Sustainable building in iran

Case study: An animal hospital and wildlife-rehabilitation centre

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PREFACE

Before you lies the Bachelor Thesis “Sustainable building in Iran. Case study: An animal hospital and wildlife-rehabilitation centre”. It has been written to fulfill the graduation requirements of the Civil Engineering and Management bachelor programme at the University of Twente (UT). I was occupied doing research and writing the thesis from the 16th of April until the 19th of August.

The thesis assignment was commissioned by Stichting Simba Nature Protection and Education Foundation. The main research question was formulated along with my guidance from the Universty of Twente, João Miguel Oliveira dos Santos and Silu Bhochhibhoya.

I would therefore like to thank João Miguel Oliveira dos Santos and Silu Bhochhibhoya for their great help assisting me in writing this thesis and providing me with valuable feedback on how to write the thesis. I would also like to thank Marjan van der Schaaf from Stichting Simba who aided me by providing important data and feedback. I really appreciated the weekly meetings we had.

Also, I like to thank my girlfriend, who, despite the long distance, motivated me to apply for the assignment and work on this thesis. Finally, I would like to thank my family, friends and “colleagues of the Natuur Museum Fryslan” who made the period from April until August very pleasant.

I hope you enjoy reading the thesis.

Johannes Flisijn

Enschede, August 20th, 2018

ABSTRACT

The goal of the bachelor thesis is to design a sustainable animal hospital and wildlife-rehabilitation centre in Shiraz, Fars province in Iran. The thesis assignment is commissioned by Stichting Simba Nature Protection and Education Foundation. Stichting Simba is committed to protect flora and fauna and providing environmental education in Iran. The design and future realisation of the animal hospital and wildlife-rehabilitation centre is an aid to perceive the goals of Stichting Simba. To develop a design that meets the goals of Stichting Simba a main research question is prepared:

> *How to design a sustainable animal hospital and wildlife-rehabilitation centre in Iran in terms of environmental and economic aspects?*

This question is divided into sub-questions that help to elaborate the main research question. The sub-questions are:

1. How can the animal hospital and wildlife-rehabilitation centre energy needs be covered by using renewable energy sources?
2. What are the economic and environmental impacts of the building?
3. How can the use of water and the waste of water be managed in a sustainable way?

To be able to answer these questions, information was necessary on how the design of the animal hospital and wildlife-rehabilitation centre would become. For the design process the design method of Nigel Cross was used. This design method is a seven-step approach to realize a complete design. For this thesis only the first three steps were undertaken to give a preliminary design in the time available, that satisfies the needs of Stichting Simba. The first step was to determine the objectives of the design based on the project assignment and other needs and wishes from Stichting Simba. Objectives of importance are sustainability, safety, accessibility and attractiveness. With these objectives the method proceeds with the second step, determining the functions of the design. It became clear that the design should facilitate a place where animals could be aided to recover or get better. But also, it should be a place where people can recreate, educate and live. The third step of the design method provides a list of requirements and guidelines that the design must meet. Building code regulations are analysed, but also regulations for the well-being of animals are studied. With these regulations a design has been made that fulfils these regulations and can be used to answer the research questions.

To answer the first sub-question, how to cover the energy supply and demand of the design, building code regulations of importance were determined. Dutch building regulations state that a design should comply with heat resistance values of building elements (thermal shell). Also, the design should comply with an energy performance coefficient (EPC) that determines the energy use of a design with a certain functionality. For this project the functionality is said to be a health area due to the many animal health care facilities in the design. Since Iran is on the most seismic active regions in the world attention is given to the bearing construction of the design. The design is equipped with a bearing construction from engineered wood. In terms of strength and cost-effectivenes this proved to be one of the best solutions. Furthermore, renewable energy sources that are available in Iran are investigated to determine the possibilities for the design. Due to the enormous number of sunshine hours the design will be implemented with photovoltaic solar panels to produce electricity. Thermal energy will be used to provide the building with heating and cooling by means of a geothermal heat pump. This all results in a design that consumes an average of 36000kWh a month. Categories that are major contributors of energy consumption are domestic hot water and fans, pumps and controls, which provide the building with heated water and ventilation. With the use of the photovoltaic solar panels the design can produce 18000kWh a month during the summer. The energy performance coefficient is determined to be 0.85, where the building code regulation requires a value of 0.8.

To answer the second sub-question an environmental life cycle assessment and an economic life cycle assessment have been performed. The goal of the environmental life cycle assessment was to give insight in the potential environmental impact of building materials used in the design of the animal hospital and wildlife-rehabilitation centre. The system boundary used for this assessment was a cradle to gate analysis, which includes the extraction, the manufacturing process and the transportation of the building materials to the construction site. To determine the potential environmental impact of the building materials four impact categories were chosen. With the developed design the quantity of building materials was calculated and the transportation distance of the building materials to the construction site measured. The life cycle impact assessment was carried out by GaBi 6.115, which is a software application that is used to determine the potential environmental impact. From this assessment it could be concluded that the ground floor of the design had the highest impact on the four impact categories. This could be related to the building materials concrete and linoleum (used for flooring), which proved to be contributing the most to the four impact categories.

The goal of the economic life cycle assessment was to determine the overall costs of the building materials that are used to construct the animal hospital and wildlife-rehabilitation centre. For this assessment it was chosen to use the Iranian currency as well as the Dutch currency, because Stichting Simba aims at attracting investors from Europe and Iran to make the project a reality. The assessment showed that the building materials concrete, window and frame and door and frame are the costliest for the design. The total costs of the building materials of the animal hospital and wildlife-rehabilitation centre are estimated at €582,152.80.

The third research question has not been answered in this research study. It is therefore recommended that this analysis should be done in a later stage. It is expected to be of great importance to assess the quantity of water and the quality of water needed. Techniques on how to collect water, store water and preserve or reuse water should be investigated to provide Stichting Simba with valuable information of the possibilities for the animal and wildlife-rehabilitation centre, as it is assessed that water is a scarcity in Iran and precipitation is absent in the summer months.

Cover photo: (Rosengarten, 2018)

TABLE OF CONTENTS

1. INTRODUCTION

PROJECT FRAMEWORK

The Bachelor Thesis project is aimed at designing a sustainable animal hospital and wildlife-rehabilitation centre in Iran. The project is necessary because no facilities such as an animal hospital and wildlife-rehabilitation centre are present yet in Iran. The realisation of such a facility could be an aid to reach the goal of the organisation to aid the Iranian wildlife population, Iranian domestic animals and provide nature education to the Iranian people.

The need for this project can be underlined by the fact that several animal species are disappearing from the Iranian wildlife scene or even worse, face extinction, like the Iranian cheetah (Khosravifard, 2010). The goal of the animal hospital and wildlife rehabilitation centre is to create a safe environment for Iran wildlife and domestic animals. Combined with other projects Stichting Simba undertakes it can help to achieve the goal to keep species preserved and give animals the care they need. If the project is successful, more centres can be created across Iran.

ORGANISATION'S GOAL

Stichting Simba Nature Protection and Education Foundation (Figure 2) is an environmental NGO. Its goal is Iranian nature protection and nature education. One of the primary goals of Stichting Simba is Iranian fauna protection. The Iranian landscape includes a wide range of animals like leopards, gazelles, hyenas, wolves, bird species and many others. As of 2001, 20 of Iran's mammal species and 14 bird species are endangered ((Van der Schaaf, Nature Protection, 2017). These include the Baluchistan bear, Caspian seal, Persian fallow deer, Siberian white crane, hawksbill turtle, green turtle, Oxus cobra, Latifi's viper, dugong, Persian Leopard, Caspian Sea wolf, dolphins and the most endangered the Asiatic cheetah, which are only found in Iran nowadays with a population of less than 50 cheetahs. Furthermore at least 74 other animal species are on the red list of the International Union for the Conservation of Nature (Van der Schaaf, Nature Protection, 2017).

Figure 2 Logo Stichting Simba

A second goal of Stichting Simba is the preservation of Iranian flora. Approximately 10% of Iran is forested and the most extensively in the Caspian region. Many tree species can be identified that grow in the Iranian landscape. Also, more than 2000 plant species are grown in Iran. The land covered by Iran's natural flora is four times that of Europe. Because of a growing pressure on these species from urbanization, global warming etc preservation is needed (Van der Schaaf, Flora & Fauna, 2017).

The third goal of Stichting Simba is to educate Iranian people about the importance of wildlife conservation. By teaching people that every person, animal and all nature has the right to life and is valuable for this world, a respect and appreciation of nature is created (Van der Schaaf, Education, 2017).

MOTIVE

The title of this Bachelor Thesis is "Sustainable Building in Iran". But what is sustainability and how can it be described? The World Commission on Environment and Development (1987) defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet those of the future" (Jamshidi, Asadi, & Motiee, 2014).

The United Nations explain that sustainable development is "the collection of methods to create and sustain development which seeks to relieve poverty, create equitable standards of living, satisfy the basic needs of all peoples, and establish sustainable political practices all while taking the steps necessary to avoid irreversible damages to natural capital in the long term in turn for short term benefits by reconciling development project with the regenerative capacity of the natural environment" (Samari, 2012).

These definitions of sustainable development can be linked to the three spheres of sustainability (Figure 3). The spheres represent three different categories. Sustainability can be described as a mixture of these three categories. The following spheres are identified:

- Economic; profit, cost savings, etc.
- Environmental; natural resource use, pollution prevention, etc.
- Social; standard of living, equal opportunity, etc.

Figure 3 Three spheres of sustainability (Kurry, 2011)

An important sector for sustainable development is the construction and building sector. The "cradle to grave" aspects of the construction and building that are related to create, use and disposal of built facilities, create economic and social advantages to the society. But it simultaneously constitutes negative effects on the environment. Important areas of sustainable development include associated greenhouse gas with energy use emissions, water generation, water consumption, construction materials consumption and integration of buildings, and their discharge with other social systems and infrastructure (Samari, 2012).

One of the main reasons of the expansion and importance of sustainable development in architecture is that construction and in general built environment designers affect their surrounding environment directly (Mohammadabadi & Ghoreshi, 2011).

The construction of a building requires resources such as raw materials, energy and water. Furthermore, the construction of a building produces waste and generates harmful emissions. It is required to design an environmentally sustainable method because during the construction of a building greenhouse gases (GHGs) are being released in to the atmosphere. These are one of the major contributors to climate change (Eiraji & Namdar, 2011).

Nowadays buildings consume up to 30% of the overall energy use across the world (Lucon & Urge-Vorsatz, 2014). It is predicted that this percentage will rise to 50% by the year 2050. Due to this enormous energy consumption buildings produce up to 30% of the GHGs released into the atmosphere every year. This causes numerous problems around the world including global warming and climate change. When analysing energy and consumption issues it is revealed that cooling and heating of modern buildings is responsible for 10-20% of the total energy use of buildings in developed countries and this ratio increases to 50% in less developed ones (Sahebzadeh, Heidari, Kamelnia, & Baghbani, 2017).

To address the emission of the GHGs the way buildings are constructed must be analysed to identify possible alterations that can benefit the environment. Sustainable architecture seeks to minimize the negative environmental impact of buildings by enhancing efficiency and moderation in the use of materials, energy, and development space (Eiraji & Namdar, 2011).

An example of sustainable architecture is the creation of a green building. A green building can be seen as the full life cycle of a building which tries to maximize the conservation of resources (energy, land, water and materials), helps to protect the environment and reduce pollution, provides people with healthy, appropriate and efficient use the space, and natural harmony of the building (Roodgar, Mahmoudi, Ebrahimi, & Molaei, 2011). All these aspects can be traced back to the three spheres of sustainability. A green building satisfies for all the criteria of sustainability and is a viable solution to sustainable building.

Also, traditional climate aware constructions known as vernacular architecture have been able to consume much less energy and produce much less pollution compared to modern buildings and provide a comfortable and sustainable living environment by adapting to different climates. A vernacular building is a building that is built by local people using traditional technologies from locally available materials matching the environmental context to accommodate domestic ways of life (Sahebzadeh, Heidari, Kamelnia, & Baghbani, 2017). An example is the historic city of Yazd in Iran. In this city a densily urban development can be seen. This to reduce the amount of direct sunlight exposure and to maximize the shadow coverage of alleys and urban spaces (Saljoughinejad & Rashidi Sharifabad, 2015).

PROBLEM DESCRIPTION

Iran has enormous reserves of oil and natural gas and is one of the most important centres of these energy sources in the world. But because of the growing foreign and domestic demand of these energy sources it is important to find ways to improve energy consumption from renewable energy sources to save the environment. The lack of energy can be considered as one of the major problems of the future. Therefore, the Iranian government is committing to new policies that focus on renewable energy sources.

In the past traditional Iranian designers had to present environmental elements as their buildings would have been very cold in winter in the northern regions and very hot or humid in summers in the southern regions (Eiraji & Namdar, 2011). They needed to cope with the climatic conditions with the knowledge and materials that were available at that time. The traditional Iranian architecture is called vernacular architecture. This kind of architecture, as mentioned in the previous paragraph, can provide a way of living that satisfies the need to produce less energy, produce less pollution and to provide a comfortable living environment.

In the last century the architecture based on climatic conditions has been diminished in Iran. Buildings have become more modernized and therefore have an increased negative impact on the environment. Modern materials have entered the constructions and there is little regard for energy preservation (Roodgar, Mahmoudi, Ebrahimi, & Molaei, 2011). This leads to a decrease of energy resources, more pollution and irreparable damage to the environment as can be seen in Figure 4

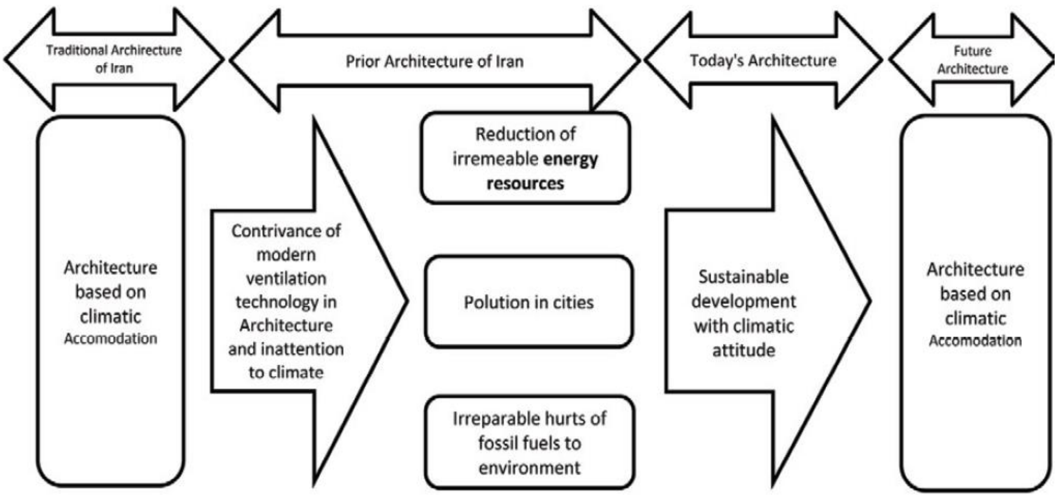


Figure 4 Traditional to future Iranian architecture (Roodgar, Mahmoudi, Ebrahimi, & Molaei, 2011)

Because of incompatible designs and rapid population growth and improvement in urbanism, not only are future buildings not prosperous, but they also comprise wasting more than half of the energy demand (Roodgar, Mahmoudi, Ebrahimi, & Molaei, 2011). The architecture of the future should return to the ideas from the traditional Iranian architecture. It must be based on climatic conditions. Only then a decrease of energy consumption, pollution and irreparable damage to the environment can be realized.

RESEARCH AIM

The goal of the project is to design a sustainable animal hospital and wildlife-rehabilitation centre in Iran. The study is taking into account economical and environmental aspects of sustainability. Economic sustainability represents profitability and cost savings. Environmental sustainability represents the use of natural resources, pollution prevention etc. This research study focuses on two of the three spheres of sustainability, namely the economic sustainability and the environmental sustainability. The social sustainability is disregarded in this project. Therefore, the research aim of this Bachelor Thesis project is to design an economic and environmentally sustainable animal hospital and wildlife-rehabilitation centre in Iran.

RESEARCH QUESTIONS

MAIN RESEARCH QUESTION

With the preliminary research about sustainability and the project framework the research aim is defined. The main research question this project aims to answer is:

> *How to design a sustainable animal hospital and wildlife-rehabilitation centre in Iran in terms of environmental and economic aspects?*

From this main research question several sub-questions are elaborated. They are introduced in the next sections.

SUB-QUESTIONS

ENERGY SUPPLY AND DEMAND

To identify how the energy production and energy consumption of the animal hospital and wildlife-rehabilitation centre can be analysed several sub-questions are formulated. They are as follows.

1) How can the animal hospital and wildlife-rehabilitation centre energy needs be covered by using renewable energy sources?

   This question is divided in sub-questions. Consecutively answering the sub-questions will lead to an answer on the main research question.

   a) What are the climatic conditions of the region?
   b) Which renewable energy sources fit these climatic conditions the best?
   c) How can the energy need of the building be made more efficiently?

ECONOMIC AND ENVIRONMENTAL LIFE CYCLE ASSESSMENT

To assess the economic and environmental impact of the animal hospital and wildlife-rehabilitation centre several questions are formulated. They are as follows.

2) What are the economic and environmental impacts of the building?

   This question is divided in sub-questions. Consecutively answering the sub-questions will lead to an answer on the main research question.

   a) What kinds of building materials and components will be used?
   b) What is the environmental impact of the building from a life cycle perspective?
   c) What is the economic impact of the building from a life cycle perspective?

WATER MANAGEMENT

To identify how the collection of water and the reuse of waste water can be managed, several questions are formulated. They are as follows.

3) How can the use of water and the waste of water be managed in a sustainable way?

   This question is divided in sub-questions. Consecutively answering the sub-questions will lead to an answer on the main research question.

   a) Which techniques are currently available to harvest (drinking) water?
   b) Which techniques are available for waste water treatment?
   c) How can the demand of water be managed and reduced?

BACKGROUND INFORMATION

DEMOGRAPHIC

Iran (Figure 5), officially called the Islamic Republic of Iran is a nation in the Middle-East (Western Asia). The capital of Iran is the city of Tehran. The nation has 32 provinces. In 2016 the population of Iran consisted out of 79 million inhabitants. The official language in Iran is Persian, but the Turkish language and others are also prevalent. Iran is a nation with multiple religions.

Figure 5 Map of Iran (Daily News Hungary, 2017)

Religions that can be distinguished are: Muslims, Christians, Zoroastrians, Jews and others. Muslims are by far the biggest ethnicity in the nation with a percentage of 99%.

CLIMATE

GENERAL CLIMATE

The Iranian climate is diverse. According to Mohammadabadi (Mohammadabadi & Ghoreshi, 2011) the Iranian climate can be divided into four major regions. Eiraji (Eiraji & Namdar, 2011) explains the characteristics of the regions more in depth:

- *Hot and dry region*: This region is characterized by the fact that there hardly is any precipitation during six months of the year, which makes it very hot and dry. It is in the central parts of the Iranian plateau.
- *Cold and snowy region*: This region that is also known as the mountain region and is in the northern and western parts of Iran.
- *Hot and humid region*: This region is in the northern shores of the Persian Gulf and the Sea of Oman. Because this region is near to the shores it is always very humid and hot.
- *Humid and rainy region*: This region is located near the southern shores of the Caspian Sea. In this region the precipitation is about two meters a year and an average humidity of about eighty percent.

CLIMATE SHIRAZ

The intended location of the animal hospital and wildlife-rehabilitation centre is near the city of Shiraz, Fars Province in Iran. Based on the four major climate regions that are mentioned before, the Fars province is *hot and dry*. According to weather data (Shiraz Monthly Climate Averages, 2018) the temperature in Shiraz becomes almost 40 degrees Celsius in summer and drops to 0 degrees Celsius in the winter months. The precipitation in the region is very low and there are several months during the summer there is not any rainfall at all. Detailed figures of the temperature and the precipitation can be found in Appendix B together with information about wind speed, humidity and the amount of sun hours during a month.

ENERGY SOURCES

The primary energy production of Iran consists of 5 main resources: coal, oil, natural gas, hydro and nuclear energy. The production of energy by renewable energy sources is growing every year. In Table 1 the energy production of various means of production are shown.

Table 1 Energy production Iran (WorldData.info, 2018)

ENERGY SOURCE	TOTAL IN IRAN (BN KWH)	PERCENTAGE IN IRAN (%)
FOSSIL FUELS	531.61	83.2
NUCLEAR POWER	8.31	1.3
HYDRO POWER	88.81	13.9
RENEWABLE ENERGY	1.28	0.2
OTHER ENERGY SOURCES	8.95	1.4
TOTAL PRODUCTION CAPACITY	638.95	100

Iran is largely dependent on oil and natural gas to satisfy the domestic energy demands. It is expected that the total energy consumption of Iran will grow with an average annual rate of 3.5% until the year 2030 (Bayomi & Fernandez, 2018). The Iranian landscape is very suitable to make use of renewable energy sources such as solar energy and wind energy. Iran has a great potential for solar energy, with more than 300 clear sunny days on two third of the Iranian landscape. But despite the enormous potential of solar power it is not very popular in Iran. This has to do with the current economic situation of the country and policies regarding renewable energy sources (Korsavi, Zomorodian, & Tahsildoost, 2018).

2. DESIGN PROCESS

INTRODUCTION

The process of designing is a crucial part of project. Especially in large projects, when there is a lot information available and multiple objectives and requirements must be considered, it is important to identify system abstractions, to determine overall structure and to recover architectural design information (Muller, 1993).

The design method for the animal hospital and wildlife-rehabilitation centre that is being used is het Nigel Cross method (Cross, 2005). This method consists of 7 steps that lead up to a final design that satisfies the needs and wishes of Stichting Simba and can identify system abstraction and provide overall structure and design information. In Table 2, the 7 steps and their description are shown.

Table 2 Nigel Cross Method 7 steps

STEP	DESCRIPTION
1. CLARIFYING OBJECTS	To clarify design objectives and sub-objectives, and the relationships between them.
2. ESTABLISHING FUNCTIONS	To establish the functions required and the system boundary of a new design.
3. SETTING REQUIREMENTS	To make an accurate specification of the performance required of a design solution.
4. DETERMINING CHARACTERISTICS	To set targets to be achieved for the engineering characteristics of a product, such that they satisfy customer requirements.
5. GENERATING ALTERNATIVES	To generate the complete range of alternative design solutions for a product, and hence to widen the search for potential new solutions.
6. EVALUATING ALTERNATIVES	To compare the utility values of alternative design proposals based on performance against differentially weighted objectives.
7. IMPROVING DETAILS	To increase or maintain the value of a product to its purchaser while reducing its cost to its producer.

Because of the limited amount of time available for this research study only the first three steps are completed to give a preliminary design of the animal hospital and wildlife-rehabilitation centre. It is recommended that in the future the remaining four steps of the design method are completed to provide a better design that matches the needs and wishes of Simba Nature Protection and Education Foundation.

OBJECTIVES

The first step is defining the objectives of relevance for the project. To define the objectives of importance the project assignment by Simba Nature Protection and Foundation is studied. The project assignment can be found in Appendix A.

The major objective of this study is to design an animal hospital and wildlife-rehabilitation centre. The most important sub-objectives that are recognized are: sustainability, safety, cost-effectiveness, accessibility and attractiveness. These objectives are divided into lower objectives that support the main objective of the research study. The total list of objectives can be found in Appendix C.

FUNCTIONS

The second step of the design process is concerned with defining the functions of the main objectives of the research study. The functions determine the performances of the animal hospital and wildlife-rehabilitation centre should acquire. In Appendix D the functions of this research are shown. The most important functions of the animal hospital and wildlife-rehabilitation centre that are being recognized are:

- Facilitate a centre to provide animal care and stay
- Assure sustainability
- Guarantee safety
- Facilitate a living and working environment for employees
- Provide a building that offers recreation, and education

During the design process the functions should be kept in mind to guarantee a design that fullfils the needs and wishes of the client. From the list of functions and the objectives the building properties that are ought to be present based are determined. The building properties can be found in Appendix E.

REQUIREMENTS

The third step of the design process is defining the requirements of the object to be designed. It is required to make an accurate specification of the requirements to come to a satisfying design solution. Because the design object has several important requirements they are divided into sub-groups. In the next paragraphs the requirements per sub-group are explained.

BUILDING REQUIREMENTS

To determine the requirements for the animal hospital building code regulations have been studied. One of the wishes of the client, Stichting Simba, was that the Dutch building code (Bouwbesluit Online, 2018) would be used. The reason for this decision is that the results of this research are being used to attract investors to make the project real. To be able to show that the building satisfies the assumed stricter, building regulations of The Netherlands, investors may be more enthusiastic to donate money for the good cause of the Iranian wildlife. The applicable Dutch building code regulations can be found in Appendix F.

ANIMAL HOSPITAL REQUIREMENTS

To determine the requirements for the animal hospital animal and wildlife-rehabilitation centre animal shelter regulations have been studied. Also, for these requirements regulations from The Netherlands have been applied (Besluit houders van dieren, 2014) due to the lack of information about animal shelter regulations from Iran. Also, it is assumed that these regulations are more extendended and the well-being of animals is more important in The Netherland than it is in Iran. The Dutch animal requirements focusses on the appropriate care facilities for animals. It gives insight in the following topics:

- Animal housing facilities that provide enough living space
- Animal housing facilities that provide a healthy environment
- Health protocol regulations

The regulations state that an animal hospital should contain three different rooms, besides the normal residency of the animals, to facilitate space where animals can be kept in case of a desease. The rooms that are required are shown in Table 3.

Table 3 Different shelter rooms animal hospital

TYPE OF ROOM	DESCRIPTION
QUARANTINE ROOM	For animals from whom the health and vaccination state are unknown
ISOLATION ROOM	For animals that (may) have a contagious illness
ILLNESS ROOM	Room for animals which are sick but not contagious

The animal hospital regulations can be found in Appendix G.

ANIMALS EXPECTED

To determine which species the animal hospital and wildlife-rehabilitation centre should be able to facilitate has been assessed by Simba Nature Protection and Education Foundation (NGO Simba, 2017). Also, the quantity of different species has been assessed by this foundation. In Table 4, the expected animals and the expected quantity that should be able to be provided with shelter are shown.

Table 4 Number of animals expected

SPECIES	QUANTITY EXPECTED
DOG	100
CAT	50
HORSES	10
DONKEYS	25
GAZELLES	50
DEER	52
CHEETAH	5-6
FELINES	10
WOLF	5-10
FOX	15
SHEEP	50
GOATS	50
RODENTS	20
RAT/MOUSE AND SIMILAR ANIMALS	30
BIRDS	100-200
REPTILES AND AMPHIBIANS	30
OXES	2
WILD BOAR	2
SMALL PREDATORS	20
CAMELS	10
DISCARDED ANIMALS	5-10

ANIMAL REQUIREMENTS

To determine the amount of floor area that is necessary to provide enough living space for the different areas different regulations have been studied. Regulations that were used are regulations for keepers of animals (Besluit houders van dieren, 2014) and the Dog and Cat decree from the Netherlands (Honden- en kattenbesluit, 1999) that provide information on the amount of space and other facilities necessary for animals. These regulations can be found in Appendix I and Appendix J. To determine the regulations of the other, some more exotic animals, regulations from the European Association of Zoos and Aquaria are being used (EAZA, 2014). To determine the amount of space required for these animals guidelines for zoos in India (CZA, 2011) and Switzerland (Minimum requirements for the Keeping of Wild Animals, 2001) have been applied that give a good insight in the amount of floor area necessary. In Table 5, the minimum amount of floor area required for indoor and outdoor stays of all the expected animals are shown based on the regulations and guidelines mentioned above.

Table 5 Minimum amount of floor area for animals

SPECIES	FOR GROUPS OF UP TO N ANIMALS					FOR EVERY ADDITIONAL ANIMAL	
		Outdoor enclosure		Indoor enclosure		Outdoor	Indoor
	Number (n)	Surface (m2)	Volume (m3)	Surface (m2)	Volume (m3)	M2	M2
(WILD) HORSES	5	1000	-	8 per animal	-	100	-
DONKEYS	5	1000	-	8 per animal	-	100	-
GAZELLE	10	500	-	4 per animal	-	40	-
DEER	8	500	-	4 per animal	-	60	-
CHEETAHS	2	200	-	25 per animal	-	20	-
LEOPARDS	2	50	150	25 per 2 animals	75	15	12
WOLVES	2	100	-	12 per 2 animals	-	20	6
FOXES	2	30	-	8 per 2 animals	-	4	1
SHEEP	8	400	-	4 per animal	-	40	-
GOATS	4	400	-	4 per animal	-	50	-
RABBITS	5	20	-	-	-	2	-
RATS/MICE	2	-	-	5 per 2 animals	10	-	1,5
REPTILES/AMPHIBIANS	2	3	-	3 per 2 animals	-	1	1
BIRDS							
WILD BOARS	2	100	-	4 per animal	-	20	-
OXES	2	200	-	8 per animal	-	20	-
CAMELS	3	300	-	8 per animal	-	50	-
TIGERS/LIONS	2	80	-	30 per 2 animals	-	20	15
SMALL PREDATORS	2	16	-	16 per 2 animals	-	4	4
DOGS	5						
CATS	5					0,6	

In Appendix H the amount of floor area for all the expected animals in the animal hospital and wildlife-rehabilitation centre can be found.

DESIGN

With all the known regulations and the three completed steps from the Nigel Cross method a design is made that fulfils most of the requirements set. In Figure 6 the 3D view of the design of the animal hospital and wild-life rehabilitation centre can be found.

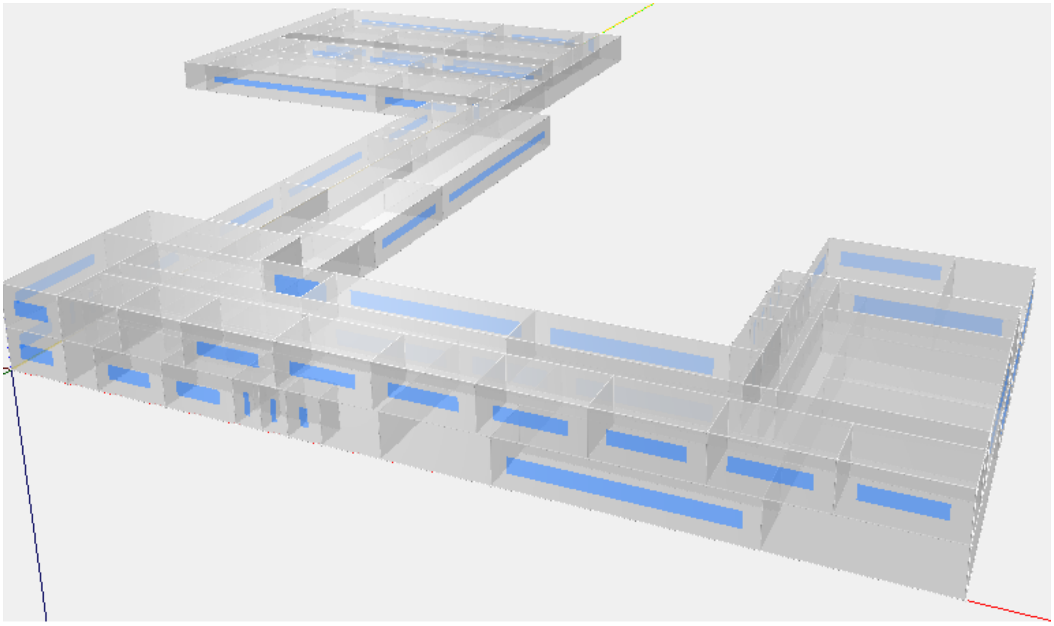


Figure 6 3D view of Animal hospital and wildlife-rehabilitation centre

In Appendix L more details of the animal hospital and wildlife rehabilitation centre can be found.

3. ENERGY SUPPLY AND DEMAND

THERMAL SHEEL

Regulations state that the building envelope must meet certain values when it comes to thermal insulation. From the Dutch building code (Bouwbesluit Online, 2018) heat resistance values are given for different elements of a building. In comparison the heat resistance values from the Iranian building code are presented as well. The values can be found in Table 6.

Table 6 Heat resistance values

BUILDING ELEMENT	HEAT RESISTANCE NETHERLANDS (M^2K/W)	HEAT RESISTANCE IRAN (M^2K/W)
VERTICAL OUTSIDE WALL, TOILET AND BATHROOM	4.5	0.72
HORIZONTAL OUTSIDE WALL, TOILET AND BATHROOM	6.0	1.4
SEPARATION WALL	3.5	0.6
WINDOWS, DOORS AND FRAMES	2.2	0.4

It can be concluded that the values from the Dutch building code are stricter and to achieve these values improved insulation techniques should be implemented in the building.

EPC

The Energy Performance Coefficient (EPC) is a second indicator from the Dutch building code that determines if a building meets energy performance specifications. The specifications that must be met are dependent on the functionality of the building. In Table 7 the EPC values for different building functionalities are given.

Table 7 EPC values building functionalities

BUILDING FUNCTIONALITY	EPC VALUE
RESIDENTAL AREA	0.4
GATHERING AREA	1.1
HEALTH AREA	0.8
OFFICE AREA	0.8
EDUCATION AREA	0.7
SHOPPING AREA	0.9

From this information, it can be concluded that the animal hospital must meet multiple criteria demands for the EPC value because it contains multiple building functionalities. Note of importance is that the EPC regulations are being replaced by a new energy performance method in 2020, the BENG method (Energieprestatie - BENG, 2018). The BENG method assess the energy performance of a building by 3 criteria which can be found in Table 8.

Table 8 BENG method criteria

BUILDING FUNCTIONALITY	ENERGY NEED (KWH/M^2)	PRIMARY FOSSIL FUEL USE (KWH/M^2)	PERCENTAGE RENEWABLE ENERGY USE (KWH/M^2)
RESIDENTIAL AREA	≤25	≤25	≥50
UTILITY AREA	≤50	≤25	≥50
EDUCATION AREA	≤50	≤60	≥50
HEALTH AREA	≤65	≤120	≥50

The building is assessed by its energy need, use of primary fossil energy sources and the use of renewable energy sources in kWh/m^2 per year. For this research study the building has been assessed with the EPC values, but the BENG method will be regarded as well.

EARTHQUAKE RESISTANCE

Iran is one of the most active seismic regions in the world (Nowroozi & Ahmadi, 1986). Due to the possibility of seismic events the animal hospital should be able to withstand these forces. To withstand the variable and dynamic loads that occur during an earthquake the bearing construction of the building must be able to absorb these loads. Therefore, the bearing construction of the building must be able to deform during the earthquake and not fail. A building material that is recommended in terms of strength and cost-effectiveness is engineered wood (Pampanin, 2015). Because of these characteristics a wooden bearing construction has been chosen for the animal hospital.

BUILDING ENVELOPE

The combination of the regulated heat resistance values from the Dutch building code and the bearing construction chosen in the previous paragraphs, a building envelope has been designed that fulfils both criteria. In Table 9 important values of the elements of the building envelope are shown.

Table 9 Values building envelope elements

BUILDING ENVELOPE ELEMENT	RC-VALUE (M^2K/W)	FLOOR DENSITY (KG/M^2)	TOTAL THICKNESS (MM)
GROUND FLOOR	3.51	851.74	446
1ST FLOOR	3.51	851.74	446
EXTERNAL WALL	4.50	226.82	298
INTERNAL WALL	1.42	23.21	70
ROOF	6.00	33.38	304

The detailed information of the building envelope elements, such as the chosen materials, thermal conductivity and specific heat of these materials can be found in Appendix K.

RENEWABLE ENERGY SOURCES

Iran has a vast supply of renewable energy sources, but due to the enormous dependency of fossil fuels, does not use it to maximize its potential (Sahebi, Almassi, Sheikhdavoodi, & Bahrami, 2013). The intended location of the animal hospital is near the city of Shiraz, Fars Province. Renewable energy sources that can be beneficial in this area are solar energy, wind energy and thermal energy.

The solar energy potential in Iran is very high. The average monthly sunshine hours of the Fars Province are between 275 and 300 (Alamdari, Nematollahi, & Alemrajabi, 2013). The enormous amount of sunshine can be used to provide the animal hospital with solar energy. The solar irradiation is estimated to provide around 5400-5700 Wh/m^2 per day (Kashani, Izadkhast, & Asnahi, 2014).

ENERGY DEMAND

To determine the demand of energy of the animal hospital, the software application VaBi Elements (Vabi Elements, 2018) has been used. With this software application the energy consumption of a designed building can be calculated. The energy demand of 6 different categories will determined which gives the total energy consumption of the building. The categories are: heating, cooling, lighting, domestic hotwater, office equipment and fans, pumps and controls. To provide valuable results, weather data files from the area of Shiraz have been used (Weather data files, 2018).

ENERGY SUPPLY

One of the major goals of Stichting Simba is to design an animal hospital that is self reliant in terms of energy use. Therefore, possibilities for renewable energy sources are investigated and applied to the building. As mentioned before the use of solar energy is highly beneficial in Iran. With an average amount of nearly 300 sunshine hours a month, a lot of energy can be provided by the sun. The design of the animal hospital allows a proportional amount of photovoltaic solar panels to be placed on the roof. Calculations showed that in total 450 photovoltaic solar panels of 1.93m^2 could be placed on the roofs of the animal hospital. This number has been used for the energy calculations.

Further the availability of thermal energy is used to provide heating and cooling for the building. To do so a geothermal heat pump will be implemented to extract heat and cold from the Iranian soil.

RESULTS

The energy performance calculation has been performed with VaBi Elements which can determine the energy use and production of energy of a building. Also, the EPC value of the building can be calculated. To provide a valuable result for the energy calculations the climate data from the city of Shiraz is used. In Figure 7 the energy consumption and the energy production in kWh/m^2 of the animal hospital are given.

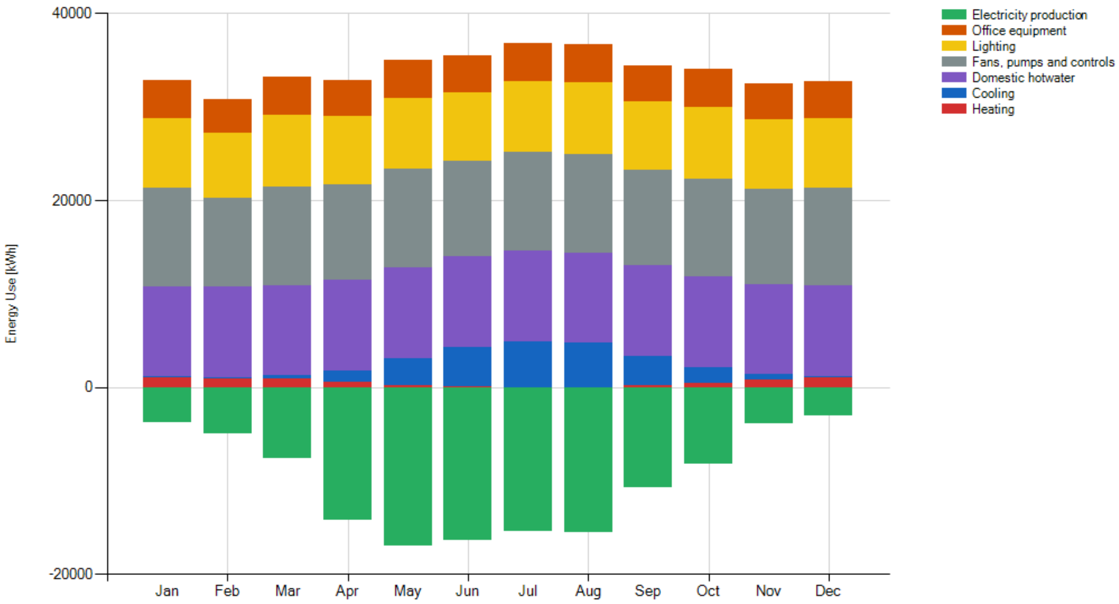


Figure 7 Energy consumption and production animal hospital

The result shows that the building uses an enormous amount of energy which varies between 30,000 and 37,5000 kWh per month. The major contributors of energy use are the domestic hotwater and the fans, pumps and controls which consume almost 50% of total energy. The energy use for heating and cooling on the other hand is very low. This can be explained due to the use of geothermal energy for the heating and cooling. Further, the result shows that the supply of energy is the highest from April until August. In these months the sun provides the most energy which is stored by the photovoltaic solar panels.

To determine the energy performance of the animal hospital the EPC value of the building is calculated. This value is calculated by Vabi Elements. The animal hospital contains several building functionalities and therefore a choice has been made to analyse the building for only the health area criteria, seeing it to be the biggest part of the animal hospital. From the calculations the EPC value of the animal hospital is 0.85 where a value of 0.80 or less is required. So minor adjustments are necessary to meet the criteria for the EPC. It must be mentioned that the EPC value for the apartments has to be 0.4 and for future references the different building functionalities should be calculated independently to provide a better insight in the energy performance of the building.

To analyse the data with the future BENG method Figure 8 shows the energy use of the different categories in kWh/m^2.

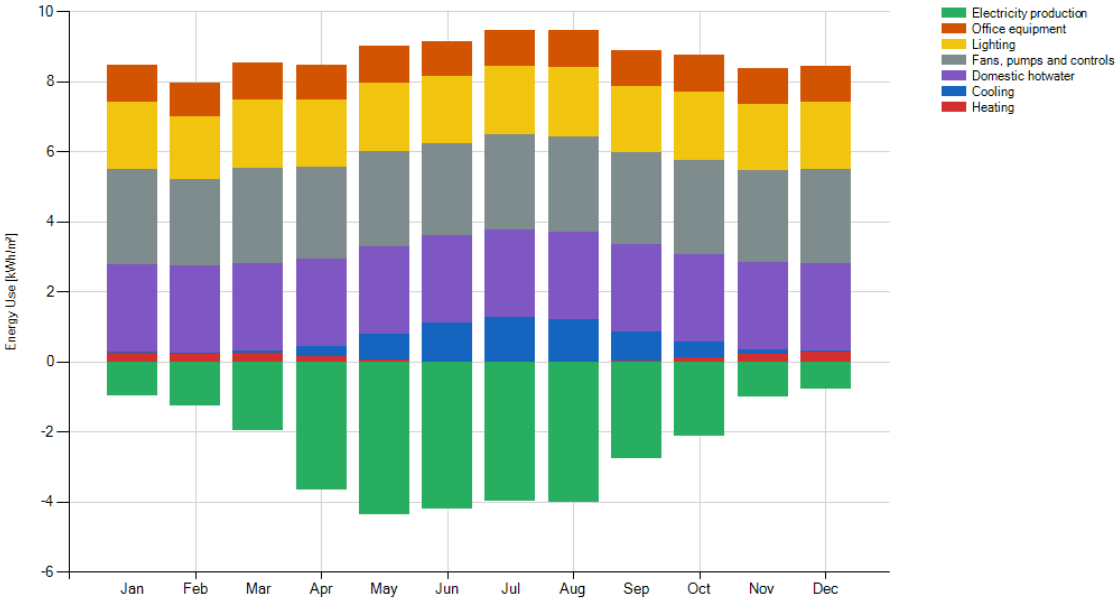


Figure 8 Energy consumption and production animal hospital per m²

From this data it is concluded that the animal hospital uses a total amount of 105.2 kWh/m². The BENG method states that the maximum amount of energy used for a health building is ≤65 kWh/m². For future regulations the design of the building should be adjusted to meet the criteria set by the BENG method.

4. ENVIRONMENTAL LIFE CYCLE ASSESSMENT

METHODS

The life cycle assessment was conducted by following the standardised method by the ISO 14040 and ISO 14044 series. This method includes four aspects: goal and scope, the life cycle inventory, the life cycle impact assessment and the interpretation. (ISO 14040:2006 Environmental Management - Life Cycle Assessment - Principles and Frameworks, 2006) (ISO 14044 Environmental Management - Life Cycle Assessment - Requirements and Guidelines, 2006)

GOAL AND SCOPE DEFINITION

INTENDED APPLICATION

The intended application of the life cycle assessment is to give insight in the potential environmental impact of the building materials chosen in the design of the animal hospital and wildlife-rehabilitation centre.

INTENDED AUDIENCE

The intended audience of this study is the examiners of this research study and the chairman of Stichting Simba Nature Protection and Education Foundation.

SYSTEM BOUNDARIES

The system boundary of the life cycle assessment determines what is included and what is left out. The whole animal hospital and wildlife-rehabilitation centre is evaluated as shown in Figure 9. The system boundary for this research study is from cradle to gate. This includes the environmental impact of the manufacturing phase, which includes the extraction of materials, the manufacturing process of the materials and the transportation of the materials to the construction site.

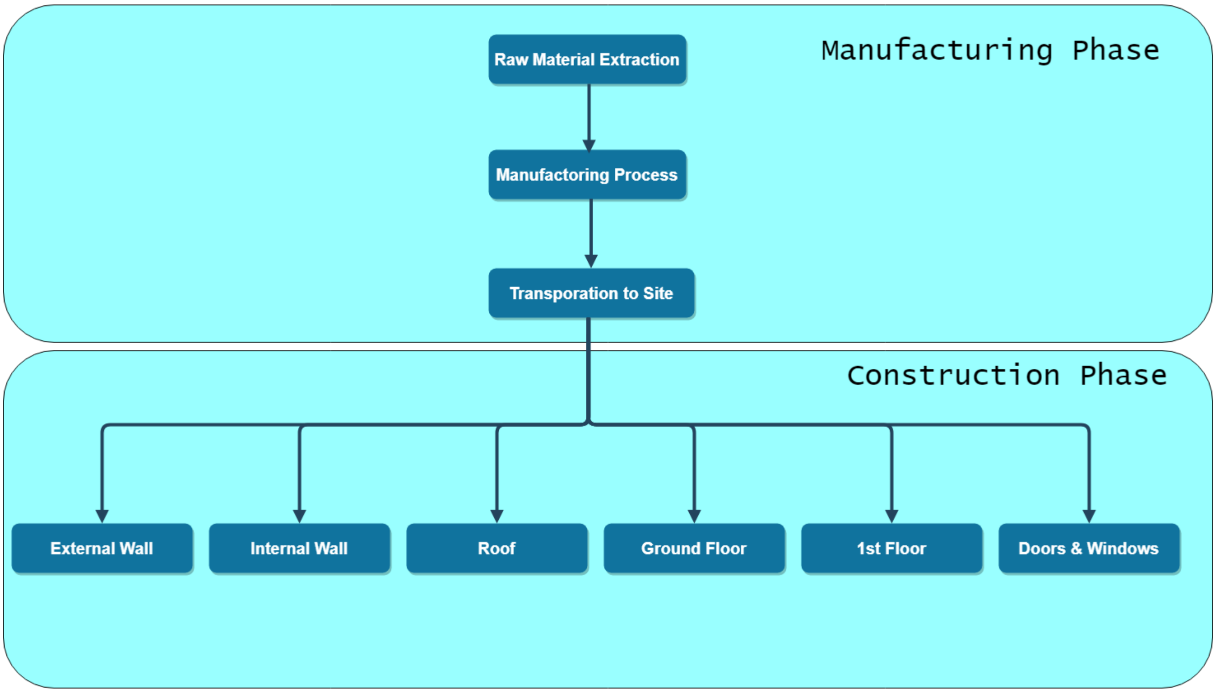


Figure 9 System boundary life cycle assessment

The life cycle assessment has been carried out in GaBi 6.115 (GaBi LCA Software, 2018). Because of data limitations of the educational database that was used some assumptions have been made. The life cycle impact assessment is determined with the indicator approach ReCiPe, which is included in GaBi 6.115.

FUNCTIONAL UNIT

The functional unit of the building is the total amount of building materials needed in kilograms. As mentioned earlier the function of the building is an animal hospital and wildlife-rehabilitation centre located in Shiraz, Fars Province in Iran. To protect the building against earthquakes a timber framed construction has been chosen. The external walls are provided with a sand-lime brick exterior and the ground floor is reinforced concrete structure as is demanded by the building code. The total building size is 4048m^2 gross floor area and includes ten apartments, museum, restaurant, shop, educational centre, examination rooms, quarantine rooms etc. This is shown in Figure 10.

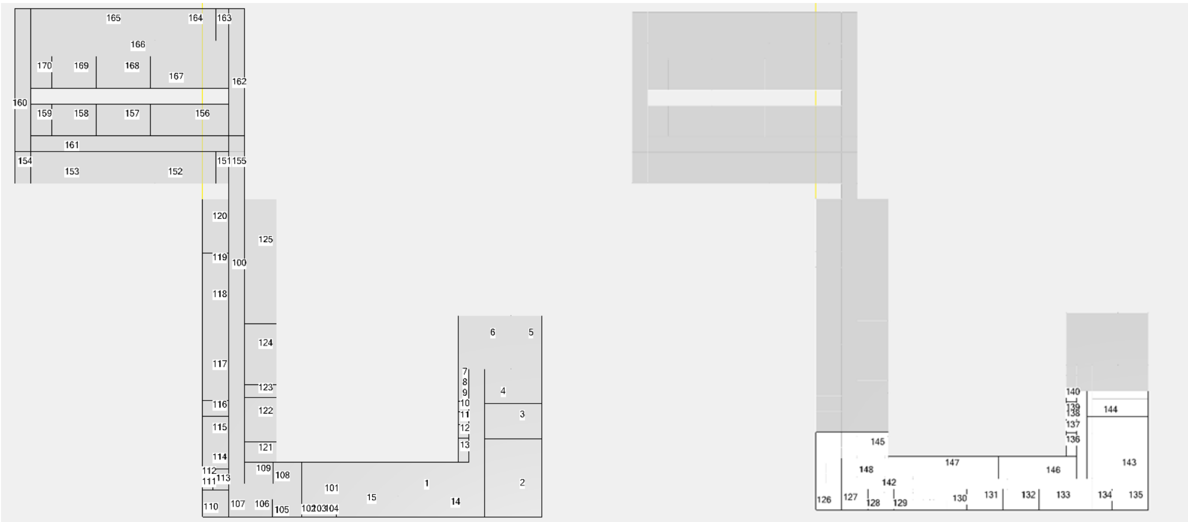


Figure 10 Lay-out animal hospital ground floor and 1st floor

LIFESPAN

The intended lifespan of the animal hospital and wildlife-rehabilitation centre is 50 years. This is based on the building code regulation that states that a new building needs to have a lifespan of at least 50 years (Bouwbesluit Online, 2018).

IMPACT CATEGORIES

To assess the total environmental impact of the animal hospital four impact categories are chosen. With these impact categories the impact of the chosen building materials on the environment will be assessed. The impact categories of importance for this life cycle assessment are shown in Table 10.

Table 10 Impact categories

IMPACT CATEGORY	UNIT OF MEASUREMENT
CLIMATE CHANGE (GLOBAL WARMING)	kilogram CO_2 equivalence
TERRESTRIAL ACIDIFICATION	kilogram SO_2 equivalence
FRESHWATER EUTROPHICATION	Kilogram P equivalence
OZONE DEPLETION	kilogram CFC-11 equivalence

LIFE CYCLE INVENTORY

BUILDING MATERIALS

To assess the total environmental impact of the building materials, an inventory is made to assess the quantity of materials necessary for the building. This can be seen in Table 11.

Table 11 Quantity Building Materials

SUB-STRUCTURE	MATERIALS	KILOGRAM/M^2	KILOGRAM/BUILDING
EXTERNAL WALL	Sand-Lime Brick	200	469,000
	Mortar	13.1	22,888
	EPS	4.35	7,600.3
	Gypsum Plasterboard	10	17,472
INTERNAL WALL	Gypsum Plasterboard	10	29,055
	Glass wool	1.61	4,677
	Gypsum Plasterboard	10	29,055
ROOF	Gypsum plasterboard	10	40,474
	Glass wool	6.76	27,363
	Chipboard	11.3	45,736
	Bitumen	3.6	14,570
GROUND FLOOR	EPS	3.48	10,865
	Reinforced concrete C30-37	750	2,341,777
	Screed C20-25	100	312,237
	Linoleum	3	9,367
1ST FLOOR	Gypsum plasterboard	10	9,251
	EPS	3.42	3,163
	Reinforced concrete C20-25	750	693,832

	Screed C12-15	100	92,511
	Linoleum	3	2,775
DOORS & WINDOWS	Door	28	4,996
	Double glass	20	6,894
	PVC Frame Window	1.09	375
	PVC Frame Door	29.6	5,282

TRANSPORTATION DISTANCE

To determine the potential environmental impact of the animal hospital and wildlife-rehabilitation centre the transportation distance of the building materials from the gate to the construction site have been taken in to account. The transportation distances are determined by identifying suppliers of the different building materials. In Table 12, the total weight of al the building materials and their corresponding transportation distances are shown. Furthermore, the transport system chosen from GaBi 6.115 is visualized. For all the materials a truck with a 27ton payload capacity is used.

Table 12 Transportation data

Materials	Quantity ($x10^3$ kg)	Distance (km)	Transport system from educational database
Sand-lime Brick	469	20	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Mortar	30.7	20	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Bitumen	14.6	932	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Chipboard	45.5	1332	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Gypsum plasterboard	131.25	374	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
EPS	24.26	800	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Glass wool	31.98	20	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Linoleum	12.15	900	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity

PVC	5.66	150	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Doors	5	150	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Windows	6.89	150	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity
Concrete	3438.5	20	Truck-trailer, Euro 4, 34 - 40t gross weight / 27t payload capacity

ASSUMPTIONS

Due to data limitations of the educational database from GaBi 6.115 that was used several assumptions were made. The processes of the manufacturing of the sand-lime bricks and mortar were not included. From literature reviews certain assumptions were made about the quantity of resources and energy consumption needed to produce these goods.

In Figure 11, the flow diagram of a sand-lime brick plant is shown. The ratio sand:lime that is required to produce sand-lime bricks that satisfies in terms of strength and stability is defined as 1:7.33 (Calcium Silicate Bricks or Sand Lime Bricks for Masonry Construction, 2017)

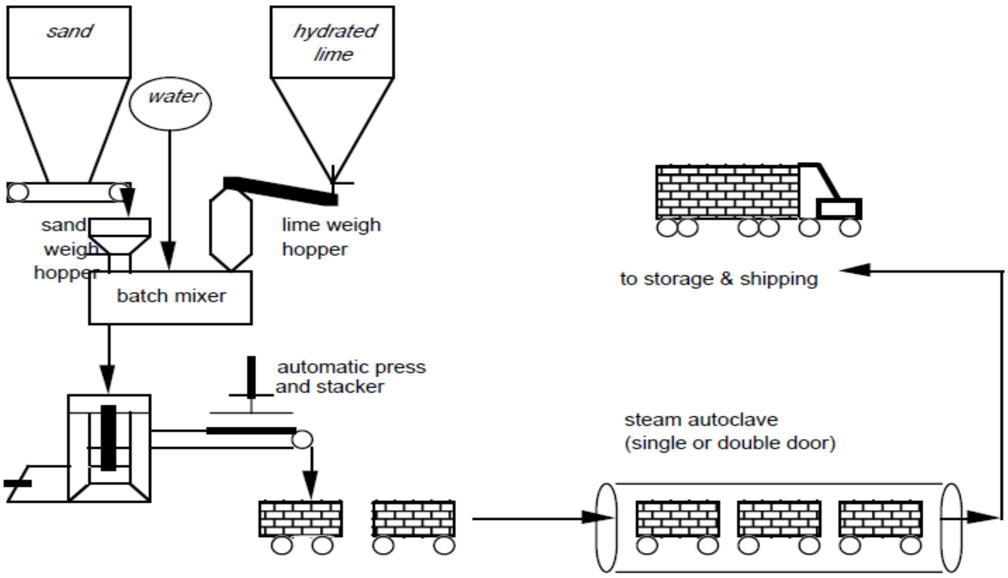


Figure 11 Flow diagram production sand-lime brick (Calcium Silicate Bricks or Sand Lime Bricks for Masonry Construction, 2017)

LIFE CYCLE IMPACT ASSESSMENT

The life cycle impact assessment tries to quantify the magnitude and significance of the potential environmental impacts of the building materials used for the animal hospital and wildlife-rehabilitation centre (LC-Impact, 2013). For the quantification the indicator approach ReCiPe 2016 has been used. ReCiPe determines the potential environmental impact with 18 midpoint indicators and 3 endpoint indicators. The midpoint indicators focus on single environmental problems, where endpoint indicators highlight the environmental impact of the study area on three higher levels, being damage to human health, damage to ecosystems and damage to resource availability (Life Cycle Assessment, 2011). These indicators are shown in Figure 12.

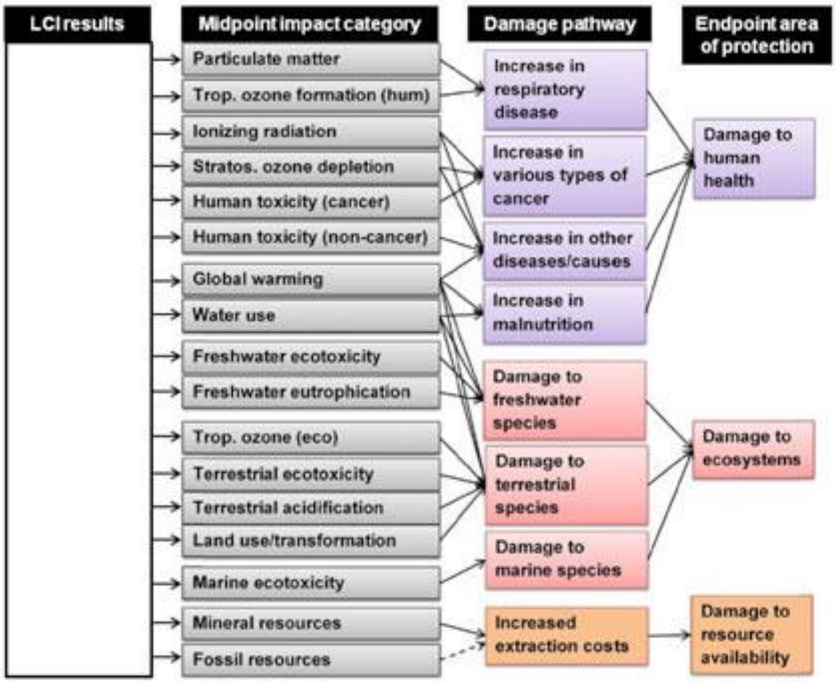


Figure 12 Life cycle impact assessment indicators ReCiPe (Life Cycle Assessment, 2011)

For this study 4, midpoint indicators are chosen as impact categories to determine the magnitude of the potential environmental impact of the building materials, as shown in Table 10.

The life cycle impact assessment is performed for all the sub-structures of the animal hospital and wildlife-rehabilitation centre and its materials. The sub-structures that are assessed are:

- External wall
- Internal wall
- Roof
- Ground floor
- 1st floor
- Doors & windows

In Table 13 the results of the life cycle impact assessment of the sub-structures of the building are shown.

Table 13 LCIA Building Components

IMPACT CATEGORY	UNIT	EXTERNAL WALL	INTERNAL WALL	ROOF	GROUND FLOOR	1ST FLOOR	DOORS & WINDOWS
CLIMATE CHANGE	kg CO_2 Eq.	129275,3	21529,8	80990,1	353639,6	96081,9	27301,9
TERRESTRIAL ACIDIFICATION	kg SO_2 Eq.	304,0	79,4	417,7	643,2	182,2	118,3
FRESHWATER EUTROPHICATION	kg P Eq.	0,531	0,064	0,399	1,523	0,451	0,216
OZONE DEPLETION	kg CFC-11 Eq.	0,00109	0,00094	0,00321	0,00321	0,00110	$5{,}95*10^{-8}$

It is concluded that the ground floor has the biggest impact on three out of four impact categories. Only for the impact category Ozone Depletion the ground floor is tied with the roof. This is shown in Figure 13.

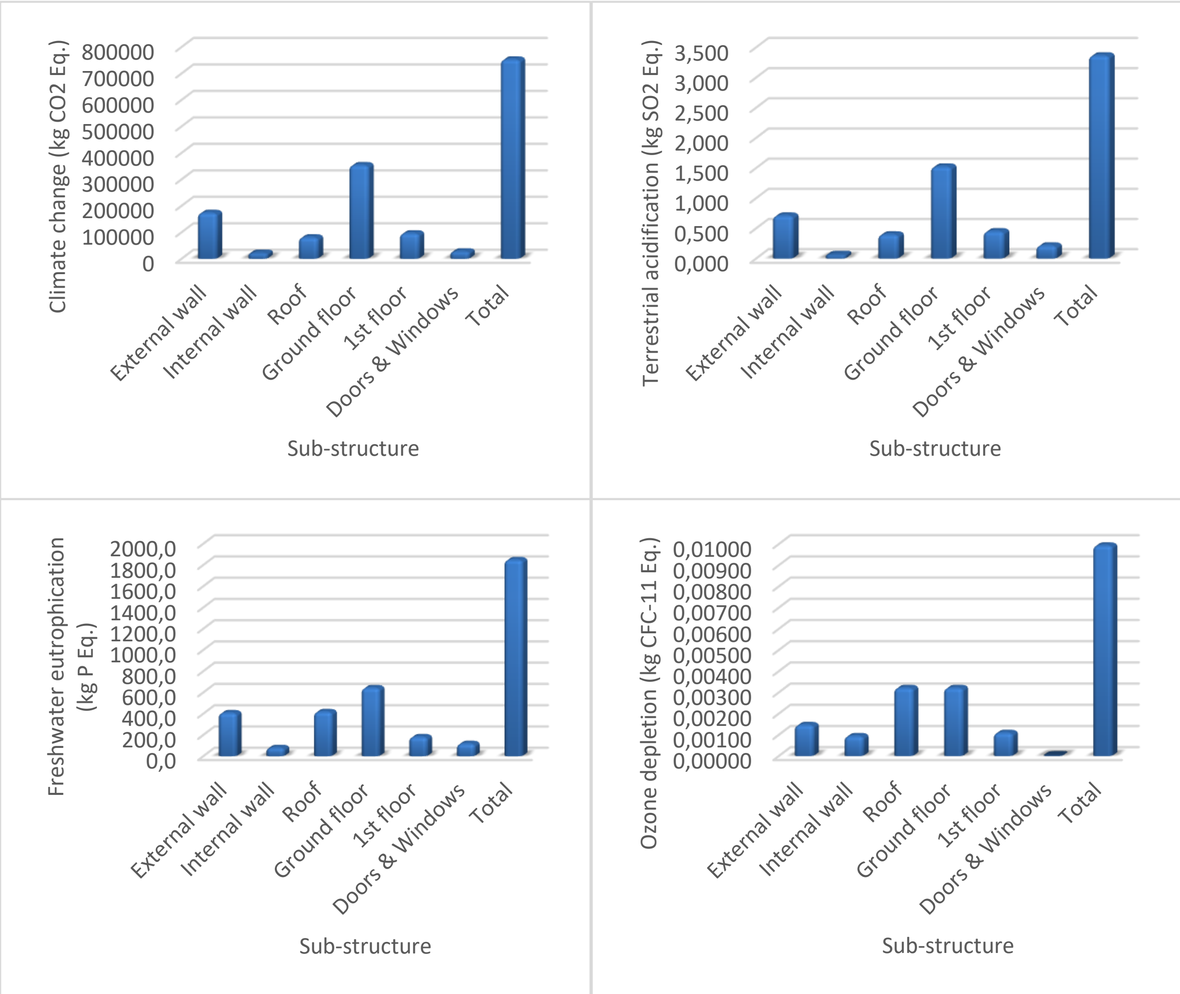


Figure 13 Values impact categories sub-structures

The big impact of the ground floor on the four impact categories can be contributed to the use of (reinforced) concrete and linoleum. The reinforced concrete contributes to about 76% of the total amount of kg CO_2 equivalence emittance and about 64% to the total amount of SO_2 equivalence emittance of the ground floor. The linoleum flooring contributes for 74% to the freshwater eutrophication and 69% to the ozone depletion. Figure 14 shows the percentage contribution of a single building material related to the total of the impact category is visualized. The result shows that concrete contributes more than 50% to the total amount of kg CO_2 emission and up to 33% of the total amount of kg SO_2 emission. The linoleum flooring contributes 46% to the total amount of freshwater eutrophication and contributes 44% to the Ozone depletion.

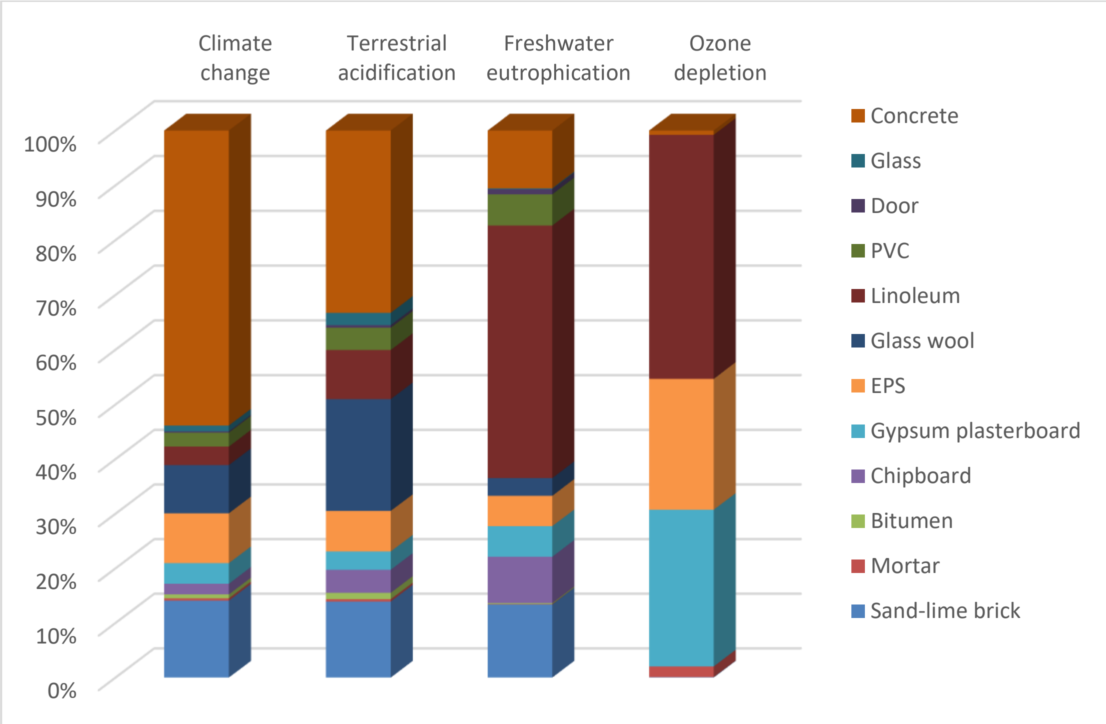
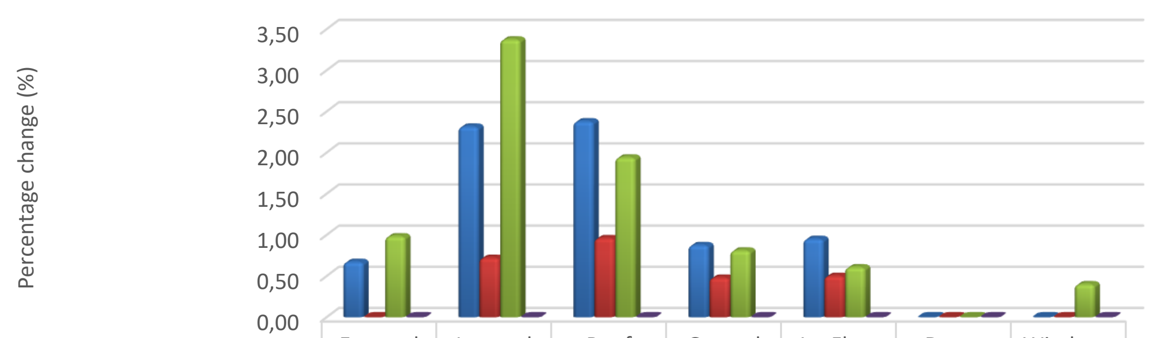


Figure 14 Impact materials on total value impact categories

SENSITIVITY ANALYSIS

The sensitivity analysis was performed to indicate the sensitivity of the transportation distance and the sensitivity of energy consumption of building materials that were not included in the educational database of GaBi 6.115. To determine the sensitivity of the transportation distance the transport of every building material for all sub-structures of the Animal hospital and wildlife-rehabilitation centre was increased with 50%. In

Figure 15, the results of this sensitivity analysis are shown. From this figure it can be concluded that the transportation distance has minor effect on the specified impact categories. The sub-structures internal wall and the roof appear to be the most sensitive to changes in the transportation distances.



	External Wall	Internal Wall	Roof	Ground Floor	1st Floor	Doors	Windows
Climate change	0,67	2,32	2,38	0,88	0,95	0,00	0,00
Terrestrial acidification	0,00	0,72	0,96	0,48	0,50	0,00	0,00
Freshwater eutrophication	0,98	3,38	1,94	0,81	0,61	0,00	0,40
Ozone depletion	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Figure 15 Sensitivity analysis transportation distance

The sensitivity of the energy consumption of sand-lime bricks and mortar were analysed as well. The energy consumption of these building materials was not included in GaBi 6.115. The energy consumption of these building materials was identified by a research study. This makes the results of the life cycle assessment uncertain. In Figure 16, the sensitivity analysis of the energy consumption of the building materials sand-lime brick and mortar is shown. From this figure it appears that especially the energy consumption of the sand-lime brick is very sensitive, as it has a very big impact on the four impact categories with a 50% increase in energy consumption. Furthermore, the building material mortar has a major effect on the freshwater eutrophication with about 21%, where it's impact on the other impact categories is minor.

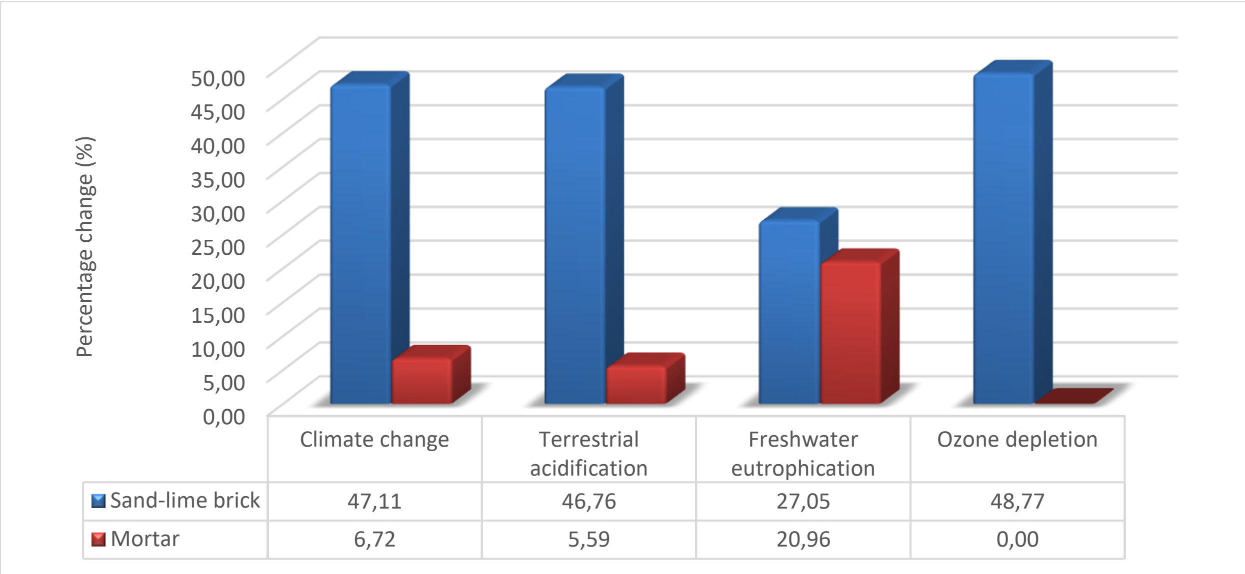


Figure 16 Sensitivity analysis energy consumption sand-lime brick

5. ECONOMIC LIFE CYCLE ASSESSMENT

INTRODUCTION

To assess the economic sustainability of the animal hospital and wildlife-rehabilitation centre the costs of the building materials need to be determined. The method to determine the economic stability is called life cycle costing. The life cycle costing analysis is conducted by following the standardised method by ISO 15686 series (ISO 15686 - Buildings and constructed assests -Service life planning - Part 5: Life-cycle costing, 2017). It can be described as a method of economic analysis for all costs related to the research area throughout the life cycle (Duyan & Ciroth, 2013). In the following paragraphs an inventory is being made of all the materials used and the costs that are related to these materials to assess the total costs of the animal hospital. The costs of the materials and the total costs will be given in Iranian Rial (IRR) and Euros (€) because Stichting Simba aims at using the results to attract European and Iranian investors to make the project come true.

GOAL AND SCOPE

The goal of the life cycle costs analysis is to determine the overall costs of the building materials that are used to construct the animal hospital and wildlife-rehabilitation centre. Like the life cycle analysis, the life cycle costs are determined from cradle to gate. This includes the costs of the building materials that are needed and the transportation costs to deliver the materials to the construction site.

LIFE CYCLE COSTS INVENTORY

To determine the costs of the building materials first an inventory was made to assess which materials are used to construct the animal hospital. The prices of the building materials are from Iranian suppliers. To give a good understanding of the costs of the animal hospital the corresponding costs of the materials in Euros is also given. In Table 14, the value of the Iranian Rial in terms of Euros is shown and vice versa.

Table 14 Valuta difference Iranian Rial and Euro (XE Currency Charts, 2018)

RIAL 1.0000	€0.0000193360
€1.0000	RIAL 51,716.90
Date of currency conversion	**31-07-2018 12:00**

With this currency conversion the prices of the building materials are calculated in Rials and in Euros. In Table 15 the costs of the building materials that are being used are shown.

Table 15 Price materials in Rial and Euros

MATERIAL	PRICE (RIAL/M^2)	PRICE (€/M^2)
SAND-LIME BRICK	425,000	8.22
MORTAR	512,000	9.90
BITUMEN	123,000	2.38
CHIPBOARD	262,200	5.07
GYPSUM PLASTERBOARD	46,600	0.90
EPS	84,600	1.64
GLASS WOOL	381,500	7.38
LINOLEUM	370,000	7.15
PVC FRAME DOOR	77,435,700 per door	1,497.30 per door
DOOR	10,325,300 per door	199.65 per door

WINDOW & FRAME	16,084,000		311.00	
CONCRETE	1,450,000	per m^3	28.04	per m^3

LIFE COSTS ASSESSMENT

Now that the prices of the building materials are known the total price of the animal hospital and wildlife-rehabilitation centre can be determined. This is shown in Table 16.

Table 16 Total prices building materials

MATERIAL	TOTAL PRICE (RIAL)	TOTAL PRICE (€)
SAND-LIME BRICK	995,860,000	19,255.99
MORTAR	1,199,718,400	23,197.8
BITUMEN	497,840,040	9,626.25
CHIPBOARD	1,061,249,256	20,520.36
GYPSUM PLASTERBOARD	1,377,892,832	26,642.99
EPS	540,651,528	10,454.06
GLASS WOOL	2,652,561,870	51,290.04
LINOLEUM	1,497,567,600	28,597.03
PVC FRAME DOOR	6,427,163,100	124,275.90
DOOR	856,999,900	16,570.98
WINDOW & FRAME	5,544,170,884	107,202.30
CONCRETE	7,610,615,000	147,159.10
TOTAL	**30,262,290,410**	**585,152.80**

It can be concluded that the use of concrete, the PVC door frames and the windows and frames are the most cost expensive materials for the building. These three building materials contribute more than 64% to the total costs calculated. In total the costs of the building materials are assessed at €585,152.80 and RI 30,262,290,410.

SENSITIVITY ANALYSIS

To check the uncertainty of the results of the life costs assessment a sensitivity analysis has been performed. The parameter that was analysed is the currency conversion that has been considered between the Iranian Rial (IRR) and the Euro (€). In Figure 17 the sensitivity of the currency conversion is shown.

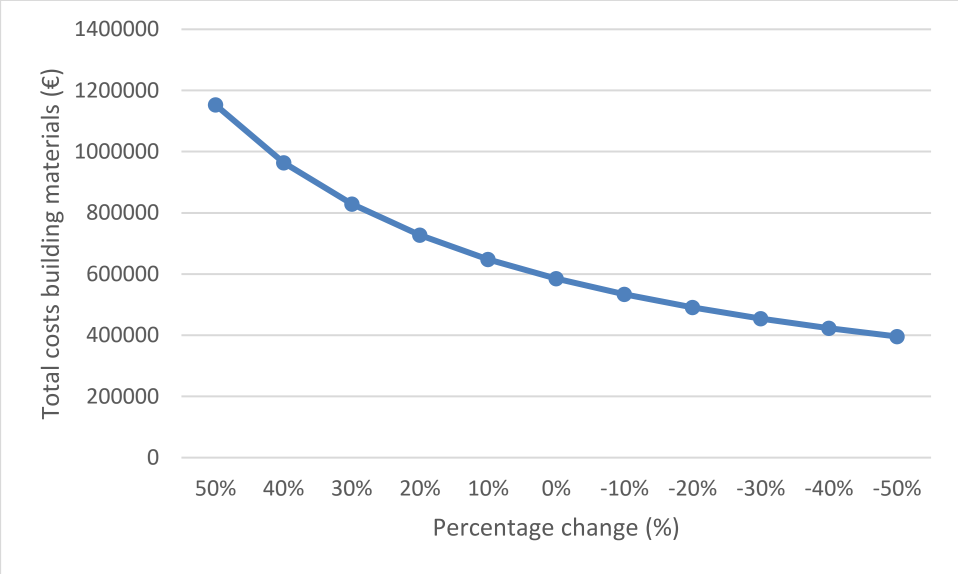


Figure 17 Sensitivity analysis currency conversion

In this figure, the change in total costs of the building materials is plotted against the percentage change of the value of the Iranian Rial in terms of the Euro. It can be concluded that the costs of the building materials are influenced by the current currency of the Iranian Rial. However, the total costs increase enormously when you can buy less Iranian Rial for the same amount of Euro. From the figure it is determined that with a 50% increase of the value of the Iranian Rial the costs in Euros almost doubles. Therefore, is can be concluded that the currency conversion is sensitive to changes.

6. CONCLUSION

The goal of the bachelor thesis was to design a sustainable animal hospital and wildlife-rehabilitation centre in Shiraz, Fars Province in Iran. Based on the goals of Stichting Simba, that included the protection and preservation of flora and fauna and nature education, the main research question was prepared.

> *How to design a sustainable animal hospital and wildlife-rehabilitation centre in Iran in terms of environmental and economic aspects?*

This has been determined by elaborating two sub-questions that address the energy supply and demand, and the environmental and economic life cycle assessment of the design of the animal hospital and wildlife-rehabilitation centre.

With the design method of Nigel Cross the objectives, functions and requirements of the design became clear. This information led to a design of the animal hospital and wildlife-rehabilitation centre that meets most of these objectives, functions and requirements. Building code regulations state that a building needs to meet heat resistance criteria and energy performance coefficients. The energy supply and demand of the design has been determined wit VaBi Elements. From this analysis it became clear that the energy needs of the design exceed the production of energy by renewable energy sources. Further analysis showed that with the chosen building materials, that comply with the heat resistance criteria, the criteria for the energy performance coefficient value was almost met. Therefore, some adjustments are necessary to achieve the building code regulations.

The environmental life cycle assessment gave insight in the potential environmental impact of the building materials used in the design of the animal hospital and wildlife-rehabilitation centre. The results show that for four chosen impact categories, the ground floor of the design has the highest contribution of emissions to the environment. It was determined that the building materials concrete and linoleum were responsible for the major part of these emissions.

The economic life cycle assessment showed the overall costs of the building materials that were used for the design of the animal hospital and wildlife-rehabilitation centre. For this analysis price data from Iranian suppliers was used. The results of this analysis show that the costs of the overall design are estimated at a total price of €582,152.80.

The thesis does not provide an answer on how to manage the use of water and the waste of water in a sustainable way due to limiting time to perform the research study. Nonetheless, the research showed that to design a sustainable animal hospital and wildlife-rehabilitation centre attention must be given to the energy performance of the design. The thermal shell of the building must meet the regulations from the building code. The same goes for the energy performance coefficient. Especially the energy performance coefficient determines if the design meets the criteria for a sustainable building. Because the energy performance coefficient not met the building code regulations, improvements must be made. The environmental life cycle assessment showed that the use of concrete and linoleum should be diminished to lower the potential environmental impact. To provide an improved environmental sustainability research should be undertaken to determine other possibilities for the building materials concrete and linoleum. The economic life cycle assessment showed that the use of concrete, windows and doors are the biggest contributors to the overall costs of the design. To provide an improved economic sustainability, other building material should be studied to determine if there is a better solution.

7. RECOMMENDATIONS

The research showed that the design method of Nigel Cross, which is a 7-step method, was only completed for the first three steps. It is therefore recommended that in the future the design method is fully completed. By determining the characteristics of the project and generating alternatives, more potential solutions for the design can be created that in the end may lead to a better design.

Also, the research showed that energy performance coefficient did not meet the building code regulations. It is therefore recommended that the design is altered in such a way that the energy performance coefficient satisfies. Subsequently is it also recommended for future studies to use the BENG-method, since this method will be the new standard from 2020.

The research showed that by using concrete and linoleum the potential impact on the environment is very high. It is therefore recommended to study the potential environmental impact ofdifferent building materials to determine if there is a better solution.

The economic life cycle assessment showed that the costs of concrete and windows and doors are high compared to the other building materials. Therefore, it is recommended to study the effect of different building materials on the overall costs of the animal hospital and wildlife-rehabilitation centre.

The final recommendation is to perform the water management study. Due to time limitations of this research study this area has not been analysed. But it is deemed to be important to design a sustainable animal hospital and wildlife-rehabilitation centre.

BIBLIOGRAPHY

(2013). Retrieved from LC-Impact: http://lc-impact.eu/methodology-home

(2018). Retrieved from Horeca Nederland: https://www.khn.nl/website/belangenbehartiging/ondernemen/horeca-omgeving/ruimtelijke-ordening/inrichtingseisen

Alamdari, P., Nematollahi, O., & Alemrajabi, A. (2013). Solar energy potentials in Iran: A review. *Renewable and Sustainable Energy Reviews*, 778-788.

Bayomi, N., & Fernandez, J. E. (2018). Trends of energy demand in the Middle East: A sectoral level analysis. *International journal of energy research*, 731-753.

(2014). *Besluit houders van dieren.*

Bouwbesluit Online. (2018, July 1). Retrieved from Rijksoverheid: https://rijksoverheid.bouwbesluit.com/Inhoud/docs/wet/bb2012

Calcium Silicate Bricks or Sand Lime Bricks for Masonry Construction. (2017). Retrieved from The Constructor: https://theconstructor.org/building/calcium-silicate-bricks-masonry-construction/17256/

Cross, N. (2005). *Engineering design methods.* Chisester: John Wiley & Sons, Ltd.

CZA. (2011). *Guidelines on Minimum Dimensions of Enclosures for Housing Exotic Animals of Different Species.*

Daily News Hungary. (2017, December 4). Retrieved from https://dailynewshungary.com/hungary-iran-strengthening-economic-ties/

Duyan, O., & Ciroth, A. (2013, June). Retrieved from OpenLCA: https://www.openlca.org/wp-content/uploads/2015/11/How-to-perform-Life-Cycle-Costing-in-openLCA.pdf

EAZA. (2014). *Standards for the Accomodation and Care of Animals in Zoos and Aquaria.*

Eiraji, J., & Namdar, S. (2011). Sustainable Systems in Iranian Traditional Architecture. *Procedia Engineering 21*, 553-559.

Energieprestatie - BENG. (2018). Retrieved from Rijksdienst voor Ondernemend Nederland: https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/wetten-en-regels-gebouwen/nieuwbouw/energieprestatie-beng

GaBi LCA Software. (2018). Retrieved from Thinkstep: https://www.thinkstep.com/software/gabi-lca

GaBi Software [Software]. (2018).

Golsteijn, L. (2017, March 3). *News*. Retrieved from SimaPro: https://simapro.com/2017/updated-impact-assessment-methodology-recipe-2016/

(1999). *Honden- en kattenbesluit.*

(2006). *ISO 14040:2006 Environmental Management - Life Cycle Assessment - Principles and Frameworks.* Geneve, Switzerland: International Organization for Standardization.

(2006). *ISO 14044 Environmental Management - Life Cycle Assessment - Requirements and Guidelines.* Geneva, Switzerland: International Organization for Standardization.

(2017). *ISO 15686 - Buildings and constructed assests -Service life planning - Part 5: Life-cycle costing.* Geneva, Switzerland: International Organization for Standardization.

Jamshidi, O., Asadi, A., & Motiee, N. (2014). Assessment of Sustainability of Greenhouse Culture and Identifying Factors Affecting in Alborz Province. *Middle-East Journal of Scientific Research 19 (5)*, 625-630.

Kashani, A., Izadkhast, P., & Asnahi, A. (2014). Mapping of solar energy potentials and solar system capacity in Iran. *Internation Journal of Sustainable Energy, 33:4*, 883-903.

Khosravifard, S. (2010). *Iran's Wildlife Under Threat*. Retrieved from Institute for War and Peace Reporting: https://iwpr.net/global-voices/irans-wildlife-under-threat

Korsavi, S., Zomorodian, Z., & Tahsildoost, M. (2018). Energy and economic performance of rooftop PV panels in the hot and dry climate of Iran. *Journal of Cleaner Production*, 1204-1214.

Kurry, A. (2011, December 21). *Sustainable development*. Retrieved from Macauly honors college: https://macaulay.cuny.edu/eportfolios/akurry/2011/12/21/sustainable-development/

Life Cycle Assessment. (2011, June 6). Retrieved from National Institute for Public Health and the Environment: https://www.rivm.nl/en/Topics/L/Life_Cycle_Assessment_LCA/ReCiPe

Lucon, A., & Urge-Vorsatz, D. (2014). Buildings. In O. Edenhofer, & R. Pichs-Madruga, *Climate Change 2014: Mitigation of Climate Change* (pp. 671-738). Cambridge: Cambridge University Press.

Microsoft Excel [Software]. (2007).

(2001). *Minimum requirements for the Keeping of Wild Animals.*

Mohammadabadi, M., & Ghoreshi, S. (2011). Green Architecture in clinical centres with an approach to Iranian sustainable vernacular architecture (Kashan City). *Procedia Engineering 21*, 580-590.

Muller, H. (1993). A reverse engineering approach to subsystem structure identification. *Software Maintenance: Research and practice Vol.5*, 181-204.

NGO Simba. (2017). Retrieved from Simba Nature protection: https://ngosimba.nl/#nature

Nowroozi, A., & Ahmadi, G. (1986). Analysis of earthquakes in Iran based on seismotectonic provinces. *Techtonophysics*, 89-114.

Pampanin, S. (2015). Towards the “Ultimate Earthquake-Proof” Building: Development of an Integrated Low-Damage System. *Perspectives on European Earthquake Engineering and Seismology* , 321-358.

Roodgar, M., Mahmoudi, M., Ebrahimi, P., & Molaei, D. (2011). Sustainability, architectural topology and green building evaluations of Kashan-Iran as a hot-arid region. *Procedia Engineering 21*, 811-819.

Rosengarten, J. (2018). *Media Planet*. Retrieved from Development and Innovation: http://www.industryandbusiness.ca/development-and-innovation/sustainable-building-considering-more-than-the-bottom-line

Sahebi, Y., Almassi, M., Sheikhdavoodi, M., & Bahrami, H. (2013). Feasability study for replacement of renewable sources of energy, in selected segments Fars Province. *Middle-East Journal of Scientific Research*, 1119-1125.

Sahebzadeh, S., Heidari, A., Kamelnia, H., & Baghbani, A. (2017). Sustainability Features of Iran's Vernacular Architecture: A Comparative Study between the Architecture of Hot-Arid and Hot-Arid-Windy Regions. *Sustainability Volume 9, Issue 5, Article 9*, 1-28.

Saljoughinejad, S., & Rashidi Sharifabad, S. (2015). Classification of climatic strategies, used in Iranian vernacular residences based on spatial constituent elements. *Building Environment, nr 92*, 475-493.

Samari, M. (2012). Sustainable Development in Iran: a Case Study of Implementation of Sustainable Factors in Housing Development in Iran. *International Proceedings of Economics Development and Research vol.37*, 207-211.

Shiraz Monthly Climate Averages. (2018, July 31). Retrieved from World Weather Online: https://www.worldweatheronline.com/shiraz-weather-averages/fars/ir.aspx

Vabi Elements. (2018).

Van der Schaaf, M. (2017). *Education.* Retrieved from Simba Education Environment: https://ngosimba.nl/#education

Van der Schaaf, M. (2017). *Flora & Fauna*. Retrieved from Simba Education Environment: https://ngosimba.nl/#florafauna

Van der Schaaf, M. (2017). *Nature Protection.* Retrieved from Simba Education Environment: https://ngosimba.nl/#nature

Weather data files. (2018). Retrieved from Energy Plus: https://energyplus.net/weather-location/asia_wmo_region_2/IRN/IRN_Shiraz.408480_ITMY

WorldData.info. (2018). Retrieved from Energy consumption in Iran: https://www.worlddata.info/asia/iran/energy-consumption.php

XE Currency Charts. (2018, July 31). Retrieved from XE: https://www.xe.com/currencycharts/?from=IRR&to=EUR&view=12h

List of figures

List of tables

APPENDIX A PROJECT ASSIGNMENT

Project code: S06- Animal hospital and wildlife-rehabilitation care in Yazd, central Iran

Contact person: Marjan van der Schaaf

Description of the project:

Simba Nature Protection and Education Foundation (NGO Simba, 2017) intends to establish an animal hospital and wildlife-rehabilitation care in Iran.

In the hospital many kinds of wild and domestic animals (varying in size from for example a rabitt or a cat to animals with the size of an adult horse or donkey) will receive medical treatment. The hospital will be established for animals which are injured or otherwise in need, but is also open for animal owners who want to have medical treatment for their animals, of course against paying the treatment costs.

Once the injured animals are cured and rehabilitated, wild animals will be returned to nature and domestic animals without an owner will be placed with a new owner or participate in for example dog training programs of Stichting Simba Nature Protection and Education Foundation.

The following demands are important for the animal hospital and wildlife-rehabilitation care:

Technical

- Earthquake proof
- Water, electricity etc. is supplied completely by renewable energy sources such as air to water technology, solar technology and wind energy
- Environmentally friendly techniques for waste water of the centre, recycling of other waste etc.
- European standards
- Affordable
- A zoo-like park environment suitable for the specific landscape surrounding the centre where visitors can enjoy their day

The hospital and wildlife-rehabilitation care

- Entrance / reception
- Treatment rooms
- Operating rooms
- Quarantine space
- Office space
- Spacious indoor and outdoor facilities for large numbers of domestic and wild animals

- Rehabilitation facilities for large numbers of domestic and wild animals

General

- Restaurant / conference centre
- Shops
- Playing area with some playground equipment
- Children farm / educational centre / small museum
- Sufficient housing facilities for staff, volunteers and internship students
- Office space
- Barn / engine house for maintance and the necessary technical equipment
- Indoor parking space for 2 ambulances
- Sufficient parking facilities for visitors, staff and volunteers

Due to these general facilities the hospital and wildlife-rehabilitation care is able to generate its own income and is not depending on continuous funding by Stichting Simba Nature Protection and Education Foundation.

Funding for the establishment of the hospital and wildlife-rehabilitation care will be acquired by general fundraising activities.

Support request:

So far there have been no activities regarding the project whatsoever. This means the first thing which needs to be done is to make a concrete plan, in which all the above ideas are incorporated. The attached technical guidelines can be helpful for this but are only a suggestion which leaves room for improvement.

The necessary size of the park, the land which is needed, the equipment, the engineering, the finances and all other details have to be made concrete and written down in a project plan. The project plan has to be clarified by 2D and 3D drawings, powerpoint presentations etc.

The plan can be used both for fundraising purposes and for the realization of the project and will be the guideline for other animal hospital and wildlife-rehabilitation cares Stichting Simba Nature Protection and Education Foundation wants to establish in other parts of Iran.

Right now we need your help to prepare this plan, in future assistance is also required for the realization of the plan.

General structure:

The facility must be constructed of materials that are safe and strong to enclose the animals in both indoor and outdoor facilities. All facilities will be maintained in good repair. Cages should be designed to minimize human contact with animals.

Indoor facilities for abandoned wildlife or wildlife undergoing medical treatment:

- Wildlife that are injured, ill, or very young may be kept in small enclosures to restrict their activity.

- Wildlife requiring a heat source (such as a heat lamp or heating pad) shall be given room enough in their enclosure to move away from or off the heat source as comfort dictates. Note: Infant or very young wildlife may require a constant heat source.

- Cages shall have visual barriers to minimize the animal viewing humans and/or other species to reduce imprinting, socialization, habituation, or stress.

- The ambient temperature shall remain reasonably constant and compatible with the health of the animal.

- The rooms shall be well ventilated and free of drafts.

- The rooms shall be well lit for the animal‟s comfort and ease in locating food, perches, etc., but cycled to the animal‟s normal photoperiodism. Lighting shall not be excessive or direct, and the animal should have access to a sheltered or darkened area in its enclosure.

- All entrances to indoor facilities shall remain locked when unattended.

Outdoor facilities for rehabilitation of wildlife:

Safety:

- The outdoor facilities shall be built with such materials and in such a manner as to be safe for the wildlife enclosed. There shall be no sharp objects, dangerous corners, points with steeply sloped banks, no toxic paints or stains, or poisonous vegetation.

- A double-door or other protective device on doors (e.g., hanging tarp) shall be provided to reduce the chance of wildlife escaping when humans are entering or leaving the enclosure.

- All outdoor facilities shall remain locked when unattended.

Dimensions:

- The outdoor facility shall be large enough to allow the species adequate space for exercise.

- See attached standards for individual species. Cubic footage (i.e., avian or arboreal species) or square footage (i.e., terrestrial species) equivalents may be substituted for specific dimension listed (unless noted).

Siding and roofing:

- Outdoor facilities for birds shall be well ventilated and shall be constructed of solid walls (consisting of wood, fiberglass, or their equivalent), nylon netting, or plastic-coated wire. No chicken wire, chain-link, or hardware cloth shall be used unless covered with vertical lathe, fiberglass screen, vertical doweling, nylon netting, burlap, or other suitable covering to keep birds from coming in direct contact with the wire.

- Siding shall be sunk below ground level, secured to a wood or concrete base, or otherwise attached to the flooring facilities that house carnivores (bear, coyote, fox, cougar, bobcat, lynx, raccoon, badger, skunk, fisher, marten, river otter, or weasel). Special precautions need to be taken with dangerous mammals such as bear and cougar to prevent them from seeing people. Cages must be designed so that food can be provided and cages cleaned without the animals seeing people (i.e., hatch doors to close animals off in separate cage sections).

- Artiodactyla (deer, mountain goat, mountain sheep, or elk) and carnivores (bear, coyote, fox, cougar, bobcat, lynx, raccoon, badger, skunk, fisher, marten, river otter, or weasel) shall be housed in outdoor facilities that restrict visual and audio contact with humans and domestic animals.

Flooring:

- Flooring shall be suitable for the species and can include concrete, gravel, woodchips, and natural ground.

- Perching birds must be given perches (blocks of wood, sticks, etc.) in the initial and recovering cage floor, allowing them to be elevated above their excrement. Consideration must be made for non-perching birds to avoid contamination with fecal material (i.e., net bottom pens for seabirds).

Cover:

- Outdoor facilities shall provide protected areas where wildlife can retreat from inclement weather, drafts, or direct sun.

- Dens or shelters shall be provided for lagomorphs (rabbits and hares), rodents, insectivores (shrews and moles), and carnivores.

- Visual barriers (e.g., shrubs or bamboo screens) shall be placed in outdoor facilities to allow the wildlife to retreat from human sight, or from other wildlife if housed in groups, to reduce imprinting or habituation to humans, and stress.

Perches for birds:

- Perches shall be the proper size for the species to perch comfortably.

- Perches shall be numerous and spaced to encourage exercise and to provide natural social spacing for grouped birds.

Perches may be constructed of:

- Natural limbs.

- Wood doweling covered with ¼” Astroturf, hemp rope, or indoor/outdoor carpeting for raptors.

- Platforms covered with ¼” Astroturf or indoor/outdoor carpeting for raptors.

- Bow, block, ring, or screen perches for raptors.

Grouping:

- Abandoned wildlife should be raised with others of their species whenever possible to ensure proper species imprinting.
- Incompatible species shall not be housed together.
- If several animals are housed together, they shall each have sufficient space for exercise and be able to maintain normal social distances from one another according to their species.

Special Note: Raptors being rehabilitated using falconry techniques may be kept in facilities as outlined in the falconry regulation.

Food:

- All food for wildlife consumption shall be fresh or frozen, clean, and nutritious.
- Type and amounts of food shall be appropriate to the species, age, and health of the animal.
- Food receptacles shall be kept clean and sanitary, be an appropriate size for the species, and be easily accessible by the animal.
- Wildlife shall be supplemented with vitamins and/or minerals as necessary for their health and growth at the advice of a licensed veterinarian.

Water:

- Water provided to wildlife for drinking shall be fresh and uncontaminated.
- Water receptacles shall be kept sanitary, safe for the animal"s use, and not easily tipped over.
- Water, separate from drinking, shall be provided for species requiring bathing, swimming, or misting necessary for its health, exercise, or behavioral needs.

Sanitation:

- Worming protocols for roundworm control should be instituted under the guidance of a veterinarian to decrease the chances of Toxacara sp and Baylis sp transmission to humans. Feces should be disposed of in a safe manner.

Sanitation – Indoor Facilities:

- Excreta shall be removed frequently from enclosures to prevent wildlife from becoming soiled and to minimize disease, flies and odors. Feces shall be handled with rubber gloves and feces contaminated bedding will be removed daily and disposed of by burying or burning, or treated with appropriate chemicals.

Sanitation – Outdoor Facilities:

- Pens or runs using gravel, sand or dirt shall be sanitized regularly, and completely changed when necessary (depending on size of cage, number of animals contained, etc.), but no fewer than two changes per year.

- Enclosures shall be sanitized after being occupied by any wildlife. Sanitizing may be done by washing with hot water (180 degrees F at source) and soap or detergent, or by washing all soiled surfaces with a detergent solution followed by a safe and effective disinfectant, or by cleaning all soiled surfaces with saturated live steam under pressure.

- Drainage shall be adequate for rapid elimination of excess water from enclosure (both indoor and outdoor). If possible, drainage draining into another pen or pond should be avoided.

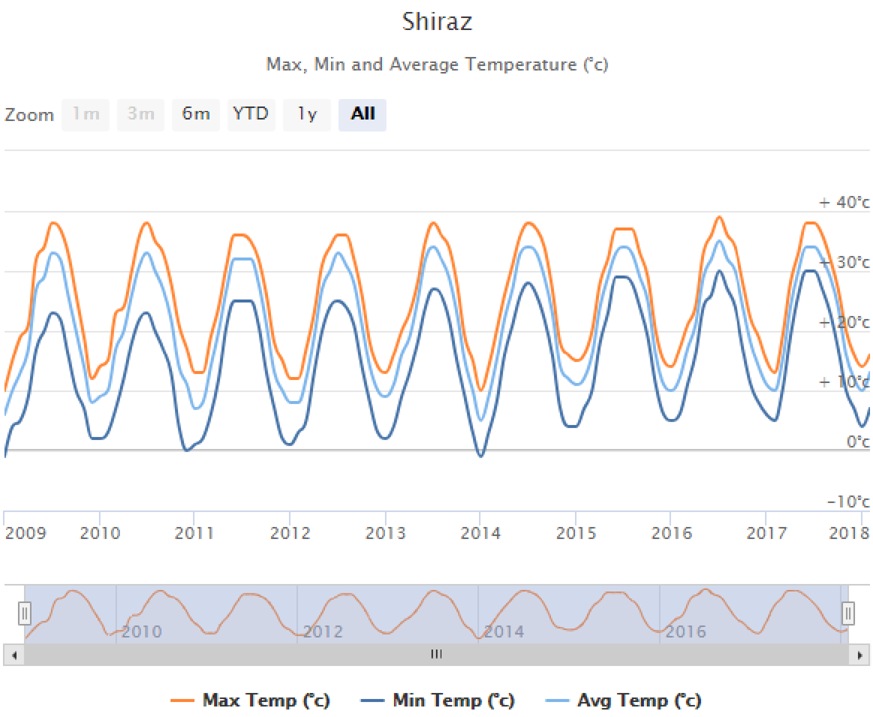
- Quarantine areas shall be available to keep wildlife suspected to have an infectious or transmissible disease separate from other animals in the facility.

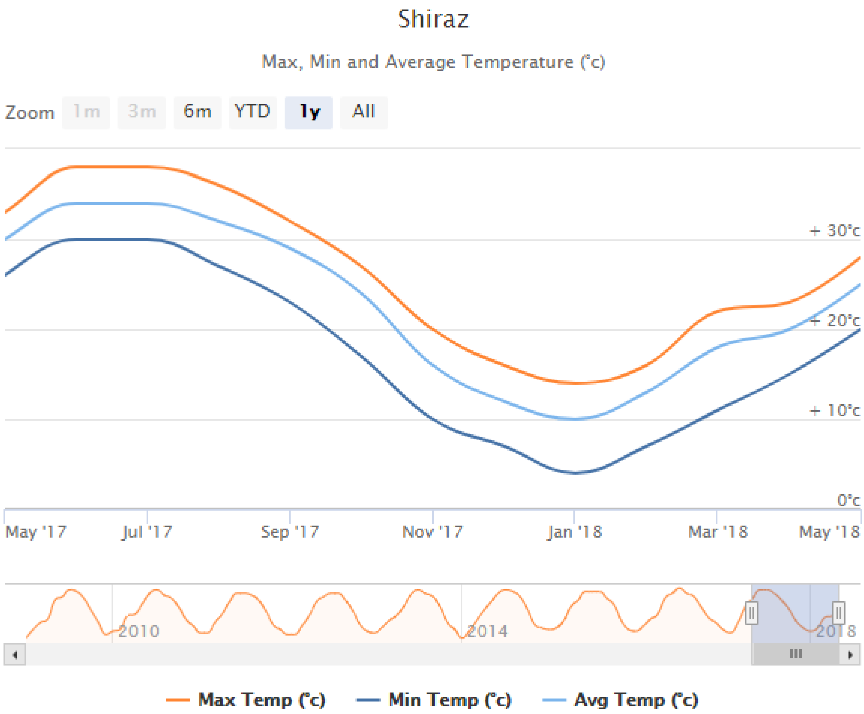
- Trash and garbage shall be removed from the premises frequently to protect the health of the animals and to minimize flies and odors.

- Pest controls shall be established that are safe and effective to eliminate insects and ectoparasites that might affect the health of the animals.

APPENDIX B CLIMATE

TEMPERATURE





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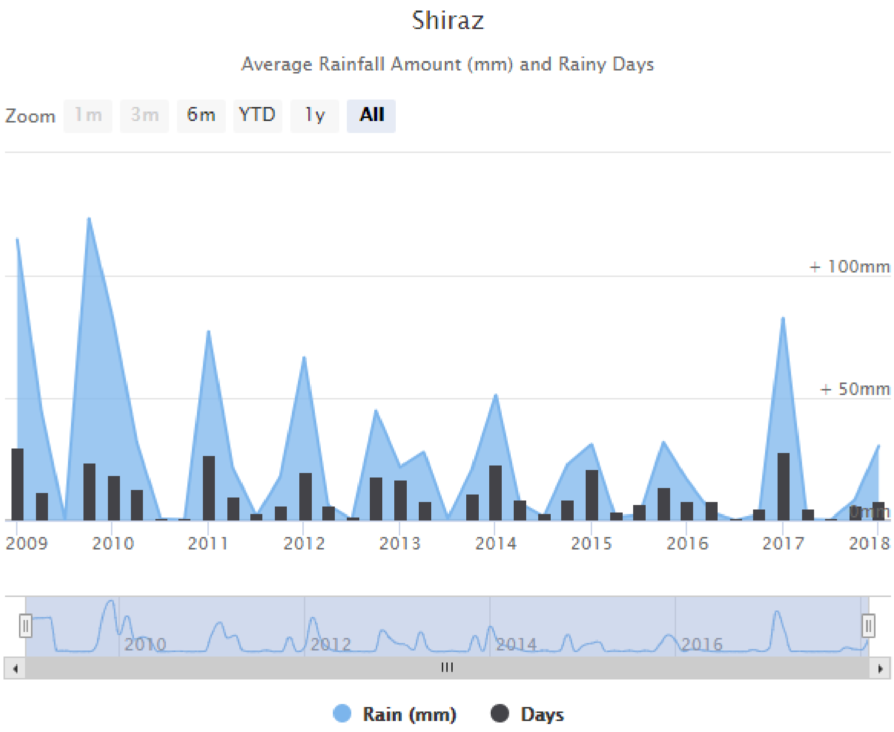
Shiraz
Average Rainfall Amount (mm) and Rainy Days
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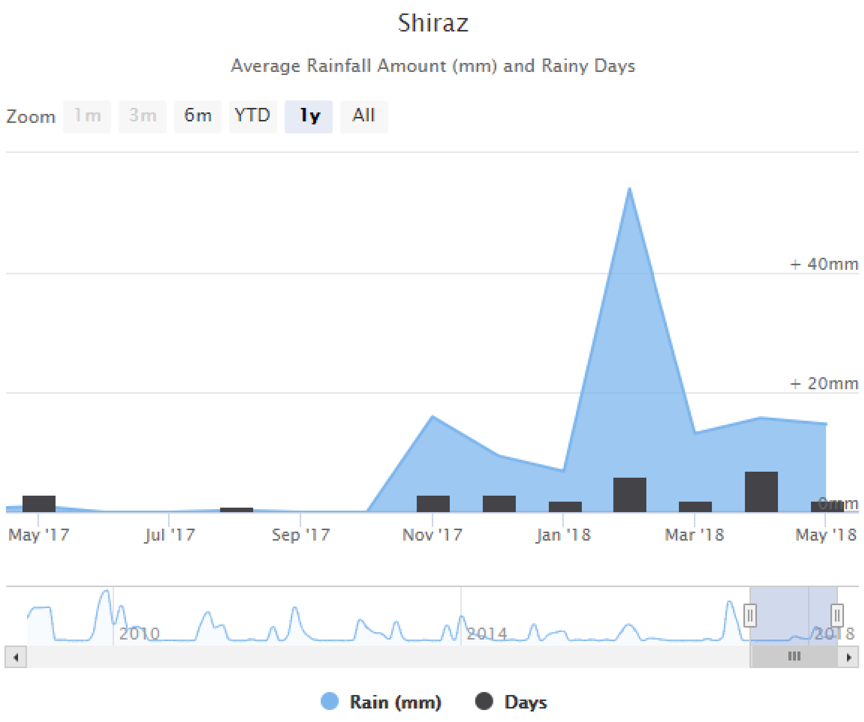
+ 100mm
+ 50mm
0mm
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
2010 2012 2014 2016
Rain (mm) Days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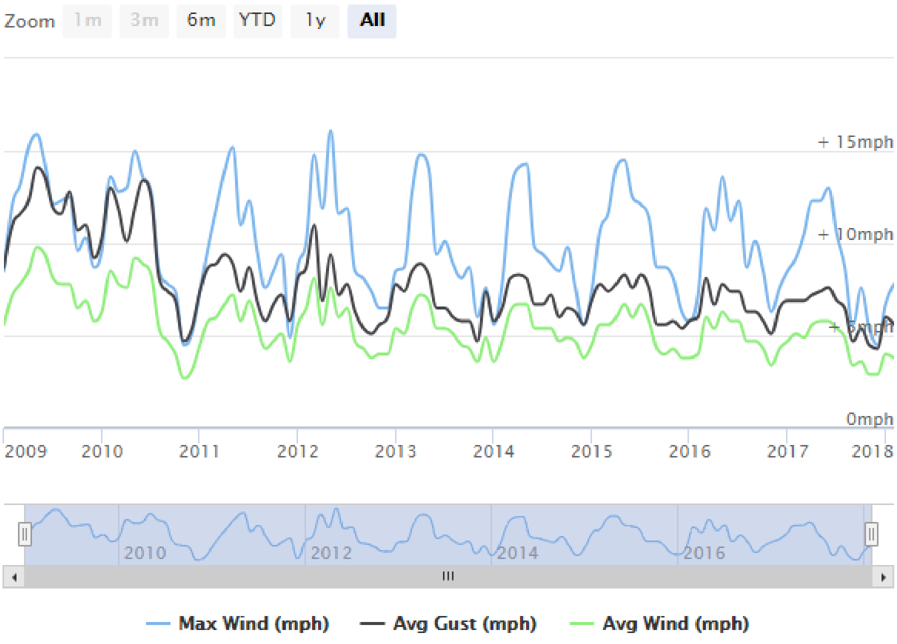
2010 2014 2018
Rain (mm) Days

WIND SPEED

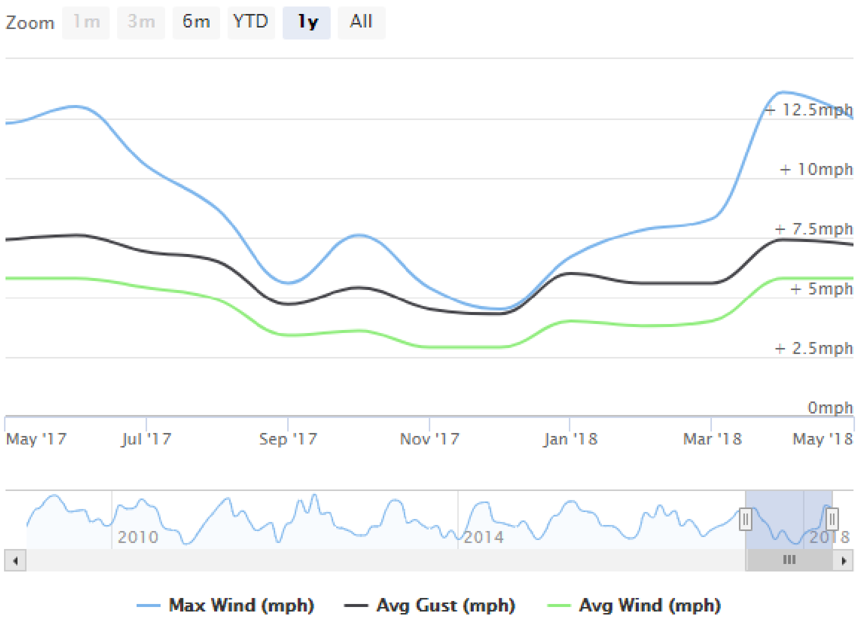
Shiraz

Average and Max Wind Speed and Gust (mph)

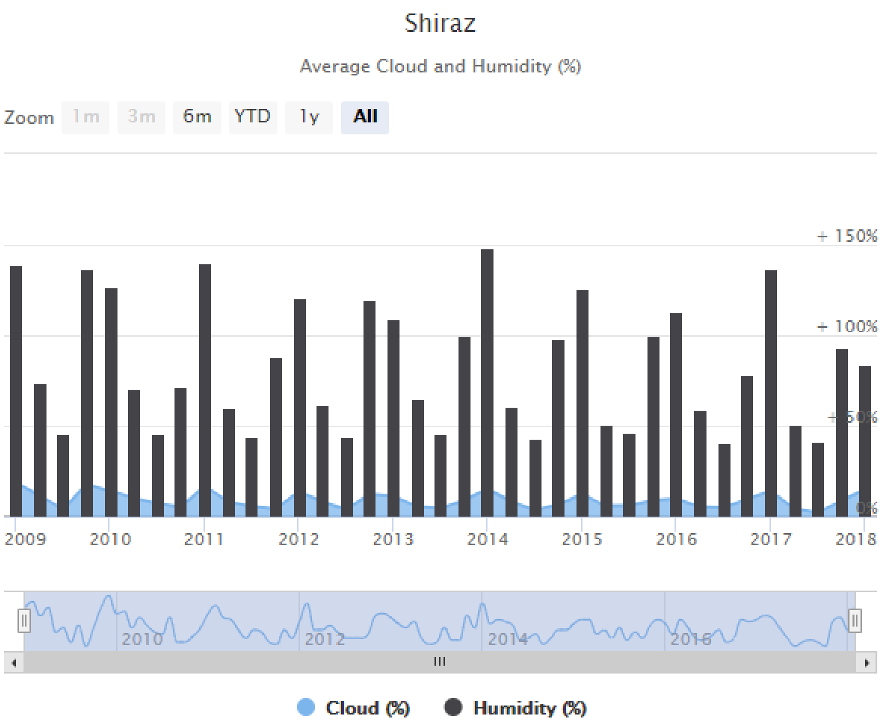


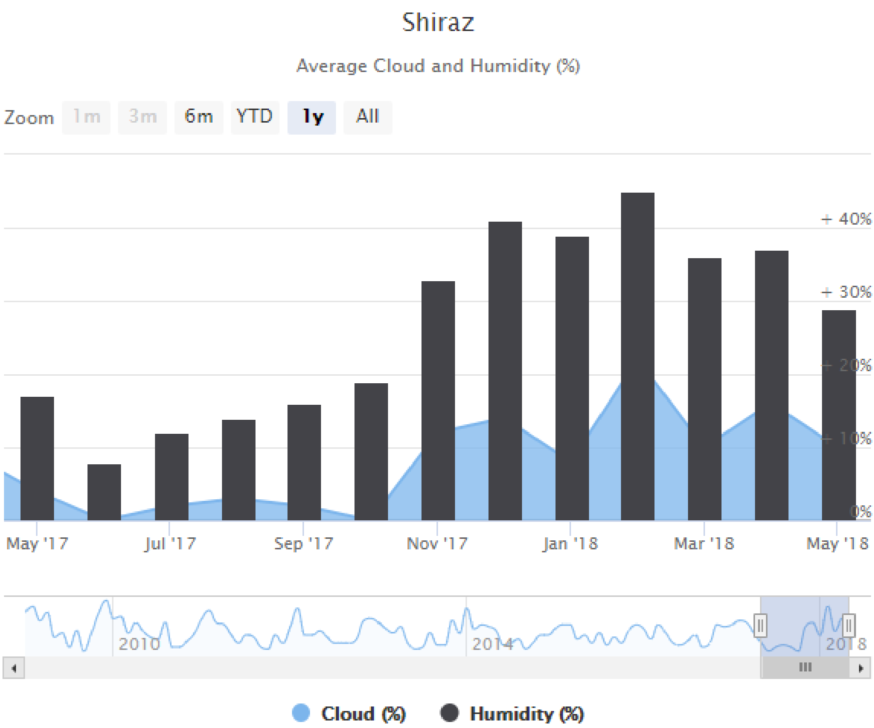
Shiraz

Average and Max Wind Speed and Gust (mph)

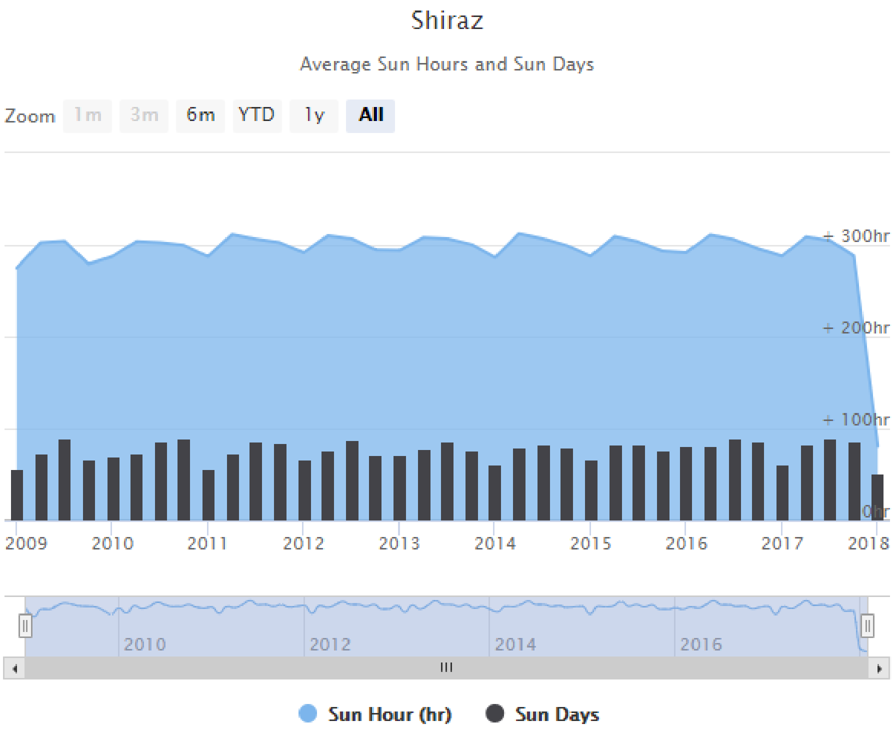


CLOUD AND HUMIDITY





SUN HOURS AND SUN DAYS


Shiraz
Average Sun Hours and Sun Days
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200hr
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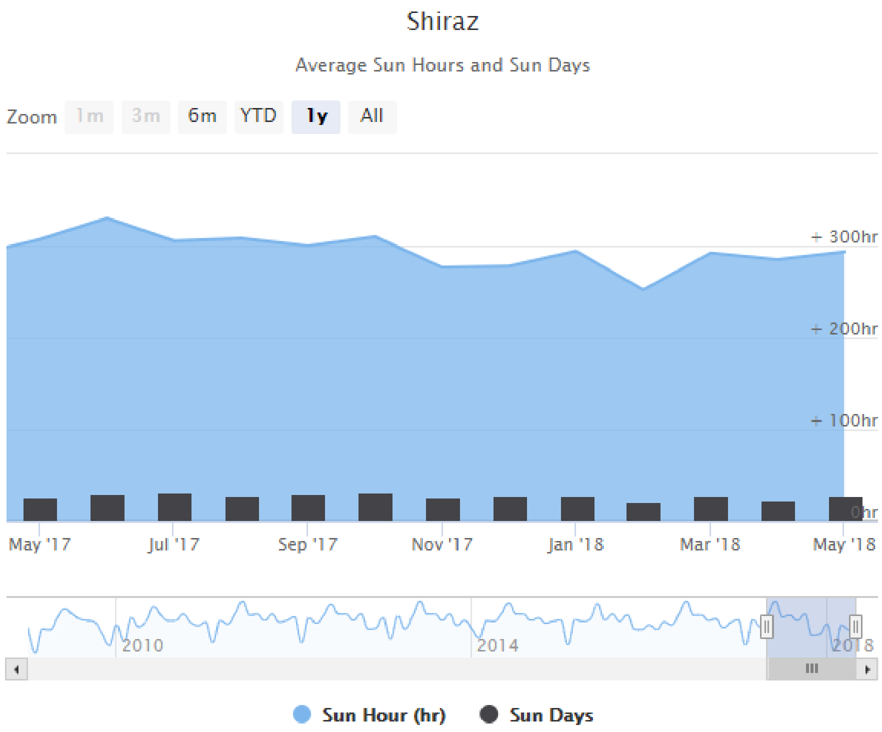
Sun Hour (hr) Sun Days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Average Sun Hours and Sun Days
Zoom 1m 3m 6m YTD 1y All
300hr
200hr
100hr
0hr
May '17 Jul '17 Sep '17 Nov '17 Jan '18 Mar '18 May '18
2010 2014 2018
Sun Hour (hr) Sun Days

APPENDIX C OBJECTIVES

- Animal hospital and wildlife-rehabilitation centre
    - Safe
        - User/non-user
            - Low risk of injuries
            - Low risk of death
            - Provide shelter
        - Building
            - Low risk of collapse
            - Low risk of fire
            - Low risk of intrusion
            - Weather resistant
                - Waterproof
                - Windproof
                - Sunproof
                - Earthquake proof
        - Animals
            - Low risk of injuries
            - Low risk of death
            - Provide shelter
    - Sustainable
        - Minimal energy use
            - Renewable energy
            - Efficienct utilities
        - Minimal water use
            - Rainwater harvesting
            - Air to water technology
            - Reuse wastewater
        - Sustainable production

        - Minimize carbon footprint
        - Use local materials
        - Reduce greenhouse gases
    - Sustainable materials
        - Long life span
        - Low maintenance
        - Recyclable
    - Climate adaption
        - Wind prevention
        - Drought prevention
        - Heat prevention
        - Cold prevention
- Attractive
    - User
        - Practical
            - Working space
            - Lay-out
        - Comfortable
            - Thermal comfort
            - Light/ Lighting
        - Visual appeal
    - Non-user/visitor
        - Visual appeal
        - Blending in with environment
- Accessible
    - User
        - Reachable
        - Emergency services
        - Parking opportunity

        - Non-user/visitor
            - Parking opportunity
- Cost-effective
    - Low building costs
    - Low maintenance costs
    - Low energy costs

APPENDIX D FUNCTIONS

I. Facilitate an animal hospital and wildlife-rehabilitation centre

   a. Provide a centre for animal care and animal stay

      i. Provide medical treatment

         1. Treatment rooms
         2. Operating rooms
         3. Quarantine rooms
         4. Isolation rooms
         5. Illness rooms
         6. Lab
         7. Pharmacy

      ii. Facilitate regular rooms

         1. Reception
         2. Waiting room

      iii. Provide animal housing

         1. Provide indoor facilities

            a. Provide living area

               i. Cage
               ii. Stable

            b. Provide comfort

               i. Sanitation
               ii. Heating
               iii. Lighting
               iv. Ventilation
               v. Space
               vi. Shelter

            c. Provide safety

               i. Locks

         2. Provide outdoor facilities

a. Provide living area
    i. Cage
    ii. Stable
    iii. Exercise area
b. Provide comfort
    i. Sanitation
    ii. Heating
    iii. Lighting
    iv. Space
    v. Shelter
c. Provide safety
    i. Locks
    ii. Fences

b. Provide a living environment for employees
    i. Provide permanent living spaces
        1. Provide living/dining area
            a. Livingroom
        2. Provide sleeping area
            a. Bedroom
        3. Provide cooking area
            a. Kitchen
        4. Provide sanitation
            a. Toilet
            b. Bathroom
    ii. Provide variable living spaces
        1. Provide sleeping area
            a. Bedroom
        2. Provide (shared) cooking area
            a. Kitchen

3. Provide (shared) living area
    a. Livingroom
4. Provide (shared) sanitation
    a. Bathroom
    b. Toilet

c. Provide a working environment for employess
    i. Offices
    ii. Barn
    iii. Sanitation
    iv. Storage facilities
    v. Technical facilities
    vi. Canteen / break room
    vii. Locker room
d. Provide recreation
    i. Provide restaurant
        1. Dining area
        2. Kitchen
        3. Terrace
        4. Storage area
    ii. Provide conference centre
    iii. Provide shops
        1. Fruit
        2. Natural cosmetics
        3. Souvenirs
        4. Pet supplies
    iv. Provide playing area
        1. Playground
        2. Equipment
    v. Provide relaxation areas

1. Zoo-like park
2. Terraces

vi. Provide sanitation

e. Provide education

i. Provide museum

1. Storage
2. Display area
3. Shop
4. Depot
5. Workspace

ii. Provide children farm

iii. Provide educational centre

f. Provide safety

i. Provide a safe structure

1. Structural stability
2. Earthquake resistance

ii. Provide fire safety

1. Escapes routes
2. Fire spread prevention

iii. Provide weather resistance

1. Assure waterproofing
2. Assure windproofing
   a. High walls
   b. Enclosed area
3. Assure sunproofing
   a. Sunblinds
   b. Roofing

iv. Provide shelter

1. Roof

        2. Walls
    v. Prevent animal escapes
        1. Double doors
        2. Locks
        3. Fences
    vi. Prevent crime
        1. Locks
        2. Fences
        3. Security camera
g. Provide utilities
    i. Lighting
    ii. Water
    iii. Heating
    iv. Cooling
    v. Ventilation
h. Provide parking
    i. Parking place visitors
    ii. Parking place employees
    iii. Parking place emergency services
i. Be sustainable
    i. Minimize energy use
        1. Provide renewable energy sources
            a. Attain solar energy
                i. Photovoltaic solar technology
                ii. Solar thermal technology
            b. Attain wind power
                i. Wind turbine
            c. Attain low temperature geothermal energy
                i. Geothermal heatpump + Ground-coupled heat exchanger

d. Attain bio energy

i. Biomass boiler

e. Facilitate energy storage

i. Batteries

2. Minimize heat transfer

a. Floor insulation

b. Wall insulation

c. Roof insulation

d. High-performance glazing

e. High-performance doors

ii. Minimize water use

1. Harvest rainwater

a. Catchment area

b. Conveyance system

c. Storage system

d. Distribution system

2. Reuse wastewater

a. Ozonation

b. Ultrafiltration

c. Aerobic treatment

d. Forward osmosis

e. Reverse osmosis

f. Advanced oxidation

3. Air to water technology

a. Fog fences

b. Atmospheric water generator

iii. Adapte to climate

1. Prevent drought

a. Landscaping

b. Rainwater storage

2. Prevent heat

   i. Light-coloured materials

   ii. Landscaping

   iii. Orientation building

   iv. Insulation

3. Prevent cold

   a. Orientation building

   b. Insulation

4. Prevent wind

   a. High walls

APPENDIX E BUILDING PROPERTIES

Animal hospital and wildlife-rehabilitation centre

General
- Reception
- Office Space
- Restaurant
- Conference Centre

Medical
- Treatment Rooms
- Operating Rooms
- Quarantine Room
- Pharmacy
- X-ray
- Laboratorium

Animal Residency
- Indoor Facilities
  - Cages
  - Rooms
- Outdoor Facilities
- Rehabilitation Facilities

Recreational
- Shops
- Playing Area
- Children Farm/Educational Centre/Museum
- Relaxation areas

Other
- Housing facilities
  - Permanent
  - Variable
- Barn/Engine House
- Parking facilities
  - Visitors
  - Staff

APPENDIX F BUILDING REQUIREMENTS

BUILDING CODE REGULATIONS

TECHNICAL BUILDING INSTRUCTIONS FROM THE POINT OF VIEW OF SAFETY

GENERAL STRENGTH OF THE BUILDING CONSTRUCTION

FUNDAMENTAL LOAD COMBINATIONS

1. The construction does not fail during a lifespan and fundamental load combinations according to NEN-EN 1990

EXTRAORDINARY LOAD COMBINATIONS

1. The construction does not fail during a lifespan and extraordinary load combinations according to NEN-EN 1990.

DETERMINATION METHOD

1. Steel construction NEN-EN 1999 or NEN-EN 1993
2. Stony material NEN-EN 1992 or NEN-EN 1996
3. Steel-concrete NEN-EN 1994
4. Wood construction NEN-EN 1995

STRENGHT DURING FIRE

LENGHT OF TIME SUCCUMB

1. Floor, stairs and escape does not succumb within 30 minutes

2. Does not succumb within 60 minutes in case of fire in adjacent building

DETERMINATION METHOD

1. Extraordinary loadcombinations NEN-EN 1990

2.

a. Steel NEN-EN 1992

b. Stony material NEN-EN 1993

c. Steel-concrete NEN-EN 1994

d. Wood NEN-EN 1995

e. Brickwork NEN-EN 1996

f. Aluminum NEN-EN 1999

g. Fire resistance of materials NEN 6069

STAIRS

DIMENSIONS STAIRS

1. Normal stairs Minimal width: 0,8m

Fire stairs Minimal width: 0,8m

2. Maximum height stairs: 4,0m

LIMITATION OF THE DEVELOPMENT OF FIRE AND SMOKE

INSIDE AREA

1. Fireclass D – NEN-EN13501-1

OUTSIDE AREA

1. Beneath 5m Fireclass D – NEN-EN13501-1

2.Above 5m Fireclass B – NEN-EN13501-1

ROOF AREA

1. Topside roof not flammable – NEN 6063

TECHNICAL BUILDING INSTRUCTIONS FROM THE POINT OF VIEW OF HEALTH

PROTECTION AGAINST SOUND FROM THE OUTSIDE

SOUND FROM THE OUTSIDE

1. External separation construction has a sound-proofing of at least 20dB – NEN 5077

PROTECTION AGAINST SOUND FROM INSTALLATIONS

ADJACENT AND SAME PARCEL

1. Installations cause at most a soundlevel of 30dB

SOUND-PROOFING BETWEEN SPACES

OTHER PARCEL, SAME PARCEL AND WITHIN THE SAME LIVINGSPACE

All according to NEN 5077

PREVENTION OF MOIST

PREVENTION OF MOIST FROM THE OUTSIDE

1. External separation construction of the residental area, toilet and bathroom is waterproof – NEN 2778

2. Internal separation construction between residental area, toilet and bathroom is waterprooft – NEN 2778

4. Separation structure between residental area, toilet and bathroom has a specific airflow of at most $20*10^{-6}$ $m^3/(m^2*s)$ – NEN 2690

TEMPERATURE FACTOR

1. Separation construction with heath resistance as mentioned in **5.**3 has a temperature factor of at least 0,65 relative to the temperature of the indoor area – NEN 2778

WATER ABSORPTION

1. Separation construction of a toilet or bathroom has to a height of 1,2mm above the floor a water absorption average not greater than $0.1kg/(m^2*s^{0,5})$ en nergens hoger dan $0.2kg/(m^2*s^{0,5})$

VENTILATION

VENTILATION ACCOMODATION, RESIDENTAL AREA, TOILET AND BATHROOM

1. Accomodation has a provision of ventilation of at least 0,9 dm^3/s per m^2 with a minimum of 7dm3/s – NEN 1087

2. Residental area has a provision of ventilation of at least 0,9 dm^3/s per m^2 with a minimum of 7dm3/s – NEN 1087

4. A room with a cooker has a provision of ventilation of at least 21 dm^3/s – NEN 1087

6. A toilet has a provision of ventilation of at least $7dm^3/s$ – NEN 1087

7. A bathroom has a provision of ventilation of at least $14dm^3/s$ – NEN 1087

THERMAL COMFORT

1. Air speed supplied are is not greater than 0,2 m/s – NEN 1087

ADJUSTABILITY

1. The provision of supplying fresh air is adjustable from 0-30% capacity and has a lowest setting of at most 10% and highest setting of 100% two different settings that differ at least 10% – NEN 1087

2. The provision of mechanical supply of fresh air has a lowest setting of at most 10% and highest setting of 100% and one more setting – NEN 1087

VENTILATION OTHER ROOMS

1. Traffic space 0,5 dm^3/s per m^2 floor area – NEN 1087

4. Storage room household waste bigger than $1,5m^2$ has a non-closable provision of air supplu with a capacity of at least $10dm^3/s$ per m^2 floor area – NEN 1087

LOCATION OF THE OPENING

1. Supplied air can be only limited contaminated with exhausted air – NEN 1087

- Ventilation dilusion factor of 0,01

3. Inflow and outflow of air at least 2m from parcel boundary

AIR QUALITY

1. The supply of air comes direct from the outside

5. The supply of air for a room with household waste comes direct from the outside and goes direct to the outside

7. There has to be at least a $21dm^3/s$ exhaust of air from a room with a cooker

8. The exhaust of air from a toilet and a bathroom has to go direct to the outside

SPUTTERING FACILITY

CAPACITY

1. Residential area with a sputtering facility has a capacity of at least 6dm^3/s per m^2 floor area – NEN 1087

2. Residental room has a sputtering facility with a capacity of at least 3dm^3/s per m^2 floor area – NEN 1087

SUPPLY OF COMBUSTION AIR AND EXHAUST OF SMOKE

ATTENDANCE

1. Room with heating device has provisions for the supply of combustion air and exhaust of smoke.

THERMAL COMFORT

1. Air speed is not greater than 0,2m/s – NEN 1087

FLOW DIRECTION

1. Smoke flows from the heating device to the air exhaust – NEN 1087

DAYLIGHT

DAYLIGHTAREA

1. Amount of daylight area is at least 10% of total floor area – NEN 2057

2. Residental area has at least 0,5m^2 daylight area – NEN 2057

TECHNICAL BUILDING INSTRUCTIONS FROM THE POINT OF VIEW OF USABILITY

RESIDENTAL AREA AND RESIDENTAL ROOM

ATTENDANCE

1. A living area has at least 18m^2 floor area not common residental area

2. At least 55% is residental area

DIMENSIONS RESIDENTAL AREA AND RESIDENTAL ROOM

1. There is at least 5m^2 floor area

2. Width residental area is at least 1,8m

3. Width residental room is at least 1,8m

4. In residental area lies a residental room with floor area of at least 11m^2 with a width of at least 3m

6. Minimum height of residental area and residental room is 2,6m

TOILET

ATTENDANCE

1.There has to be at least 1 toilet present

DIMENSIONS

1. Toilet has a minimum floor area of 0,9m x 1,2m

2. Disabeld toilet has a minimum floor area of 1,65 m x 2,2m

3. Toilet has a height of at least 2,3m

BATHROOM

ATTENDANCE

1. There has to be at least bathroom present

DIMENSIONS

1. Floor area of at least 1,6m^2 and width of at least 0,8m

2. Bathroom and toilet together have an area of at least 2,2m^2 and a width of at least 0,9m

5. Minimum height bathroom is 2,3m

ACCESSIBILITY

FREE PASSAGE

1. Passage has a free width of at least 0,85m with a height of at least 2,3m

FREE PASSAGE TRAFFIC ROUTE

1. Traffic route has a free width of at least 0,85m with a height of at least 2,3m

OUTSIDE STORAGE

ATTENDANCE, ACCESSIBILITY AND DIMENSIONS

1. Living area has as a side function a closable storage room with a floor area of at least 5m^2 and a width of at least 1,8m with a height of at least 2,3m

3. Storage room is direct accessible from the public road via the connecting terrain

RAIN PROOF

1. Storage room is rain proof – NEN 2778

OUTSIDE AREA

ATTENDANCE, ACCESSIBILITY AND DIMENSIONS

1. Living area has an outside area with a floor area of at least 4m^2 and a width of at least 1,5m that is direct accessible via the living area

POSITIONS

ATTENDANCE

1. Living area has in at least one residential area a position for a kitchen counter and a cooker

2. Living area has a position for a heating device conform the dimensions of the heating devince

3. Living area has a position for a warm water device conform the dimension of the warm water device

DIMENSIONS

1. Position for a kitchen couter has a floor area of at least 1,5m x 0,6m

2. Position for a cooker has a floor area of at least 0,6 x 0,6m

TECHNICAL BUILDING INSTRUCTIONS FROM THE POINT OF VIEW OF ENERGY SUFFIENCY AND ENVIRONMENT

ENERGY SUFFICIENCY

ENERGY PERFORMANCE COEFFICIENT

1. EPC (living area) of at least 0,4 – NEN 7120
2. EPC (health area) of at least 0,8 – NEN 7120
3. EPC (retail area) of at least 1,7 – NEN 7120

THERMAL INSULATION

1. Heat resistance of vertical outside wall, toilet and bathroom is at least 4,5m^{2}K/W – NEN 1068
2. Heat resistance slanted and horizontal outside wall, toilet and bathrom is at least 6,0m^{2}K/W – NEN 1068
3. Heat resistance of separation wall is at least 3,5m^{2}K/W – NEN 1068
5. Heat resistance internal separation structure is at least 4,5m^{2}K/W – NEN 1068
6. Heat resistance windows, doors and frames is at most 2,2W/m^{2}K and an average of 1,65W/m^{2}K– NEN 1068

AIR VOLUME FLOW

1. Total of air volume flow residental areas, toiet and bathrooms is at most 0,2m^3/s – NEN 2686

ENVIRONMENT

BUILDING SUSTAINABLE

1. The exhaust of greenhouse gases and the depletion of raw materials of the composition of construction parts is quantified

TECHNICAL BUILDING INSTRUCTIONS FROM THE POINT OF VIEW OF INSTALLATIONS

LIGHTING

LIGHTING ESCAPE ROUTE

4. Enclosed room where via an escape route leads has a lighting installation of at least 1 lux

CONNECTION ON PROVISION FOR ELECTRICITY

1. Lighting installation is connected to a provision for electricity as mentioned in 6.8

PROVISION FOR TAKING AND USING ELECTRICITY

PROVISION FOR ELECTRICITY

1. Provision for electricity satisfies for
    a. Low voltage – NEN 1010

WATER SUPPLY

DRINKING WATER SUPPLY

1. Supply of drinking water satifies for NEN 1006

WARM WATER SUPPLY

1. Supply of warm water satisfies for NEN 1006

DRAINAGE OF DOMESTIC WASTE WATER AND RAINWATER

DRAINAGE OF DOMESTIC WASTE WATER

1.Living area has a provision for the drainage of domestic waste according to NEN 3215

DRAINAGE RAINWATER

1. The roof has a provision to catch and drain rainwater according to NEN 3215

2. Provision for cathing and draining rainwater is airtight and watertight according to NEN 3215

DETERMINATION OF FIRE

SMOKE DETECTORS

1. An enclosed room where via an escape route leads has one or more smoke detectors according to NEN 2555

FIRE ESCAPES

DOORS IN ESCAPE ROUTES

1. The door of an escape route does not turn against the flight direction

SELF CLOSING DOORS

1. A door needs to be self closing in case of a fire to resist the fire

FIGHTING FIRE

PROVISION FIRE WATER

1. The construction has a sufficient fire water provision

3. Distance between fire water provision and fire brigade entrance is at most 40m

4. Fire water provision is unlimited accessible

ACCESSIBILITY OF EMERGENCY SERVICES

ACCESSIBILITY CONSTRUCTION FOR EMERGENCY SERVICES

1. Between public road and construction is a connection road that is suitable for emergency services

ACCESSIBILITY OF BUILDING FOR DISABLED PEOPLE

ACCESSIBILITY

1. Path to the building has a width of at least 1,1m

PREVENTION OF CRIME

PREVENTION OF COMMON CRIME

1. Doors can be locked

SAFE MAINTENANCE OF BUILDING

SAFETY MEASURE FOR MAINTENANCE

1. Maintenance need to be performed safely

ELECTRONIC COMMUNICATION

ACCESSPOINT

1. There is access to a connection to a electronic communication network

OTHER REGULATIONS

REGULATIONS RESTAURANT

1. At least one catering location present with a floor area of at least 35m2
2. A catering location needs to have a height of 2,6m according to the Building Code
3. A catering location has a good functioning mechanical ventilation equipment that has a direct connection with the outside air en has a ventilation capacity of 3,8 x 10^3 m3/s per m2 of floor area. This means a ventilation frequency of 5,7 times per hour with a height of the room 2,6m.
4. There must be a facility to provide electricity
5. There must be a water facility to provide fresh drinkwater for consumption and hygiene.
6. There must be a facility to make a phone call
7. In the premises of the catering location are at least two complete and seperate toilet facilities available
8. Every toilet facility contains at least one or more decent and closable toiletrooms and one or more facilities to clean hands with good running water
9. The toilet facilities are not directly accessible from the catering location

Source: (Horeca Nederland, 2018)

REGULATIONS KITCHEN

OTHER REGULATIONS BUILDING CODE

- Reception and storage of incoming goods
- Preparation space for cold and hot products
- Emmission space for prepared meals
- Dishwashing area

REGULATIONS HACCP

- “Dirty and clean lines” do not cross each other by seperating them physically

- Preventing the occurence of rodents by using the right materials
- The use of materials that are easy to clean.

REGULATIONS FIRE PREVENTION

- Fire extinguisher
- Fire blanket
- Evacuation plan
- Escape routes
- Smoke detectors

ARBO REGULATIONS

- Working areas on the correct height
- A work area without bumps so that delivery **cars** can enter easily
- Sufficient daylight
- Anti slip flooring

REGULATIONS ENVIRONMENT

- Seperating fat
- Air suction devices with filters

GUIDELINES TYPE OF RESTAURANT

- Middle-class restaurant
- Capacity: 1,25-1,75 m2 per guest (earning area)
- Non-earning area is 60% of earning area
- Non-earning area is kitchen, wardrobe, storage etc.
- Goal is to accomadate 50 visitors
- Earning area = 50 x 1,50= 75m2
- Non-earning area = 75 x 0,6 = 45m2
- Total area = 120m2

APPENDIX G ANIMAL HOSPITAL REQUIREMENTS

ANIMAL HOUSEKEEPING AND ANIMAL CARE

- Animals have sufficient freedom of movement
- The space and materials are adapted to physiological and ethological needs the animal naturally has
- The animals are protected against bad weather conditions in case of outside housing
- The space hinders the natural behaviour of the animals as least at possible
- A pregnant animal has sufficient en suitable nesting space
- An animal does not experience any fear or stress due to its housing
- The quantity of animals and the composition of the animal species is such that the healt and well being of the animals is not harmed

HOUSEKEEPING SICK ANIMALS

An animal shelter needs to have three rooms (in the Netherlands)

- Quarantaine room; for animals from whom the health and vaccination status is unknown. An animal with such a status has to be placed in that room for 7 days after the vaccinations
- Isolation room; for animals that (may) have a contagious illness
- Illness room; Room for animals which are sick but not contagious

These rooms have to be fully separated from all the other rooms (illness room as an exeption)

HEALTH PROTOCOL

Animal health has to be checked on a daily basis and measures have to be taken against diseases and sick animals have to be properly taken care of.

OPEN STANDARDS

New regulation states that animals need to have sufficient freedom of movement and adequate space. For cats and dogs the minimum standards of the dog and cat decree are taken in to account.

APPENDIX H ANIMAL REQUIREMENTS

Dogs

Quantity: 100

Area required per dog: $3.0m^2$, with short side at least 1.2m and height 1.8m

Total area required: $300m^2$ (indoor and outdoor)

Cats

Quantity: 50

Area required per cat: $0.85m^2$ per 2 cats, with short side at least 0.65m and height 0.6m

More than 2 cats: $3.0m^2$ and above 5 cats for every additional cat $0.6m^2$

Total area required: $30m^2$ (indoor and outdoor)

Horses

Quantity: 10

Area required per horse: Indoor: $8m^2$ per horse

Outdoor: $1000m^2$ per 5 horses and every additional horse $100m^2$

Total area required: Indoor: $80m^2$

Outdoor: $1500m^2$

Donkeys

Quantity: 25

Area required per donkey: Indoor: $8m^2$ per donkey

Outdoor: $1000m^2$ per 5 donkeys and every additional donkey $100m^2$

Total area: Indoor: $200m^2$

Outdoor: $3000m^2$

Gazelles

Quantity: 50

Area required per gazelle: Indoor: $4m^2$ per gazelle

Outdoor: $500m^2$ per 10 gazelles and every additional $40m^2$

Total area required: Indoor: $200m^2$

Outdoor: $2100m^2$

Deer

Quantity: 50

Area required per deer: Indoor $4m^2$ per deer

Outdoor: $500m^2$ per 8 deer and every additional $60m^2$

Total area required: Indoor: $200m^2$

Outdoor: $3020m^2$

Cheetahs

Quantity: 10

Area required per leopard: Indoor: $25m^2$ per 2 leopards and for every additional $12m^2$

Outdoor: $50m^2$ per 2 leopards and for every additional $15m^2$

Total area required: Indoor: $121m^2$

Outdoor: $170m^2$

Leopards

Quantity: 10

Area required per leopard: Indoor: $25m^2$ per 2 leopards and every additional $12m^2$

Outdoor: $50m^2$ per 2 leopard and every additional $15m^2$

Total area required: Indoor: $121m^2$

Outdoor: $170m^2$

Wolves

Quantity: 10

Area required per wolf: Indoor: $12m^2$ per 2 wolves and every additional $6m^2$

Outdoor: $100m^2$ per 2 leopards and every additional $20m^2$

Total area: Indoor: $60m^2$

Outdoor: $260m^2$

Foxes

Quantity: 15

Area required per fox: Indoor: $8m^2$ per 2 foxes and every additional $1m^2$

Outdoor: $30m^2$ per 2 foxes and every additional $4m^2$

Total area: Indoor: $21m^2$

Outdoor: $82m^2$

Sheep

Quantity:	50
Area required per sheep:	Indoor: $4m^2$ per sheep
	Outdoor: $400m^2$ per 8 sheep and every additional $40m^2$
Total area:	Indoor: $200m^2$
	Outdoor: $2080m^2$

Goats

Quantity:	50
Area required per goat:	Indoor: $4m^2$ per goat
	Outdoor: $400m^2$ per 4 goats and every additional $50m^2$
Total area:	Indoor: $200m^2$
	Outdoor: $2700m^2$

Rabbits

Quantity:	20
Area required per rabbit:	Outdoor: $20m^2$ per 5 rabbits and every additional $2m^2$
Total area:	Outdoor: $50m^2$

Rats and mice

Quantity:	30
Area required per rat:	Indoor: $5m^2$ per 2 rats and every additional $1.5m^2$
Total area:	Indoor: $42m^2$

Reptiles and amphibians

Quantity:	30
Area required per reptile:	Land: $3m^2$ per 2 reptiles and every additional $1m^2$
	Water: $3m^2$ per 2 reptiles and every additional $1m^2$
Total area:	Land: $58m^2$
	Water: $58m^2$

Birds

Quantity:	200
Area required per bird:	Pray bird (25): $20m^2$ per 2 birds and every additional $8m^2$

	Regular birds (175): 12m^2 per 8 birds and every additional 1m^2
Total area:	Pray birds: 204m^2
	Regular birds: 179m^2

Wild boars

Quantity:	2
Area required per boar:	Indoor: 4m^2 per boar
	Outdoor: 100m^2 per 2 boars
Total area:	Indoor: 8m^2
	Outdoor: 100m^2

Oxes

Quantity:	2
Area required per ox:	Indoor: 8m^2 per ox
	Outdoor: 200m^2 per 2 oxes
Total area:	Indoor: 16m^2
	Outdoor: 200m^2

Camels

Quantity:	10
Area required per camel:	Indoor: 8m^2 per camel
	Outdoor: 300m^2 per 3 camels and every additional 50m^2
Total area:	Indoor: 80m^2
	Outdoor: 650m^2

Tigers / lions

Quantity:	10
Area required per tiger:	Indoor: 30m^2 per 2 tigers and every additional 15m^2
	Outdoor: 80m^2 per 2 tigers and every additional 20m^2
Total area:	Indoor: 150m^2
	Outdoor: 240m^2

Small predators

Quantity:	20

Area required per pred.:	Indoor: $16m^2$ per 2 predators and every additional $4m^2$
	Outdoor: $16m^2$ per 2 predators and every additional $4m^2$
Total area:	Indoor: $88m^2$
	Outdoor: $88m^2$

APPENDIX I DECREE KEEPERS OF ANIMALS

KEEPING OF ANIMALS

1. The freedom of movement of an animal shall not be limited in such a way that the animal suffers, or harm is inflicted.
2. An animal shall have enough space for its physological and ethilogical needs.
3. An animal shall, if kept outside, be provided with shelter against bad weather conditions, health risks and predators.
4. The keeper of the animal that is placed in a building or a cage makes sure that the animal can not escape from that location.

HOUSING

1. A room where an animal is kept, shall be sufficient lit and darkened to meet the physiological and ethological needs of the animal.
2. Animal housings, such as the floor, where an animal resides, and establishments for shelter of the animal, shall be designed, built and maintained in such a way that is does not harm or injure the animals of inflicts pain. And, it does not have sharp edges or projections on which the animal can harm itself.
3. In the room where the animal is kept, no materials will be used that are unfit or harmful for the animal.
4. The materials used can simply be cleaned and disenfected.

HOUSING AND CARE

1. A companion animal is being kept in a therefor sufficient room. This means at least:
    a. The animal has sufficient freedom of movement;
    b. The room and the used materials are adapted to the physological and ethological needs of the animal;
    c. The animal needs to be protected against bad weather conditions, predators and health risks;
    d. If an animal is pregnant, the animal shall have enough and appropriate nesting space;
    e. The animal should not experience any unnecessary fear or stress due to its housing facilities;
    f. The quantity and composition of animals and animal species shall be in such way that is does not influence the health of the animal in a negative way.

HOUSING OF SICK AND SUSPECTED TO BE SICK ANIMALS

1. A facility features at least three seperate rooms for housing and care of sick and possible sick animals.
2. The in the first section mentioned rooms are:
    a. A quarantine room for (companion) animals who arive at the hospital and the health status is unknown or the vaccination status is unknown or incomplete;
    b. An isolation room for (companion) animals that are suspected of a contagious disease or has clinical symptoms of a contagious disease;
    c. A room for the housing of (companion) animals that are ill, but do not have a contagious disease or are suspected of carrying a contagious disease.
3. (Companion) animals, as mentioned in the second decree of rooms, are being kept solitary, unless it is not necessary from a veterinary standpoint.

4. The rooms, as mentioned in the second decree, parts a and b, are fully seperated from the facility.
5. The room, as mentioned in the second decree, part c, can be a part of the indoor stay of the facility that can be seperated from the other housing facilities and animals.

REVIEW

1. A permit (in case of a zoo) is given if the following demands are met:
   a. if during the establishment of the animal housings the following aspects are taken in to account:
      - the species moving behaviour, by facilitating the stay with as much as possible elements similar to its natural habitat;
      - the climate the animal naturally lives and its own biorytmh, by providing the animal stay with adequate shelter, protection against extreme weather conditions and adequate climatecontrol and lighting;
      - the species social behaviour, by providing the stay with solitary housing of for the species adequate rest and shelter place, and in case of grouphousing a rest and shelter place that offers the animal the possibility to isolate itself from other animals;
      - the species mating behavior, by separating the animals at an adequate manner of by providing the stay with provisions that make species mating behavior possible;
      - the species excretion behavior, by facilitating the stay with an adequate excretion site for the species;
      - the space that is necessary to keep all the animals that are expected;
   b. the animal stays are provided with an adequate separation that prevents the outbreak of animals and are a safe barrier between the animals and visitors;
   c. the facility is equiped with a quarantaine room and a treatment room;

Article 8

1. The facility features indoor stays
2. If in the facility animals are being kept, the facility needs to contain one or more multiple outdoor stays or playing areas.
3. An indoor or outdoor stay meets the following conditions:
    a. the floor, the walls, the gates or the fences are made from such materials that the animals can not get injured or poisened by them;
    b. the floor is made of liguid-tight and stiff material;
    c. it has upright wall, with at least one of the walls made in such a way that the animals can look outside the stay, and it can be locked off.
4. An indoor stay meets the following conditions:
    a. It is frost free, draft free and dry;
    b. It can be ventilated sufficiently;
    c. It can be lit by an electric light installation;
    d. During daytime it is sufficiently lit by daylight, and the ambient temperature is at most 30 degrees Celsius.
5. Unless an outdoor stay has a direct connection to an indoor stay, an outdoor stay is partially roofed, such that is provides cover against weather influences like sun, precipitation and wind.
6. A playing area meets the following conditions:
    a. It is part of the facility;
    b. The fence is of such material that the animals can not get injured or poisoned by it, and the area can be locked off.

Article 9

1. A facility features one or more sickbays in which one or more indoor stays are applied, that in total can provide at least one tenth of all the dogs and cats in the facility.
2. A sickbay that, to prevent contamination, can be seperated from other indoor stays.

Article 10

1. A facility features one or more quarantine rooms in which one or more indoor stays are applied, that in total can provide at least one tenth of all the dogs and cats in the facility.
2. The quarantine room is arranged in such a way that contamination between the animal species themselves is prevented.

Article 11

1. Dogs and cats are not placed with each other in one stay (indoor or outdoor).
2. If more than one dog is present in the facility, at least 2 and at the most 20 dogs are placed together in an indoor or outdoor stay.
3. If more than one cat is present in the facility, at least 2 and at the most 20 cats are placed together in an indoor or outdoor stay.
4. Every dog or cat has in the indoor or outdoor stay continous access to a facility that provides drinking water, unless this is not suitable because of health reasons.

Article 12

1. An indoor and outdoor stay for dogs has a height of at least 1,8 meter.
2. The for dogs available floor area in square meters is in the indoor and outdoor stays with a withers:

   a. until 0,3 meter, at least equal to the product of (1+n) and 1,0;
   b. from 0,3 meter to 0,5 meter, at least equal to the product of (1+n) and 1,2;
   c. from 0,5 meter, at least equal to the product of (1+n) and 1,5,
   d. where the shortest side is at least 1,0 meter, as in part a, and at least 1,2 meter, as in part b and c, where the letter n is for the quantity of dogs with the concerned withers that is situated with eacht other in the indoor or outdoor stay. If dogs of different sizes are placed together the withers of the biggest dog is taken in to account for the calculation of the floor area.
3. The second decree is of a corresponding application to:
   a. The total available floorarea of a connected indoor and outdoor stay of a facility, when there is an open connection between the indoor and outdoor stay and the available floor area is the indoor stay is at least 2,25 m^2;
   b. the available area of the outside playground

Article 13

1. The for the cats available room in the indoor or outdoor stay is at least:
   a. 0,85 m^2 of floor area when 2 cats are placed together, with the short side of the area is at least 0,65 meter and the height of the indoor or outdoor stay is at least 0,6 meter;
   b. 3 m^2 of floor area when more than 2 cats are placed together, increased with 0,6 m^2 of floor area for every cat above 5, with the short side of the area is at least 1 meter and the height of the indoor or outdoor stay is at least 1,8 meter.
2. In the indoor stays are from 0,15 meter above the floor resting places with a length of at least 0,35 meter and a width of at least 0,20 meter.

Article 14

1. In deviation with article 11, 2nd and 3rd decree:
   a. A dog or cat in a quarantine room is housed solitary;
   b. A dog of cat will be housed solitary if the health or well being of the dog or cat, or other dogs or cats, allows this.
2. In deviation with article 12, second decree, with solitary housing the available space for a dog is:
   a. a dog with withers until 0,3 meter at least 2 m^2 of floor area, with the short side at least 1 meter and the height of the indoor or outdoor stay at least 1,8 meter;
   b. a dog with withers of 0,3 meter until 0,5 meter at least 2,4 m^2 of floor area, with the short side of at least 1,2 meter and the height of the indoor or outdoor stay at least 1,8 meter;
   c. a dog with withers from 0,5 meter at least 3 m^2 of floor area, with the short side at least 1,2 meter and the height of the indoor and outdoor stay of at least 1,8 meter.
3. With solitary housing the available room for a cat is at least 0,47 m^2 of floor area, with the short side at least 0,65 meter and the height of the indoor or outdoor stay is at least 0,6 meter.
4. With solitary housing the available rom for a tomcat that is kept for breeding purposes a floor area of at least 6 m^2 is needed, with the short side at least 1 meter and the height of the indoor and outdoor stay at least 1,8 meter.

Article 15

1. Every pregnant and nursing dog has in the indoor stay a place to nest.
2. The short side of the nesting place, as mentioned in the first decree, has a length of at least twice the withers of the dog or cat where the nesting place is meant for.

3. Every dog has in the indoor or outdoor stay the availability of a clean and dry berth that insulatest the cold that arises from the floor of the room.

Article 17

A dog has to be given the opportunity to spent two hours a day in an outdoor stay or playing area, as mentioned in article 8, second decree.

Article 18

1. A facility is cleaned daily and regularly disinfected.
2. In rooms where cats and dogs are kept no death animals are saved.

APPENDIX K BUILDING ENVELOPE

GROUND FLOOR

MATERIAL	THICKNESS (MM)	THERMAL CONDUCTIVITY (W/M*K)	DENSITY (KG/M^3)	SPECIFIC HEAT (J/KG*K)
LINOLEUM FLOORING	2.5	0.170	1200	1470
SCREED	50	1.300	2000	840
REINFORCED CONCRETE	300	1.900	2500	840
INSULATION (EPS)	116	0.035	15	1470

Rc-value	3.51 m^2*K/W
Floor density	851.74 kg/m^2
Total thickness	446 mm

1ST FLOOR

MATERIAL	THICKNESS (MM)	THERMAL CONDUCTIVITY (W/M*K)	DENSITY (KG/M^3)	SPECIFIC HEAT (J/KG*K)
LINOLEUM FLOORING	2.5	0.170	1200	1470
SCREED	50	1.300	2000	840
REINFORCED CONCRETE	300	1.900	2500	840
INSULATION (EPS)	116	0.035	15	1470
GYPSUM PLASTERBOARD	13	0.230	90	840

Rc-value	3.51 m^2*K/W
Floor density	851.74 kg/m^2
Total thickness	446 mm

EXTERNAL WALL

MATERIAL	THICKNESS (MM)	THERMAL CONDUCTIVITY (W/M*K)	DENSITY (KG/M^3)	SPECIFIC HEAT (J/KG*K)
BRICKWORK	100	0.800	2100	840
CAVITY	40	-	-	-
INSULATION (EPS)	145	0.035	35	840

GYPSUM PLASTERBOARD	13	0.230	90	840

Rc-value	4.50 m^2*K/W
Wall density	226.82 kg/m^2
Total thickness	298 mm

INTERNAL WALL

MATERIAL	THICKNESS (MM)	THERMAL CONDUCTIVITY (W/M*K)	DENSITY (KG/M^3)	SPECIFIC HEAT (J/KG*K)
GYPSUM PLASTERBOARD	13	0.230	900	840
INSULATION (MINERAL WOOL)	46	0.035	35	840
GYPSUM PLASTERBOARD	13	0.230	900	840

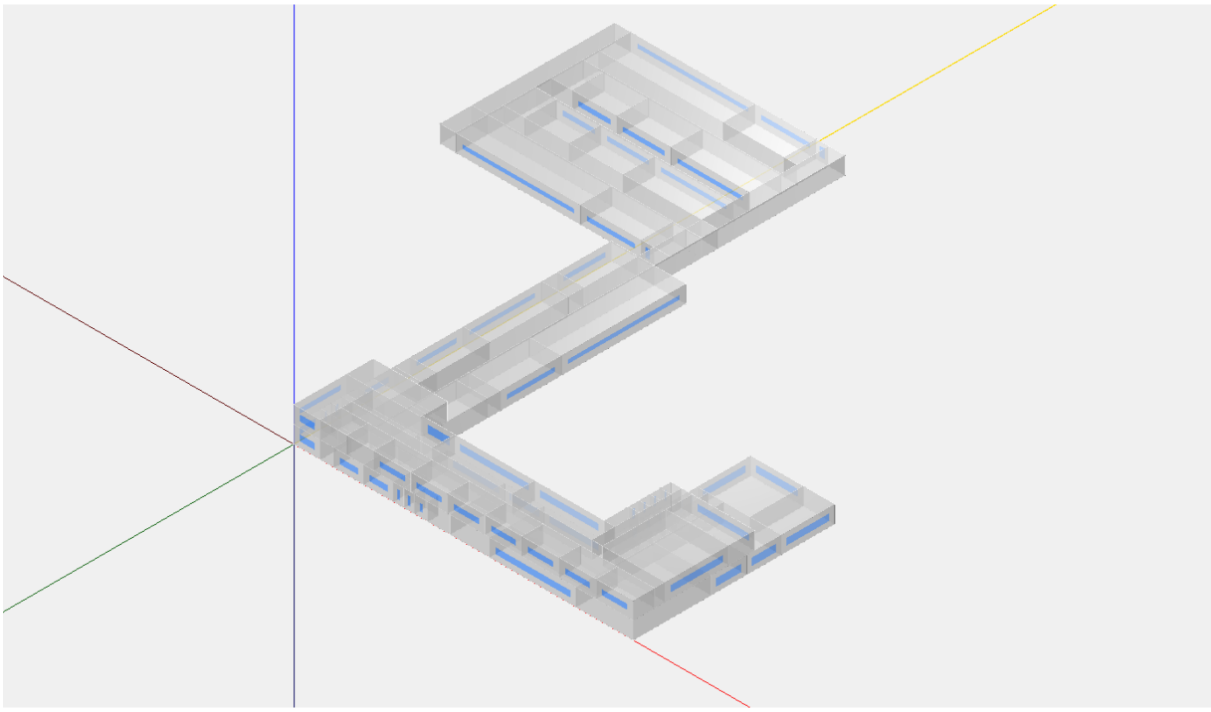
Rc-value	1.42 m^2*K/W
Wall density	23.21 kg/m^2
Total thickness	70 mm

ROOF

MATERIAL	THICKNESS (MM)	THERMAL CONDUCTIVITY (W/M*K)	DENSITY (KG/M^3)	SPECIFIC HEAT (J/KG*K)
BITUMEN	3	0.170	1200	1470
CHIPBOARD	25	0.100	450	1880
INSULATION (MINERAL WOOL)	193	0.035	35	840
CAVITY	70	-	-	-
GYPSUM PLASTERBOARD	13	0.230	900	840

Rc-value	6.00 m^2*K/W
Roof density	33.38 kg/m^2
Total thickness	304 mm

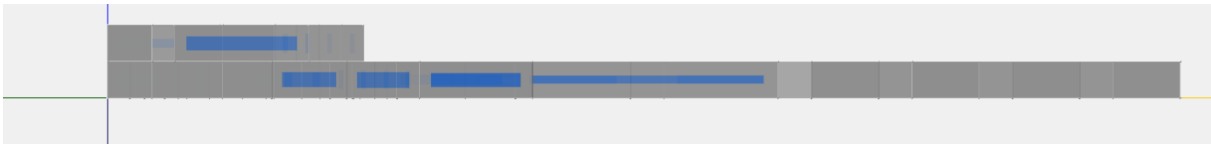
Top view



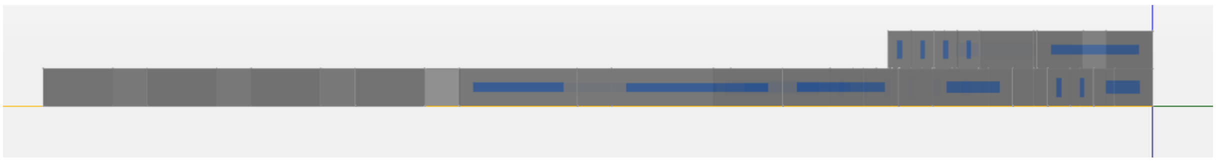
Front view (South)

Back view (North)

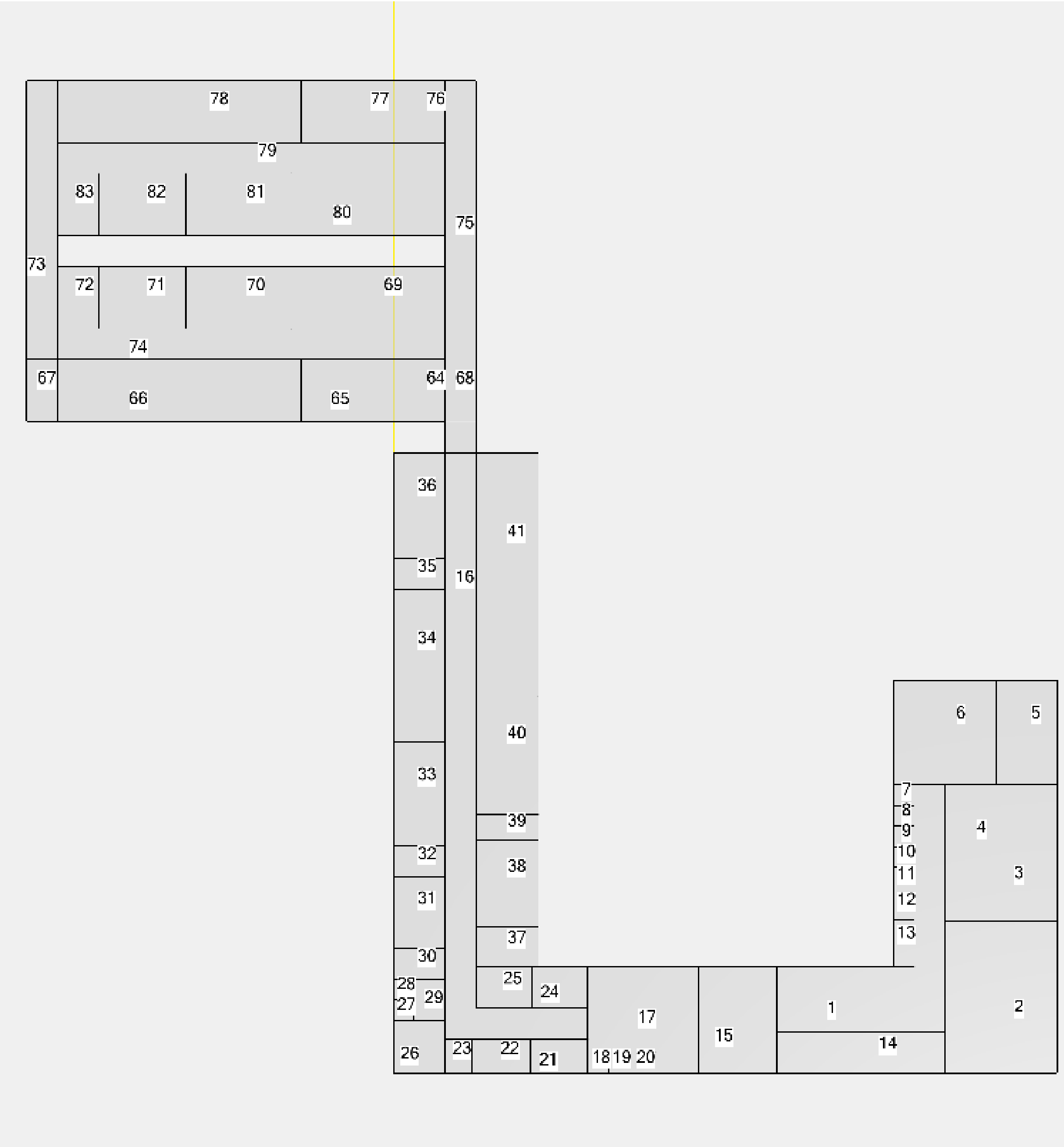
Side view (East)



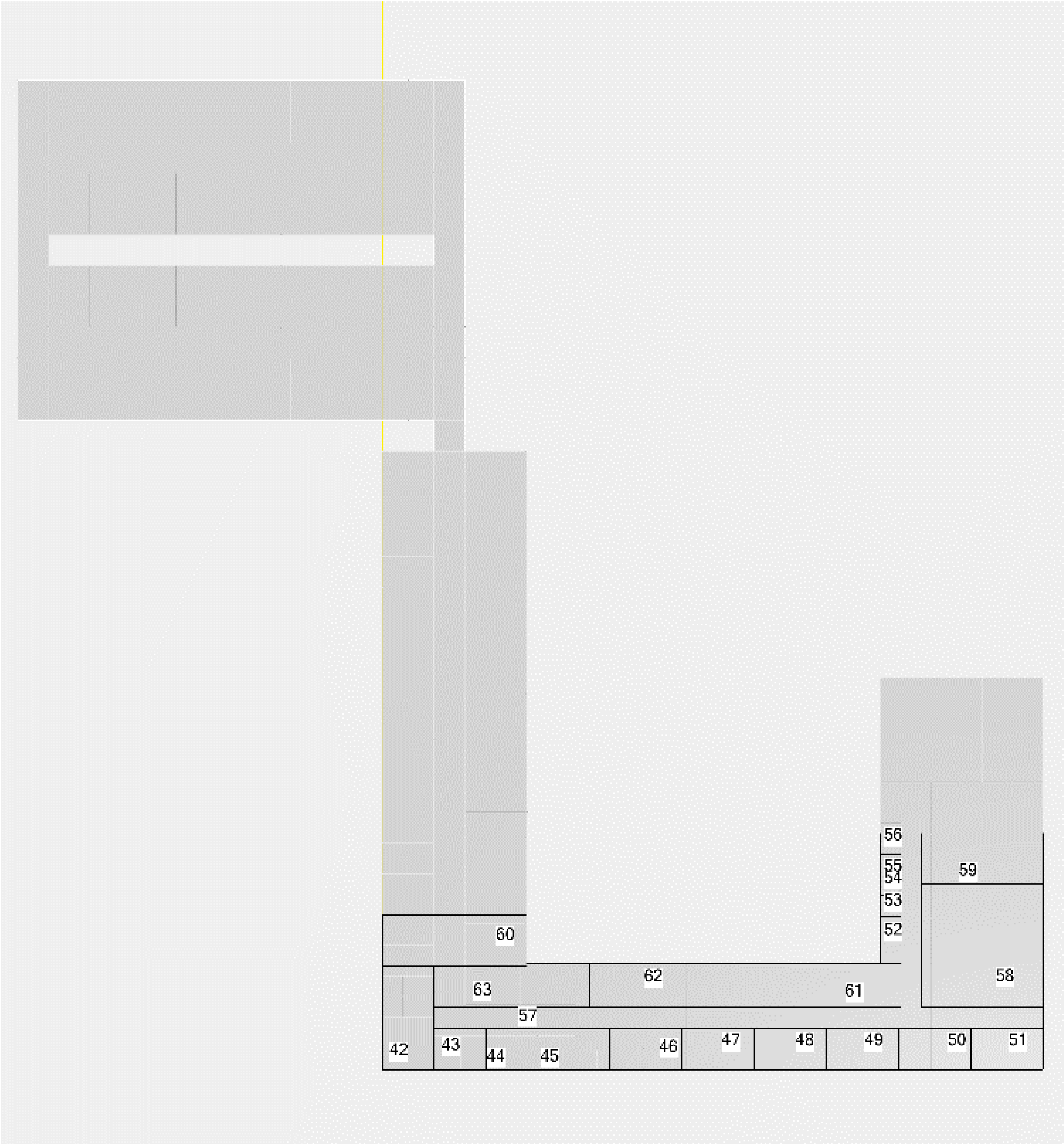
Side view (West)



Floorplan ground floor



Floorplan 1st floor



Rooms animal hospital and wildlife-rehabilitation centre

NR.	NAME
1	Hallway
2	Museum
3	Educational centre
4	Conference room
5	Restaurant kitchen
6	Restaurant
7	Toilet Male 1
8	Toilet Male 2
9	Toilet Female 1
10	Toilet Female 2
11	Toilet Disabled 1
12	Toilet Disabled 2
13	Staircase
14	Shop
15	Reception
16	Hallway
17	Waiting room
18	Toilet Male 3
19	Toilet Female 3
20	Toilet Disabled 3
21	Exam room 1
22	Exam room 2
23	Storage 1
24	Treatment room 1
25	Treatment room 2
26	Break room / Canteen
27	Toilet Male 4
28	Toilet Female 4
29	Locker room
30	Entrance 1
31	Operating room
32	Radiology
33	Recovery room
34	Illness felines
35	Entrance 2
36	Illness small animals
37	Pharmacy + lab
38	Illness dogs
39	Illness cats
40	Illness big animals
41	Illness medium sized animals
42	Relaxation room
43	Bathroom Males

44	Bathroom females
45	Small Appartment 7
46	Small Appartment 6
47	Small Appartment 5
48	Small Appartment 4
49	Small Appartment 3
50	Small Appartment 2
51	Small Appartment 1
52	Staircase 1st Floor
53	Toilet Male 5
54	Toilet Male 6
55	Toilet Female 5
56	Toilet Female 6
57	Hallway
58	Offices
59	Canteen / Kitchen
60	Laundry and facility room
61	Big appartment 1
62	Big Appartment 2
63	Big Appartment 3
64	Isolation cats
65	Isolation big animals
66	Isolation medium sized animals
67	Emergency entrance
68	Hallway
69	Isolation felines
70	Isolation small animals
71	Isolation dogs
72	Storage
73	Hallway
74	Hallway
75	Hallway
76	Quarantine cats
77	Quarantine big animals
78	Quarantine medium sized animals
79	Hallway
80	Quarantine felines
81	Quarantine small animals
82	Quarantine dogs
83	Storage