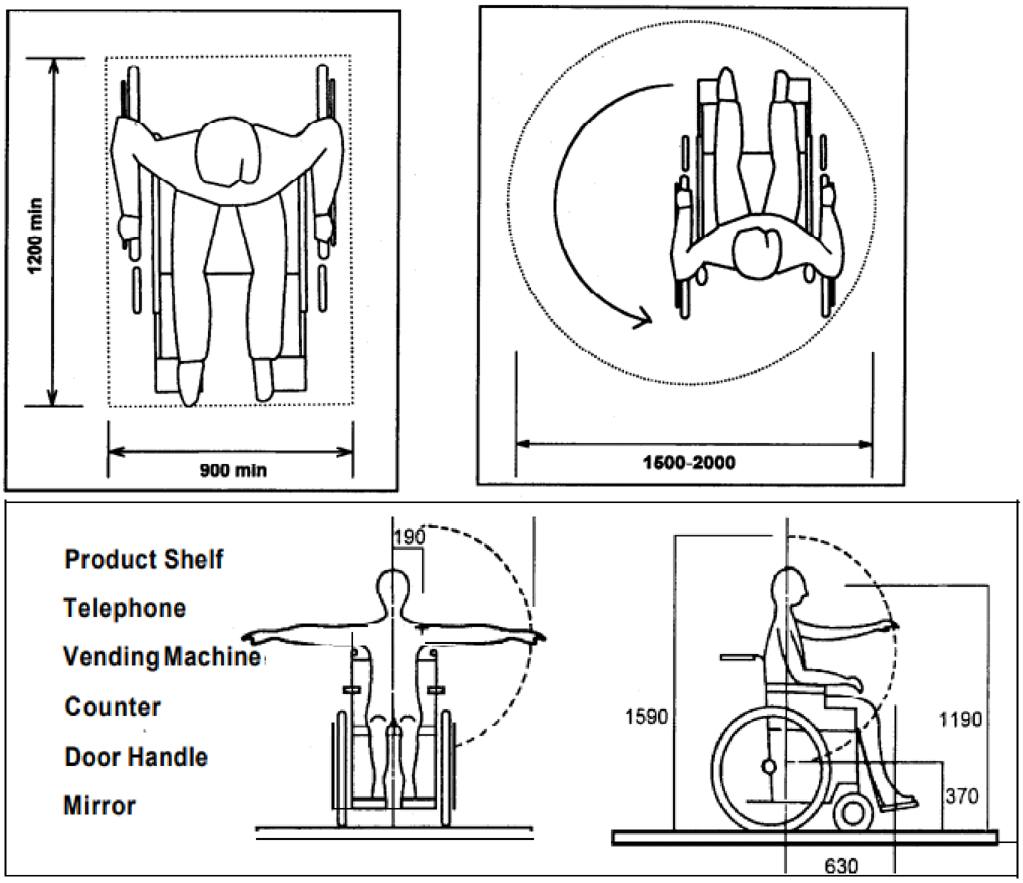


Figure 5. Space allowance for non-ambulatory guests (Reprinted CPWD 1998)

Figure 5 shows the design measures taken for the non-ambulatory guests in the Agricola building. It can be seen that the elevators are wide enough to allow full rotations of wheelchairs. It can also be seen that product shelves, telephones, vending machines, counters and door handles are accessible at shoulder's height.

Semi-Ambulatory Disabilities (Persons with Impaired walking)

People with semi-ambulatory disabilities use walking aids such as crutches and cranes. People in this group maybe amputees or have chest ailments or heart problem (CPWD 1998, 14.) To ensure the safety of this group, the corridors in the Agricola building follow the statutory 90 cm requirement (F1 2005, Decree 231 2017.) The floor finishes are also made of non-slippery materials, thereby ensuring safe passage. Furthermore, hand rails are designed in the toilets to support body weight.

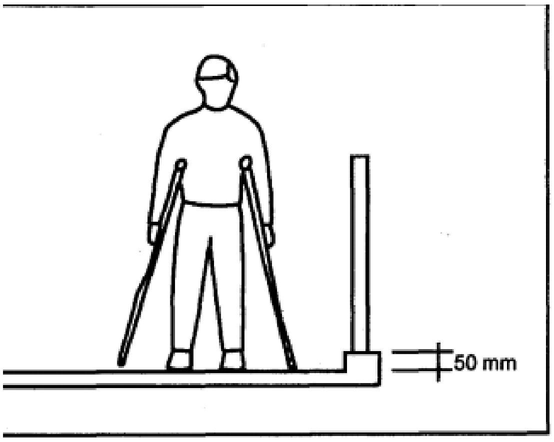


Figure 6. Shape of corridors (Reprinted CPWD 1998, 14)

Figure 6 shows the space allowance for semi- ambulatory people. The design of the corridors of the Agricola building allows enough width for the passage of people in this disability group.

Sight Disabilities

Sight disabilities comprise total blindness or impaired vision. People with sight disabilities use their other senses to get around so it is important to give instructions through, for example, the sense of touch. (CPWD 1998, 15.) The design of the Agricola building uses guiding blocks to guide them within the building and also to facilitate the outside passage. Information boards with braille are installed in the lobby, elevators and service floors. Equipment for audible announcements is also planned on every floor. The floor spaces should be continuously checked for unnecessary protruding objects that might make walking unsafe in the building. (F1 2005, Decree 231 2017.)

Hearing Disabilities

People with hearing disabilities are totally deaf or have hearing difficulties. They often use the sense of sight to gather information about the surrounding. For people in this group, there is a clear information board, illuminated signals and diagrams for easy access (CPWD 1998.)

Since elderly people might suffer, either partially or fully, from any of the disabilities mentioned above, the existing design guidelines can be used.

5 Hotel Agricola

The location of the accommodation and the service it provides are the most important aspects of marketing the hotel. The Agricola hotel project is located in the heart of the Kallio district near Sörnäinen metro station, which is very near to the city center, about 2.2 km from the central railway station. According to the journey planner provided by Helsinki Regional Transport Authority, the Agricola building can be reached by tram, metro and bus and it only takes 10-15 minutes to reach the city center depending on the traffic as shown in figure 7. (HSL 2018.)

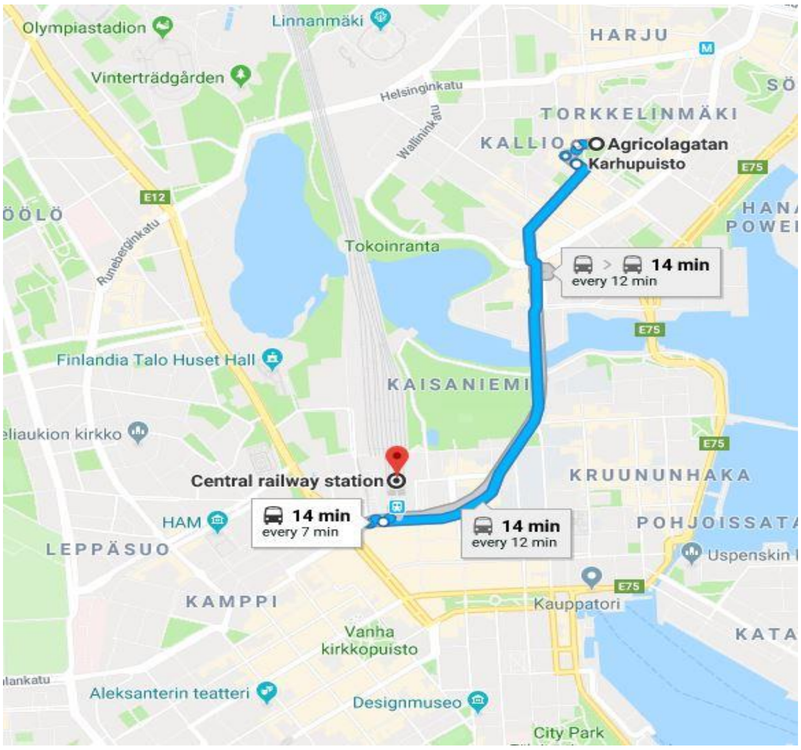


Figure 7. Location of the project from the central railway station

The target groups of the Agricola hotel project are both local people and international tourists. There are a number of tourist attractions within walking distance from the building, such as the Kallio church, the Hakaniemi tori market place, as well as a number of restaurants and bars. Most of the city's tourist attractions are a maximum of 15 minutes' drive from this location. As can be seen from the map, attractions like the Helsinki Art Museum (HAM), Designmuseo, Olympiastadion and Linnanmaki are all with in a maximum of 4 km distance.

The tourism market across the world is growing very fast as the middle class in most developing countries is fairly large. (Kharas, 2017) The number of tourists in Finland has risen since 2007. The gross added value from the tourism grew faster than the rest of the Finnish economy, at an astounding 18% since 2007 as shown in figure 8. There was a total of 14.6 million overnight stays of local tourists and 5.8 million of foreign tourists in 2017. (TEM 2018.)

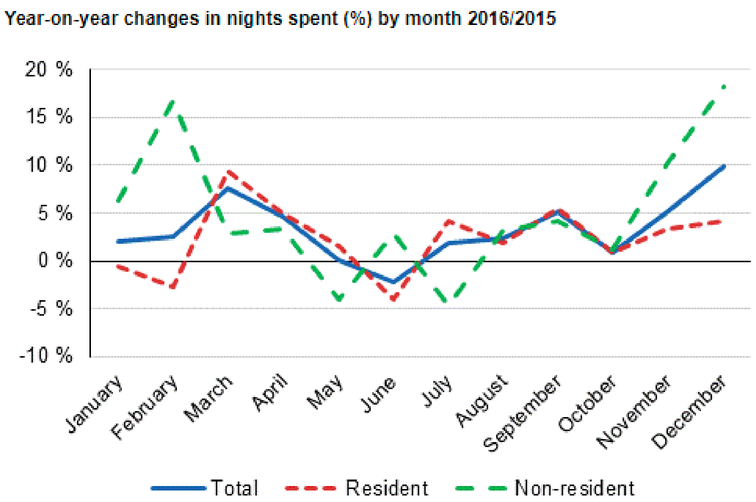


Figure 8. Night spent by tourists in Finland (Reprinted from Statistics Finland)

The Agricola hotel does not only give accommodation. It has a restaurant, bar, saunas, and swimming pools as well. The restaurant and bar are both open to the public but the other spaces are exclusively for hotel guests. The hotel has 24 rooms on a floor excluding the third floor. On this floor there are 21 rooms due to the big columns that are protected by the law. The top floor has 14 guest rooms and the rest of the area is used for administrative offices. This gives a total of 107 guest rooms. The hotel floors are designed for maximum space use.

5.1 Operations and Facilities

The Agricola hotel is designed in terms of operation. The Agricola hotel facilities are designed to be economic in terms of operational cost. The focus is to convert the Agricola building in to a four-star hotel. In this class, a hotel must be equipped with additional amenities like a sauna and swimming pool. It must also have a restaurant, a bar and its own parking (RT 85-10554 E hotels and motels, 4.)

There is a minimum requirement for the rooms as well (RT 85-10554 E hotels and motels, 4.) All hotel rooms are to have air conditioning with a thermostat option. The bathrooms are to be tiled and equipped with a toilet seat, wash basins and showers. Hair dryers and trouser presses are also to be included. The beds have at least double spring mattresses. The floor finish material is parquet. The rooms have bright enough lighting equipment. Room service is available to all guests 24/7. The specific layouts of each room are discussed below.

5.2 Rooms

There are three types of rooms to accommodate the guests. The rooms vary in size from 18 m^2 in the single rooms to 35 m^2 in suites as can be seen in table 2.

Table 2: Hotel Rooms

Room Type	Area Range (m2)	Total Number
Single	18.5- 21.5	49
Double	22- 26	44
Suite	31- 35	14
Total		**107**

Single rooms

The single rooms are equipped with a shower or bath tub. The single rooms are also equipped with towels, floor mats, plastic water cups, hair dryers, travel size soaps, shampoos, conditioners and body lotion. Each room is air conditioned.

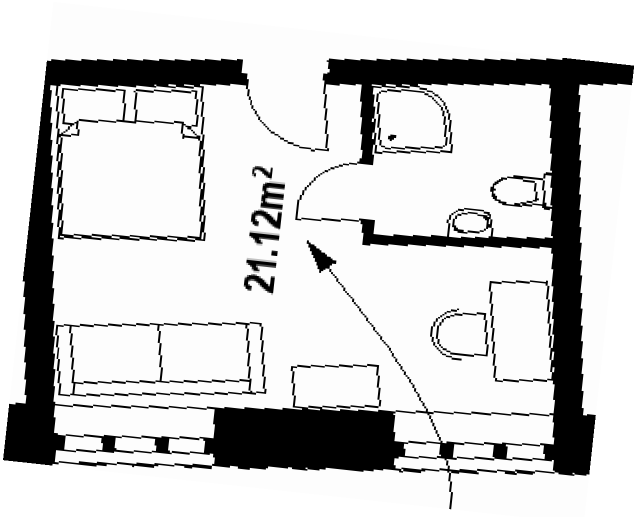


Figure 9. Single room layout

The rooms have TVs with international channels, king size bed, a sofa which can be turned in to bed if necessary, and spacious wardrobes. A single room layout of size 21.12 m^2 can be seen in figure 9.

Double rooms

The double bed rooms are designed for two people. They contain one king size and one queen size bed, placed side to side a few feet apart. The double room has one bathroom with a bath tub, shower, toilet seat and sink. The bathrooms are equipped with towels, floor mats, plastic water cups, hair dryers, travel size soaps, shampoos, conditioners and body lotion.

The double rooms contain one or two bed side tables, one or two arm chairs, a standard desk and an office chair. The room also features a storage space that includes a small closet and small dresser. It also contains an iron and ironing board.

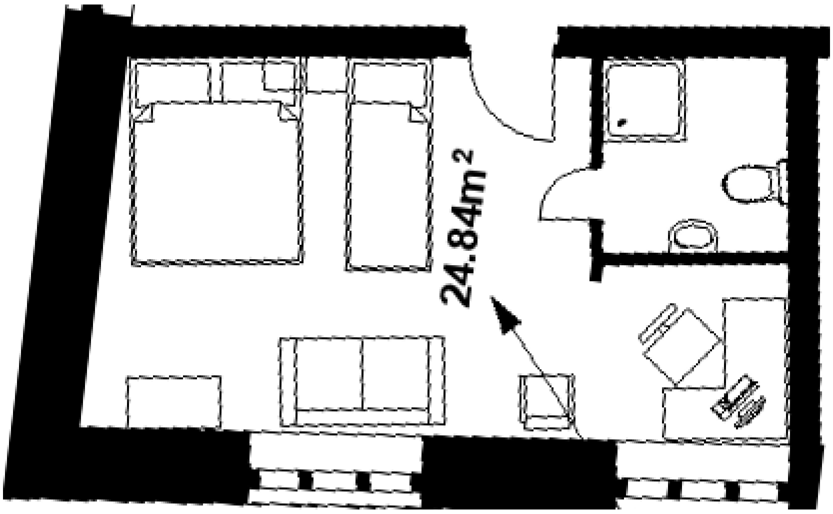


Figure 10. Double bed room layout

The double rooms have standard air conditioning with thermostat control. They have flat screen TVs with international channels as well. There is a land line phone which is free for local calls. The room also has a mini bar with cold refreshments and snacks. A double room layout of size 24.84 m^2 can be seen in figure 10.

Suites

The suites are the biggest rooms in the Agricola hotel. They average about $34m^2$, and there are three of them on every floor except the third. The suites are designed to accommodate families. The rooms contain two king size beds and a bathroom with a bathtub, in addition to the amenities found in the double rooms.

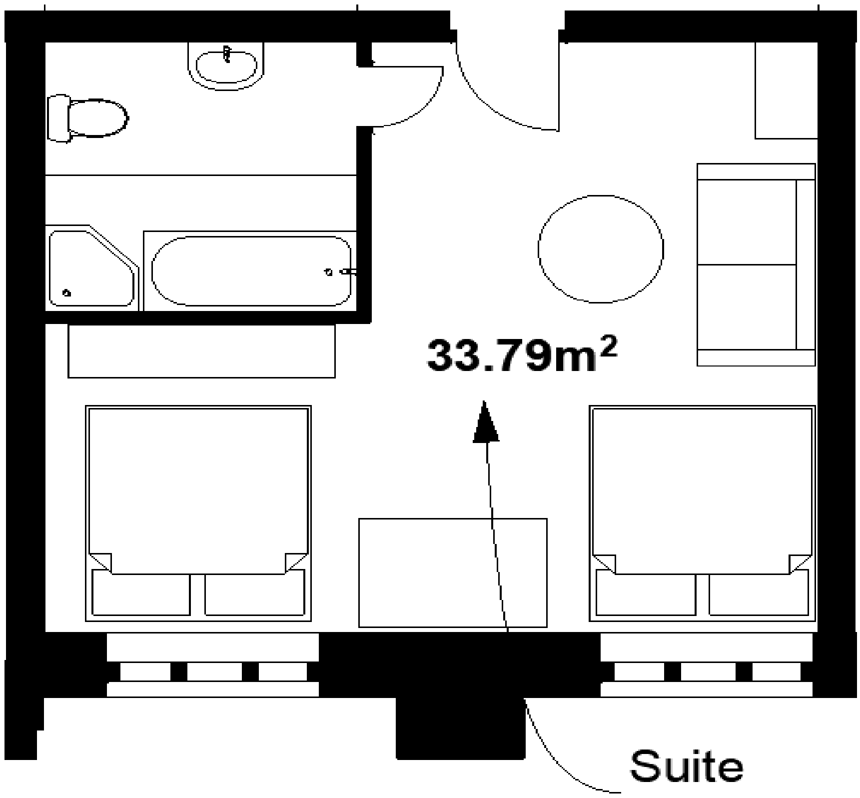


Figure 11. Suite floor plan

The rooms contain one or two bed side tables, a proper saloon space and a standard work desk. The suites also have air conditioning with thermostat control. They have 42-inch flat screen HDTVs. There is a land line phone which is free for local calls. The minibars in these rooms are personalized according to the guest's need. They also feature decadent chandeliers, state of the art furniture, a painting and more. A suite floor plan of size 33.79 m^2 can be seen in figure 11.

5.3 Entrance, Lobby and Corridors

The main entrance of the hotel is decorated with canopy. (RT 85-10554 E hotels and motels, 6.) There are sofas in the lobby where people can wait until their rooms are ready, state of the art display materials such as LCD touch screens where people can have access to information about the hotel, as well as news and local bus schedules. The hotel lobby also has information boards written with braille for people with sight disabilities. There are also loud enough speakers for announcements on the floor.

A reception desk, an office, telephone line, a switch board, cloak rooms and toilets are also situated in the lobby, as well as the restaurant and the bar. The lobby acts as a socializing area, a waiting room and a meeting point.

The corridors occupy a considerable space in the hotel. They are renovated with the best possible materials as they are the first ones subjected to wear and tear conditions. The parts of the corridors right at the top of the stair case on each floor are protected by law so there is no new construction in those spaces. (Lehtinen 2018.)

5.4 Restaurant and Saunas

The design of a hotel restaurant is very important. The design is usually made considering people per square meter since other variables such as table layout might change from time to time. (Neufert 2012, 466.)

The Agricola hotel has a breakfast buffet served in the main restaurant. The bar is open according to a fixed schedule. The kitchen is located behind the restaurant to make it easier to serve freshly cooked meals to the guests.

To increase the revenue of the hotel, the restaurant and bar are open to outside customers. Both are located near the street level, so their location is ideal for this purpose. Hotel guests are not disturbed as the outside customers do not cross to the hotel floors.

The hotel has also saunas and swimming pools. The saunas are located in the first basement. The floor heights in the building are equal except for the first basement, which is a bit lower, only 2.6 m high, and so are the facilities in this space such as saunas and showers. The swimming pool is located one floor down, in the second basement. A part of second basement shares the same ceiling with the first basement which is around 5 m. This height makes it ideal for its purpose as it allows better air circulation and visual comfort (RT 97 10474.)

5.5 Cleaning and Staff Facilities

The hotel has cleaning rooms on two floors. However, due to the size of the hotel, the laundry services are done by another company. There is not enough space for laundry machines and drying facilities. The other facilities are not discussed in this thesis.

6 Technical Design

The Agricola building, as discussed in the second chapter, is a historical building protected by law from any modifications on its façade and some interior areas. Before continuing energy renovation and simulation discussions, it is important to clarify which parts of the building are protected and which ones can be modified.

The protected parts of the building are its façade, staircases, the open space on the third floor with big columns and the corridor spaces at the top of the staircases. In these protected parts, the original design cannot be altered. The facades can only be painted the exact same color as the original but with new high performance paint. Lighting can also be added to the façade to highlight the aesthetics of the building at night. (Lehtinen 2018.)

The energy renovation discussed in this chapter is focused on walls, windows, roof, HVAC and energy production.

6.1 Walls

A Significant amount of heat is lost through the envelope of the Agricola building. According to the simulation done on Wufi, the U- values of the exterior walls is 0.72 W/m^2K. This amounts to a heat loss of about 30 kwh/m^2 of floor area. In addition to thermal resistivity, moisture performance has an impact on the thermal performance of a wall. The external walls of the Agricola building are susceptible to rain and different weather conditions as there are no overhangs on them for protection. The thermal performance of a wall is decreased by rain that also results in the deterioration of the structure (Straube 1998, 108.)

According to decree 4/13 of the Finnish building code (Decree 4/13 2013), historic buildings undergoing renovation have a different scope of calculation for U-values. The original U-value of the external walls can be multiplied by 0.5, but this value has to be better than 0.6 W/m^{2}K (Decree 4/13 2013.) The U- value for the external walls of the Agricola building is 0.72 W/m^{2}K x 0.5 = 0.36 W/m^{2}K which is less than 0.6 W/m^{2}K.

Additionally, the Agricola building envelope and the joints between its components, such as joints between windows, doors, and surrounding structures are sealed. This is done to protect the thermal insulation layers from the effects of air flow. Repair works on the cracks and openings of the building are done to further improve the tightness. This also results in an increased performance of the structure as the chance of heat escaping is greatly minimized.

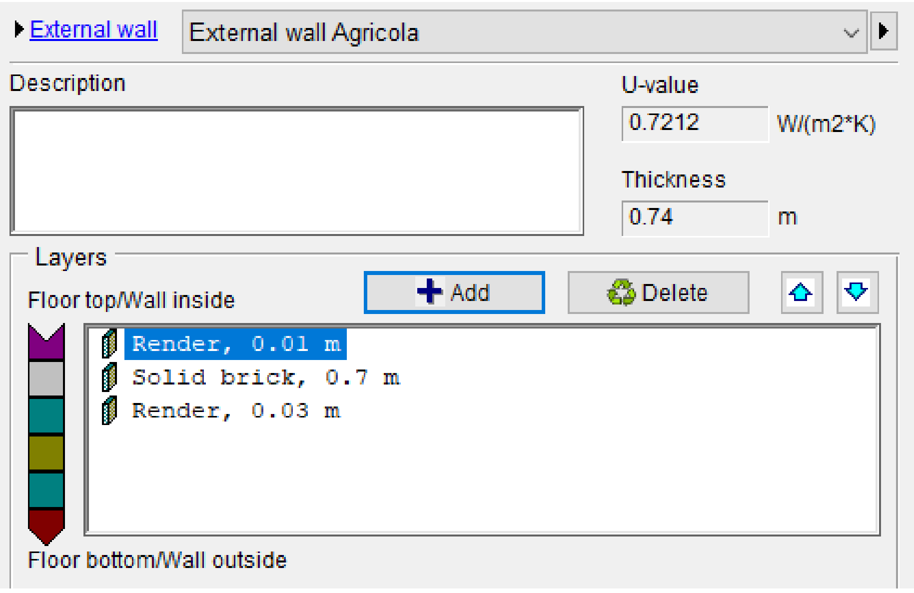


Figure 12. Exterior wall simulation with IDA ICE

The wall in the original building, as can be seen in figure 12, is assumed to be about 0.75 m thick as it is a typical value for buildings of that era. The wall is composed of two to three brick layers and 30-40 mm render. There might be an air layer as well but for this paper only the brick and render layers are taken. The simulation of the exterior wall is done in IDA ICE. As mentioned in chapter 1, no exact data about the component materials could be found.

The interior is redesigned to be a hotel. Therefore, existing walls have to be taken down, with the exception of load bearing walls, and more partitions made. Less expensive materials with better U-values are used for this.

The walls in the different parts of the Agricola building are different according to their purpose. For example, the wall used as a partition between the hotel rooms cannot be used in the kitchen or in other service areas. However, due to the limited scope of the study, only the walls between the hotel rooms and office spaces are discussed in detail. The walls for the service spaces can be found in appendix 1.

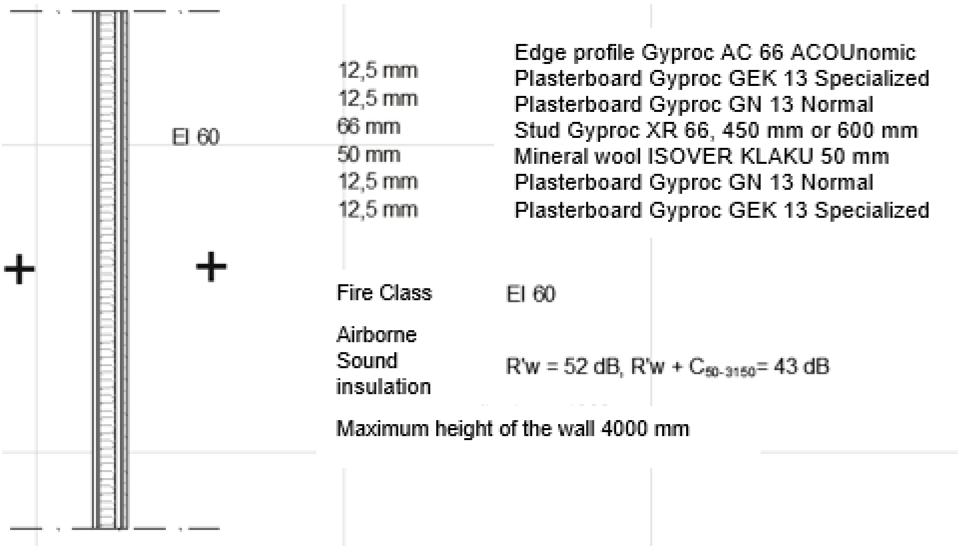


Figure 13. Internal wall between hotel rooms

The internal walls of the Agricola hotel building are designed to give maximum performance in terms of energy efficiency, fire resistance and acoustics. They are designed according to the requirements of the Finnish building code on fire safety and acoustic performance.

The internal walls of the Agricola hotel building are designed to be EI 60 as shown in figure 13. It means they can prevent the passage of flames and hot gases to the other side of the wall whilst preventing any temperature rise for 60 minutes. This gives the occupants enough time to evacuate the premise and go to safety.

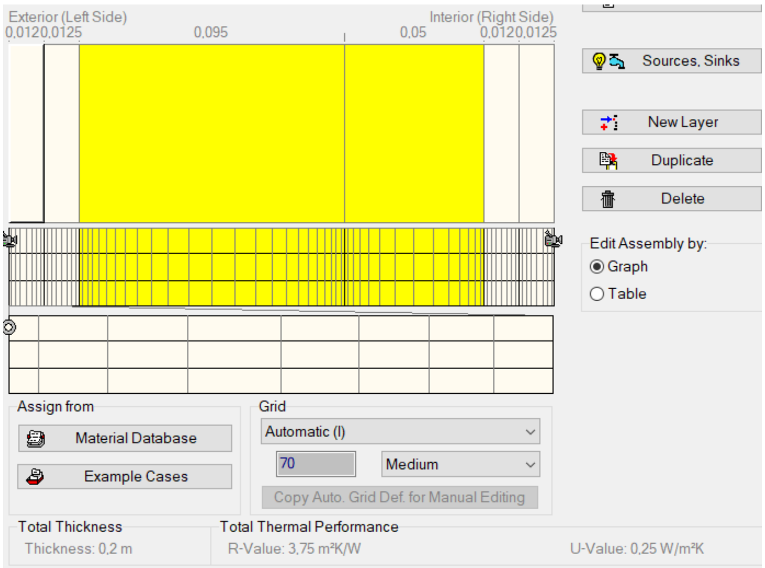


Figure 14. Wufi simulation of the internal walls

Figure 14 shows the simulation of the internal wall components using Wufi. The software was used to find the U-value of the partition walls used between the hotel rooms. Here, each component of the wall is added as a layer into the program with specified thickness. The software has a database from which materials can be selected. If a specific material is not available, it is possible to define one based on its physical properties. The program gives out the thermal as well as other properties such as moisture performance of the component.

6.2 Windows

The other major area of improvement for better energy performance is replacing the windows. Since the building is historically protected, the design of the windows cannot be changed. However, the glass and frames of the windows can be replaced with better materials with the exact shape and look. The windows on the Agricola building have U-values greater than 1 W/m^{2}K, no accurate data is available though.

The windows on the Agricola building are double glazed windows at the moment. They have a good U-value and are fairly new. However, since there is no renovation work on the exterior walls as discussed in the previous section, the energy demand of the Agricola building is high. Replacing the current windows with better performing triple glazed argon windows with U-value of 0.49 W/m^{2}K offsets the excess energy demand to a certain degree. The new windows have timber frames of U-value 0.72 W/m²K. This will result in a significant reduction of annual heating demand.

The advantage of having triple glazed glass is that it makes it possible to heat the air before it enters into the building. During the summer times, triple glazing allows high level of solar gains, capturing warmth from the sun light, and because of its good thermal insulation, it keeps the air inside. Triple glazing increases thermal comfort inside the rooms as it prevents heat loss (Rodriguez 2016.)

Triple glazed windows also deliver very good acoustic performance, greatly minimizing noise levels. Acoustic quality is important in hotels. Guests need not be disturbed by noises from the outside. Triple glazed windows also provide greater security than other kinds of windows since there are three layers of glasses. These windows are stronger and more rigid than other types. All in all, these windows perform very well in extreme weather conditions (Rodriguez 2016.) There is a very little risk of condensation formation on the windows (Greenage 2013.)

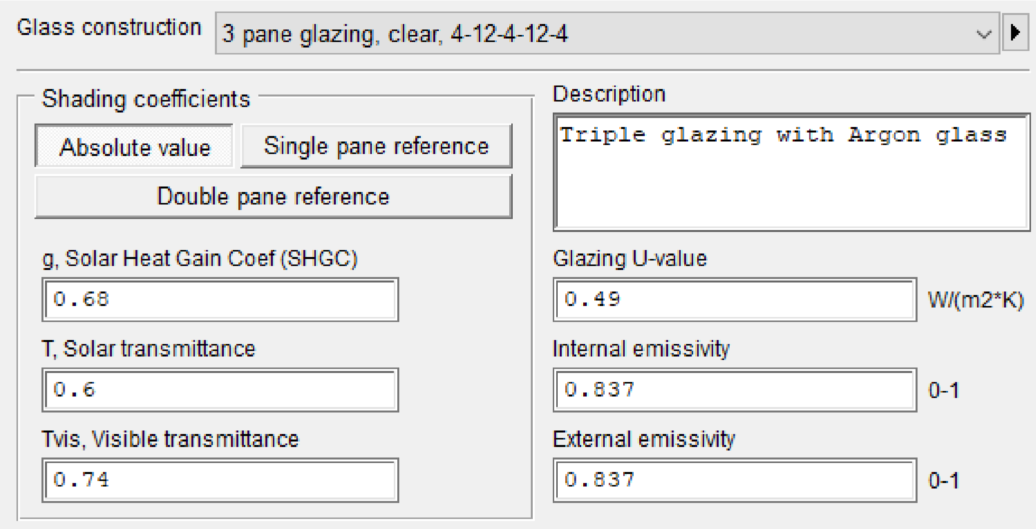


Figure 15. Window simulation with IDA ICE

Figure 15 shows the simulation of the triple glazed windows in IDA ICE. The software automatically loads the properties for the selection.

Figure 16. Triple glazed window (Reprinted KJM 2017)

Figure 16 shows the section of a triple glazed window. As it can be seen from the figure, the window has three panes of glass. The many panes increase the efficiency and reduce noise as discussed above.

6.3 The Roof

The roof is the structure that separates the building from the outside environment. It consists of functional parts such as air and vapor barriers, ventilated spaces, decking, roofing and drainage along with different structural elements (Kattoliitto 2017, 6.)

As with any other building element, roof systems have certain regulations and guidelines, the main ones being the EU building code and the national building code of Finland. There are also other voluntary guidelines such as the RT construction file, water and moisture proofing code of practice (RIL 107) and certificates given by VTT (Kattoliitto 2017.)

The current roof of the Agricola building should be changed. The roof is one of the main structure through which much of the building heat is lost. The need to replace the roof arises from the fact that the materials are old and perform rather poorly. There is also a possibility of water being trapped on the roof structure as it gets deformed through time.

An inverted roof system is chosen for the Agricola hotel building. In this kind of installation, the water proofing is installed directly on the roof deck and it also acts as a water vapor barrier. The thermal insulation is installed on the top of the roofing and covered with another material like a fabric. The final layer should be heavy enough to keep the insulation in place. Such materials include gravel or concrete slabs (Kattoliito 2017, 8.)

One of the basic advantages of using inverted roofs is that the insulation protects the membranes from extreme weather conditions, such as frost, which is very common in Finland. It also protects the membranes from UV radiation and the expansion and contraction that are as a result of summer-winter temperature cycles. (BRE 2018.)

The insulation used in the Agricola building should be resistant to moisture, water pressure and mechanical stress. The thermal properties of the insulation material should be kept intact during seasonal changes. Rain water is drained off along the top surfaces. The use of insulated slabs grooved on the underside, or filter fabrics or a drainage membrane on the top of the water proofing is recommended. (Kattoliitto 2017.)

There are many properties of the roof system described above that makes it ideal for the Finnish weather. The main one is the protection of the roofing membrane from frost, mechanical stress, solar radiation, air pollution and other stresses. The vapor barrier of this structure is always adequate too, meaning there is no need of installing additional vapor retarders and or the like.

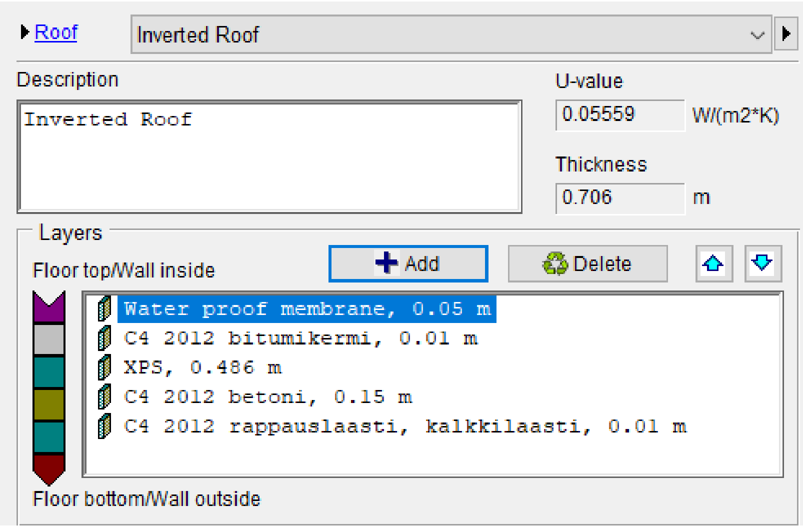


Figure 17. Inverted Roof IDA ICE simulation

Figure 17 shows the simulation of the inverted roof system in IDA ICE. The inverted roof system of Agricola building has a water proofing membrane that also functions as a vapor barrier. The XPS boards are anchored to the base with bitumen. The removal of water from the structure is enhanced by a drainage system between the insulation and the water proofing. The insulation is covered by a filter fabric.

The type of insulation used in the roof system is XPS. XPS stands for extruded polystyrene which is one of the most energy efficient insulation materials in the market. The specific XPS used is ClimaFoam®. Climafoam is a type of XPS board manufactured by Knauf Insulations. This XPS board has a compressive strength of 300 kPa and is ideal for extreme climatic conditions. This board provides a very high thermal resistance which is good for the Finnish climate. The insulation board has a thermal conductivity of 0.028 W/m^{2}K. The excessive compressive strength of the material helps keeping the cold out while retaining the strength of the concrete slab. The moisture properties of this material are also excellent. Rain water or any other form of water has negligible impact on the thermal conductivity. *(*Knauf Insulation manual 2017.) These properties make climafoam XPS board ideal for the inverted roof system of the Agricola hotel building.

The simulation shows that the U-value of the roof is improved to 0.055 W/m^{2}K. This value is much better than the statutory value of 0.09 W/m^{2}K. (C3 2010, 7.)

7 Building Energy simulation with IDA ICE

IDA ICE is a detailed and dynamic multi-zone simulation application used to study the thermal indoor climate, as well as the energy consumption of an entire building (EQUA 2018.) This software models a building, the systems and controllers that run in the building, and ensures the lowest possible energy consumptions by altering the parameters used in the design. Generally, it simulates indoor environment quality and energy consumption of a given building.

IDA ICE is capable of accepting detailed input data, such as envelope materials, climate data, wind profile, glazing properties, scheduling, HVAC, and lighting. It offers the possibility of showing how all the factors interact in the simulation calculations. It has a rich library with predefined materials and conditions, allowing a very accurate user input (EQUA 2018.)

7.1 Building Envelope

Large amount of heat is lost through an envelope of a building. Heat is lost through a conductive process through building components, convectively through air leakage and through structural connections (Nguyen 2017, 6.) Therefore, it is important to study the design of the building envelope with respect to the environment.

Most buildings in cold climates are equipped with mechanical ventilations. The major parts of a typical mechanical ventilation system are air handling unit (AHU), pumps, ducts, and diffusers. The system has a clear impact on indoor environment quality. Energy is required for air circulation, heating, drying or humidification. A good ventilation system does all of these activities with as little energy as possible (Nguyen 2017.)

In determining the ventilation system to be used, there are certain decisions to be made, such as the required flow rate, the number of components in the system (AHUs, fans and such), the choice of controlling programs and their schedules, and the type of air flow (constant or variable).

7.2 Heating

The heating energy of a building is sum of the zone heating, ventilation heating and district hot water (DHW). The heating system is mainly responsible for the indoor thermal comfort. A typical heating system has a generation side which can be district heat, electrical energy or any other heat source, a distribution side which distributes this produced energy to zones, and a control system (Nguyen 2017.)

The heating system of the Agricola hotel building is a hybrid one. The primary source of energy for the system is district heating but solar panels and photovoltaic (PV) collectors are also present. The heating system is designed to handle maximum load.

7.3 Energy Calculations

The maximum heating power (kW) is the sum of the peak AHU heating, zone heating and power needed for DHW production. The total sum from these variables is used to dimension the heat generation capacity of the heating system (D3 2010.)

The energy need of a building (kWh) is the sum of the energy needed for heating, cooling, lighting and other applications. The heating energy is the sum of zone heating, DHW production and air heating minus solar gains and the energy recovered from exhausts and internal heat gains (Nguyen 2017, 9.)

The purchased energy is the difference of the total heat demand minus the energy produced from renewable sources such as solar energy for the case of the Agricola hotel building.

8 Agricola Hotel Building Simulation

The simulation of the Agricola hotel building is based on the requirements of the Finnish building code. The building component data are given in the chapters above. They are the values and parameters used in the energy simulation of the building.

The increased energy demand of the Agricola hotel building is compensated by the use of renewable energy sources on site. Some other parameters, such as weather data and thermal losses used in the simulation are given below.

8.1 IDA ICE settings

In order to run a simulation, global data and location conditions have to be defined first. As shown in figure 18, Helsinki is chosen for the location and climate data in the simulation for the Agricola hotel building.

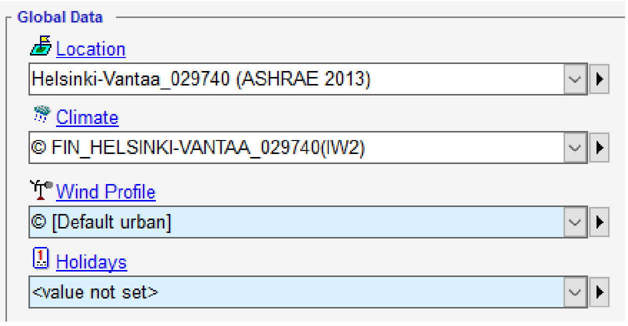


Figure 18. Global data

The internal floors are mostly not altered since they satisfy the minimum requirements set forth in the D3 building code. However, the internal floors in the bathrooms are altered because of the under floor heating system added to those spaces. The installation of an under floor heating system requires space for pipes beneath the surface of the floor.

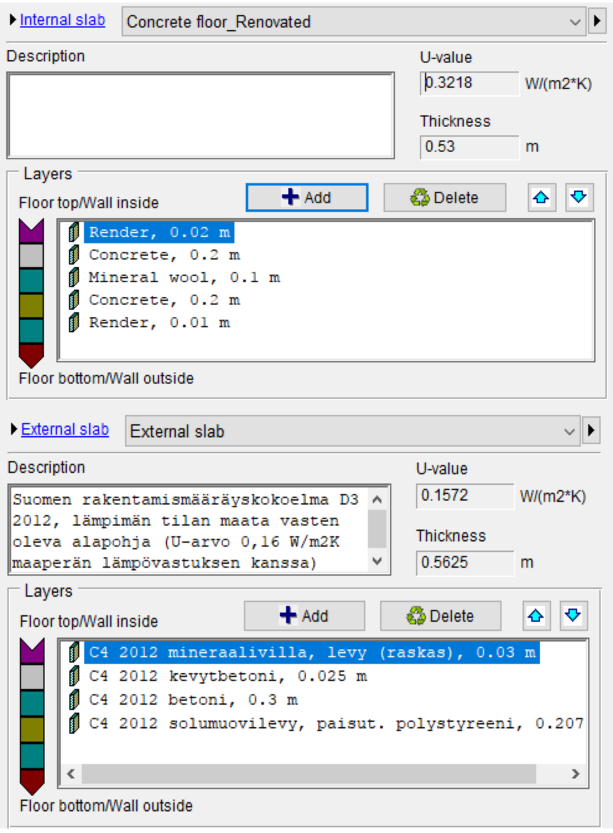


Figure 19. Internal and External Floor components

Figure 19 shows the materials used in the internal and external slab structures in the simulation process of IDA ICE. However, because of the limited scope of this thesis, slabs are not discussed.

Table 3 shows the details of the building envelope. The building components which have a direct and an indirect effect on the energy performance of the building are listed in table 3.

Table 3. Building envelope details

Building element	Value	Remark
External Walls	$U_{external}$: 0.72W / m^{2}K $U_{internal}$: 0.25 W / m^{2}K	The U value of the external wall is multiplied by 0.5 upon changing the purpose of the building
Floor	$U_{Internal}$: 0,32 W / m^{2}K $U_{external}$:0,16 W / m^{2}K	
Roof	U : 0.055 W / m^{2}K	Inverted Roof System
Window	8.2% of total envelope area Type: 3 plane glazing Frame U-value: 0.72 Glazing U-value: W / m^{2}K Visible transmittance: 0,74	
Door	U: 1.006 W / m^{2}K	Finnish building code D3 2012,(U requirement 1 W / m^{2}K

The transmittance properties of the building components listed in the table above are of major importance because most of the uncontrolled heat loss occurs through heat exchange between surfaces such as walls, floors and windows. (Gungör 2015.)

8.2 Thermal Bridges and Infiltration

Thermal bridge, also referred as cold bridge, is the part of the building envelope where otherwise uniform thermal resistance is significantly changed by full or partial penetration of the building envelope by materials with different thermal conductivity (Burke 2016). It may occur at junctions between walls, floors and ceilings. They are places where the heat can escape quickly.

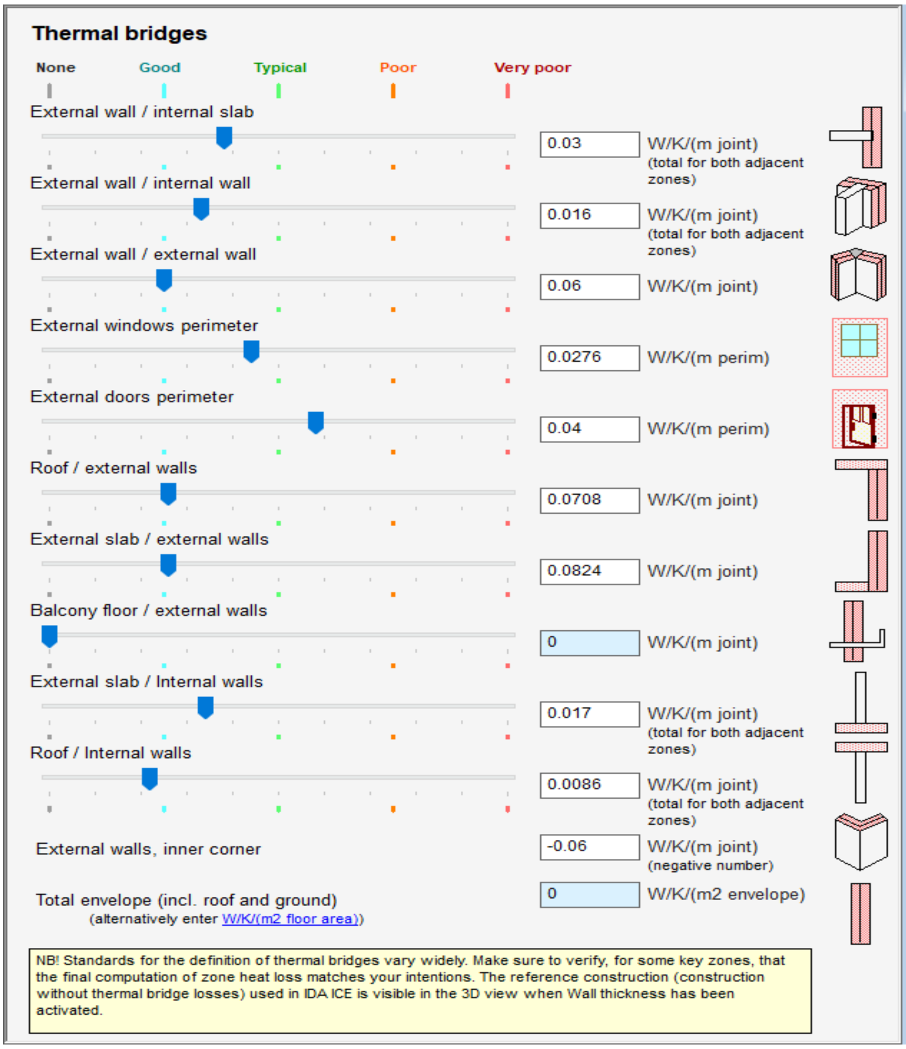


Figure 20. Thermal bridges

Figure 20 shows the thermal bridge selection for the Agricola hotel building. As it can be seen from the figure, the thermal bridge selection option has five options ranging from None to Very poor. Improvements in air tightness of the Agricola building improve the thermal bridge coefficients.

Infiltration is the amount of air leakage from the building. It is measured with a standardized air tightness test. Each room in the Agricola building will get the distributed effect of this infiltration. Fixed infiltration value of 0.14465 is used in the simulation. 0.14465 is the result of the infiltration calculation based on the D3 of the Finnish building code. According to the D3 document (D3 2010.), infiltration is calculated using the following formula.

$$q_{v,vuotoilma} = \frac{q_{50}}{3600 \cdot x} A$$

Where q_{50} is the average leakage air exchange of the building envelope $m^3/(h \cdot m^2)$,

A is the area of the building envelope (base floor included) m^2

X is a coefficient, which is 35 for buildings with one floor, 24 for buildings with two floors, 20 for buildings with three and four floors, and 15 for buildings with five or more floors.

3600 is a coefficient which converts the air flow from m^3/h unit to a m^3/s unit.

According to D3, the leakage air value $q_{50} = 2.0\ m^3/hm^2$

Using the formula above, $q_{v,vuotoilma}$ is found to be 0,2046 which leads to a 0,14465 ACH value in IDA ICE.

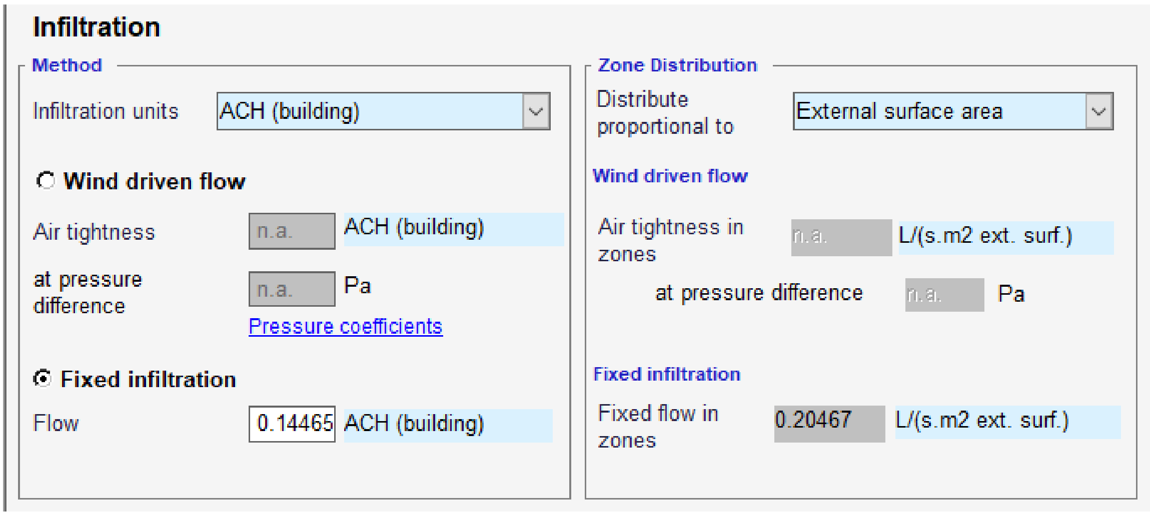


Figure 21. Infiltration setting on IDA ICE

Figure 21 shows the settings for the infiltration calculation on IDA ICE. As it can be seen from the figure, a fixed infiltration rate of 0.14465 ACH is used and this is equivalent to 0.20467 L/s.m^2 of external surface.

8.3 Internal Gains and 'Extra energy and losses'

Internal gain is the sensible and latent heat emitted within an internal space from any sources that result in an increased temperature and humidity within the space. The values for internal gains used in the simulation of the Agricola building, are based on surveys from building data or empirical values deemed appropriate in the industry. (Braham 2015.) The most important sources of internal heat gains in the Agricola building are occupants, lighting, office equipment and kitchen equipment.

The internal heat gains are calculated automatically in IDA ICE according to the total number of equipment used in the design. The internal gains from the different sources in the building are simulated in IDA ICE. Table 4 shows the internal gains in the building.

Table 4. Internal gains for the building (Modified Gungör 2015, 23)

Building Element	Value	Remark
Interior Lighting	10 W/m^2 (average) 32 W per equipment	These values are significantly higher in the service areas
Lighting Schedule	Always on	Lighting is automated
Receptacle Equipment	7.5 W/m^2 (average) 75 W per unit	Mostly Pcs, office equipment and so on
Equipment schedule	Always on	
Occupants	Activity level: 1.2 MET clothing: 0.7 ±0.25 CLO	Standard value
Occupant schedule	Always on	HOTEL
Kitchen equipment	50, 000 W total	Sum of all kitchen equipment found in a hotel (specific devices and their heat gain value can be found in Table 5)

The kitchen is assumed to be of the same size as that of an existing hotel in Helsinki. According to industrial kitchen design guidelines (RT 94-10443), there is a minimum standard for kitchens in accommodation spaces. The comparable four-star hotel kitchen used is assumed to have a comparable kitchen size as the Agricola hotel building. The kitchen equipment used in the IDA ICE simulation are listed in table 5.

Table 5. Equipment in a typical hotel kitchen (Modified Heiskanen 2014, 26)

Kitchen	Device	Electrical power (kW)	Heat load (W)	Total Heat load (W)
1	Food Freezer	1.5	700	1050
2	Drinks Freezer	6.0	700	4200
3	Microwave oven	10.0	220	2200
4	Heating cabinet	2.0	350	700
5	Stove	17.0	280	4760
6	Grill	9.0	730	6570
7	Salamander	6.0	875	5250
8	Fryer	16.0	600	9600
9	Fridge	0.5	700	350
10	Oven	20.0	280	5600
11	Dishwasher	20.0	440	8800
12	Warm food serving line	3.0	325	975
13	Cold food serving line	2.0	325	650
14	Cooling cabinet	6.0	700	4200
15	Ice maker	0.5	700	350
16	Refrigerator	0.5	700	350
17	Coffee machine	5.0	175	875
Total		125.0		56480

Energy efficient kitchen equipment are used in the Agricola hotel building. Since it is difficult to determine the heat load of each equipment in the kitchen, a value from a comparable hotel kitchen in Helsinki is used. However, the kitchen equipment in the Agricola hotel building are assumed to have a 10% less heat load. This is because new and modern equipment is assumed to release less heat than old equipment.

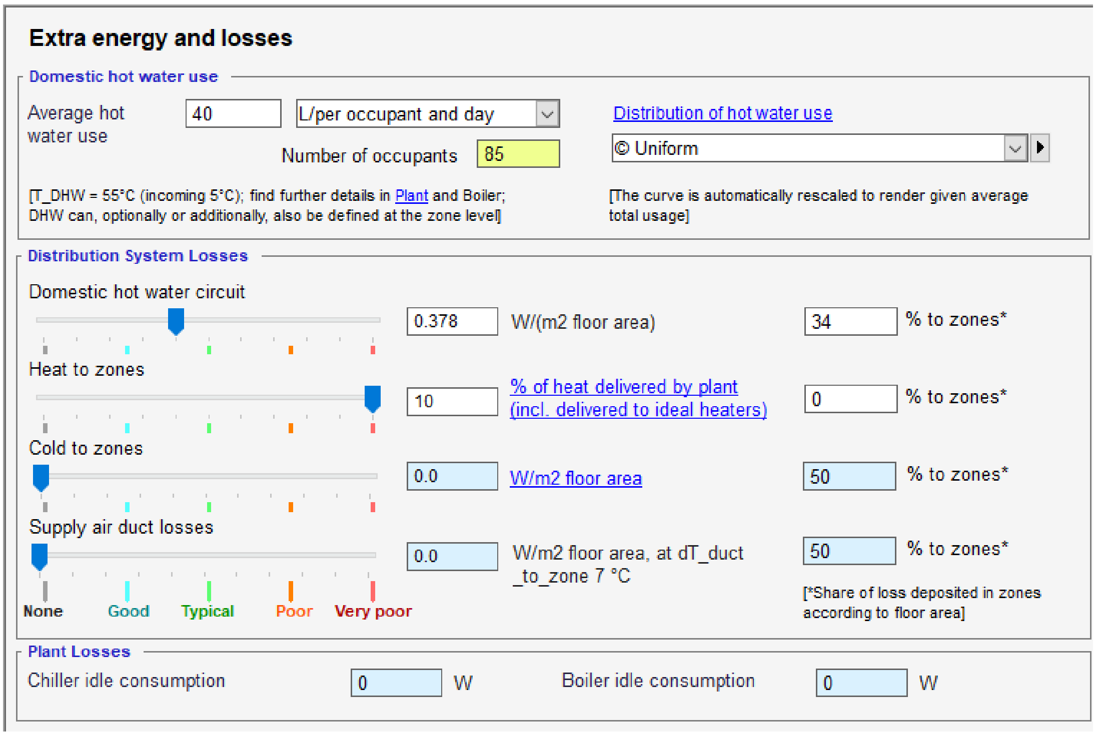


Figure 22. Settings for Extra energy and losses

There are energy losses from DHW production and HVAC systems. These system losses are taken into account in the energy calculation as seen in figure 22. The system loss values help in modeling the simulation to be as accurate as possible when compared to the actual performance.

9 HVAC Design

The design of Ventilation and Heating for Agricola building is done with MagiCAD. In this section, first, MagiCAD is introduced and then, the design of ventilation and heating is discussed.

9.1 MagiCAD

MagiCAD is a major piece of BIM software for HVAC, electrical and piping design mainly in Nordic countries but also elsewhere. MagiCAD was developed in 1998 by a Finnish company Progman Oy, which is part of the international Glodon group. The MagiCAD program is used approximately over 50 countries with more than 20,000 licenses. (Progman Oy 2016.)

MagiCAD is an add-in program, mainly installed on other CAD programs such as AutoCAD and Revit. Both AutoCAD and Revit are developed by Autodesk Incorporation, an American multinational company. Using a database with over a million verified products from more than 180 manufacturers, MagiCAD allows mechanical, electrical and plumbing design. It allows an accurate modeling and test of a building's MEP systems. With ready-made or pre-configured project templates, which can be market-specific and localized, the chances of human mistakes can be avoided. Users can get complete discipline-specific design and tools for calculation combined with different features and functions. (Progman Oy 2016.) Some of the features and functions are:

- a Project Management option which allows the user to combine information of all floors and carry out the calculations as one system.
- a database of products with 3D design.
- IFC support.
- Bills of Materials.
- plugins with product and system from manufacturers. (Progman Oy 2016.)

MagiCAD ventilation

MagiCAD ventilation offers a comprehensive BIM solution for the design and ventilation calculation. Maintaining quality indoor air in a modern building is one of the most challenging design tasks. MagiCAD ventilation allows the best ventilation design solutions for the Agricola building to maintain required indoor air quality. MagiCAD ventilation provides several functions such as duct sizing, flow summation, sound calculations, pressure calculations, balancing and bill of materials. (Progman Oy 2016.)

MagiCAD Piping

Designing heating, cooling and water systems is one of main functions of MagiCAD Piping. It has several other functions and features to save the design time. Connections between pipes, radiators, and other devices are done automatically. Complete sizing and balancing calculations are based on verified data from manufacturers, or on user-defined values. Different suitable devices for the project are recommended on the basis of data or manufacturer products. (Progman Oy 2016.)

MagiCAD for AutoCAD

MagiCAD for AutoCAD 2016 is chosen to design heating and ventilation system of the Agricola building project. The user interface with tools for designing ventilation and piping can be seen as figure 23.

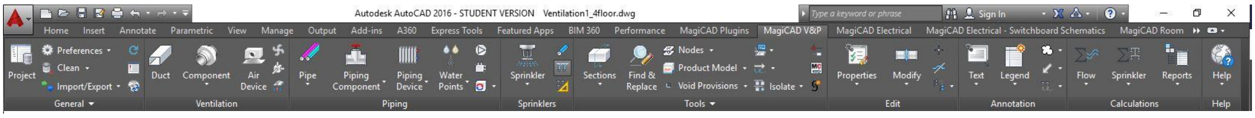


Figure 23. MagiCAD for AutoCAD ventilation and piping tab

From figure 24, the tab of MagiCAD V&P can be seen active, and all the tools related to it are displayed. Alongside the MagiCAD tabs, tabs of AutoCAD can also be seen to the left. Tabs like Performance, BIM360, Express tools on the left belong to AutoCAD.

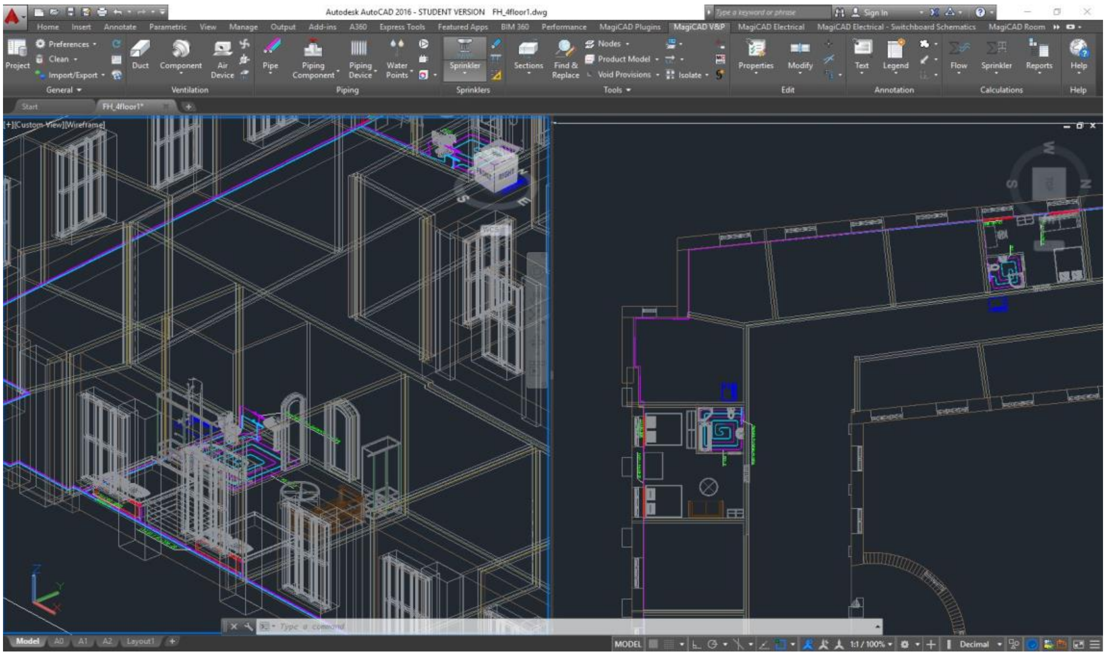


Figure 24. Autocad display

Figure 24 shows how AutoCAD interface looks like with two vertical viewports. The viewport on the left has a 3D view and on the right there is a top view showing a part of a floor plan. The views can be selected by the user.

Although MagiCAD has numerous functions, more relevant functions related to Agricola building project are discussed below.

Radiator selection

The selection of the radiator can be done as shown in figure 25 where the radiator system is selected.

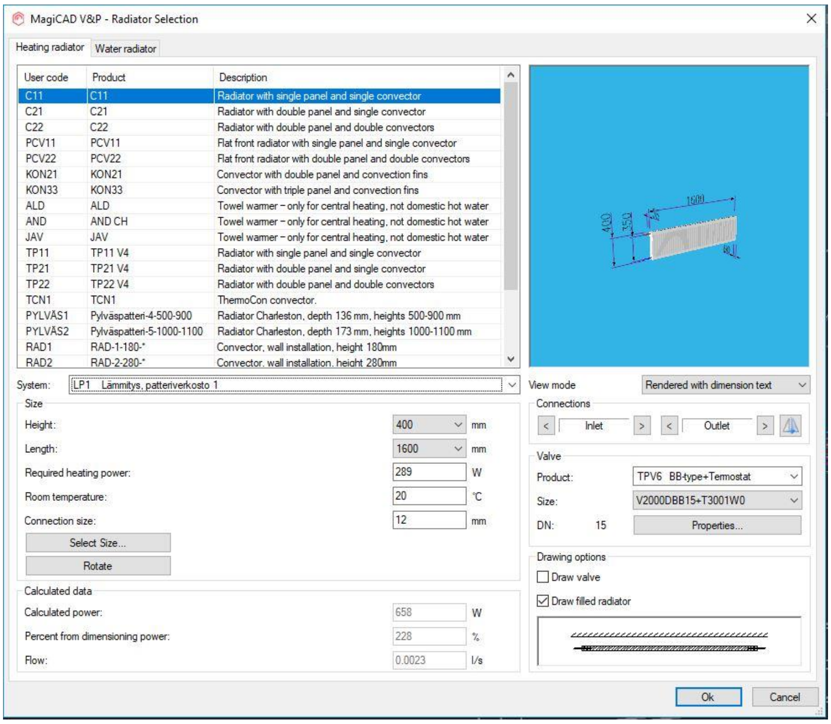


Figure 25. Radiator selection from MagiCAD

The size of the radiator can be chosen from the system, or the height and length of the radiator can be set as required. The selection can be made with the 'Select size' function as shown in figure 25. Most of the radiators in the Agricola building have the same length as the window, and one of the radiators of the suite has a required heating power set as 289 W with the room temperature 20° Celsius.

A single panel convector radiator, or type C11, manufactured by Purmo, is a traditional steel plate radiator that meets the quality and performance requirements with good aesthetic look.

Part properties

Figure 26 shows a dialog box with the heating supply pipe properties. Different properties like part type, system, storey, product, material, etc. are listed on in the box.

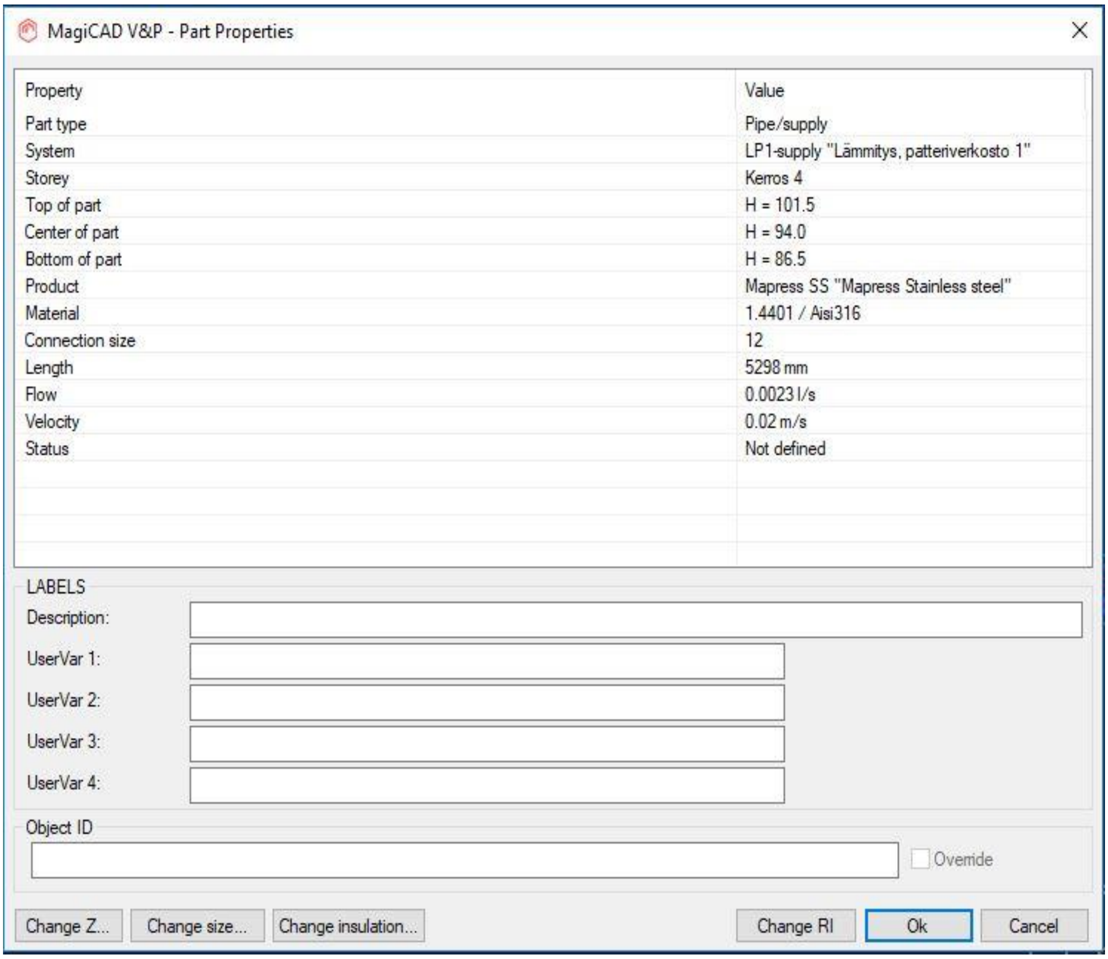


Figure 26. Part properties

The left side of figure 26 shows the properties of the pipe and the right side of the figure shows their respective values. On the lower level of the dialog box, change options such as change Z (angle), change size, change insulation are available for the selected pipe.

Product selection

MagiCAD offers a range of products to select from. Products descriptions and different configurations of various manufacturers are available. Figure 27 shows the window for the selection of the different products available in the MagiCAD library.

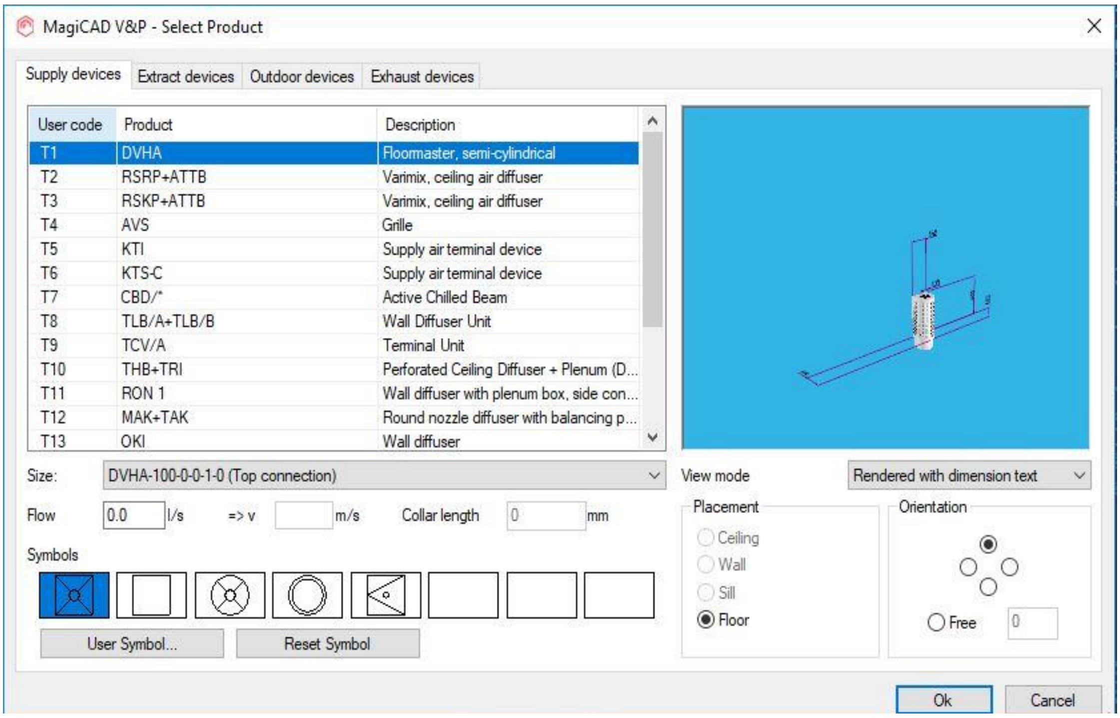


Figure 27. Product selection

Figure 27 above lists the supply devices, with the product's name and description, for ventilation. The dimension view can be seen on the right. The placement and orientation options for the product can be seen just under the rendered frame.

Product properties

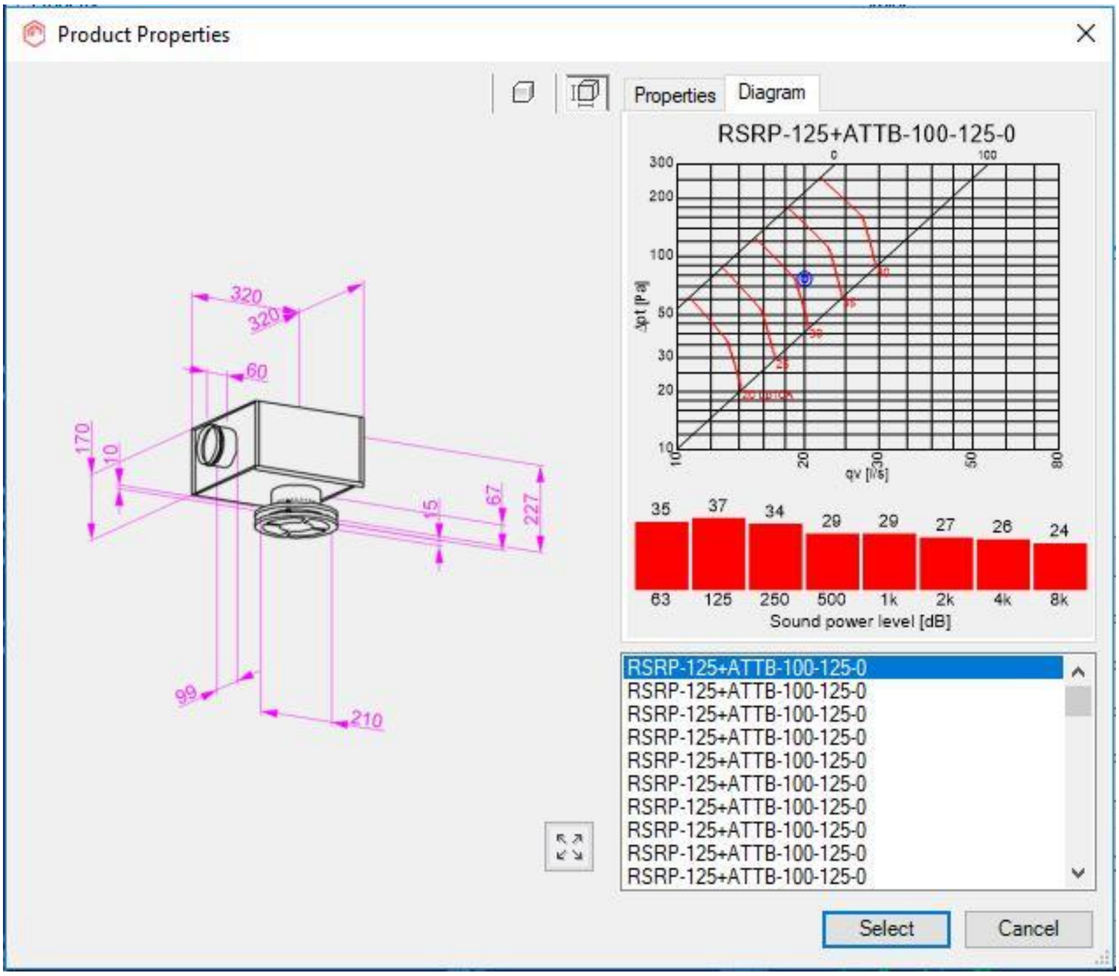


Figure 28. Product properties

Figure 28 shows the properties of an air terminal device with the dimensions on the left, after balancing the duct system. The right side of the figure shows the pressure loss diagram of the device.

Sizing methods

For heating/cooling, ventilation and water systems, the sizing method can be selected separately from the one that is used for selecting duct and pipe sizes for the systems. The sizing methods are found in the Project Management dialog box under the group (Project > Ducts/Pipes/Water systems > Sizing methods) as shown in the figure 29 below.

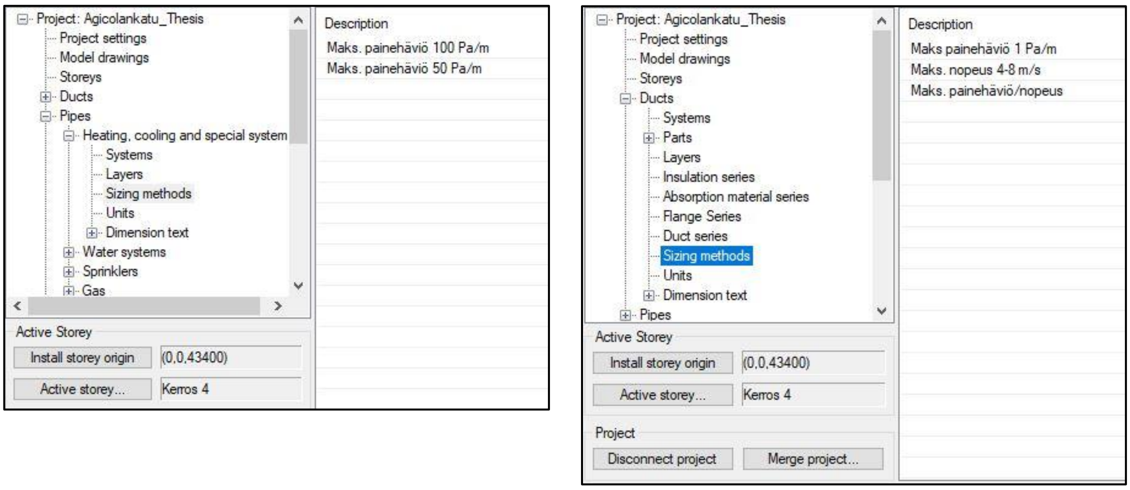


Figure 29. Sizing methods for heating (left) and ducts (right).

The right side of the figure describes the settings for the sizing methods for the duct. The methods can be edited, or a new one can be inserted according to user requirements.

Calculations in MagiCAD

MagiCAD provides a complete solution for calculations of flow summation, sizing and balancing of the ducts and pipe sizes according to the user-specific settings and sizing methods.

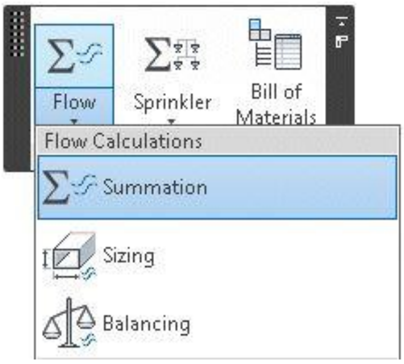


Figure 30. Calculations, Sizing and Balancing

Figure 30 shows active flow calculations; Summation, Sizing and Balancing. The flow summation option calculates the flows from devices like air terminals, radiators, etc. Pressure drops are not calculated, and the size of the duct or pipe cannot be changed with this function.

Sizing option calculates the flows from the devices and selects the pipe or duct sizes in accordance with the criteria set to the system in sizing methods. However, pressure drop is not calculated.

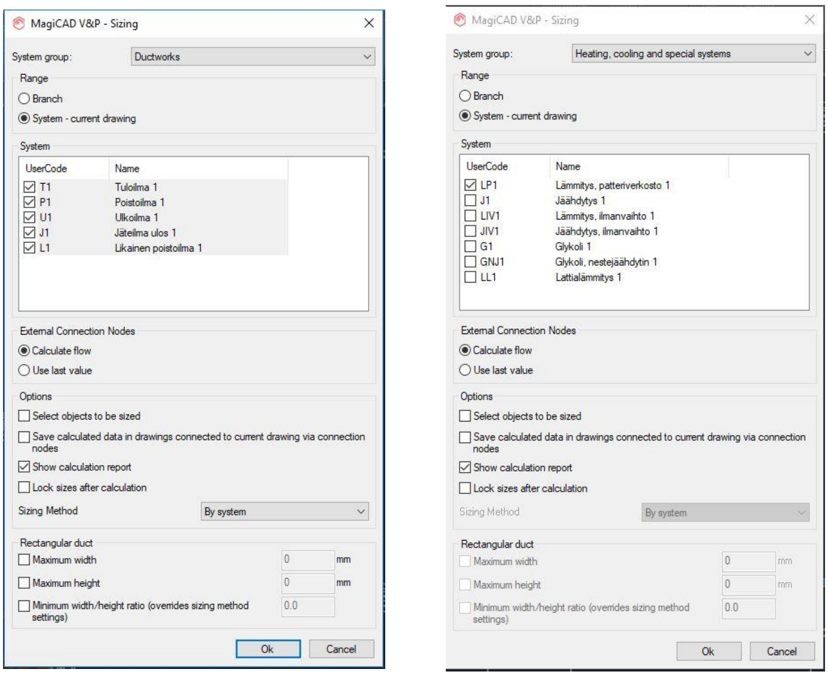
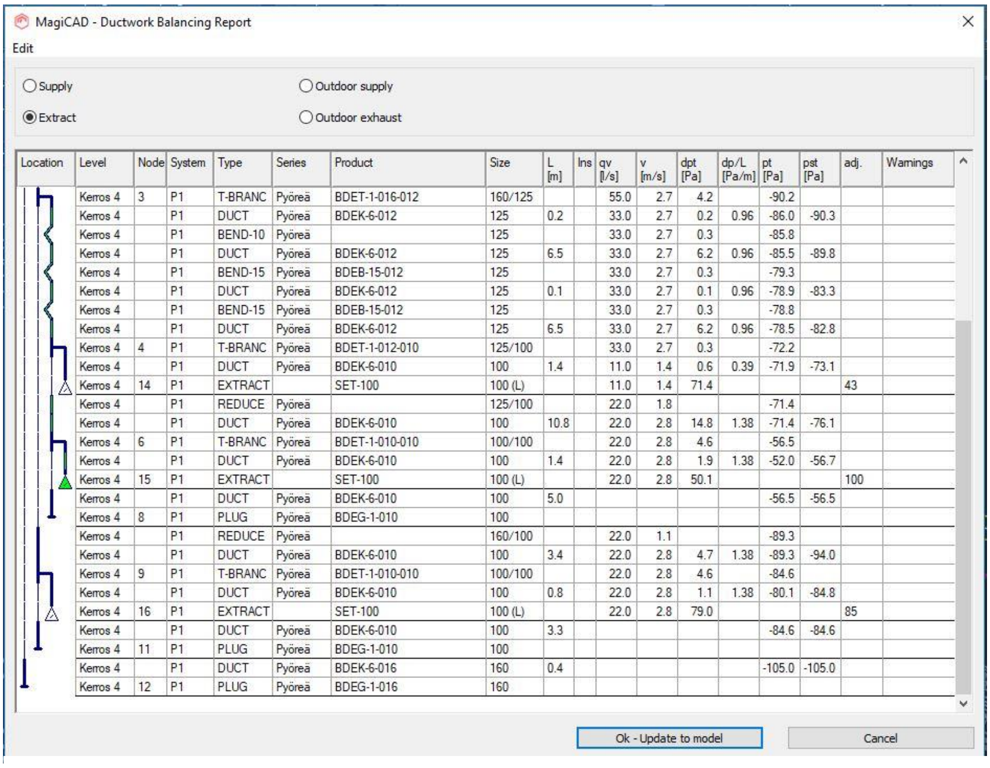


Figure 31. On the left, Sizing for ductworks, on the right, Sizing for Heating, cooling and special systems

Figure 31 shows the sizing option for both system group Ductworks (left) and Heating, cooling and special systems (right).



Location	Level	Node	System	Type	Series	Product	Size	L [m]	Ins	qv [l/s]	v [m/s]	dpt [Pa]	dp/L [Pa/m]	pt [Pa]	pst [Pa]	adj.	Warnings
	Kerros 4	3	P1	T-BRANC	Pyöreä	BDET-1-016-012	160/125			55.0	2.7	4.2		-90.2			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-012	125	0.2		33.0	2.7	0.2	0.96	-86.0	-90.3		
	Kerros 4		P1	BEND-10	Pyöreä		125			33.0	2.7	0.3		-85.8			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-012	125	6.5		33.0	2.7	6.2	0.96	-85.5	-89.8		
	Kerros 4		P1	BEND-15	Pyöreä	BDEB-15-012	125			33.0	2.7	0.3		-79.3			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-012	125	0.1		33.0	2.7	0.1	0.96	-78.9	-83.3		
	Kerros 4		P1	BEND-15	Pyöreä	BDEB-15-012	125			33.0	2.7	0.3		-78.8			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-012	125	6.5		33.0	2.7	6.2	0.96	-78.5	-82.8		
	Kerros 4	4	P1	T-BRANC	Pyöreä	BDET-1-012-010	125/100			33.0	2.7	0.3		-72.2			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-010	100	1.4		11.0	1.4	0.6	0.39	-71.9	-73.1		
	Kerros 4	14	P1	EXTRACT		SET-100	100 (L)			11.0	1.4	71.4				43	
	Kerros 4		P1	REDUCE	Pyöreä		125/100			22.0	1.8			-71.4			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-010	100	10.8		22.0	2.8	14.8	1.38	-71.4	-76.1		
	Kerros 4	6	P1	T-BRANC	Pyöreä	BDET-1-010-010	100/100			22.0	2.8	4.6		-56.5			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-010	100	1.4		22.0	2.8	1.9	1.38	-52.0	-56.7		
	Kerros 4	15	P1	EXTRACT		SET-100	100 (L)			22.0	2.8	50.1				100	
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-010	100	5.0						-56.5	-56.5		
	Kerros 4	8	P1	PLUG	Pyöreä	BDEG-1-010	100										
	Kerros 4		P1	REDUCE	Pyöreä		160/100			22.0	1.1			-89.3			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-010	100	3.4		22.0	2.8	4.7	1.38	-89.3	-94.0		
	Kerros 4	9	P1	T-BRANC	Pyöreä	BDET-1-010-010	100/100			22.0	2.8	4.6		-84.6			
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-010	100	0.8		22.0	2.8	1.1	1.38	-80.1	-84.8		
	Kerros 4	16	P1	EXTRACT		SET-100	100 (L)			22.0	2.8	79.0				85	
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-010	100	3.3						-84.6	-84.6		
	Kerros 4	11	P1	PLUG	Pyöreä	BDEG-1-010	100										
	Kerros 4		P1	DUCT	Pyöreä	BDEK-6-016	160	0.4						-105.0	-105.0		
	Kerros 4	12	P1	PLUG	Pyöreä	BDEG-1-016	160										

Figure 32. Ductwork balancing report - Extract

After calculating the flows from the devices and the pressure drops, balancing balances the whole system. The ductwork and pipe systems are balanced to a minimum pressure level by default. User-specified minimum pressure drops can be set for air devices, flow dampers and balancing valves. Manufacturers' product information is used when calculating pressure drops for supply and exhaust devices, silencers, flow dampers, etc. However, sizing is neglected when the balancing is done. An example of a calculation report for ductwork balancing is shown in figure 32. The results are given in a tree view.

Bill of Materials

A bill of materials is a complete list of products and their quantities used in a system group. It shows the total number of equipment used for the Agricola project.

MagiCAD V&P - Bill of materials

File Edit

Class	Size	Series	Product	N	L [m]	Insul. A	s [mm]	Surface area
Duct	100	Pyöreä	BDEK-6-010	14	51.6			16.2 m²
Duct	125	Pyöreä	BDEK-6-012	7	34.3			13.5 m²
Duct	160	Pyöreä	BDEK-6-016	12	24.9			12.5 m²
Duct	200	Pyöreä	BDEK-6-020	2	4.3			2.7 m²
Bend-15	125	Pyöreä	BDEB-15-012	2				0 m²
Bend-90	160	Pyöreä	BDEB-90-016	4				0.6 m²
Bend-90	200	Pyöreä	BDEB-90-020	1				0.3 m²
Bend-03	160	Pyöreä		1				0 m²
Bend-05	160	Pyöreä		1				0 m²
Bend-07	125	Pyöreä		2				0 m²
Outlet	100/100	Pyöreä	BDET-1-010-010	4				0.2 m²
Outlet	125/100	Pyöreä	BDET-1-012-010	2				0.1 m²
Outlet	160/125	Pyöreä	BDET-1-016-012	2				0.2 m²
Outlet	160/160	Pyöreä	BDET-1-016-016	2				0.2 m²
Reduction	250/125			1				0 m²
Reduction	250/160			2				0.1 m²
Reduction	250/200			1				0 m²
Reduction	125/100	Pyöreä		2				0 m²
Reduction	160/100	Pyöreä		2				0 m²
Plug	100	Pyöreä	BDEG-1-010	4				
Plug	160	Pyöreä	BDEG-1-016	2				
Outdoor air device	200	R1	RISD-200	1				
Supply air device	100	T2	RSRP-125+ATTB-100-125-0	3				
Extract air device	100	1	SET-100	3				
Exhaust air device	125	J1	EYMA-2-012	1				

Figure 33. Bill of materials

As shown in figure 33, the report gives accurate list of information about the product used, their series and size with surface area.

9.2 Ventilation

For the Agricola hotel project, Swegon Gold RX, manufactured by Swegon Group AB, was chosen as the Air Handling unit for its high heat and humidity recovery and low energy consumption. (Swegon 2017)

Figure 34. Swegon Gold RX AHU (Swegon 2017)

Figure 34 shows the Swegon Gold RX air handling unit equipped with a rotary heat exchanger. The wheels are made of aluminum foils featuring many small channels. The air flows through the small channels and transfers its heat to the storage mass. (Klingenburg USA, LLC)

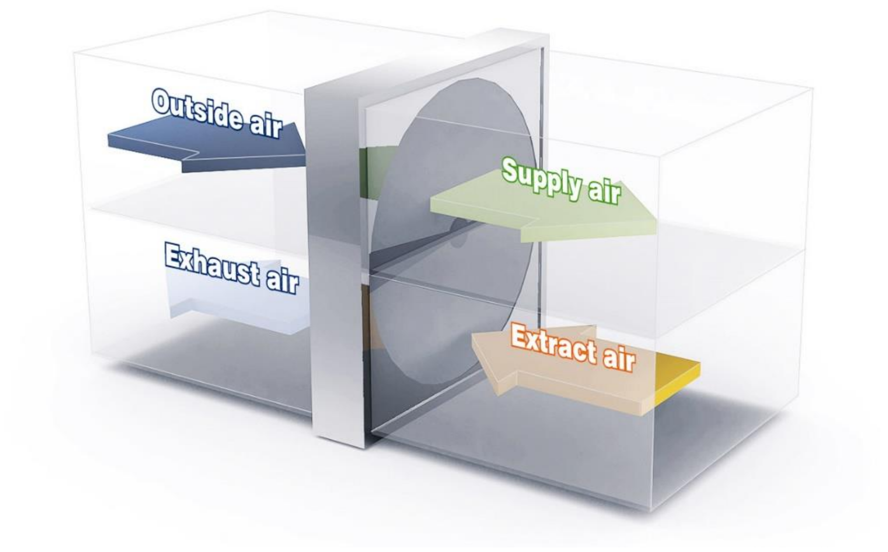


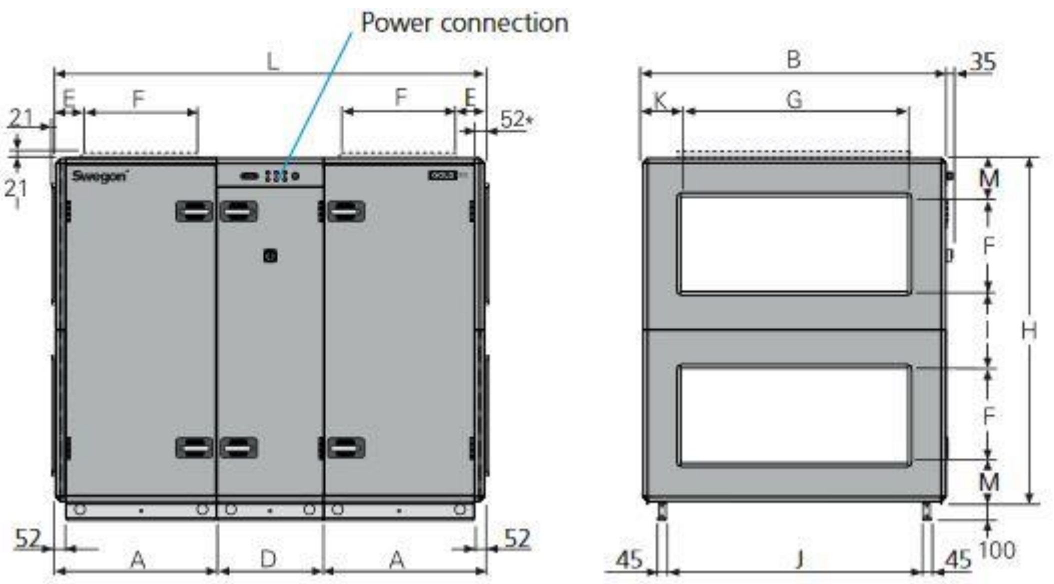
Figure 35. Heat recovery system and operating principle (Klingenburg 2017)

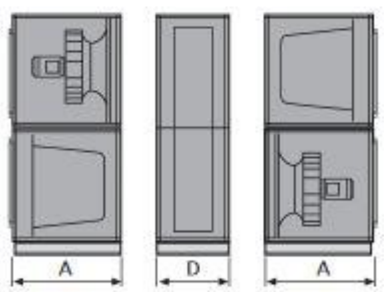
Supply air is the external air coming into the building whereas exhaust air is the used indoor air leaving the building. As shown in figure 35, the wheel of the exchanger rotates between these air current. Outside air flows through half the heat accumulator, while the exhaust air crosses the other half. During this process, heat carried by the extract air is accumulated by the storage mass in the rotation of the wheel. The wheel continues to rotate carrying the heat from the extract air until it crosses the path of the supply air to which the heat is transmitted. As a result, the supply air has a significant increase in temperature while entering the building. The heat recovery is around 80 to 85% and some of the moisture in extract air recirculates back which helps to stabilize the moisture level in the building. As the device has high heat recovery and low energy consumption, it assures sustainable ventilation of the building. The unit chosen for the Agricola project allows several automation settings to be easily maintained and run in ecological energy saving programs. (Klingenburg 2017)

The drive equipment in the unit controls the rotor speed and it is useful if defrosting of the rotor is needed. Defrosting can be done by reducing the rotor speed. However, if the frost problem is considerable, as may be in severe conditions, a drip tray with drainage is required. To prevent a condensation and frosting problem, outside air duct and exhaust ducts should be insulated properly. (Rotary heat exchangers for Heat Recovery in Ventilation Systems, 2015)

Because of the rotation of the wheel, the two airstreams might mix with each other. To prevent this, the unit has a purging sector which reduces the transmission of extract air to the supply air. (Rotary heat exchangers for Heat Recovery in Ventilation Systems, 2015) The purging sector is effective if there is a correct pressure potential and proper fan configuration. (Klingenburg 2017)

As outdoor air has many impurities which may enter a building, the Swegon Gold RX has an F7 class filter for both supply air ventilation and extract air ventilation to maintain the indoor air quality. These filters are efficient for particles up to 1 µm. Small dust particles, spore, cement dust and carbon are some of the particle materials which are separated by filters. (KS Klima-Service 2018)





A	848
B	1600
D	565
E	200
F	500
G	1200

H	1811
I	405
J	1354
K	200
L	2261
M	203

Figure 36. Dimensions of the Swegon Gold RX AHU (in mm) (Swegon 2017, 59)

As shown in figure 36, the unit is 2261 mm by 1600 mm by 1811 mm in size. The other dimensions of the AHU are listed in the lower right-hand corner of the figure 36.

9.2.1 Air flow calculation

The required airflow rate is calculated for each of the Agricola hotel room types. The regulations and guidelines from the D2 national building code of Finland for Indoor climate and ventilation of buildings were used for the calculations. All the calculations have supply and extract airflows. The calculation assumes 30% higher airflow when the hotel rooms are occupied and decreases the air flow by 60% when the rooms are unoccupied for a longer time. The height of most of the rooms is 4 meters but only 3.5 meters is used for the calculation purposes. To maintain air quality and comfort, the air change rate is according to D2 in the Finnish building code. The total supply and extract air flow values are calculated by summing up the figures of each room type and their air flow values. The airflow values of each room type can be seen in appendix 3. The total airflow can be seen in table 6.

Table 6. Total airflow need; from excel calculation

	Rooms		
	Single	Double	Suite
Extract	14.3	28.6	28.6
Supply	13.0	26.0	26.0
Rooms in each floor			
2nd floor	11	10	3
3rd floor	11	10	0
4th floor	11	10	3
Fifth floor	11	10	3
Sixth floor	6	6	3
Total amount	50	46	12
Total extract	715	1315.6	343.2
Total supply	650	1196	312
Total extract need	**2373.8**	l/s	
Total supply need	**2158**	l/s	

The airflow of air handling unit ranges between 300 -2500 l/s (1080 – 9000 m^3/h). The total supply and extract air requirement for the rooms and other common areas is estimated to be around 4500- 5000 l/s. So, two ventilation units are needed to cover the required air flow for the building.

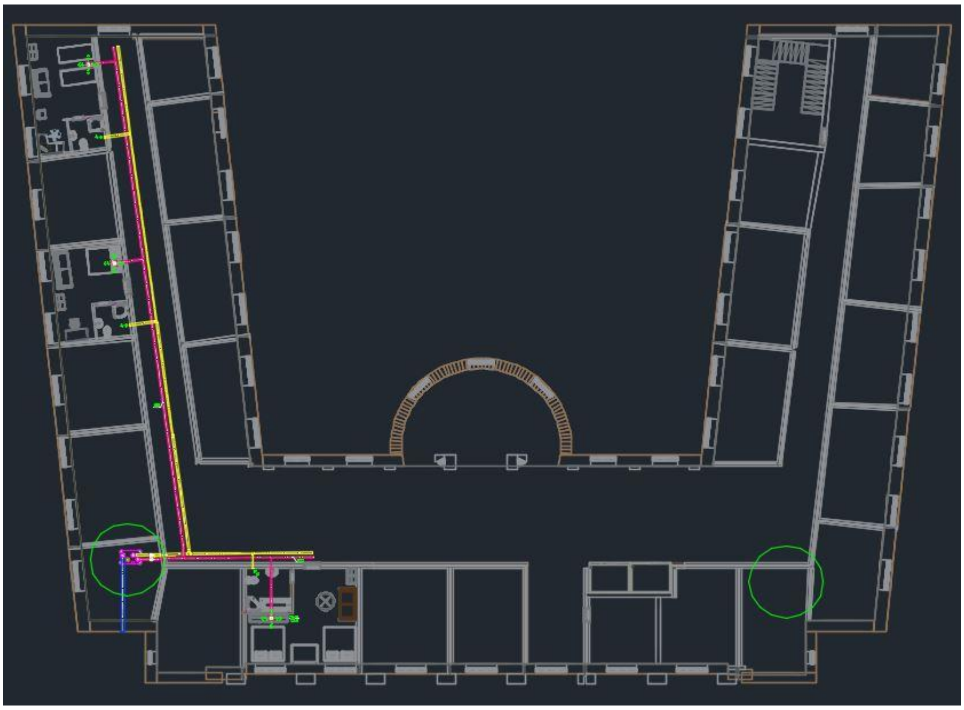


Figure 37. Shaft locations (green circles); figure taken from MagiCAD design

As shown by the green circles in figure 37, each machine is placed in the technical room near the existing shafts on the sixth floor of the building. 3D ventilation design can be seen in Appendix 3.

9.2.2 Ventilation duct size calculation

The pipe sizes for each room were calculated with a spreadsheet, as shown in figure 40. To prevent noise produced by the flowing air in the pipes, the air velocity in the pipes should be under 4m/s (D2 2008.)

Duct sizing	Single	Double	Suite
qv [m3/s]	0.0143	0.0286	0.0286
v [m/s]	4	4	4
A [mm2]	3575	7150	7150
r [mm]	33.7	47.7	47.7
d [mm]	67.5	95.4	95.4
Duct size [mm]	**100**	**100**	**100**
A = qv / v			
qv : Air flow rate		r : radius	
v : air speed		d : diameter	
A : duct cross sectional area			

Figure 38. Duct sizing; from excel calculations

As seen from the calculations in figure 38, the pipes in the double and suite rooms are dimensioned at 100 mm. The duct sizes for single rooms are also dimensioned at 100 mm as recommended by MagiCAD sizing. Practically, it is easier to install pipes with the same connection size, with no pressure difference and noise.

9.3 Heating

One room from each room type on the fourth floor with different heat loads were chosen for heating calculations. Radiators in the rooms and under floor heating (UFH) in the bathroom were used to meet the required heating load. Each room chosen has two windows which determined the number of radiators used.

Figure 39. Simple heating design; from MagiCAD

A simple design was done in MagiCAD for the space heating in the three rooms of different room types on the fourth floor as shown in figure 39. 3D heating design can be seen in Appendix 3.

9.3.1 Radiators

Radiators are heat exchangers which distribute thermal energy for space heating. Despite the name, heat is transferred through convection and very little through radiation. (British Stainless-Steel Association 2003.)

As most of the radiators in the Agricola building are very old, they need to be replaced. As the building has different types of spaces, different types of radiators are used as required. As show in figure 40, rooms have panel radiators and corridors have mostly column radiators.

Figure 40. On the left, compact panel radiator, on the right, Column radiator (Purmo 2016)

As a panel radiator has large convector plate, heat is emitted across a larger area and distributed the heat more effectively, making it an energy efficient design. (Purmo 2016).

9.3.2 Pipe system

Basically, there are two types of pipe systems, one-pipe systems and two-pipe systems. The type of the installed system affects the dimensioning of pipe and radiators. (Grundfos, 2017)

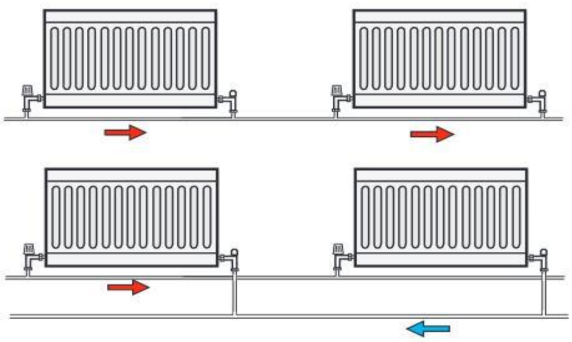


Figure 41. One pipe(above) and two pipe(below) systems (The 50plus Organization Ltd 2006)

Earlier systems used a one pipe system where, as shown in figure 41, same pipe connects all the radiators and acts as both the supply and return pipe. As the water flows through different radiators, the temperature decreases along the way. Therefore, the size of the pipe and radiator must be larger to meet the heat output. A two-pipe system is chosen for the Agricola project, which has two pipe circuits; one for supply and other for return. Each radiator is connected to both circuits as shown in figure 41. Unlike in a one-pipe system, the water flows at the same temperature all along the circuit and the radiators get same flow temperature. (The 50plus Organisation Ltd 2006.)

Mapress stainless steel is chosen for the pipework as it offers many benefits materially, economically and ecologically. Stainless steel is also known for its corrosion resistant properties. It can be easily bent and cut with proper tools because of its ductility. It can be used for many types of water, and the system is safe from contamination also. Unlike other materials, stainless steel has a longer lifetime, more than 50 years, and it is completely recyclable. Comparing with copper or plastic, the initial cost is higher, but there is no maintenance and replacement required over its life-cycle. (British Stainless-Steel Association 2003.)

As shown in figure 39, Radiators R1, R2 and R3 are for the room type Suite, Single bedroom and double bedroom respectively. From MagiCAD design, the nominal flow rate of R1, R2 and R3 is 0,0023 l/s, 0,002 l/s and 0,0036 l/s respectively with the heating output 289 W, 241 W and 440 W respectively.

Figure 42. Top view of radiator (width in mm). (Purmo 2016)

The radiators chosen for Agricola building are manufactured by Purmo. From their many different products, Compact 11 is chosen as it has one of the most efficient designs and suits aesthetically, the traditional interiors. It is made from cold rolled steel sheet and has the maximum operating temperature at 120°C. (Purmo 2016.) Top view and cross section of the radiator can be seen in figure 42 and figure 43 respectively. The system temperature of the heating system for the radiators is 70/40°C. It is the supply/return temperature of the water.

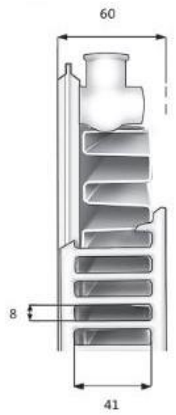


Figure 43. C11 cross-section (dimensions in mm). (Purmo 2016)

A Radiator valve is an important component of the radiator heating system as it regulates the hot water flow into the radiator, hence, controlling the temperature of the space. Honeywell V2000DBB15 with thermostat is chosen as the radiator valve. The thermostatic radiator valve used in the design is seen in figure 44.

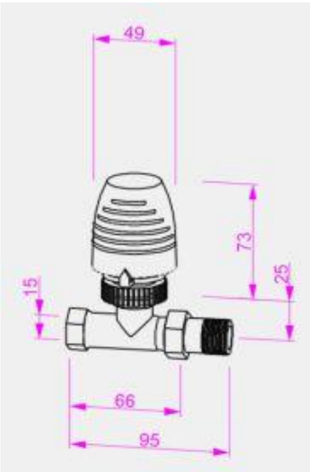


Figure 44. Dimensions of the valve; from MagiCAD design

From the second to the sixth floor, on average, the number of radiators needed is estimated to be 216 which may cost up to 50,000 euros with cost of installation. The calculation of the estimation can be seen in Appendix 2.

9.3.3 Underfloor Heating (UFH)

As the name suggests, underfloor heating system is installed under the floor. It is an ideal system to distribute the heat evenly in a space. The heat distribution is upwards, reducing the draught risk. As the heat distribution is from floor to ceiling, as shown in figure 45, the heat wasted at the ceiling of the room is avoided achieving optimum comfort. As the system avoids heat waste in a space and the heating system runs on a lower temperature, this helps saving the operation cost. (CTS Plumbing & Building 2017)

Figure 45. Conventional radiator system vs under floor heating (The Solid Wood Flooring Company 2018)

Compared with conventional radiators, underfloor heating is more expensive to install, yet the system provides more efficiency, better air quality and more space which makes it an optimum choice (CTS Plumbing & Building 2017).

There are two types of underfloor heating: electric and hydronic (water-based). Electric based system has a network of conductive wires installed under the floor. Hydronic system has series of pipes connected to a manifold, which pumps the hot water under the floor, and is linked to the district heating system which is the primary heating source of the Agricola building. As seen in figure 46, a series of pipes acts as a large radiant surface as the pipes are installed in a continuous loop. (Tradesmen Supply 2006.)

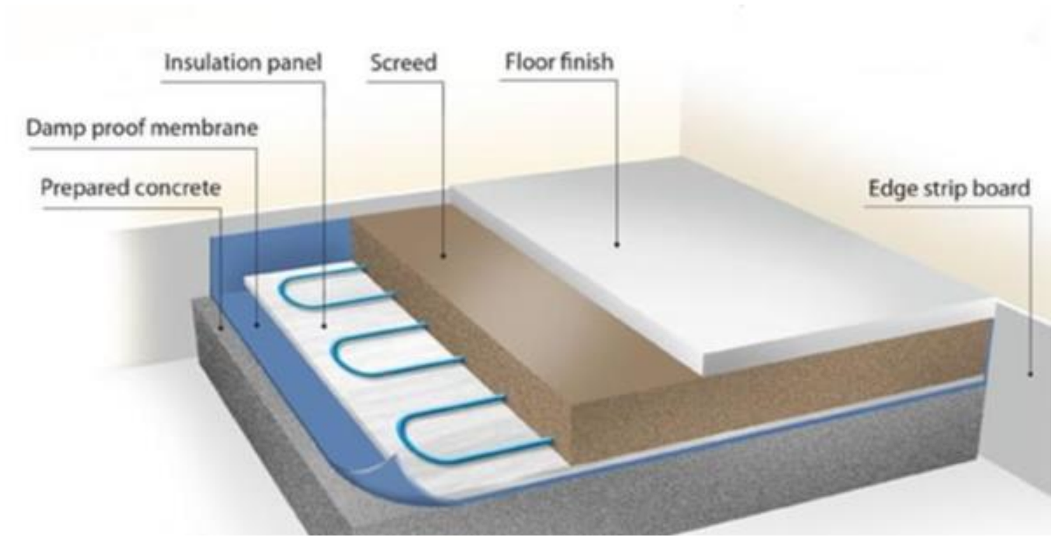


Figure 46. Hydronic underfloor heating (CTS Plumbing & Building 2017)

The electric system is relatively inexpensive and easy to install. However, the electric system has more running costs than a water-based heating system, and the water-based system is more efficient than radiators. In Agricola project, to install the under-floor heating system, either floor level must be reduced or raised accordingly. Water based system is chosen for bathroom and toilets in the Agricola building as it is already connected with district heating.

There is around 406 m^2 of floor area to be heated with underfloor heating in the Agricola building. The installation of the pipes is at 200 mm center-to-center which equals to 5 meters per square meter. Multilayerd Uponor wirsbo Q&E pePEX is chosen as the piping component for the Agricola project.

Crosslinked polyethylene or PEX has numerous advantages over other pipes, like rigid and metal. The installation of this pipe is easier and requires fewer fittings than other piping systems. A PEX system is considered to be quieter than copper pipe systems. The pipe has corrosion resistant property. (Tradesmen Supply 2006.) The estimated length of total pipes required in the Agricola building is around 2250 m. In average, the system costs around 35 euros per m^2. The calculation can be seen in Appendix 2.

As shown in figure 40, Underfloor heating UFH1, UFH2 and UFH3 are for the room type Suite, Single bedroom and double bedroom, respectively. A sample design of the suite bathroom's underfloor heating is shown in figure 47.

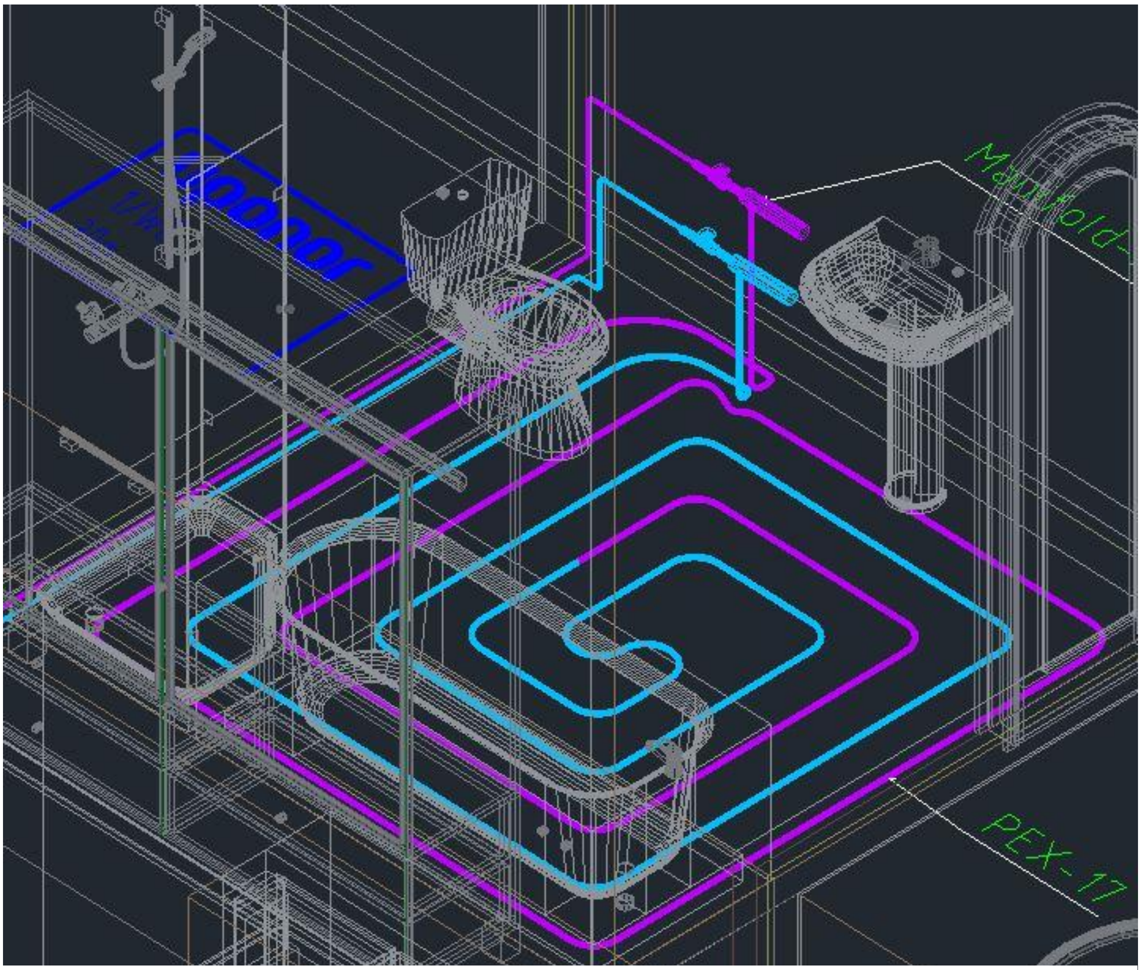


Figure 47. Sample design of underfloor heating from MagiCAD

Bathroom in a suite has floor area of $6m^2$ and a heating load of around 75 W. The pipe is laid in the 200 mm apart centre-to-centre and the total length of pipe required for this space is 30 m. The system temperature of the system is 35° to 40 °C.

10 Renewable Energy Production

One of the aims of the Agricola building project is energy sustainability. In order to achieve that, clean energy sources have to be used. The motivation, besides contributing positively to the climate, is financial and compliance with different national regulations. Sustainable solutions can easily be used to decrease the total energy demand of the building.

The selected renewable energy production methods in Agricola project are solar electric PVs and, solar thermal. Several factors have been considered before selecting these renewable energy sources. The most important factors were: the availability of the renewable energy source (the Sun), cost of installation and usage, national regulations, characteristics of the energy profiles to be offset by the new installations, and available incentives to change to renewable sources.

10.1 Solar Electric PV

PV arrays convert the energy from the sun to electricity. They have modules that can be mounted on or near a building. A power inverter converts the DC current into AC electricity (Hayter and Kandt 2011).

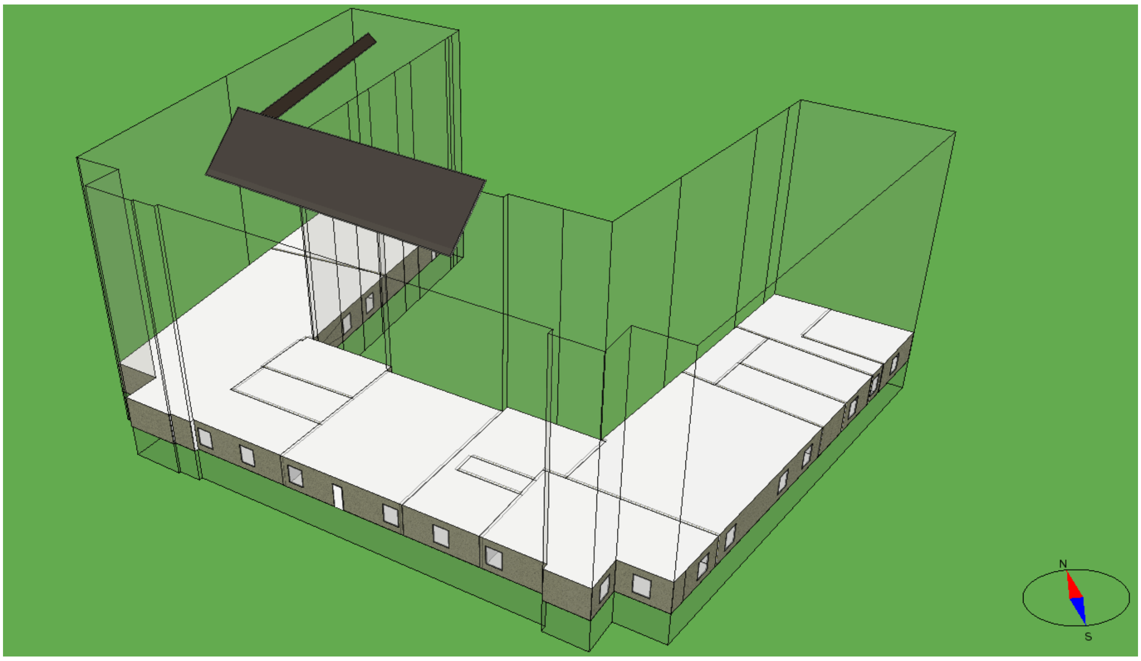


Figure 48. Orientation of the solar thermal and solar electric systems on the roof

PV modules are the main building blocks for the Agricola building. They can be arranged in arrays to increase the electricity production. The system has all the necessary components to serve the demand of a commercial application. Figure 48 shows the orientation of the solar thermal and solar electric systems on the roof of the Agricola building.

Electricity Generation Mechanism

The photovoltaic effect is a physical process by which a PV cell converts the photons in the sun rays to electricity. The amount of energy contained in the photon is related to the wavelength of the solar spectrum. When photons hit the surfaces of the PV cells, they are either absorbed or reflected. Only the absorbed ones are used in the generation of electricity. (UPRM 2015.) Figure 49 shows a scheme of a PV system.

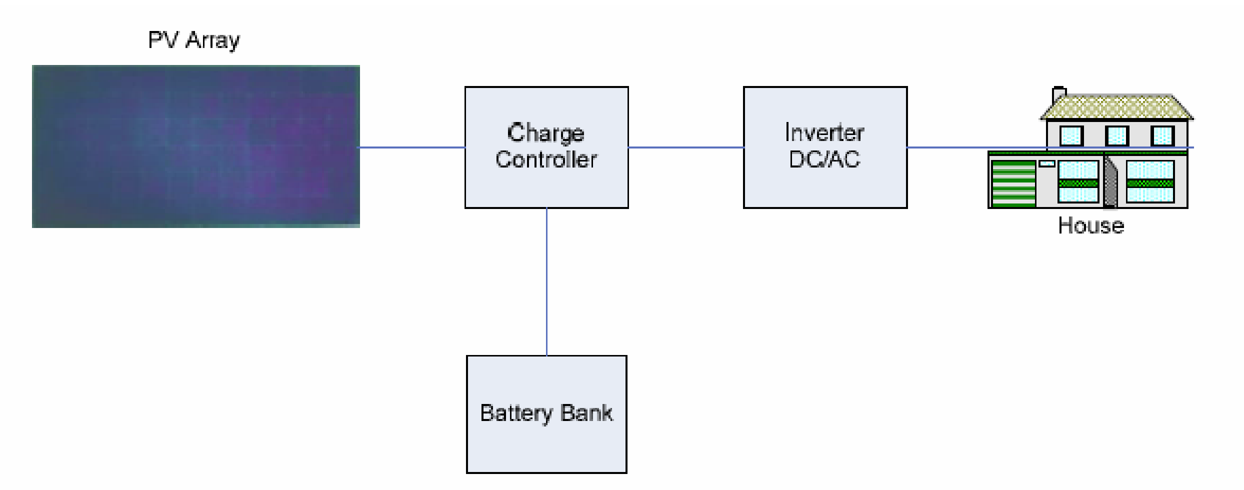


Figure 49. Solar Electric PV System (Reprinted (UPRM 2015, 6)

The components of the system are (UPRM 2015, 13-22)

- Photovoltaic modules: are composed of photovoltaic cells which convert the solar energy in to electricity. A PV module is just an array of PV cells arranged in a series or parallel connections according to the energy demand.

- Inverters: used to transform DC current to AC currents. The inverters used in the Agricola building require batteries to operate. The batteries provide a constant voltage source at the DC input of the invertor.

- Batteries: used to store energy to be used at times when there is no radiation available (rainy and cloudy days, night times). They are also used for stand-by power applications.

- Charge controller: a DC to DC device controlling the current flow from the PV modules to charge batteries. They can maintain the maximum charge of the battery without overcharging or reaching the minimum design charge. Their main function includes overcharge protection and over discharge protection.

The performance of a PV system depends on a number of factors, such as orientation, inclination, shade effects, geographical location and temperature effects. All these factors have been considered in the design process.

The Agricola building is located in the middle of a stand-alone plot of land. There are no bigger buildings or trees that interfere with the panels with a shading effect. The location of the arrays has been carefully picked so that they have maximum sunlight exposure. A well-designed PV system needs to be clear of obstacles during the day time when there is maximum sun intensity. Shading can also occur from adjacent objects such as ventilation pipes and satellite dishes (Central Solar HW System Design 2011.) In these instances, such objects are to be relocated.

The orientation, in northern latitudes, should ideally be to true south in order to get optimum power production. However, the orientation does not need to be perfect because the modules produce 95% of their full power within 20 degrees of the sun’s direction. (Central Solar HW System Design 2011.)

The PV arrays of the Agricola building are located on the roof. The regulations prohibiting the installation of these systems on the roof of a historical building were not found. However, according to the information gathered from one of the interviewed architects (Lehtinen 2018.), the regulations allow to install PV panels on the roof of a historical building. But, since the façade is protected by law, nothing can be done on it. By installing the PV panels on the roof of the building, the aesthetics of the building was preserved. The modules are mounted so that gables and overhangs do not shade them.

The energy produced by PV systems is also affected by the tilt angle. The optimum tilt for a PV array equals the geographic latitude minus 15 degrees (Central Solar HW System Design 2011, 7). The location of Helsinki is 60.192059 Latitude. From this, it is easy to determine what tilt gives maximum power in the Agricola building. In both systems, 45 degrees of tilt is used. It is important to note that it is also possible to install the modules with the same pitch as the sloping roof because tilt is very forgiving (UPRM 2015.) This is because the angle of the sun varies all year long. Figure 50 shows the design of PV panels on IDA ICE.

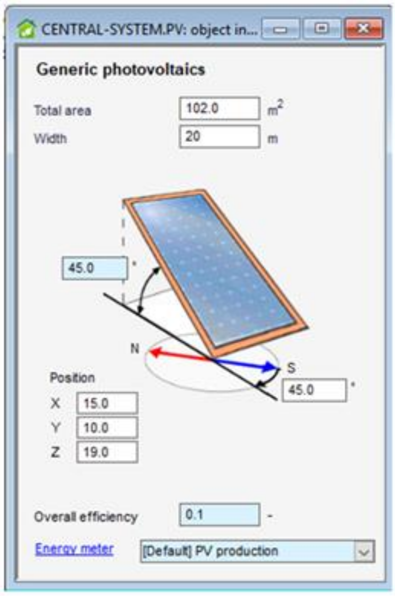


Figure 50. PV design on IDA ICE

The modular temperature also affects the performance of the system. Modular temperature increase usually results in decreased performance (Central Solar HW System Design 2011). It is necessary to have space between PV modules installation objects for cooling air circulation. A ventilation gap of 30 mm is provided behind the arrays to allow wind circulation.

10.2 Solar Thermal System

Solar thermal systems refer to solar water heaters and solar ventilation pre-heating systems. These systems are very cost effective and help reducing the cost of the energy bill. However, these systems cannot be used all year around as sun light is scarce during the winter seasons. (Hayter and Kandt 2011.)

A solar thermal system has the following components (Hayter and Kandt 2011, 9-10)

- Solar hot water system: a system of collectors to absorb heat and transfer it to water, which is stored until needed. It is reliable and requires low maintenance because it has very few parts.

- Solar ventilation preheating system: heats ventilation air for application needed. The sun warms the collector surface and the heat is conducted to the air. Then the heat escapes by convection through the fans as shown in figure 51. The collectors can be added to an existing building as well. The systems are also low cost, reliable, low maintenance, and highly efficient.

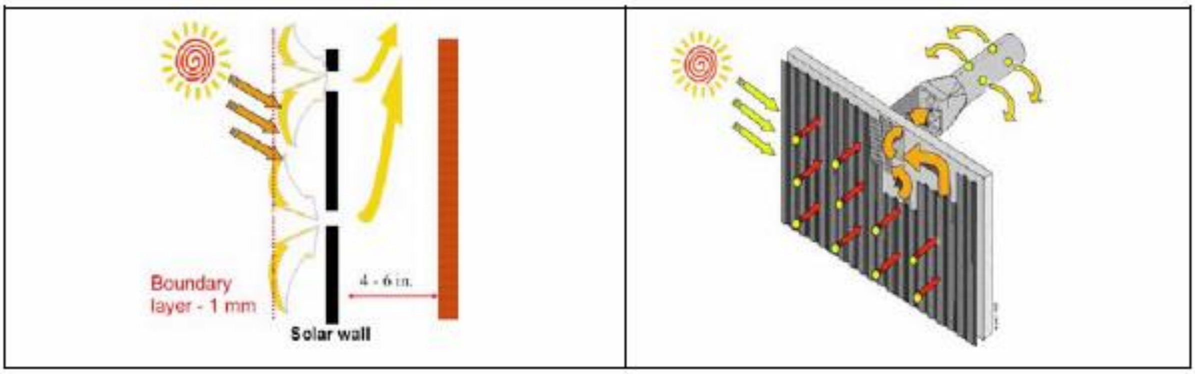


Figure 51. Ventilation preheating (reprinted from Hayter and Kandt 2011, 7)

The solar thermal system on top of the Agricola building only acts as a secondary source of hot water because of too little solar radiation in Finland. Much of the design considerations applied for PV systems are applied here as well. The orientation and tilt angle are the same. Both systems are pointed in the direction of maximum sun light intensity as shown in figure 52.

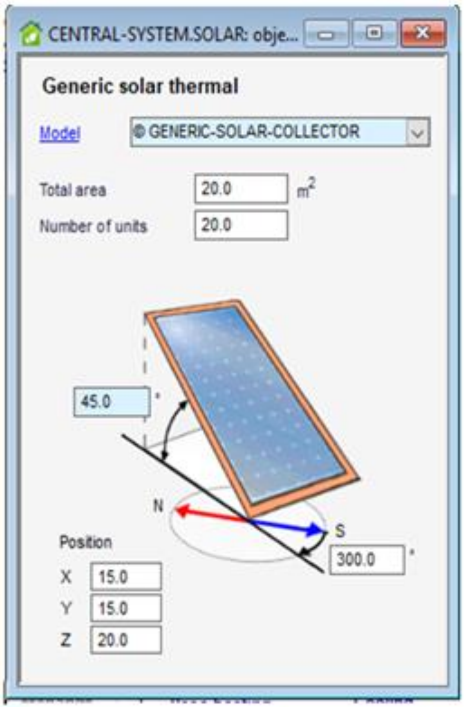


Figure 52. Design specifications for solar thermal components in IDA ICE

When adding a solar thermal system to the building, one needs to add some components to the already existing heating system. So, the following components are added to the system.

- Storage tank system
- Heat transfer fluid (water-glycol mixture) with freezing point of -23^{0}C
- Heat exchangers to transfer the heat from one loop to another
- Expansion and safety devices for each closed loop
- Controller with temperature sensors

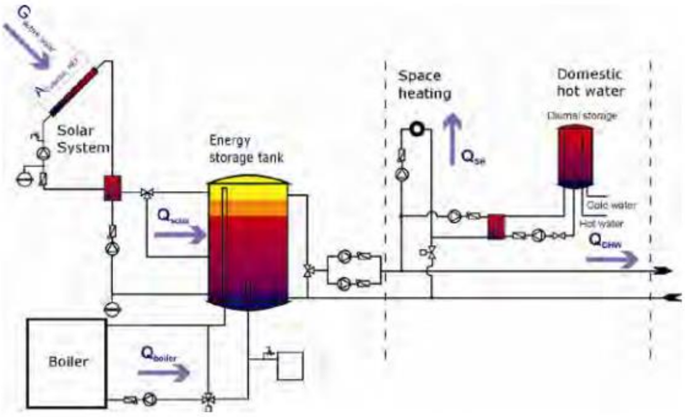


Figure 53. Solar thermal system (Central Solar HW System Design 2011, 14)

Figure 53 shows a schematic of solar thermal system for the Agricola building. It shows the allocation of heat flow in the solar thermal system.

11 Simulation Analysis

The building simulation for the Agricola building is set to run in an optimal condition. The design values defined in this paper are used. In the simulation of internal gains, 100% occupancy is assumed because of the nature of the service. The equipment density is standard for a hotel service of comparable size. The HVAC system runs 24/7 with no exceptions of holidays as the hotel is set to run all year round.

Figure 54. First floor IDA ICE design

Figure 54 shows the design layout of the rooms in IDA ICE for the first floor for the Agricola building. The occupants are assumed to be in the center of the room (by default). Their location has no significance since the heating and cooling devices in the rooms are ideal and the temperatures are constant across all rooms.

Energy Balance

The heat loss through the envelope of the building (external walls, roof, ground slabs and thermal bridges) is the most significant aspect of the energy calculation. The heat generated from the equipment, lighting and occupants (guests, staffs and outside customers) is constant.

kWh (sensible only)

Month	Envelope & Thermal bridges	Internal Walls and Masses	Window & Solar	Mech. supply air	Infiltration & Openings	Occupants	Equipment	Lighting	Local heating units	Local cooling units	Net losses
1	-7062.8	-3.9	-579.1	-6228.0	-1367.9	6347.8	0.0	1450.9	7317.6	0.0	106.8
2	-6809.5	-28.6	-447.5	-5601.5	-1310.6	5728.5	0.0	1310.6	7047.3	0.0	96.5
3	-6228.2	-44.1	-222.0	-6377.7	-1272.0	6305.4	0.0	1450.9	6269.9	0.0	106.8
4	-4264.1	-82.5	60.6	-6615.1	-913.0	5987.0	0.0	1404.1	4316.9	0.0	103.3
5	-2588.0	-96.3	332.2	-6968.2	-633.7	5964.1	0.0	1450.9	2434.3	0.0	106.8
6	-1523.5	-370.7	422.8	-6571.8	-394.8	5667.9	0.0	1404.1	1263.0	0.0	103.3
7	-761.1	-332.2	513.0	-6650.6	-282.4	5617.5	0.0	1450.9	345.8	0.0	106.8
8	-988.9	601.3	345.3	-7493.9	-362.8	5572.5	0.0	1450.9	770.5	0.0	106.8
9	-2222.4	88.2	146.0	-7247.2	-527.3	5839.0	0.0	1404.1	2412.2	0.0	103.3
10	-4209.2	94.4	-149.0	-6982.6	-876.2	6185.8	0.0	1450.9	4366.8	0.0	106.8
11	-5272.3	65.6	-380.8	-6392.1	-1006.0	6066.6	0.0	1404.1	5396.4	0.0	103.3
12	-6704.9	28.6	-574.3	-6294.9	-1308.0	6332.5	0.0	1450.9	6947.0	0.0	106.8
Total	-48634.8	-80.3	-532.9	-79423.5	-10254.6	71614.6	0.0	17083.2	48887.9	0.0	1257.5
During heating (8157.0 h)	-44338.3	2213.1	-1561.7	-56364.9	-9716.0	46846.6	0.0	12937.4	48888.9	0.0	986.8
During cooling (0.0 h)	-721.6	-1222.6	412.6	-6433.3	-84.6	6862.6	0.0	1142.9	0.0	0.0	69.8
Rest of time	-3574.9	-1070.8	616.2	-16625.3	-454.0	17905.4	0.0	3002.9	-1.0	0.0	200.9

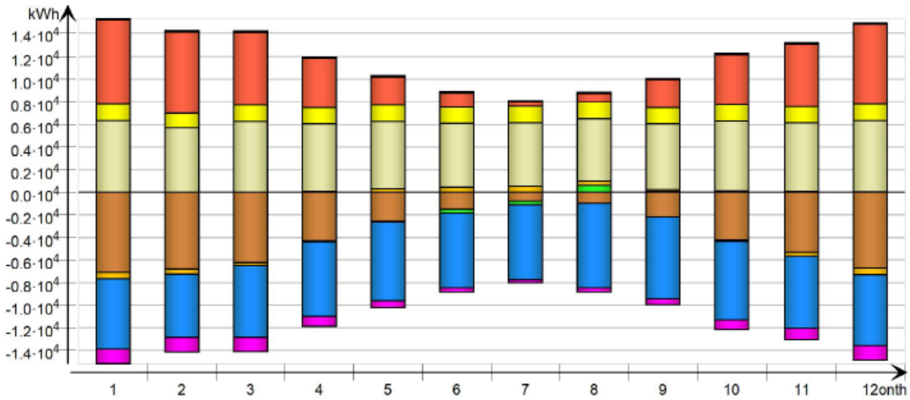


Figure 55. Energy balance of the building (whole year)

According to the schedule defined in IDA ICE, the zone heating operates during the cold months (October to April). The highest load for this operation usually occurs during the coldest months, usually December to January, while the lowest load is during the hottest month of the year, usually July. This is established from the weather data the software uses as can be seen from figure 55.

The required energy for the building (not accounting for renewable sources) is 183,123 kWh. The greatest part of the energy comes from district heating (121,825 kWh). Domestic hot water production is uniform throughout the year as shown in figure 56. The pattern for zone heating and AHU heating is very similar even though they have different values.

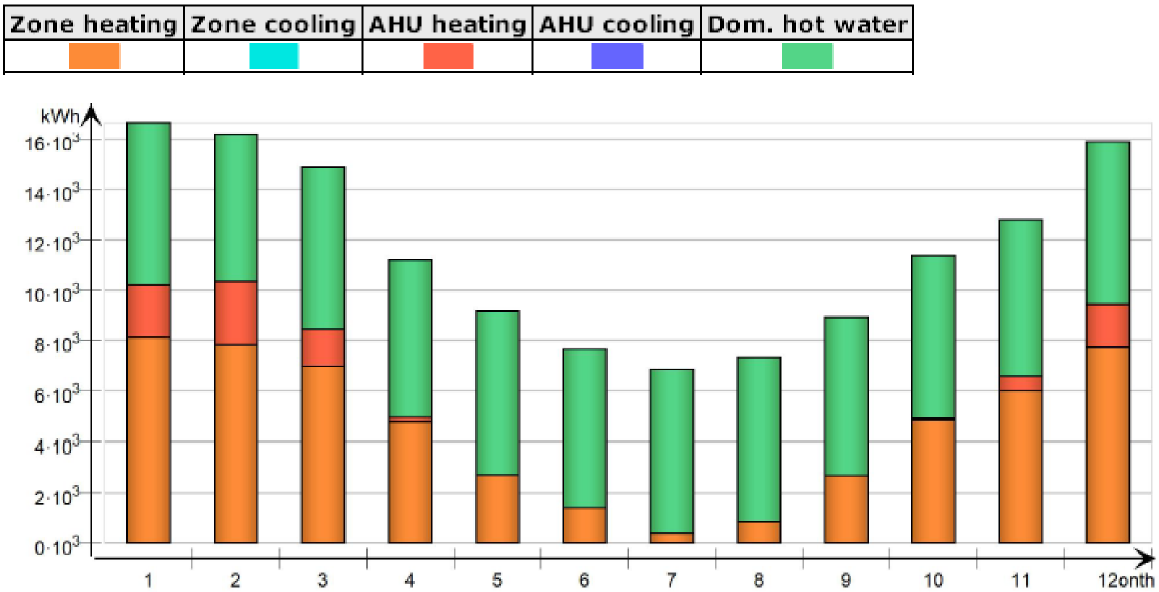


Figure 56. Used energy

Energy is also generated by the solar thermal and solar PV solutions in the building. The production of energy from these two systems is maximum during the summer months. A total of 9914.9 kWh of energy is produced per one system as shown in figure 57.

kWh

Month	Solar (PV)
1	192.1
2	376.9
3	809.6
4	1110.0
5	1468.0
6	1436.0
7	1520.0
8	1193.0
9	872.2
10	559.9
11	235.6
12	141.6
Total	9914.9

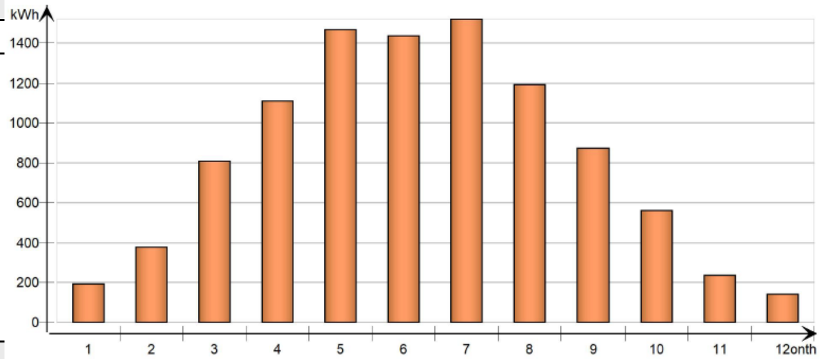


Figure 57. Renewable energy production

The use of the solar thermal and solar electric systems brings down the total purchased energy demand of the Agricola building to 173,210 kWh from 183,123 kWh. According to the D3 of the Finnish building code (D3 2010), the maximum energy demand for accommodation spaces should be 180kWh/m^2. The renovated Agricola building has a requirement of 155.1 kWh/m^2. This value is obtained from the IDA ICE simulation Delivered energy report. The table can be found in appendix 2 (Delivered Energy overview).

The energy simulation result above shows that it is possible to change the function of the building to hotel purposes without destroying its heritage value. It is even possible to improve the total energy demand of the Agricola building by adding other renewable energy solutions such as geothermal heat. Geothermal system is not added because it is more expensive and makes the project less feasible.

12 Business Plan

The project is a conveniently located hotel that has great connections to tourist sites as well as the heart of the Helsinki. The Agricola hotel offers a modest and relaxing environment for both local and international customers. The Agricola hotel expects to attract frequent travelers who require high levels of personal services.

12.1 SWOT Analysis

The SWOT analysis is a planning technique used to recognize strengths, weaknesses, opportunities, and threats. The organizational strength is the most important part here as it helps to capitalize on external opportunities and prepare contingency plans to deal with any future possible threats concerning the business.

The SWOT analysis of this project is divided into internal and external factors, so it is easier to compare and analyze them. The strengths and Weakness of the project are the internal factors.

One of the advantages for the hotel project is its unique location and building. Its location is in the heart of the Kallio district which has very easy access to the city center and to the Helsinki-Vantaa airport. The Kallio district is one of the liveliest districts in Helsinki with different trendy shops, bars and ethnic markets. A new development (Redi project) of shopping centers and offices is going on nearby in the Kalasatama area which is about 1 km from the location of the hotel. This will have a positive impact on real estate. The Agricola building itself has its own importance with architectural and historical values, as customers will see the presence of history. In addition, customers will enjoy beautiful views of the surrounding and the sea from the top storey of the Agricola building. Staff and the whole management will be very skilled and most of the personnel will speak different languages which makes communication easier. There will be clear and well communicated shared values as these values serve the needs of all stakeholders, employees, managers and clients of the organization.

As a newly built hotel and not belonging to any chain hotels, lack of recognition among visitors and targeted groups may be considered as one of the biggest weakness. The flow of tourists increases during summer and spring seasons as compared to the winter season, and this cycle should be considered as seasonal revenues and managed. As there can be seasonal revenues, hiring staff for a long period of time may be affected which requires orientation and training for new staff. Fear of future economic recession also effects the overall hotel operation.

External factors in the SWOT analysis are divided into Opportunities and Threats which cannot be controlled and are independent. Most of these factors are reactive and an organization should be prepared and adapt to them to prosper. The number of tourists visiting Helsinki and staying overnight is increasing which can be considered an opportunity. Although there are some hotels in the area, there is no direct or strong competition. Skilled personnel and the materials and supplies required to run the hotel are available in the local market which eases the operation process. New technological service and social media can be used for aggressive marketing which helps in the recognition process of the hotel. The city of Helsinki is planning some regulation on apartment renting services as this part of sharing economy has turned into a professional business which is affecting the hotel business.

Threats are the external factors which may result in some challenges and difficulties for the hotel if not acted on properly. There are competitive and brand hotels in greater Helsinki area and an introduction of new hotels could affect the demand of the market. Along with the competition with chain hotels, a rise in substitutes such as hostels, apartment renting services, guest houses, etc. could affect the demand. About 20% of the accommodation available in Helsinki is covered by Airbnb, an online apartment renting service, and its increasing. (YLE1 2017.) The economic situation on the market and changes in laws could affect the hotel, creating new difficulties in the business.

More research on SWOT analysis helps evaluating the objectives and help to make a further plan. The SWOT analysis for the Agricola hotel project is summarized below with the main characteristics of the project.

STRENGTH

- Strategy: different from the usual
- Location: Very close to the centre area as well as the airport
- Structure: Historical building of great value, architectural icon
- Skills: very skilled management and staff personnel
- Shared values: clear and well communicated

WEAKNESS

- Seasonal revenues: the flow of tourists occur during specific seasons
- Brand strength: newly built so not yet well-known
- Seasonal turnover requires on-going training for temporary staff

OPPORTUNITIES

- Market: growing number of tourists and overnight stays
- Competitors: no strong competition in the area
- Staff: required personnel to run the hotel are available in the local job market
- Suppliers: required materials available in large enough supply in the local market

THREATS

- Market entry: many competitive and global brand hotels in Helsinki
- Substitutes: furnished apartments, guest houses and Airbnb offering lower prices
- Economy: recession still not over totally

12.2 Competition Analysis

Although there is no direct competition in the area, there are many hotels in the capital region such as Hilton hotels, Marriot, Radisson Blu, Sokos hotels and Cumulus. The competitors are not only hotels but also guest houses, private apartments offering Airbnb services, hostels and accommodation services.

12.3 Market Needs

The hotel will offer its services at a very affordable price. The price ranges from €110 per night in the single bedrooms to €300 per night in the suites. The hotel demand in Helsinki is increasing with the increasing tourist influx. Helsinki, overall, has seen the slowest growth in hotel markets compared to other Scandinavian cities such as Stockholm and Copenhagen. There is a huge potential for this sector to flourish in Helsinki as well as in other major cities in Finland.

13 Marketing Plan

A Marketing plan is a comprehensive document that outlines business advertisements and marketing efforts of a project. (Westwood 2002) The right marketing plan must include everything from who, to how to reach and maintain them. It should be a roadmap to follow to get unlimited customers and improve the success of the company.

13.1 Target Customers

To identify the customers, a technique called as target market segmentation is used. This technique groups consumers with similar needs and buying behaviors into segments. Then those segments can be used for targeted advertising which is more efficient and effective than advertising to the masses. (Zelenina 2015.) So basically, it is a customer centered approach.

Figure 58 shows an example of target customers. It shows that the customers can be segmented as individuals, business, groups and leisure. The figure also shows the correlation between the segments. For instance, customers segmented under business can travel as individual or in groups.

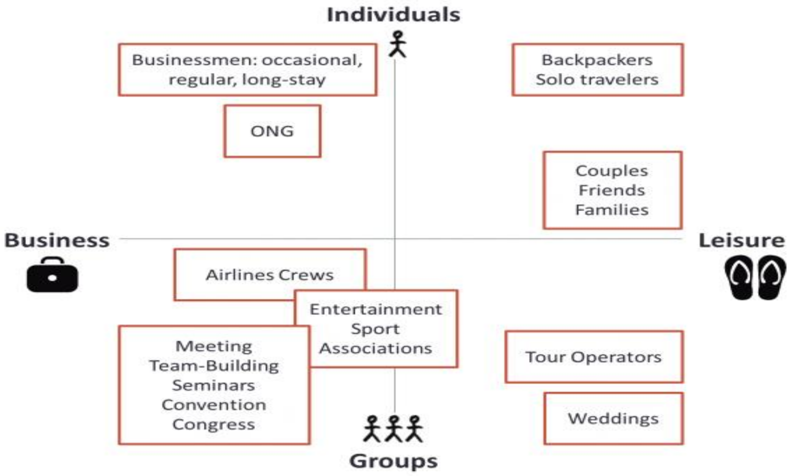


Figure 58. Target customers (Thielin F. 2017)

The reason to use this technique is to meet the customer's needs profitably and to allocate the resources and maximize the profit. It is important to know the customers and how they differ in this kind of business. The point is to appeal to the segment by addressing their specific needs. By using this technique, it is easier to gain competitiveness over other rivaling businesses whose segmentation is more superficial. The target segmentation approach is focused on Chinese customers and is explained in the next sub section.

13.2 Chinese Tourists as a Target Segment

Chinese customers are a significant group in the European tourism industry. Chinese economy is growing very fast, meaning the population has more money. (Business Insider 2018.) There has not been a deep study to understand the Chinese culture of tourism and it is one area that needs further investigation. (Zelenina 2015.)

There was an increase of 63% with overnight stays in Finland by tourists from China and this trend is increasing (YLE2 2018). There are several reasons that have contributed to the rise in numbers. One of the reasons is Helsinki-Vantaa airport being the fastest gateway to Europe for eastern travelers. Another reason is the use of Alipay in Finland, the popular Chinese mobile and online payment platform. These days almost everything is done with smart phones. Having this payment system has been a pleasant surprise for Chinese customers according to business owners in the capital region. (Big Spending Chinese Tourist 2017.)

There are several attractive qualities that make Chinese travelers stand out. Chinese people differ in values, culture and habits from European people. They tend to look elsewhere to expand their horizons. They are eager to learn new cultures, languages and new ways of living. Chinese people also travel for shopping purposes. They were the most spending tourists in Finland in 2016 according to data from statistics Finland. An average Chinese tourist spends about 896 euros per trip while the average tourist spends about 298 euros. The Chinese tourists spent a total of 214 million euros in the capital alone. (Big Spending Chinese Tourist 2017.)

According to hotel.com study (CITM 2017), the Chinese tourists spend about 31% of their budget on accommodation. This means that out of the total 214 million euros spent in the capital region, 66.34 million euros was spent on different forms of accommodation. After analyzing the numbers to per person per visit, it is about 277.76 euros. This means the Chinese tourist spends for accommodation what the average tourist spends for the whole trip. (Big Spending Chinese Tourist 2017.) This is a clear indication of how important this target group is for our business.

According to the Visit Finland survey, the most interesting things in Finland for Chinese tourists include the Finnish culture, winter-related experiences and activities, and other characteristically Finnish experiences, such as Finnish food and sauna. (Tourism Getting Ready 2017) However, these are not the only reasons Chinese people travel to Europe. They also travel for education as Finland has one of the best education systems in the world. They also travel in search of better healthcare services (Medical Tourism).

13.3 Marketing Strategy

The main point of the Agricola hotel project is to sell the service in both the short and long term. The final purpose of the hospitality industry leads to a better customer need satisfaction and attraction of new customers. By using the SMART mnemonic method to identify the specific marketing objectives, it is clear to everyone what the target is, the progress and if necessary to review the points. (Zelenina 2015)

The SMART mnemonic is an acronym that is useful in setting objectives in a project. The ‘S’ stands for Specific. It is used to define the goal simply and clearly. It is the What, Why and How of the SMART model. The ‘M’ stands for Measurable. The goals of the project should be measurable and tangible as to what has been accomplished so far. The ‘A’ stands for Attainable. The goals should be defined well enough, so they can be achievable. Achievable goals motivate employees. The ‘R’ stands for Realistic. It is important that the goal is achieved within the limits of the allocated resources and personnel. The ‘T’ stands for Time bound. The objectives of the project should be linked to a time frame to create a sense of urgency. (Virginia Edu 2017)

The importance of this strategy is to bring structure to the goals and objectives of the project as shown in table 7. SMART goals create trajectories towards certain objectives with clearly defined milestones and an estimation of the attainability of the goal. With this kind of a system, it is easier to evaluate the project’s objectives. It also helps to create transparency as the goals are clearly defined.

Table 7. SMART analysis (Modified Zelenina 2015, 35)

Feature	**Description**	**Objective 1**	**Objective 2**
Specific	Accurately determine area of research and include goals accordingly	Improve brand awareness	Increase total number of visiting guests
Measurable	Quality and quantity of performance	6-month advertisement and promotion in top social media sites	50% increment in number of overnight guests
Attainable	Possibility to accomplish each objective and get positive results	Country specific ads and promotions (Chinese and other language ads)	Providing 10% discount for people coming through social medias
Realistic	The successful realization of the plan with the allocated budget, staff and other parameters		
Time-bound	Realistic schedule to control the process and progress	6 months	1 year

The marketing objectives of the Agricola project is to share the strategic objective with creditors to fund the renovation project, to establish profits and growth target goals within the given time and to provide a positive hotel experience.

Marketing Mix-the 4Ps

The marketing mix is important tool to understand what services Agricola hotel can offer and how to plan for a successful service offering. The marketing mix is implemented through the 4P's of marketing: Product, Place, Price, and Promotion.

Product: The hotel is an alternative to the already existing establishments in the city. Strategically located, the hotel enables the guests to be in the heart of the city and yet in an environment of calm. The products and services will be different from others in the following aspects:

- Personal recognition of frequent visitors
- Customer oriented staff
- Modest yet luxurious rooms that give a sense of home away from home
- Relaxing facilities

Place: Service information will be sold through various outlets such as the Internet, direct marketing, and advertising.

Price: The pricing is focused on adding value on the service at a reasonable rate. It takes into account the location and the historical value of the building. The room prices are per night and they include continental breakfast. Tax is added to the prices below

- Single rooms -€110-120
- Double rooms -€140-160
- Suites -€250-300

The spa and some other services such as the restaurant and bar will be outsourced. The hotel will establish a guideline that aligns with the marketing plan for the outsourcing contractors.

Promotion: Core marketing activities are based on advertising and promotion. It is important to create awareness about the hotel to maximize occupancy. This can be done by organizing activities and social events, rewarding loyal customers, families or corporate clients by providing discounts or some form of free service. Advertisement can be done through the internet or by using local media such as radios, TV and newspapers.

Another medium where potential customers can be reached is through the internet. The internet in this age is the main channel to reach customers in other countries. It has cut middle men like tour operators, thereby reducing cost. The hotel advertisement can be posted in several well-established sites such as booking.com. TripAdvisor, Expedia, hotels.com, Trivago, Hotel Finder and on different social medias, blogs and internet forums.

13.4 Chinese Market

Most of the biggest social media sites such as Facebook, Twitter, YouTube and Google are blocked in China. Therefore, it is important to find other social media platforms to reach the customers there.

Table 8. Chinese social media for advertisement (Modified Zelenina 2015, 41)

Name	**Comparable platform**	**Feature**	**Advertising how?**
Q,Q	Skype, other video chat apps	Text messages, voice chats, video chats, file sharing…	Adaptation of using QQ wallets
Qzone, RenRen	Facebook, Google+	Personal account, newsfeed, chat, photo and video sharing	Advertisement through different pages
WeChat	WhatsApp	Voice messages, voice and video calls, games, shopping, booking	Advertisement through personal accounts, sending offers, QR codes…
Weibo	Twitter	Messages, posts, videos, subscription	Advertisement through posts and videos

Table 8 shows the alternate platforms to the international social media platforms and their use for the potential Chinese customers. The table also shows the feature of the Chinese platforms.

14 Payback Period

Payback period is the time required for an investment to be repaid by the net cash flow generated. It is a simple way to evaluate the risks of investing in a project. It is used to measure the amount of return of an investment relative to the cost of the investment. Investment options with shorter payback time are considered better since the investor gets the initial money investment back faster.

14.1 Expenses

The first step is to find the total cost of the renovation project. Every known cost for the project is included. It starts with the HVAC costs and proceeds to include overheads as well as licensing costs and taxation. The cost of running the hotel is also included.

The main expenses are summarized in the table 9 below. It covers the costs mainly related to the renovation of the Agricola project and the energy bill. The annual energy cost is the money that is needed to pay for the electricity usage. The partition walls are the ones used between the hotel rooms. Renovation total is the sum of all the construction costs in upgrading the building to a hotel purpose. It includes costs related to renovating each room as well as the lobby, restaurant and bar, corridors, swimming pools and saunas. The miscellaneous expenses are for any additional costs that might occur along the project. It is a safe margin to assume such a value as prices of construction materials as well as labor costs might vary. The detailed cost calculations are given in the appendix 4.

- HVAC costs = Mechanical ventilation + Radiators+ Under-floor heating + PVs
- Taxation= 0.21* Total Revenue
- Overhead costs = 0.05* Renovation Total
- Permits = 0.02* Renovation Total

Table 9. Total Renovation cost

INVESTMENT	Price (€)	
Annual Energy Cost	142544.58	
Partition walls	23790.1	
Mechanical Ventilation	89316.5	
Radiator	33000	
Underfloor Heating	47960	
PV panels	37100	
Total HVAC	207376.5	
Renovation Total	3492112	
Taxation (21%)	763339.5	
Overhead cost (5%)	174605.6	
Permits (2%)	69842.2	*estimate
Miscellaneous	300000	
Project Total	€ 5,173,610.5	

The other expenses are the human resources (HR). It is assumed that a total of 30 workers will be working in the facility and for calculation purposes, an average pay of €3500 per month for each employee is used. This adds up to a total of €1,260,000 per year.

Table 10. HR and Maintenance cost

EXPENSES (€)		
Total Workers	30	
Average Salary	42000	*3500/month
Total HR Expense	€ 1,260,000.0	
Maintenance	€ 244,447.8	*per year

Still another expense is the maintenance costs. Since it is difficult to estimate the exact figure, it is assumed that, maintenance costs would be 7% of the total renovation cost as shown in table 10.

Table 11. Total Project cost

Project Total	**€ 5,173,610.5**
Total HR Expense	**€ 1,260,000.0**
Maintenance	**€ 244,447.8**
Total Expense	**€ 6,678,058.3**

The total cost of the renovation project is the sum of the project total costs which are mostly construction costs, the HR and maintenance costs as shown in table 11.

14.2 Revenue

The project is a hotel building and upon completion it is going to start generating money from the services it is going to give for its customers. The main source of revenue for the project is the rental rooms in the hotel. The Agricola hotel has a total of 107 rooms with price range of €110- €300. An average price of €150 per room is assumed. According to Rakennustieto (RT 85-10554 E, hotels and motels), a hotel business is profitable with 60% occupancy. A factor of 0.6 in the calculation is used. The total generated amount sums up to €3,514,950 per year.

Table 12. Total Revenue

REVENUE (€)	
Total Rooms	107
Average Price	150
Operational Days	365
Occupancy Rate	0.6
Rent Bar & Restaurant	120000
	€ 3,634,950.00

The other source of revenue for the hotel is the money from the kitchen and bar rental. Both services will be subcontracted to third parties according to the hotel guidelines. The summed amount for total revenue is tabulated in table 12.

14.3 Payback Time Calculation

The net cash flow for the project is calculated as a function of total revenue and the expenses to run the hotel.

Net cash flow = Total Revenue – (Tax + Total HR Expenses + Maintenance + Energy bills)

This gives a net cash flow of €1,224,618.02 after expenses.

The payback period is calculated using the formula

$$\text{Payback period} = \frac{\text{Cost of investment}}{\text{Annual net cash flow}}$$

The cost of the whole investment is €6,678,058.3 and the project up on completion generates a net cash flow of €1,224,618.08. This gives a payback period of 5.5 years.

Table 13. Payback time

Payback	
Year 0	€ 6,678,058.3
Year 1	€ 5,453,440.2
Year 2	€ 4,228,822.1
Year 3	€ 3,004,204.1
Year 4	€ 1,779,586.0
Year 5	€ 554,967.9
Year 6	-€ 669,650.2

It is also possible to calculate the payback period by considering the net cash flow for each year. It can be seen in the table 13 above that the investment breaks even between years 5 and 6. After that, the Agricola hotel is profitable.

15 Conclusion

The main objective of the project was to study the feasibility of renovating a historic building into a hotel project. It seems that role of hotel buildings is significant, and their importance is increasing. With an increasing number of tourists and the fast growth of tourism in Helsinki, one cannot deny the importance of hotel buildings in the city.

The report highlights the importance of renovation for the Agricola building. The established benefits of the renovation of the Agricola building are categorized as economic, social, energy systems and environmental benefits. The report discusses different energy renovation methods such as replacing windows and roof structures, improving the air tightness of the building, improving the heating and ventilation system with a heat recovery system and using solar energy. The Finnish building code is used as main technical guideline for the renovation of the Agricola building. Regulations about planning, fire safety, acoustics, and accessibility were focused in the Agricola hotel project.

Given the heritage nature of the building, the renovation was done in all structures except the protected parts. The report introduced different kinds of renovation concepts for the refurbishment of the building envelope and for the improvement of building services with the sustainable approach of energy production.

IDA ICE is used as a simulation program to assess the energy requirements of the building. Different settings were chosen according to the requirements although some of the data were assumed. Climate data profile was chosen for Helsinki. Regardless of the assumed data, the simulation was thorough but there is possibility for improvement of the results. The output data can be investigated for further analysis.

The paper also shows the positive impacts of energy renovation on different levels and the possibilities for the use of renewable energy systems on site to offset the total energy demand of the building. Sample ventilation and heating design was carried out in MagiCAD.

The analyses carried out in this paper prove that it is, in fact, possible to change the purpose of the Agricola building. The results are based on location analysis, market analysis, payback time calculations, hotel supply and demand investigation, room rates and year-round occupancy levels and revenue estimation. Moreover, due to unique location and architecture, the Agricola hotel is a place where history meets modern living. The project is able to position itself at top of the market or at least head to head with the top players in the market. Interested parties should grab the opportunity to invest in this project.

References

Banerjee R. International Journal of Engineering Research and Applications. India: Guru Nanak Institute of Technology; 2015.

Big Spending Chinese Tourists boost Helsinki Tourist Trade [Online]. Helsinki, Finland: YLE;2017.
URL: https://yle.fi/uutiset/osasto/news/big-spending_chinese_tourists_boost_helsinki_tourist_trade/9761841. Accessed December 5, 2017.

BPIE. A Guide to Developing Strategies for Building Energy Renovation. EU: Building Performance Institute Europe; 2013.

Braham D. Guide A: Environmental Design. UK: CIBSE, 2015.

BRE. Inverted Roofs [Online]. UK: BRE; 2017.
URL: https://www.bre.co.uk Accessed November 7, 2017.

The suitability and use of stainless steel for plumbing applications. [Online].UK: British Stainless Steel Association; 2003.
URL: https://www.bssa.org.uk/cms/File/BSSA%20PLUMBING%20P.1-4.pdf
Accessed 1st April 2018.

Burke S. Thermal Bridges- Theory and Standards. Finland: NCC; 2016.

Business Insider. China's Middle class is Exploding [Online]. USA: Business Insider; 2016.
URL: http://www.businessinsider.com/chinas-middle-class-is-exploding-2016-8?r=US&IR=T&IR=T
Accessed: March 31, 2018.

Central Hot Water System Design. USA: US Army Corps Engineering; 2011.

Chowdhry A. Chinese International Travel Monitor. China: Hotels.com; 2017.

CTS Plumbing & Building, n.d. Underfloor Heating. [Online]. UK: CTS building solutions; 2018.
URL: https://www.ctsplumbing.co.uk/heating-systems-explained/underfloor-heating/
Accessed 1st April 2018.

C3 National Building Code of Finland, Thermal Insulation in Buildings. Helsinki, Finland: Ministry of Environment; 2010.

C4 National Building Code of Finland, Thermal Insulation. Finland: Ministry of Environment; 2003.

D3 National Building Code of Finland, Energy Efficiency of Buildings. Helsinki, Finland: Ministry of Environment; 2010.

Decree 4/13 Improving the energy performance of buildings undergoing renovation or alteration. Helsinki, Finland: Ministry of Environment; 2013.

Decree 231 Barrier-free Building. Helsinki, Finland: Ministry of Environment; 2017.

Decree 796 Noise Conditions. Helsinki, Finland: Ministry of Environment; 2017.

El National Building Code of Finland, Fire Safety of Buildings Regulations and Guidelines. Helsinki, Finland: Ministry of Environment; 2011.

E2 National Building Code of Finland, Fire Safety of production and warehouse buildings. Helsinki, Finland: Ministry of Environment; 2005.

Economidou M. Europe's Buildings under the Microscope, A country by country review of the energy performance of buildings. EU: Building Performance Institute Europe (BPIE); 2013.

EQUA. IDA ICE [Online]. Sweden: EQUA Simulation AB; 2018.
URL: https://www.equa.se/en/ida-ice. Accessed November 10, 2017.

F1 National Building Code of Finland, Barrier-free Building. Helsinki, Finland: Ministry of Environment; 2005.

Guidelines and Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons. Central Public Works Department; 1998.

Gungör G. Thermal comfort and Energy consumption of a typical office building. Gothenburg, Sweden: Chalmers University of Technology; 2015.

Gyproc CSR Lightweight Building Solutions Vol 10.2. Australia: Gyproc; 2010.

Hayter S. and Kandt A. Renewable Energy Applications for Existing Buildings. Springfield, USA: National Renewable Energy Laboratory (NREL); 2011.

Häkkinen T, Ruuska A, Vares S, Pulakka S, Kouhia I, Holopainen R. Methods and Concepts for Sustainable Renovation of Buildings. EU: VTT; 2012.

Heiskanen P. Hotelli Cumuluksen Jäähdytyksen Suunnittelu. Oulu, Finland: OAMK; 2014.

HSL Helsinki Region Transport [Online]. Finland: Journey Planner; 2018. URL: https://www.reittiopas.fi/reitti/Agricolankatu%2C%20Helsinki%3A%3A60.184308%2C24.955592/Rautatientori%2C%20Helsinki%3A%3A60.171283%2C24.942572?time=1525345259

Kharas H. The unprecedented expansion of the global middle class: an update Washington DC, USA: The Brookings Institution; 2017.

KJM. Resident R9 Windows [Online]. Hampshire, UK: KJM Group; 2017.
URL: https://www.kjmgroup.co.uk/products/windows/residence-9-
Accessed March 17, 2018.

Klingenburg USA, LLC, n.d. Rotary Heat Echangers. [Online]. USA: Klingenburg LLC; 2017.
URL: http://www.klingenburg-usa.com/knowledge/rotary-heat-exchangers/
Accessed 2nd April 2018.

Knauf Insulation manual, XPS multiuse. USA: Knauf Insulations; 2017.

Lehtinen J., Architect, Metropolia UAS, Personal Communication. Helsinki, Finland. February 2, 2018.

Metropolia UAS. About us [Online]. Helsinki, Finland: Metropolia UAS; 2018.
URL: http://www.metropolia.fi/en/. Accessed November 21, 2017.

MOE. Finnish Building Codes [Online]. Helsinki, Finland: Ministry of Environment; 2018.
URL: http://www.ym.fi/fi-FI. Accessed September 23, 2017.

Nguyen H. Energy Simulation of Sheet Metal Center with IDA ICE Software. Hämeen-linnä, Finland: HAMK; 2017.

NZCMA New Zealand Concrete Masonry Manual. New Zealand: New Zealand Concrete Masonry Association; 2013.

KS Klima-Service. Classification of filters, filter properties and typical examples of use. [Online]. Czech Republic: KS Klima services; 2018.
URL: http://www.ksklimaservice.com/en/classification-of-filters-filter-properties-and-typical-examples-of-use Accessed 1st April 2018

Neufert P. Architect’s Data. Oxford, UK: Wiley-Blackwell; 2012.

Progman Oy. Magicad for AutoCAD. [Online]. Finland: Program Oy; 2016.
URL: https://www.magicad.com/wp-content/uploads/2016/02/ENG_brochure_MagiCAD_AutoCAD_2016_single_pages.pdf Accessed 2nd April 2018.

Purmo. Column radiators - Delta H. [Online]. UK: Rettig; 2016.
URL: http://www.purmo.com/en/products/column-radiators/delta-h.htm Accessed 2nd April 2018.

Purmo. Paneeliradiaattorit - PURMO Compact [C]. [Online]. UK: Rettig; 2016.
URL: http://www.purmo.com/fi/tuotteet/vesikiertoiset-radiaattorit/paneeliradiaattorit/purmo-compact.htm#tab-tekniset-tiedot Accessed 1st April 2018.

Purmo. Panels - Compact. [Online]. UK: Rettig; 2016.
URL: http://www.purmo.com/en/products/panels/compact.htm#tab-basic-specs Accessed 1st April 2018.

Rodriguez J. Triple Glazed Windows: A Wise Energy Decision [Online]. 2016
URL: https://www.thebalancesmb.com/triple-glazed-windows-844733. Accessed March 21, 2018.

Roof system manual. Finland: Kattoliitto; 2017.

RT 85-10554 E, Hotels and Motels. Finland: Rakennustietosäätiö; 1994

RT 94-10443 Industrial Kitchens. Finland: Rakennustietosäätiö; 1991.

RT 97-10474 Swimming Pools. Finland: Rakennustietosäätiö; 1992.

Santamaria A. Business Plan- Hotel Beach Resort & Spa in Panama. Panama: Universidad Catolica Santa Maria la Antigua; 2004.

Solar Photovoltaic PV systems. Puerto Rico: University of Puerto Rico; 2015.

Straube J. Moisture Control and Enclosure Wall Systems. Ontario, Canada: University of Waterloo; 1998.

Swegon. Description of the air handling unit. [Online]. Finland: Swegon Oy; 2017.
URL:
https://www.swegon.com/Global/PDFs/Air%20handling%20units/GOLD%20version%20F/General/_en/GOLD_F_description.pdf Accessed 1st April 2018.

Swegon. Sizing, Installation, Dimensions and Weights. [Online]. Finland: Swegon Oy; 2017.
URL:
https://www.swegon.com/Global/PDFs/Air%20handling%20units/GOLD%20version%20F/General/_en/GOLD_RX_F_dimensioning.pdf Accessed 1st April 2018.

TEM. Tourism in numbers [Online]. Finland: Ministry of Economic Affairs and Employment;2016.
URL: https://tem.fi/en/finnish-tourism-in-numbers. Accessed December 5, 2017.

The 50plus Organisation Ltd, (2006.) An Introduction to radiators. [Online]
URL: http://www.the50plus.co.uk/tech_support/Modern-Central-Heating/radiator_pages.pdf
Accessed 1st April 2018.

The Solid Wood Flooring Company, (2018.) Underfloor Heating. [Online]
URL: https://www.thesolidwoodflooringcompany.com/underfloor-heating
Accessed 1st April 2018.

Thielin F. Hotel Customers Segment [Online]. Lyon, France: ThemeIsle; 2017.
URL: http://www.floriethielin.com/en/hotel-customer-segmentation/. Accessed December 1, 2017.

Tourism Business Getting Ready for Chinese Tourists [Online]. Turku, Finland: City of Turku; 2017.
URL: https://www.turku.fi/en/news/2017-04-24_tourism-business-getting-ready-chinese-tourists. Accessed December 3, 2017.

Tradesmen Supply, LLC, (2006.) PEX Information. [Online]
URL: http://www.pexinfo.com/
Accessed 1st April 2018.

University of the West of England, B, (2006.) Modern Central Heating. [Online]
URL: http://www.the50plus.co.uk/tech_support/Modern-Central-Heating/section6.htm
Accessed 1st April 2018.

Virginia edu. SMART pneumonic [Online]. USA: Virginia University; 2015.
URL: Virginia.hr.edu. Accessed January 06, 2017.

Westwood J. The Marketing Plan: A Step-by-Step Guide. London, UK: Kogan Page Limited; 2002.

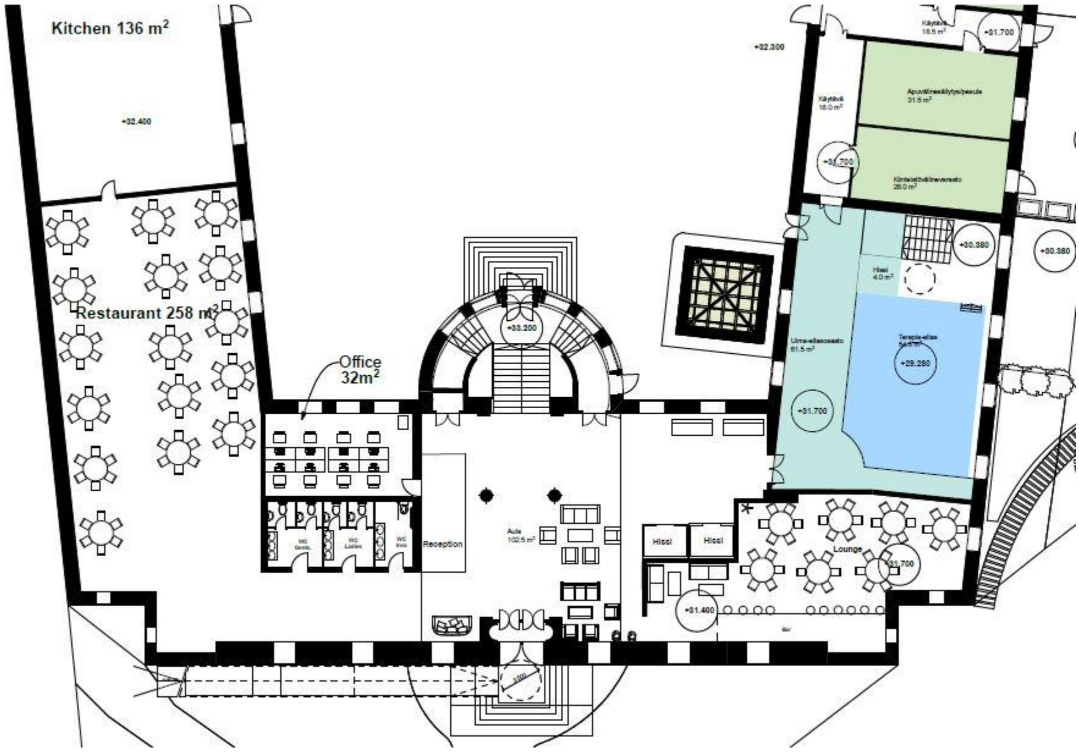
YLE1. Airbnb Shakes up Hospitality [Online]. Finland: Yle News; 2017. URL: https://yle.fi/uutiset/osasto/news/airbnb_shakes_up_hospitality_sector. Accessed March 28, 2018.

YLE2. Chinese Visits to Finland Surge [Online]. Finland: Yle News; 2017.
URL:
https://yle.fi/uutiset/osasto/news/chinese_visits_to_finland_surge_by_63/10118925
Accessed March 28, 2018.

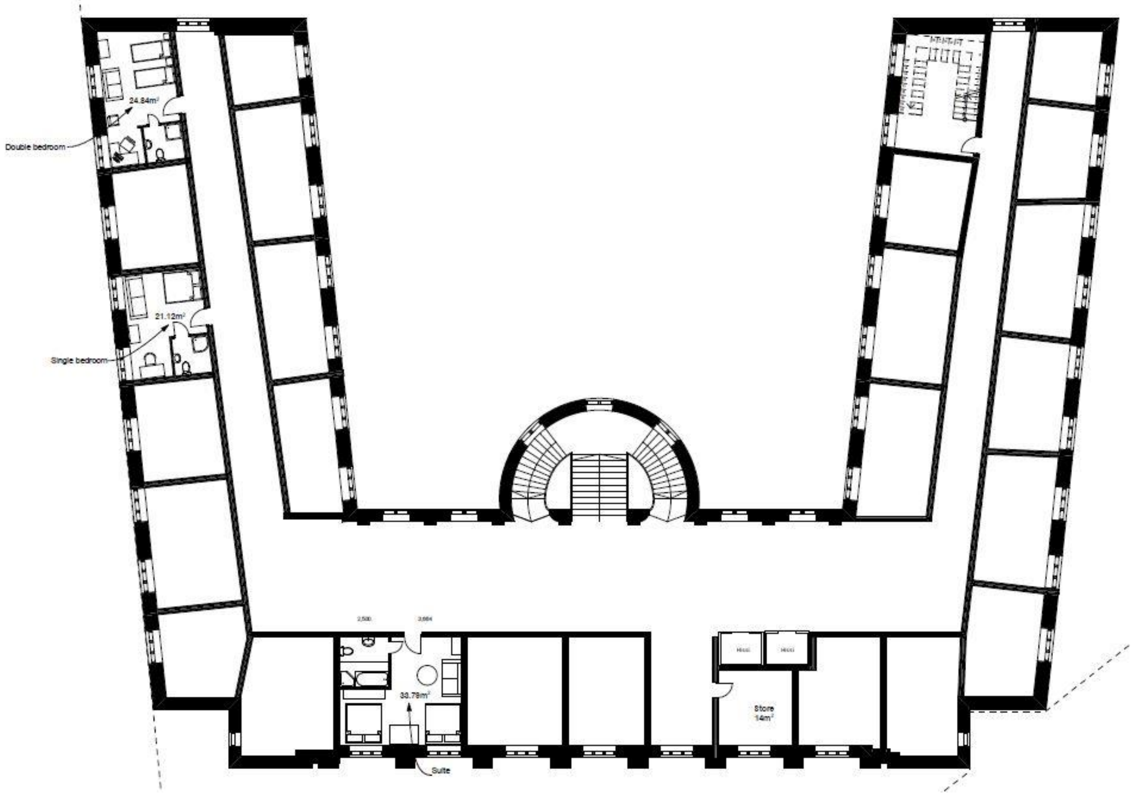
Zelenina M. Chinese Customers as a Target Segment for Hotel Industry in Mallorca. Kymenlaakso, Finland: KYAMK; 2015.

Appendices

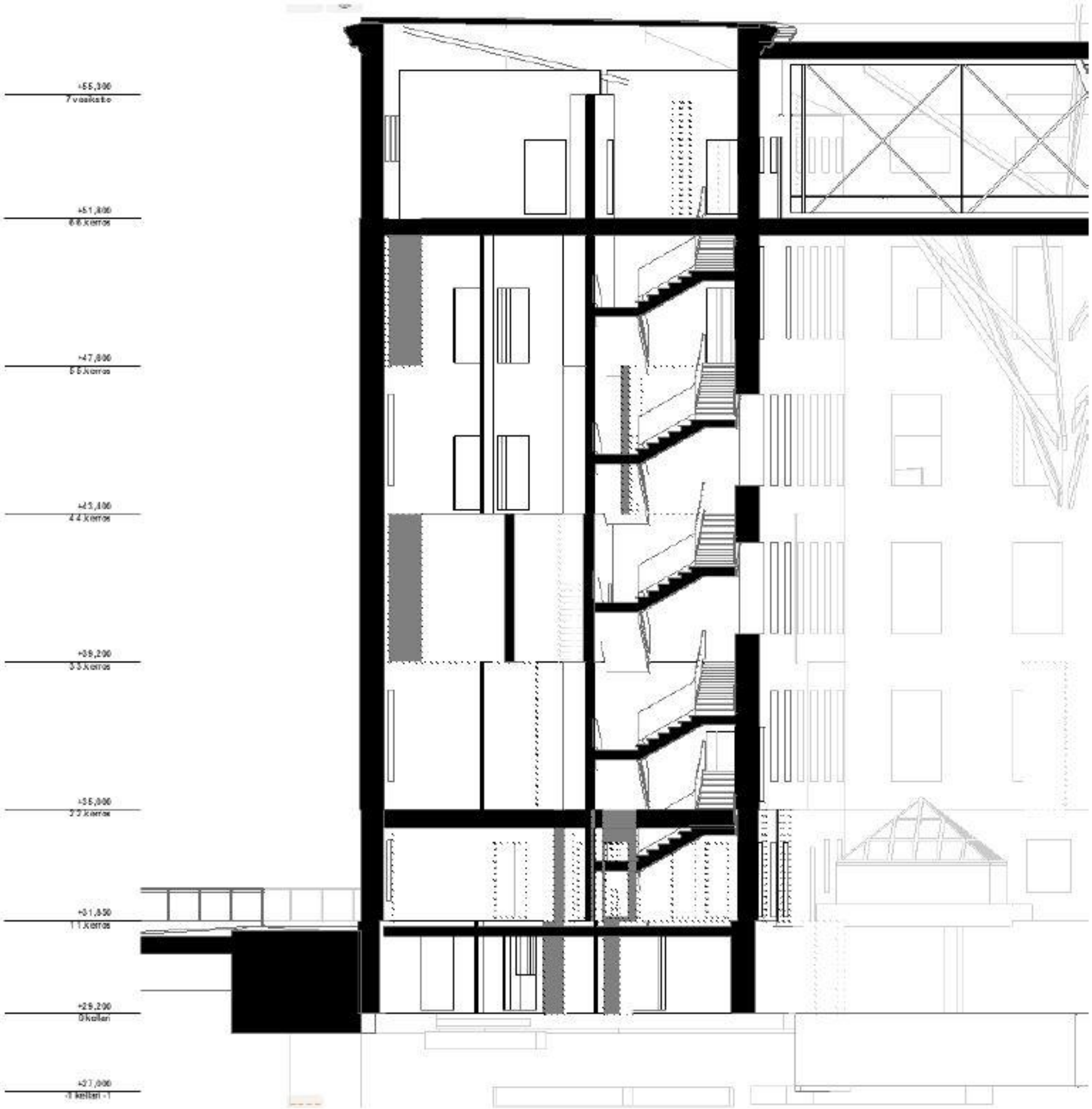
Appendix 1: Drawings



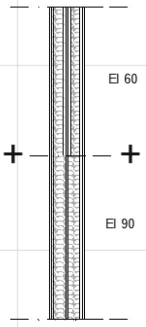
Lobby design; design from ArchiCAD



Floor plan: third floor; design from ArchiCAD



Section of staircase; design from ArchiCAD



	Reunaprofiili Gyproc AC 66-X2 ACOUnomic (lattiassa ja katossa)
12,5 mm	Kipsilevy Gyproc GEK 13 Erikoiskova uloimpana
12,5 mm	Kipsilevy Gyproc GN 13 Normaali
50 mm	MineraalivillaISOVER KL AKU 50 mm
66 mm	Rangat Gypsteel ELPR 66/40, k 600 mm
10 mm	Minimi-ilmarako
66 mm	Rangat Gypsteel ELPR 66/40, k 600 mm
50 mm	Mineraalivilla ISOVER KL AKU 50 mm
12,5 mm	Kipsilevy Gyproc GN 13 Normaali
12,5 mm	Kipsilevy Gyproc GEK 13 Erikoiskova uloimpana
	Reunaprofiili Gyproc AC 66-X2 ACOUnomic (lattiassa ja katossa)
Paloluokka	EI 60

Ilmaääneneristävyys: R'w = 57-60 dB, R'w + $C_{50-3150}$ = 55 dB,
Seinän maksimikorkeus 3200 mm

	Reunaprofiili Gyproc AC 66-X2 ACOUnomic (lattiassa ja katossa)
12,5 mm	Kipsilevy Gyproc GEK 13 Erikoiskova uloimpana
12,5 mm	Kipsilevy Gyproc GN 13 Normaali
66 mm	runkotilan täyttävä mineraalivilla ISOVER KOL tai muu vastaava kivivilla vastaavin palo-ominaisuuksin (tiheys ja sidosainepitoisuus).
66 mm	Rangat Gypsteel ELPR 66/40, k 600 mm
10 mm	Minimi-ilmarako
66 mm	Rangat Gypsteel ELPR 66/40, k 600 mm
66 mm	runkotilan täyttävä mineraalivilla ISOVER KOL tai muu vastaava kivivilla vastaavin palo-ominaisuuksin (tiheys ja sidosainepitoisuus).
12,5 mm	Kipsilevy Gyproc GN 13 Normaali
12,5 mm	Kipsilevy Gyproc GEK 13 Erikoiskova uloimpana
	Reunaprofiili Gyproc AC 66-X2 ACOUnomic (lattiassa ja katossa)
Paloluokka	EI 90

Ilmaääneneristävyys: R'w =57-60 dB , R'w + $C_{50-3150}$ = 55 dB
Seinän maksimikorkeus 3200 mm

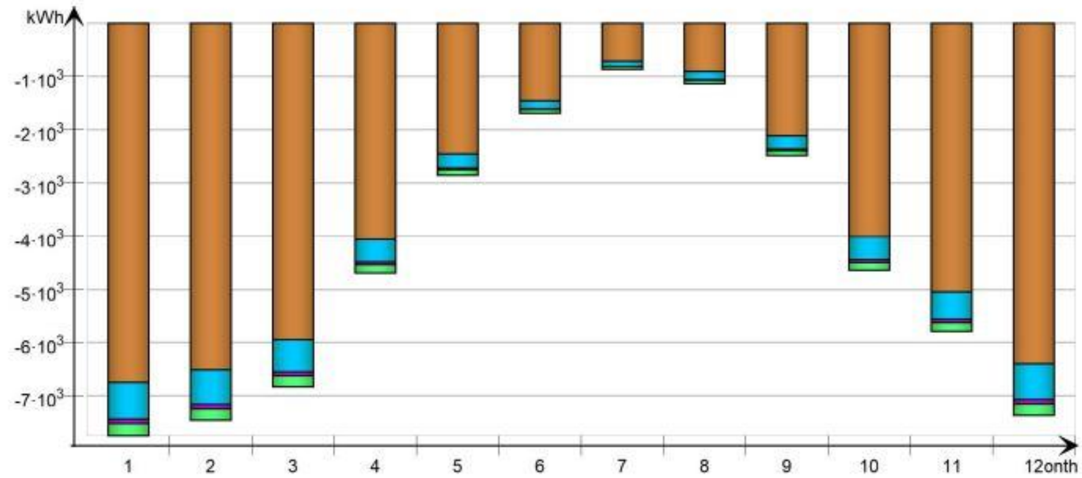
Service Space walls (Gyproc 2010)

Appendix 2: IDA ICE tables and graphs

Envelope transmission

kWh

Month	Walls	Roof	Floor	Windows	Doors	Thermal bridges
1	-6749.5	0.0	0.0	-693.9	-87.3	-225.1
2	-6512.8	0.0	0.0	-648.8	-80.8	-215.5
3	-5944.4	0.0	0.0	-607.7	-73.9	-210.0
4	-4064.1	0.0	0.0	-422.0	-48.7	-152.1
5	-2453.9	0.0	0.0	-272.7	-27.0	-107.2
6	-1444.1	0.0	0.0	-154.8	-11.4	-68.0
7	-708.6	0.0	0.0	-102.1	-2.7	-49.9
8	-914.5	0.0	0.0	-160.3	-11.2	-63.1
9	-2107.1	0.0	0.0	-249.4	-26.0	-89.3
10	-4011.0	0.0	0.0	-434.2	-51.8	-146.2
11	-5042.2	0.0	0.0	-516.8	-64.1	-166.9
12	-6406.1	0.0	0.0	-668.0	-84.1	-215.7
Total	-46358.2	0.0	0.0	-4930.6	-569.1	-1708.9
During heating	-42213.3	0.0	0.0	-4536.1	-579.1	-1542.3
During cooling	-695.8	0.0	0.0	-36.3	0.8	-26.7
Rest of time	-3449.1	0.0	0.0	-358.2	9.2	-139.9



IDA Indoor Climate and Energy
Version: 4.71
License: IDA40:ED143/R4Q2M (educational license)

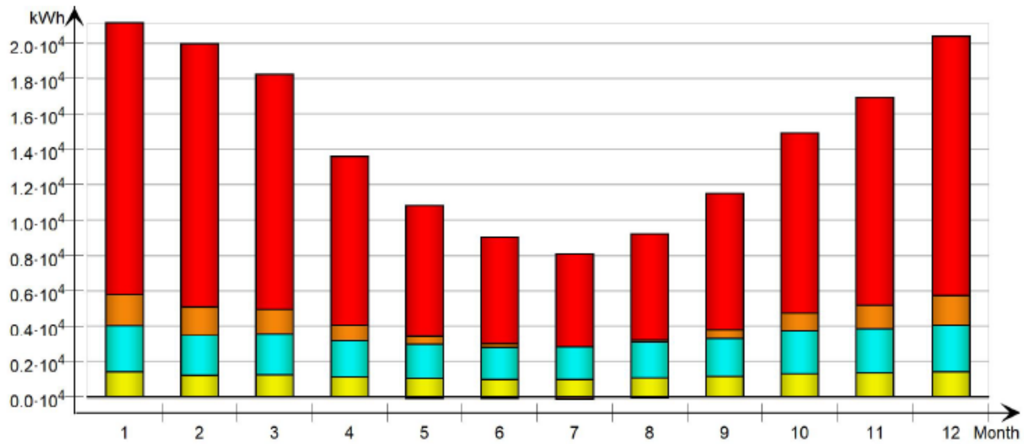
Building Comfort Reference

Percentage of hours when operative temperature is above 27°C in worst zone	19 %
Percentage of hours when operative temperature is above 27°C in average zone	1 %
Percentage of total occupant hours with thermal dissatisfaction	11 %

Delivered Energy Overview

	Used energy		Purchased energy		Peak demand
	kWh	kWh/m²	kWh	kWh/m²	kW
Lighting, facility	17084	15.3	14195	12.7	1.95
Electric cooling	11	0.0	10	0.0	0.0
HVAC aux	32110	28.8	26642	23.9	3.73
Electric heating	12093	10.8	10931	9.8	3.29
Total, Facility electric	61298	54.9	51778	46.4	
District heating	121825	109.1	121825	109.1	35.33
Total, Facility district	121825	109.1	121825	109.1	
Total	183123	164.0	173603	155.4	
Equipment, tenant	0	0.0	0	0.0	0.0
Total, Tenant electric	0	0.0	0	0.0	
	Generated energy		Sold energy		Peak generated
PV production	-9915	-8.9	-393	-0.4	-8.9
CHP electricity	0	0.0	0	0.0	0.0
Total, Produced electric	-9915	-8.9	-393	-0.4	
Grand total	173208	155.1	173210	155.1	

Monthly Purchased/Sold Energy



kWh

Month	Domestic hot water circuit	Heating
1	314.1	813.1
2	283.7	782.9
3	314.1	696.7
4	304.0	479.7
5	314.1	270.5
6	304.0	140.3
7	314.1	38.4
8	314.1	85.6
9	304.0	268.0
10	314.1	485.2
11	304.0	599.6
12	314.1	771.8
Total	**3698.4**	**5431.8**

Distribution losses

Appendix 3: Airflow calculations and MagiCAD drawings

	A	B	C	D	E	F	G
1	Air flow						
2							
3							
4							
5	Suite	34	m2				
6	Room height	3.5	m				
7							
8	Room	Supply air flow			Extract air flow		
9		Normal	Boost	Unoccupied	Normal	Boost	Unoccupied
10	Bedroom	20	26.0	8	0	0	0
11	WC / Bathroom	0	0	0	22	28.6	8.8
12	Total	20.0	26.0	8	22.0	28.6	8.8
13							
14	Supply-Extract	-2.6					
15	Air change rate	0.87	1/h	B15 formula: =F12*3.6/B5/B6			
16	Boost, increase by	30%		F11 formula =E11+(E11*B16)			
17	Unoccupied, decrease by	60%					

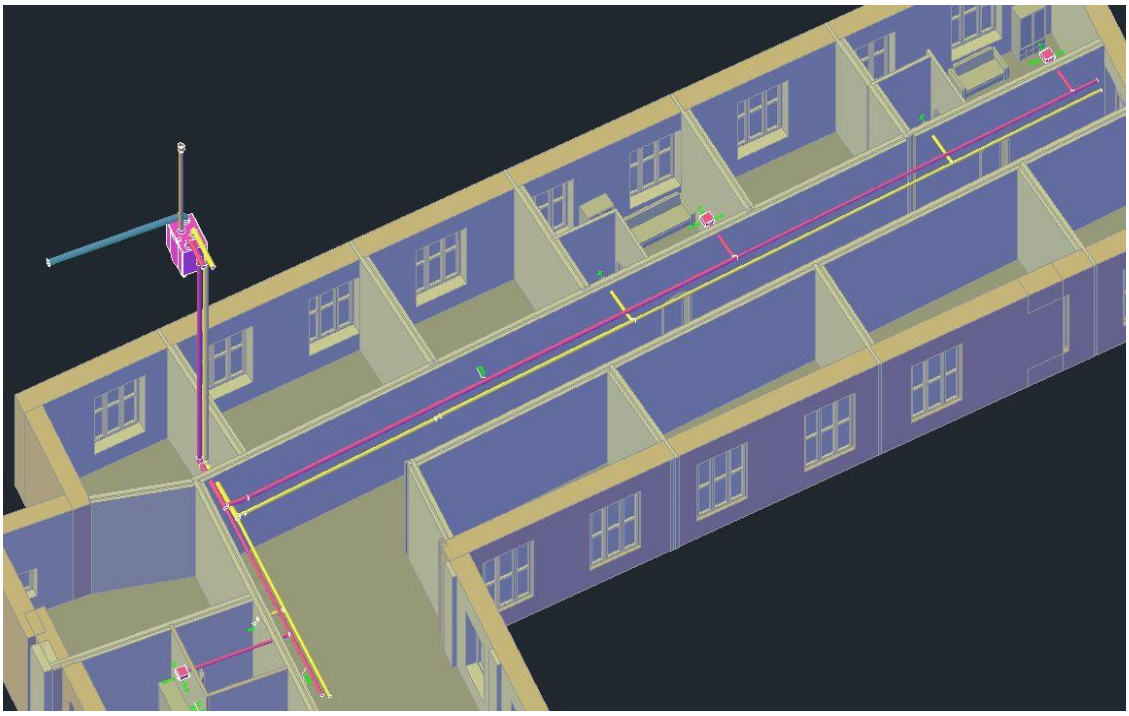
Air flow sheet for room type suite

	A	B	C	D	E	F	G
1	Air flow						
2							
3							
4							
5	Double Room	25	m2				
6	Room height	3.5	m				
7							
8	Room	Supply air flow			Extract air flow		
9		Normal	Boost	Unoccupied	Normal	Boost	Unoccupied
10	Bedroom	20	26.0	8	0	0	0
11	WC / Bathroom				22	28.6	8.8
12	Total	20.0	26.0	8	22.0	28.6	8.8
13							
14	Supply-Extract	-2.6					
15	Air change rate	1.18	1/h	C15 formula : =F12*3.6/B5/B6			
16	Boost, increase by	30%		F11 formula: =E11+(E11*B16)			
17	Unoccupied, decrease by	60%					

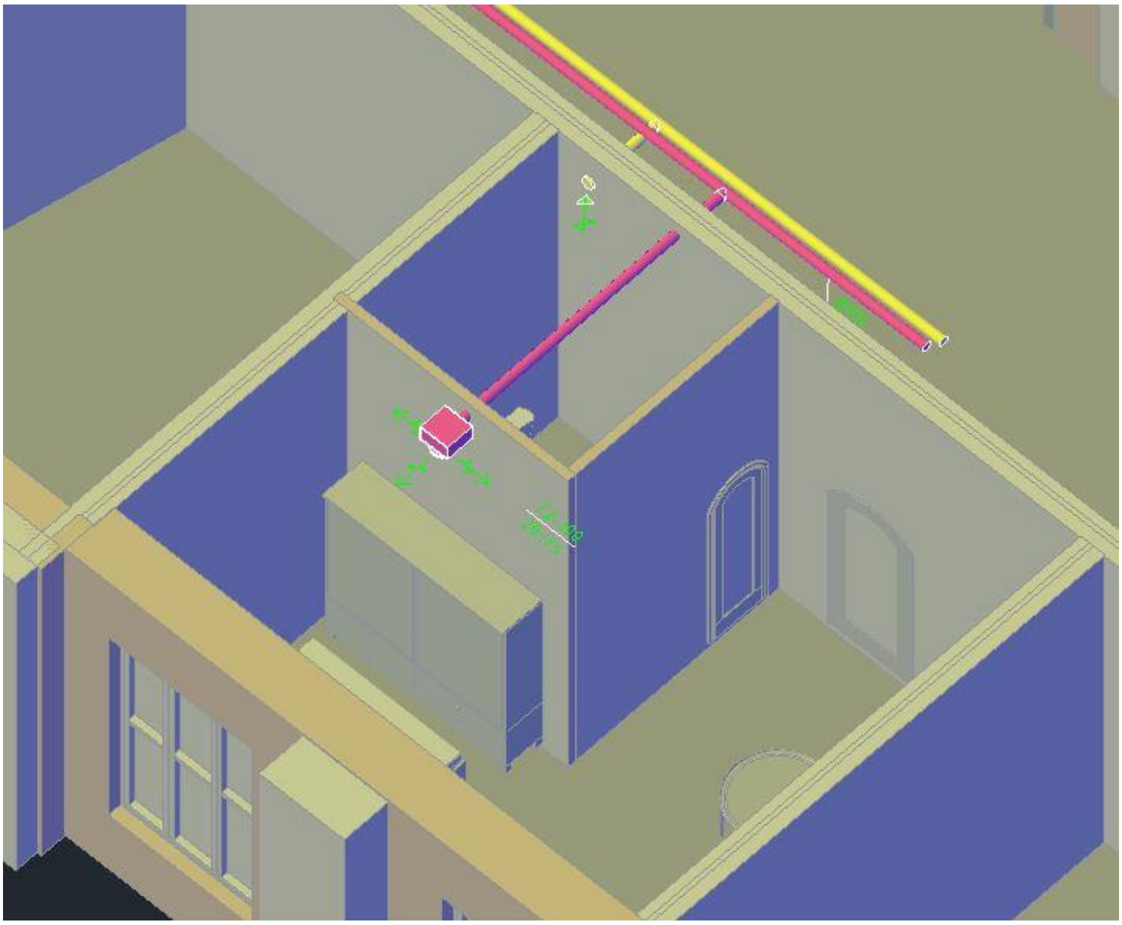
Air flow sheet for room type double bedroom

	A	B	C	D	E	F	G	H
1								
2								
3		Air flow						
4								
5		Single room	22	m2				
6		Room height	3.5	m				
7		Volume of the room	77	m3				
8		Room	Supply air flow (l/s)			Extract air flow (l/s)		
9			Normal	Boost	Unoccupied	Normal	Boost	Unoccupied
10		Bedroom / Living room	10	13.0	4			
11		WC / Bathroom	0	0	0	11	14.3	4.4
12								
13		Total	10.0	13.0	4	11.0	14.3	4.4
14								
15		Supply-Extract	-1.3					
16		Air change rate	0.67	1/h	C16 Formula : =G13*3.6/C7			
17		Boost, increase by	0.3					
18		Unoccupied, decrease by	0.6		G11 formula : =F11+(F11*C17)			

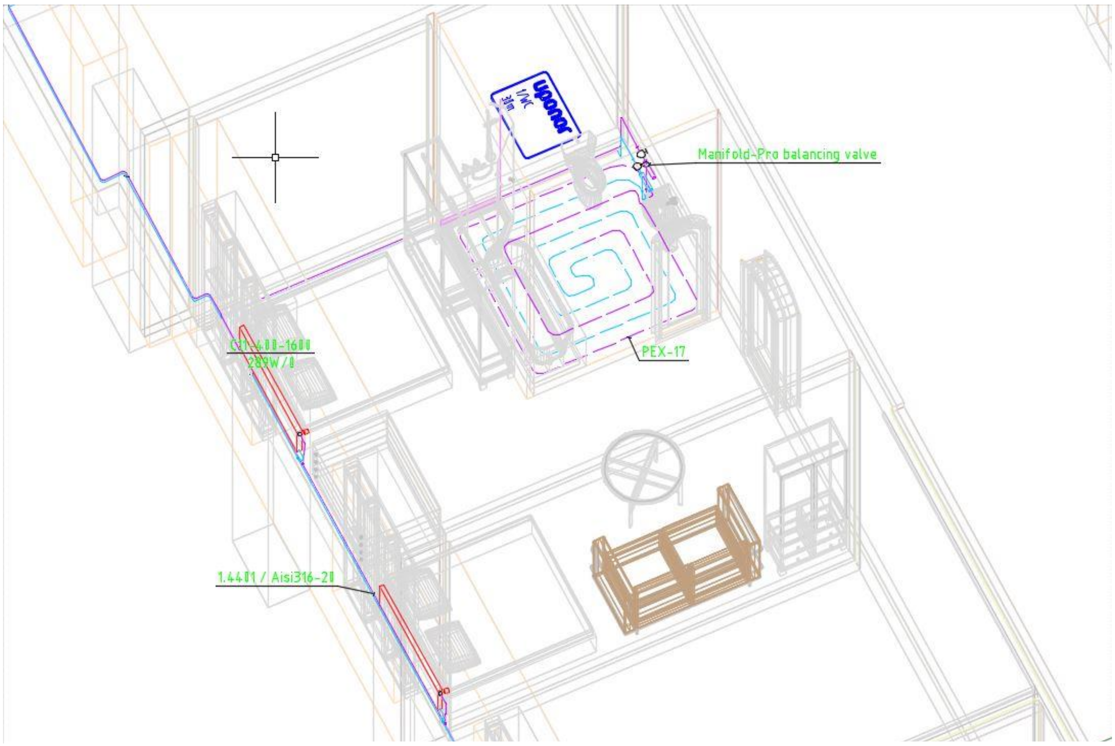
Air flow sheet for room type single bedroom



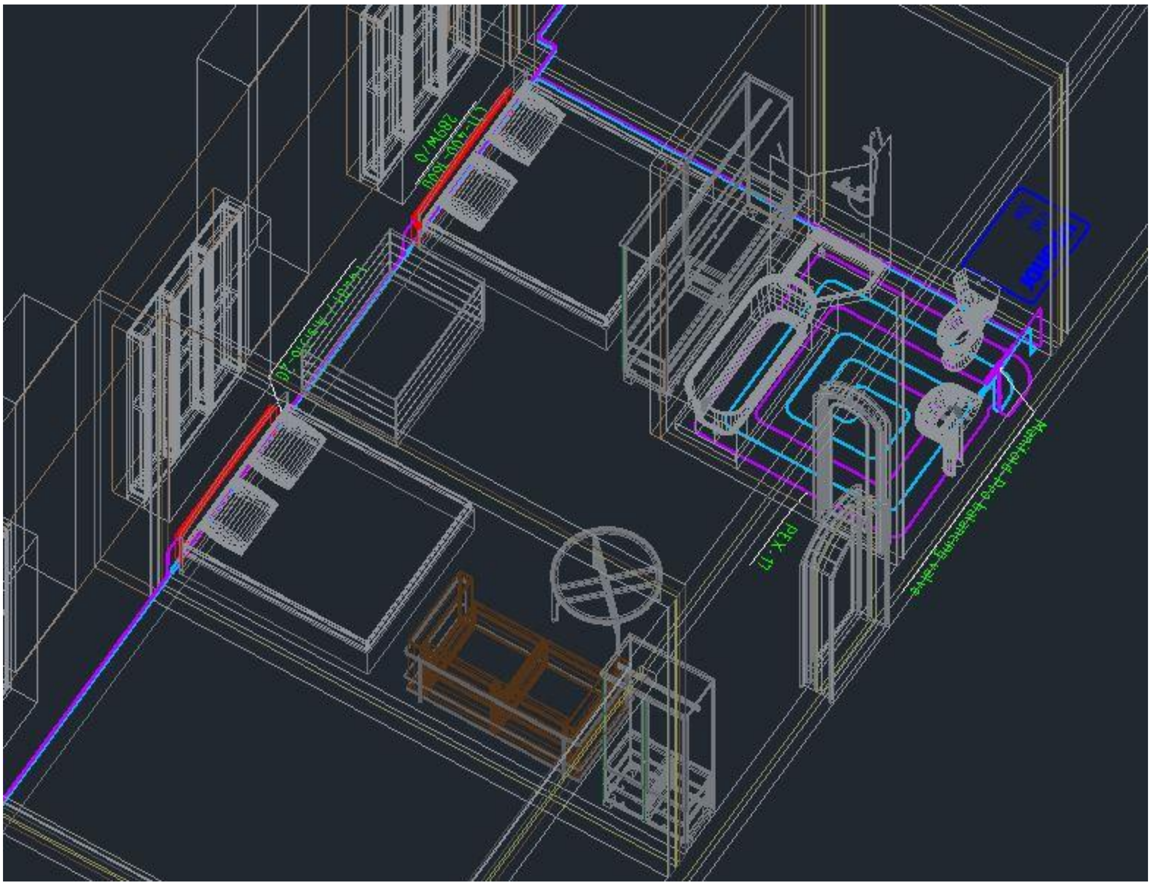
Ventilation ducts running through corridor with Air handling unit on the left side of the image



Air supply device and running ducts in suite



Wireframe display of heating system in suite



Underfloor heating and radiators in suite

Appendix 4: Payback period calculations

Bathroom full Renovation	Cost	
Demolition	438	
Lighting	169	
Replacing bathroom doors and hardware	510	
Electrical upgrades	95	
Tub to shower conversion	2135	
Shower valve and head	415	
Tub surround	1063	
Lavatory	180	
Faucet	251	
Vanity Top	45	
Vanity Base	420	
Toilet Accessories	320	
Tile flooring	515	
Toilet and Seat	424	
	6980	*per room
Total	**746860**	

Guestroom full Renovation	Cost	
Casegood Installation	70	
Bedsets	690	
Headboard	600	
Nightstands	420	
Dresser	480	
Desk	440	
Coffee Table	190	
Closet Rack	60	
Refrigirator cabinet	550	
Mini Fridge	240	
Welcome center	540	
Drapery Valance- Painted wood	180	
Tv and Mount (HD LCD including channels	800	
	5260	*per room
Total	**562820**	

Corridors	Cost	
Demolition	38	
Artwork	11	
Carpet and Pad	238	
Carpet Base	25	
Ceiling-mounted lighting	39	
Sconces	92	
Elevator Lobby Furniture	71	
Vending Area Floor Tile	23	
Ice Machine	273	
Paint Ceiling	26	
Signage pack (room number, way finding, etc)	104	
Vinyl Wall covering	150	
Window Treatment	17	
	1107	*per room
Total	**118449**	

Lobby full Renovation	Cost
Demolition	15600
Decorative Lighting	6000
Electrical	15000
Hard Surface Flooring	11500
Life Saftey	13740
Architectural Lighting	22400
Front Desk + Equipment	30000
Millwork Screen Walls	7600
Acoustical Ceiling Tile and Grid	8200
Articulated Drywall Ceiling	12500
Sound system	2000
Drywall Partitions	7450
Lobby Seatings	12300
	164290

Public Restrooms Full Renovation	Cost
Demolition	3600
Toilet Partitions	5500
Toilet Accessories	1200
Doors	1500
Toilets/Urinals	7600
Architectural Lighting	5000
Flooring	7300
Tile Walls	6800
Motion Sensing Flush valves	4500
Motion sensing Faucets	3400
Vanity Top, Faucets, Sinks	2800
	49200

Restaurant full Renovation	Cost
Demolition	5300
Banquettes	20000
Buffet Equipment	9500
Decorative Lighting	8600
Architectural Lighting	11900
Electrical	13400
Hard Surface Flooring	4000
Life Safety	7100
Millwork Buffet, Host station	26700
Millwork Screen Walls	5150
Millwork Running Trim	4150
Articulated Drywall Ceiling	19300
Sound System	1900
Tables	7700
Communal Dining Tables	4300
Communal table Stools	1900
Drywall Partitions	7900
TV and Mount (55" including programs)	4300
Miscellaneous expenses	94900
	258000

Indoor Swimming Pools	Cost
ADA Lift	11700
Architectural Lighting	20600
Acoustical Tile Ceiling	9300
Paint Door and Trim	330
Pool Deck Tile	16200
Pool Equipment	9500
Pool Furniture	6000
Pool Pak HVAC	56500
Doors	2100
Resurface Pool Bottom	4560
Paint Walls	500
Signage (Life Safety, Pool rules)	2100
Extra	2360
	141750

Bar/Lounge	Cost
Demolition	3000
Bar Die and Top	18700
Back Bar	16000
Bar Equipment	33400
Articulated Drywall Ceiling	10700
Banquettes	7300
Decorative Lighting	4000
Electrical	7400
Hard Surface Flooring	4400
Life Safety	4000
Architectural Lighting	7000
Millwork Running Trim (chair and base)	3100
Sound System	2900
TVs-50" LCD HD	2200
Tables	3800
Drywall Partitions	9900
	137800

Kitchen	Cost
Demolition	5400
Vinyl-coated Tile Ceiling	5500
Fluorescent Lighting	3460
Paint Door Frames and Trim	150
Paint Walls	155
Quarry Tile Flooring	12800
Doors	2555
Kydex paneled Walls	2300
	32320
Kitchen Equipment	**30000**
Kitchen Total	**62320**

Outdoor Amenities	Cost
Outdoor Furniture	11000
Oudoor Lighting	9500
Patio Landscaping	7000
	27500

Outdoor Parking	Cost
Clean and Seal Asphalt	10500
Stripe Spaces	3500
Pavement Resurfacing	78000
	92000
Underground Parking	**250000**
Landscaping	**27000**

Miscellaneous	**Cost**
RFID Key system	51250
Elevator	200000
Electronic Boards	30000
Hotel Sign	10000
Garbage Place	20000
Electronoc Entrance Doors	105000
	416250
Sauna	47000
Terapia allas + Spa + Jaccuzi	390873
Total	**437873**

INVESTMENT	**Price (€)**	
Annual Energy Cost	**142544.58**	
Partition walls	**23790.1**	
Mechanical Ventilation	89316.5	
Radiator	33000	
Underfloor Heating	47960	
PV panels	37100	
Total HVAC	**207376.5**	
Renovation Total	**3492112**	
Taxation (21%)	**763339.5**	
Overhead cost (5%)	**174605.6**	
Permits (2%)	**69842.2**	*estimate
Miscellaneous	**300000**	
Project Total	**€ 5,173,610.5**	
TOTAL EXPENSES	**€ 6,678,058.4**	

REVENUE (€)	
Total Rooms	107
Average Price	150
Operational Days	365
Occupancy Rate	0.6
Rent Bar & Restaurant	120000
	€ 3,634,950.00

***PROJECT BREAKS EVEN AFTER 5.5 YEARS**

Project Total	**€ 5,173,610.5**
Total HR Expense	**€ 1,260,000.0**
Maintenance	**€ 244,447.8**
Total Expense	**€ 6,678,058.3**
Yearly expenses	**€ 2,410,331.9**
Profit	**€ 1,224,618.08**

EXPENSES (€)		
Total Workers	30	
Average Salary	42000	*3500/month
Total HR Expense	**€ 1,260,000.0**	
Maintenance	**€ 244,447.8**	*per year
Annual Energy Cost	**€ 142,544.58**	*per year
Total* year	€ 1,646,992.42	

Payback	
Year 0	€ 6,678,058.3
Year 1	€ 5,453,440.2
Year 2	€ 4,228,822.1
Year 3	€ 3,004,204.1
Year 4	€ 1,779,586.0
Year 5	€ 554,967.9
Year 6	-€ 669,650.2