# MASTER THESIS

## THE IMPACT OF ENERGY EFFICIENCY ON LOW-RISE RESIDENTIAL CONSTRUCTIONS

Regarding to decisive Californian and Austrian Building Standard Codes

submitted at:

FH JOANNEUM Gesellschaft mbH

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## DECLARATION

“I declare that this paper is my own work and was written without literature other than the sources indicated in the bibliography. Information used from the published or unpublished work of others has been acknowledged in the text and has been explicitly referred to in the given list of references. This paper has not been submitted in any form for another degree or diploma at any university or other institute of tertiary education.”

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## ABSTRACT

The target of this thesis is to represent and compare the actual state of the art regarding to the Austrian building law to the Californian building law which are dealing with the energy efficiency of low-rise residential buildings. With the development respectively the publishing of the, in this paper, summarized and compared building standards, these two state codes contribute a part to the worldwide preservation of resources within constructions of low-rise residential buildings. By using the actual state of the art and obligatory Austrian energy efficiency rating tool called “Energy Certificate”, the author elaborates a case study regarding to the two current valid building codes from Austria and California. The whole thesis covers a detailed analysis about the actual energy situations in these states, an even more detailed analysis about the current climatic situations and also a direct comparison between the energy efficiency relevant building codes. Additionally it contains a chapter about different relevant building and energy units and an overview and comparison of international and local building rating systems.

To provide a forecast of the trend how future living spaces will look like, the new building trend, which is actually in development, called “Zero Net Energy Homes” is explained and some pioneer features are illustrated.

At the end, using the results from the case study, combined with the analysis of the particular building standards regarding to energy efficiency, the current differences and, more important, their impacts on low-rise residential buildings can be explained and illustrated.

*Keywords:*

*Energy Efficiency*
*Energy Certificate*
*Building Standards*
*Building Codes / Guidelines*
*Austria / California*

## KURZFORM

Das Ziel dieser Diplomarbeit ist es den aktuellen Stand der Technik der österreichischen Baugesetze, welche die Energieeffizienz von österreichischen Ein- bzw. Mehrfamilienhäusern regulieren, den U.S Amerikanischen Baugesetzen gegenüberzustellen. Mit der Entwicklung bzw. Veröffentlichung der in dieser Diplomarbeit zusammengefassten und gegenübergestellten Regeln der Technik tragen diese zwei aktuellen Regelwerke zu einem großen Schritt in Richtung weltweiter Ressourcenschonung innerhalb von kleineren und mittelgroßen Wohnhausbauten bei. Dabei bedient sich der Verfasser am derzeitig gesetzlich vorgeschriebenen Energieeffizienzbewertungssystems, dem österreichischen „Energieausweis" um in einem Fallbeispiel nach den aktuellen Regeln der Technik die Energiekennwerte eines Objektes mit zwei verschieden angewandten Baugesetzen zu ermitteln. Der gesamte Arbeitsweg führt über eine ausführliche Analyse der derzeitigen Energiesituationen in den jeweiligen Staaten, einer ebenso ausführlichen Analyse der Klimasituationen und ebenso über einen direkten Vergleich der energierelevanten Gebäuderichtlinien. Anbei werden Kapitel wie verschiedene gebäude- und energierelevante Maßeinheiten, sowie aktuelle internationale und lokale Gebäudebewertungssysteme erläutert.

Um einen Blick auf zukünftige Lebensräume zu gewähren, welche auf dem Pfad der Entwicklung nicht wegzudenken sind, wird der Gebäudestandard „Nullenergiehaus" erläutert.

Mit dem Abschluss des Fallbeispiels können die aktuellen Unterschiede und, noch wichtiger, deren Auswirkungen im Bereich der Gebäudeeffizienz zwischen Kalifornien und Österreich aufgezeigt werden.

*Schlagwörter:*

*Energieeffizienz*
*Energieausweis*
*Gebäudestandards*
*Baugesetze bzw. Baurichtlinien*
*Österreich bzw. Kalifornien*

## INDEX

# 1. INTENTION AND INTRODUCTION

Sustainability, this topic is more than ever used these days. In particular, in the construction industry, which needs a huge amount of the overall energy demands in this world, it is difficult to make plans and to progress without taking the concept of sustainability and further more energy efficiency into consideration. Many of our environmental problems today are a result of our huge energy consumption, not only because of final energy consumption, but also while creating, building or how we treat our energy sources.

But, in fact, what does sustainability mean? How is it applicable in an engineer's day? Which tools can engineers use and which laws do we have to consider to accord to the rules of our society and governments to make our environmental treatments a little bit friendlier? This topic is very interesting, especially in the U.S which is known for high energy consumption and not caring about present environmental problems. Additionally, I am very interested in different construction styles on other continents.

So I looked for a solution to connect my interest in different construction types, with rating energy efficiency of low-rise buildings and work with sustainable building standard codes as well.

The fact that I could attend an exchange program in California makes it even more interesting for me to compare nowadays requirements of low-rise residential buildings in Austria to those in California. Furthermore this thesis shall show how to deal with Californian building standard requirements and shall compare them to fitting Austrian laws and point out the main differences. I also plan on develop two energy performance certificates, to compare an average Austrian low-rise residential building with an average Californian low-rise residential building.

In the course of my master thesis I would like to illustrate the development and the impact of sustainability in the case of low-rise residential constructions between California and Austria. Of course there will be background information about sustainability and these countries such as basics, energy consumption issues or different climate facts, which are needed to understand the whole coverage. The paper will also contain a chapter about how to deal with the issue of US and SI-Unites and will show differences between new low energy house models or energy efficiency rating systems.

There will be no connection to other types of construction and there will be also no information about other countries than listed above. This paper's goal is to achieve my master's degree in civil engineering and construction management.

The fact, that we are dependent from energy at all is undisputable and can't be changed. But we can develop ecofriendly energy or force the usage of green energy sources, or at least, we can find a way to create more output out of the same energy input. That means, we have to increase our energy efficiency by develop our laws and regulations and that is exactly the main goal of this thesis.

In the end it should be a comparable and clear work, dealing with the issues of sustainability and energy efficiency, between these countries and their requirements and actual average low-rise buildings, showing "who is more aware", and where can we learn from each other about sustainability and energy efficiency in the case of low-rise residential constructions.

## 2. DEFINITION OF SUSTAINABILITY

Sustainability isn't really easy to describe. It's not just a word, having a definition. It's a long process. Becoming aware, that future generations have to live on the same planet as we do, using the same resources and breathing the same air. This process of understanding has to be transferred in our behavior. Sustainability is not only an industry issue. It is applicable to everybody, in any life situation.

The first time, somebody used a term, comparable to sustainable meanings, was in 1144. It happened in a monastery, residential monks passed a law in their association, regarding to their forests – no one is allowed to chop down more wood than the forest is able to recreate.

Since then, nobody really cared about exploiting the nature, taking was more important than giving and there were no thoughts about the boomerang effect we started with the industrialization. It took a long time until humanity got aware of the fact that our resources are not endless and that we affect our environment with exhaust emissions or the way we treat nature. In 1973, talking about the global oil crisis, people started to realize that we didn't treat our planet the way we should. It is a human weakness, that we just start acting when something fatal happens, because suddenly politics and industry started to create solutions and answers for upcoming problems.

Therefore in 1987 the World Commission on Environment and Development (WCED), also known as the Brundtland Commission, published a report, called "our common future" about their processes, out of which the todays most used definition for the term "sustainable development" came from.

*"Sustainability is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*[1]

This implies that we should be aware, that we have just one planet, and we are not the only generation living on it. Therefore we have to ensure that we reduce our energy needs, or at least increase our energy efficiency, which means more output with the same or less input. That means better energy efficiency or more efficient energy use is the goal to provide products and services by reducing the amount of energy to provide these products.

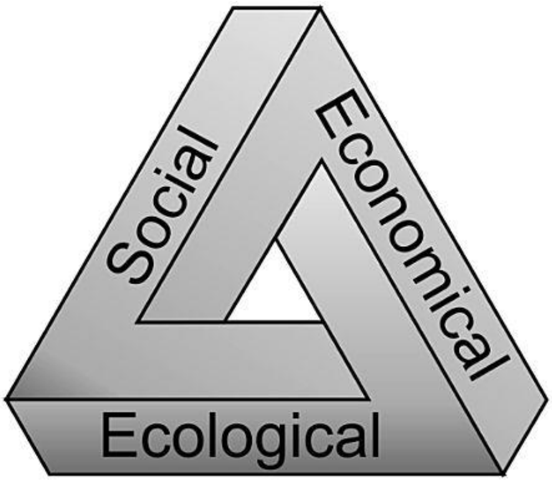
This is, especially very well applicable in the building industry by reducing $CO_2$ emissions in all construction processes which is only feasible with stricter building rules, smarter construction methods and more intelligent end-users which brings us further to the pyramid of sustainability which is also a product of the Brundtland Commission of 1987.

[1] Brundtland Commission: Report „Our Common Future" ,1987

### 2.1. Pyramid of sustainability

How is sustainable development applicable in real life situations? The goal is to achieve better conditions of living regarding to ecological, economic and social aspects. As you will see, it is not easy to recognize the borders of the three different types of sustainability. But, while trying to balance these three "columns", the overall goal is to secure and protect humanity and nature living together and make sure future generations can experience the same.

Of course, the main part construction issues are about will be from the ecological point of view. But at some point there will be overlaps and that's why it's necessary to provide the whole triangle of sustainability.




Pic. 1: The pyramid of sustainable development

#### 2.1.1. Economical Sustainability

Economical sustainability means the issue of understanding how to deal with given assets and how to manage our economic system in a way to not living above given or needed conditions. Particularly international economics is an important point to set and achieve economical sustainability. Being aware of, not exploiting other continents financially but helping them to achieve the same tiers we have, or they want to achieve, keeping in mind that future generations are dependent on our way we operate or also be aware how important the behavior with taxes is to keep social aspects high.

So the aim is to achieve economic safety and find a way to achieve international balance. This can only be done by obtaining given capital and increase spending all kinds of money in an effective way. Also accepting that profit is not the most important thing today could be a step ahead. Developing financial and labor safety for employees, keeping the financial support of health system tiers high and achieving a higher grade of energy efficiency by investing money are definitely goals for economical sustainability.

#### 2.1.2. Social Sustainability

Talking about social sustainability, people are really blessed in Austria. Once you experienced how other countries treat their inhabitants, supply them with health care or behave with homeless or workless people, you start realizing what social sustainability really means and that we really have a high tier of it.

The most important goal of social sustainability has to be to keep healthcare, health development and the access to health facilities high, cheap and overall easy. Of course this can only be achieved with spending money in an efficient way and observe that the spent money is used for the intended thing. This is a point where social and economic issues are connected and it’s also the most critical point where societies tend to fail these days. Human and nature security, the possibilities to discuss problems without fighting and the access to education are also big topics of social sustainability.

Thinking from the construction industries view, social aspects would be things like, keep access to buildings easy and for all kinds of people equal or develop how to treat employees and competitors.

#### 2.1.3. Ecological Sustainability

Last but not least, ecological sustainability. This is maybe the most famous and or widespread type of sustainability. It is, for sure, the easiest to explain and the best applicable type to construction issues.

A main goal of ecological sustainability is to protect the nature and its ecological systems with the given resources. It probably describes sustainable development at its best, meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Securing the given resources is only possible if humanity starts realizing that we have to treat nature in a friendly and balance way. Especially how we handle our given energy sources has to be changed dramatically.

# 3. BASIC FACTS ABOUT CALIFORNIA AND AUSTRIA

As a matter of fact, that this thesis deals with different construction, governmental and energy efficiency topics of California, and suitable or comparable facts about Austria, it should be interesting to learn about some basic facts about them to be able to compare them and can imagine how California can be related to Austria.

## 3.1. California [2]

California is a state of the United States of America and is located on the west coast. It's the most populated state of the United States and has 37.250.000 inhabitants. With its area of about 423.907 km², California is the third biggest state in the U.S after Alaska and Texas and is comparable in shape and area with Sweden which is about 449.965 km² big. About 12% of the whole US-American population lives in California.

The biggest cities are Los Angeles (3.800.000 residents), San Diego, San Jose, and San Francisco. All over California, 200 different languages are spoken, 50.9% of the population is White, 35.9% Hispanic, 12.3% Asian, 6.2% Black and Afro-American and about 1.1% Indians and Hawaiians. Very interesting is that 10% out of the White population are Germans. The overall population distribution is shown on the graphic on page seven.

With 1.9 trillion US-dollars, California contributes 13% of the whole US-gross domestic product which is comparable with whole Italy. The per capita gross national product is 46.488 US-Dollar which is about 58.100 € (exchange rate 1.25 from Oct 2014) and is definitely comparable with Austria which has a per capita

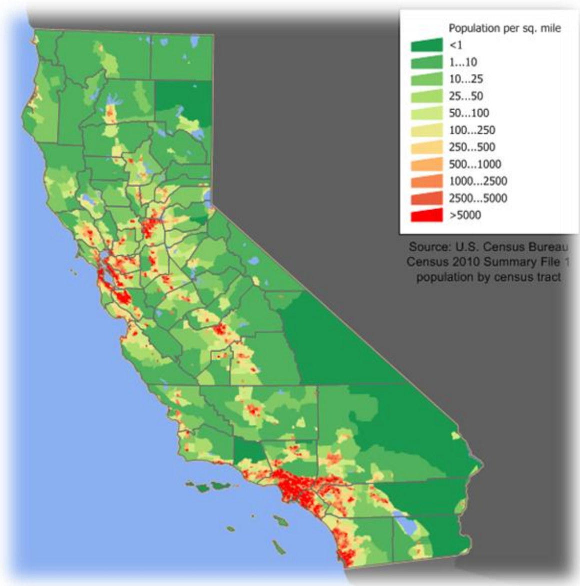
[2] Wikipedia Article: „California“ In URL: http://de.wikipedia.org/wiki/Kalifornien (Oct, 23rd, 2014)

gross national product from about 49.000 US-Dollars. The main industrial markets of California are agriculture, the oil industry and the IT-industry.

Interesting for the construction industry and construction methods is that California is split in two parts by the San Andreas Fault which is an 1100 km long and well visible cleft in the earth surface which causes a lot of troubles trough earthquakes. Especially earthquake safety calculations and drilling methods are very adapted to the San Andreas Fault in these regions. The eastern plate, which is the right part of California, drifts south and the Pacific plate drifts towards north which is the reason for heavy earthquakes. In average, the movement of each plate is 3 cm p.a. Therefore an overall drift of 6cm per year is normal. Sometimes the plates get stuck at some points and heavy tension is created.

Therefore it can happen, as it happened in 1906 in San Francisco that the plates suddenly jump for a few meters. This phenomenon caused an earthquake with 8.4 points on the Richter scale in 1906 which is described with “very heavy” and can cause destroying in an area of a few hundred kilometers. This day, the plates jumped for about 6meters in one movement. Such huge movements cause a lot of horizontal loads on buildings and can even lead to collapse of those.


Pic. 2: The position of the San Andreas Fault in CA [3]




Pic. 3: Population density of California [4]

[3] US Governmental Service: In URL: http://pubs.usgs.gov/gip/earthq3/map2b.gif (Oct, 23rd, 2014)
[4] Wikipedia Article „California“: In URL: http://www.worldofmaps.net/uploads/pics/karte-Bevoelkerungsdichte-kalifornien.png (Oct, 24th, 2014)

## 3.2. Austria [5]

Austria is a democratic and parliamentarian republic in the middle of Europe and has nine federal states. Since 1995 it is a full member of the European Union. The main political goal of Austria is to be social, liberal and neutral.

Austria is about 83.900 km² large and has about 8.500.000 inhabitants. The capital city is called Vienna or “Wien” and has about 1.800.000 inhabitants with a density of about 4230 inhabitants per km². Austria’s overall population density is about 101 people per km² and is therefore comparable to California which has a density of 88 people per km². About 75% of Austria’s area is part of the Alps or the Carpathian mountains. Austria itself is directly located on the Eurasian plate, therefore earthquakes can, and do happen, but not as much as in California which is directly located at the San Andreas fault.

The gross domestic product of Austria is about 415.8 billion US-Dollars and the per capita gross national product is about 49.000 US-Dollars per person. The Austrian main market is the tertiary sector, which contains supporting services, trading, building industry, IT-technology or tourism. About 67% of the Austrian gross national product originates from this sector. Other 32% are from the secondary sector which is all about producing and selling energy. About 1% comes from the primary sector, searching and preparing resources for selling and using them for the industry. Unluckily Austria has not really very much of the important resources like coal, oil or other rocks, therefore the Austrian economy learned how to survive mainly within the tertiary economy sector.

This is also a reason why Austrian construction companies highly force to create new and pursuit to create more efficient methods to be more competitive and have better results on the international market.

Based on very high taxes, Austria is known for its high living standard, free access to education and very good health treatments. Austria has the lowest unemployment rate of the European Union and the Austrian economy is slightly growing.

[5] Statistics Austria In URL: http://www.statistik.at/web_de/statistiken/bevoelkerung (Oct, 24th, 2014)

## 3.3. Energy demands, impacts and future plans

To compare the effects of construction laws which should make our actions more sustainable and should us make feel more responsible for our environment, it is necessary to realize the amount of our energy consumption and the size of the impact it has on the nature, especially talking about atmospheric pollution which is caused by combustion processes which are necessary for providing energy which leads to $CO_2$ emissions. A further increase of $CO_2$ in the atmosphere develops the climate warming. So before starting to think about how we can reduce our energy demand and increase our energy efficiency by construction rules, it is necessary to be aware of the situation right now. How much energy do these countries need, where does it come from and how much pollution does that cause?

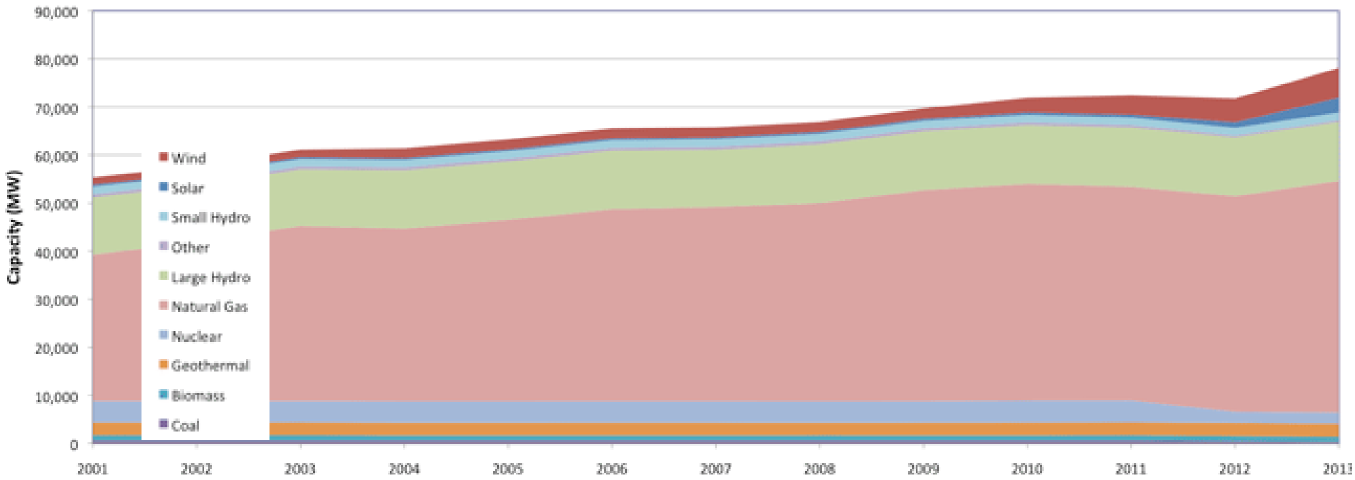
### 3.3.1. Overall energy demand and supply in California

California is one of the states in the United States which needs the most energy at all of the United States. To provide comparable information, further it will be differentiated between overall energy and electric energy.

Therefore, in fact California has the second largest demand on electricity in the United States after Texas. California produces about 70% of its electricity by itself. About 30% is imported. The installed capacity of the local electricity power plants in 2012 was about 71.000 MW, which produced about 200.000.000 MWh in 2012. The annual demand from the year 2012 was 287.678.415 MWh, therefore about 88.000.000 MWh were imported, which is about 34% of the whole electricity demand.

The mainly used resource for the production of electricity (45%) in California was natural gas. Sustainable energy resources provide 27% of the Californian produced electricity and consist out of 8% large hydro, and a mix of about 19% renewable resources like wind (8.55%), biomass (2.7%), small hydro (1.3%), geothermal (4.5%) and solar power (1.82%). The small portion of solar power is not really understandable regarding to the powerful sun in the pacific region and shows the lack of development in using renewable energy resources in general.[6]

The following graphic shows the different distribution and the big part, natural gas has in the Californian electricity production.




Pic. 4: Distribution of the installed capacity of electricity production and its sources in California [6]

The picture provides the in California installed electric capacity and the different types of resources the current power plants are using. Obviously, natural gas is the main resource which is used, while renewable energies are minor used.

Further, whole California needs 7.641 trillion British Thermal Units (BTU) overall energy per year which is about 2239 TWh or 2,239 PWh. This tells us, that California has a total consumption per capita of 201.000.000 BTU per year which is 61 MWh/year and person at 37million inhabitants.

The overall energy demand in California is distributed as following table shows:

| | Demand (BTU) | Demand (GW) | Emissions (tons) |
|---|---|---|---|
| Residential | 1.472 trillion | 431.4 TW | 66.633.601,43 |
| Commercial | 1.481 trillion | 434.01 TW | 67.097.40,40 |
| Industrial | 1.744 trillion | 511.08 TW | 79.001.787,31 |
| Transportation | 2.943 trillion | 862.46 TW | 133.267.202,86 |

Tab. 1: Distribution of energy demands and $CO_2$ emissions in California [7]

[6] Energy Almanac In URL: http://energyalmanac.ca.gov/electricity/total_system_power.html (2014)

These demands are causing overall emissions from 346.000.000 tons of $CO_2$ per year, the detailed demands and emissions split by the different sectors are shown in table 1. [7]

Thinking about, that California has the second highest electricity demand, but one of the lowest overall energy demands in the United States, sounds weird. The simple fact why this is possible is the mild climate in the pacific region which leads to less heating demands and it also shows that the overall state demands are not very significant for energy efficiency building laws. Therefore it is interesting to take a look at average household demands to have a closer look on the usage in detail to be able to compare better. Talking about energy demands of a state or a Country, it is not only the aspect of electricity which makes it interesting. Also needs like home heating, water heating or air conditioning having a big part in our daily energy demands. Especially interesting, are the average household needs.

California's Governor, Jerry Brown, passed a law that California has to reduce 20% of its energy purchase by 2018. Especially residential constructions are concerned with that rule. Title 24 of the actual Standard Building Code has changed many energy efficiency regulations for new residential buildings, which will be part of this thesis later on.

### 3.3.2. Household energy use in California

Now we take a closer look at the energy consumption in residential California households. This chapter will especially focus on water heating, air heating, air cooling and electricity use of California households.

An average Californian household exists out of 2.89 people. 65% of housing types are single family homes and 60% of them had been built from 1970 to 2009. California has about 12.400.000 households, and every household needs 62.000.000 BTU per year for residential demands which is 18169,5 kWh/year and 7000 kWh/year of electricity.

60% of all Californian household heating demands are covered with natural gas. 26.7% with electricity and only 5.3% of all household heating demands are covered with sustainable resources. Covering just these residential needs cause

[7]U.S EIA.gov In URL: http://www.eia.gov/state/data.cfm?sid=CA#ConsumptionExpenditures(2014)

66.633.60143 tons of $CO_2$ per year.[8] When talking about $CO_2$ emissions, the word $CO_2$ is a sort of generalization and stands for $CO_2$ equivalent which again stands for different gases which are increasing the greenhouse effect. This equivalent contains for example $CO_2$, methane, nitrous oxides, fluorinated hydrocarbon or sulfur.

#### 3.3.3. Overall energy demand and supply in Austria

Regarding to numbers from the Austrian Economy Organization of 2012, Austria's energy demand is about 1460 PJ or 384.450 GWh per year high. That leads to a usage from about 3300 oil equivalent units per inhabitant and that puts Austria at the fifth last position in the European Union. Only Luxemburg, Finland, Sweden and Belgium have more energy demand per capita in the European Union than Austria. Therefrom 60.318 GWh per year are just electricity needs.

Austria provides 99% of its energy demand by itself. The capacity of the installed power plants is therefore sufficient and energy imports are just needed in case of current peak demands. About 66% of Austria's electricity is provided out of fossil resources like oil (35%), gas (22%) and the rest is coal. Actually, 31% is produced out of renewable energy sources, waste burning takes 2% and imports about 1%.

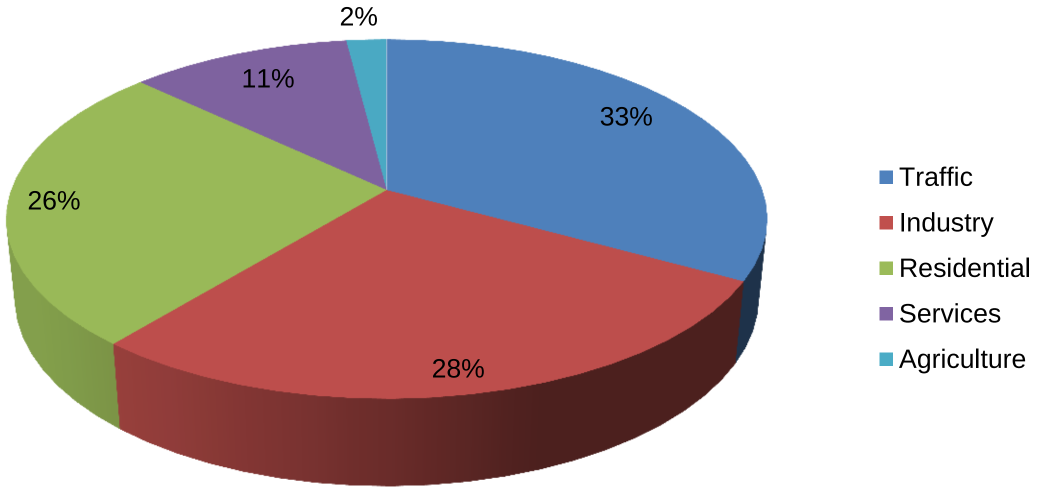
Within the renewable energy sources biogenic resources have the main part with about 50%, hydro power has about 40% and the remaining 10% are split by wind, solar and other renewable energy sources.

Austria's renewable energy goal for 2020 is, to increase providing green energy up to 34%. Also the overall energy demand is planned to be reduced to 1100 PJ per year, the energy efficiency shall be increased and the $CO_2$ emissions are planned to be lowered by 16%. Austria's plan is leaned on three main strategies. The consequent increase of energy efficiency, especially with lowering the average heating demand in buildings is one of them. This shall be achieved by intelligent development in construction methods and better construction laws. Other important strategies are increasing of the usage of renewable energy

[8] U.S EIA.gov In URL: http://www.eia.gov/consumption/residential/reports/2009/state_briefs/ (2014)

sources and the stabilization and providing the energy supply and demand system.[9]

The actual overall energy demand distribution of Austria is shown in the following diagram and includes information from Statistics Austria.




Pic. 5: Energy demands and its distribution in Austria

### 3.3.4. Household energy use in Austria

As the diagram shows, 26% of the overall energy usage in Austria is needed by the residential sector, which is about 99.928 GWh/year. 40% of Austria population lives in single family homes 55% in flats and 5% in other accommodations. Taking a closer look on Austrian statistics shows that an average Austrian household contains 2.25 people. In average every household needs about 19.800 kWh per year. Therefrom are 15.620 kWh/year for water heating, air heating or cooling and 4.187 kWh/year for electricity.

About 35.000.000 tons of $CO_2$ emissions are caused by residential energy demands like water heating, air heating/cooling or heat losses. The future plan of Austria, to lower energy demands and emissions, mentioned before, includes special ideas for residential constructions. New buildings shall approach “almost zero energy standards”, 3% of already existing buildings per year, especially built

[9] Umweltbundesamt In URL: http://www.umweltbundesamt.at/ (Oct 25th, 2014)

around 1980 shall be revised, mainly by improving or installing high tech insulation systems and at least, renewable energy usage shall be forced.

### 3.4. Résumé and Overview of the elaborated energy data

As we can see, Austria's and California's energy demands are not ideal and there is a lot of improvement possible. At least, both places are very aware of their situation and try to lower their overall energy demands and their emissions by increasing the energy efficiency or using new energy models.

To become a better imagination of the many numbers and to make it easier to compare, here is a compendium in form of a table.

| | **California** | **Austria** |
|---|---|---|
| Overall energy demand | 2239,2 TWh/year | 384,34 TWh/year |
| Overall demand per inhabitant | 61.540 kWh/year | 45.357 kWh/year |
| Overall electricity demand | 287.679 GWh/year | 60.318 GWh/year |
| Overall Household demand | 25.170 kWh/year | 19.800 kWh/year |
| Household heating demands | 18.170 kWh/year | 15.620 kWh/year |
| Household electricity demand | 7.000 kWh/year | 4.187 kWh/year |
| Overall $CO_2$ emissions | 346.000.000 tons | 80.100.000 tons |
| Residential $CO_2$ emissions | 66.633.601,43 tons | 35.021.300 tons |

Tab. 2: Overview of energy needs and emissions from CA[10] and Austria[11]

So, if we take a look at the residential $CO_2$ emissions and would divide them by the actual number of households, the result is a higher $CO_2$ emission rate in Austria per household than in California. This is again a result of the a lot milder climate which allows some parts of the Californian population to have a lower heating demand. The a lot higher overall energy demand of California is sourced by the bigger size of the state and the bigger population.

[10]U.S EIA.gov In URL: http://www.eia.gov/consumption/residential/reports/2009/state_briefs (2014)
[11]Umwelt. In URL: http://www.umweltbundesamt.at/umweltschutz/energie/energie_austria (2014)

The basic data in this table has its source on the particular official governmental internet statistic of each state / country. Further calculations are active work from the author. The detailed explanation how to convert BTU and other significant US-Units to Watt or regarding SI-Units is located in chapter 3.5.

## 3.5. Different climatic conditions

So the outcome is that climate conditions are causing heavy influence on energy efficiency and needs. Therefore the next step is to take a closer look at the different climate conditions and how they are applied in the local building laws from California and Austria.

Especially important for the calculation of the whole energy efficiency factor and the energy heating demand of a building is the average local climate. This is the only way to find out how many days and how much in numbers a building has to be heated or cooled. Therefore it is common, that local building codes dispose areas in different climate regions to be able to calculate closer to the real conditions in the respective areas and also to have one general guideline to achieve comparable results. Usually, the average climate data is coming from public statistic investigations and therefore they should be solid and trustable. Applying the rules of the building codes, connected with the provided climate data, leads to an acceptable result.

### 3.5.1. Californian climate

California's climate is very different and depends on the region where you at. It is spread from Mediterranean to subarctic, depending on the distance to the coast, elevation and latitude. Usually, coastal and southern areas are dry and warm, having hot and dry summers and mild winters. But when going upcountry and more to the north, climate changes dramatically and can be compared with the European Mediterranean climate, having warm summers and cold winters. Because of the big size of California it is hard to generalize the climate and it is not possible to provide overall data. Therefore, the California Building Code Standards disposes whole California in 16 different climate regions. Every region has a reference city, which is used to show the average climate conditions.

Additionally the climate charts tell the reader also which type of insulation they need for ceiling, walls or glazing of the building. Also the maximum percentage of glazing area in the surface of the building is provided in the climate charts.

For every region there are following basic datasets which can be used and differ a lot to each other.

1. Annual and monthly Temperature Peak
2. Annual and monthly Temperature Low
3. Annual and monthly Temperature Range
4. Heating & Cooling Degree Days based on 19°C / 27°C
5. Annual precipitation
6. Humidity
7. Wind speed

Therefore following building insulation requirements are possible to be taken out of the same chart as well:

1. Ceiling insulation
2. Wood frame walls insulation
3. Glazing U-Value
4. Maximum total area of glazing in the building’s surface

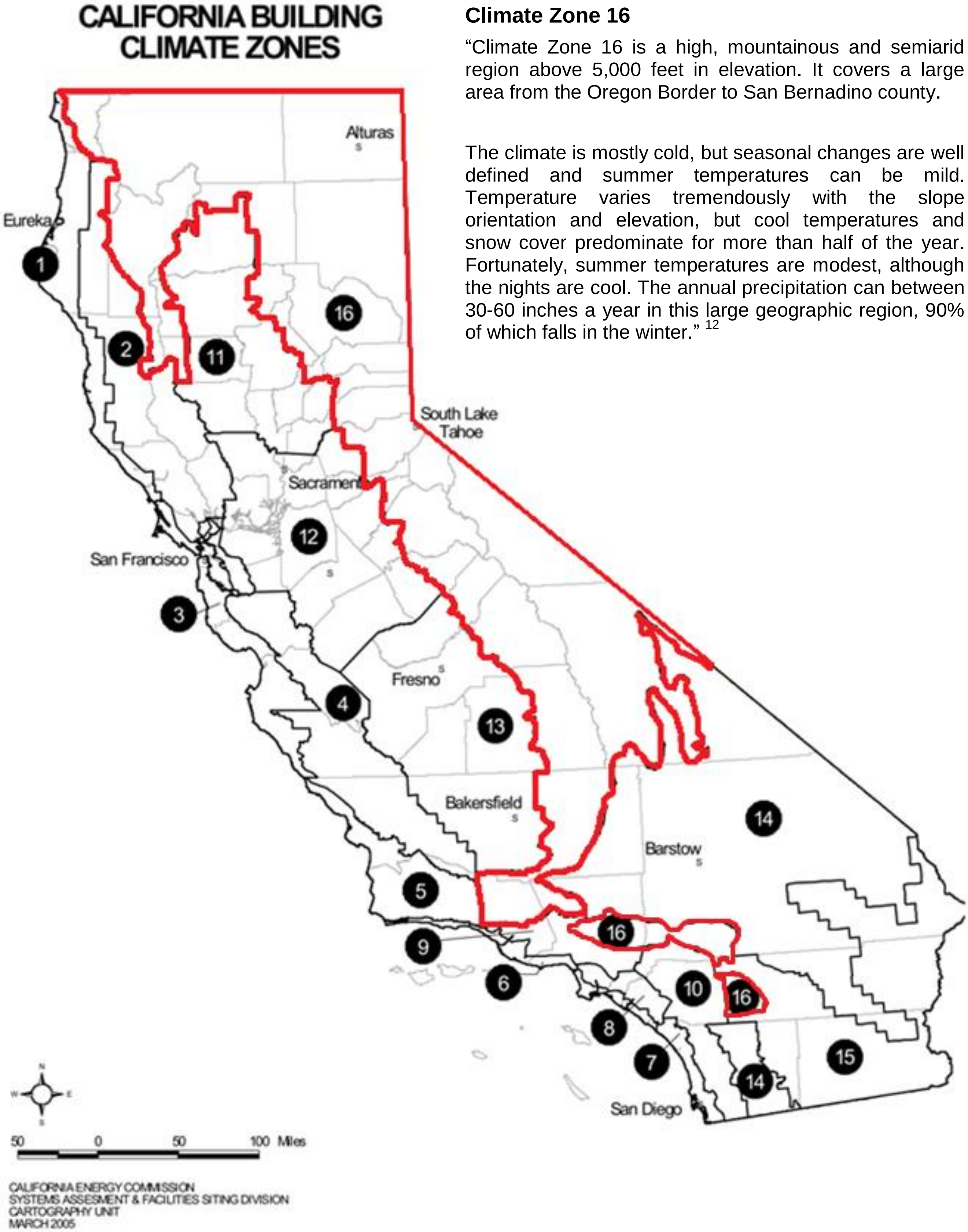
The government provides the Californian citizens with all datasets for free. Every climate region is remolded with charts, graphs, graphics and tables which can be downloaded under following URL: “http://www.pge.com/ ”. The case study, located in Chapter 8, will deal with the climate data from zone 16, because this zone is the most comparable with the Austrian climate.

Following graphic shows the disposition of California and its 16 different climate zones, including reference cities, borders and counties.

### Climate Zone 16

"Climate Zone 16 is a high, mountainous and semiarid region above 5,000 feet in elevation. It covers a large area from the Oregon Border to San Bernadino county.

The climate is mostly cold, but seasonal changes are well defined and summer temperatures can be mild. Temperature varies tremendously with the slope orientation and elevation, but cool temperatures and snow cover predominate for more than half of the year. Fortunately, summer temperatures are modest, although the nights are cool. The annual precipitation can between 30-60 inches a year in this large geographic region, 90% of which falls in the winter." [12]




Pic. 6: Disposition of California and its16 different climate zones[12]

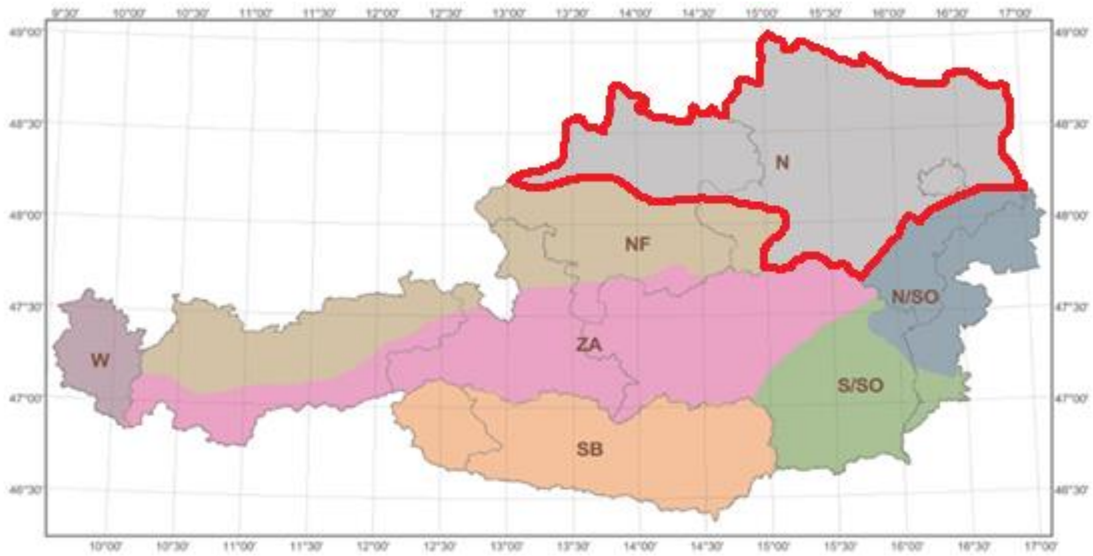
[12] California Building Standards Code, Title 24 – Part 6: California Energy Standards (Jan, 2014)

### 3.5.2. Austrian climate

Within Austria, the climate is different as well but not as different as in California of course. Typically Austrian climate is determined in eastern, western and alpine climate. Therefore generalized it can be said that the eastern climate is very dry. It has hot summers and mild winters which is the typical weather for Vienna. The alpine regions, caused by their sea levels, have typically short and mild summers and long, cold winters with much precipitation, especially snow. The eastern regions are a mix out of these two climate models and the very southern regions can experience a little influence from the Adriatic Sea.

But especially for building, construction and energy matters, the climate is determined more detailed. Therefore, Austria is disposed into seven different climate regions which are typically used to calculate or generate energy efficiency certificates for buildings, but also for assuming snow and wind loads.

The following disposition shows how Austria is ridden by the different climate regions. By selecting the suitable climate region for the existing position of the building, provided climatic data is automatically chosen by the executed program and therefore the temperature information is used to generate the difference between the averages outside and favored inside temperatures. This is needed to calculate the heating demand days, energy needs and further the efficiency.




Pic. 7: Climatic disposition of Austria and its seven different climate regions [13]

[13] Austrian Construction Institute (OIB): „Excel Tool für Wohngebäude” (Jan, 2012)

## 3.6. Relevant US- and SI-Units

As the United States of America and Europe have different unit systems and as the following chapters, which will deal with several specific building code data this chapter serves to unify these units. It shall also help to understand the conversion process and serve as code of practice to apply future conversions if needed.

The unit system basically used in the United States of America is named “United States customary units and will further be named “US-Units system” in this document. Although the United States decided to change their system to the metric or SI-System, the population didn’t accept this fact and still apply the US-Units. Because of this, California bent itself to the fact that the population still favorites the US-units and therefore they wrote the whole California Standards Building code using the US-unit system. This makes the United States of America one out of three countries which have not fully adapted to the SI-System in the world yet.

In fact, Myanmar and Liberia, the two other countries, are currently in their adaption process, therefore the United States will be the only country in the world when both countries are done. Austria is using the SI-System since 1973.

### 3.6.1. Units of length, area and volume

Following chapter deals with different units in length, area and volume and is tabularly illustrated to provide a clear overview.

Units of length:

| US Unit name | US unit short cut | SI Unit |
|---|---|---|
| 1 inch | in | 25,4 mm |
| 1 foot = 12 inch | ft | 0,3048 m |
| 1 yard = 3 foot | yd | 0,9144 m |
| 1mile = 1760yards | mi | 1,609344 km |

Tab. 3: US to SI-Units of length

Units of area:

| US Unit name | US unit short cut | SI Unit |
|---|---|---|
| 1 square survey foot | sq / ft² | 0,093 m² |
| 1 square chain | sq ch / ch² | 404,687 m² |
| 1 acre = 10 ch² | acre | 4046,873 m² |
| 1 square mile | sq mile | 2,590 km² |
| 1 township | twp | 93,240 km² |

Tab. 4: US to SI-Units of area

Units of volume:

| US Unit name | US unit short cut | SI Unit |
|---|---|---|
| 1 cubic inch | in³ | 16,387 cm³ |
| 1 cubic foot | ft³ | 28,317 dm³ |
| 1 cubic yard | yd³ | 0,765 m³ |
| 1 acre-foot | acre ft | 1233,5 m³ |

Tab. 5: US to SI-Units of volume

#### 3.6.2. Units of mass

Following chapter deals with different units of mass and is tabularly illustrated to provide a clear overview.

Units of mass:

| US Unit name | US unit short cut | SI Unit |
|---|---|---|
| 1dram | dr | 1,770 g |
| 1 ounce | oz | 28,349 g |
| 1 pound | ft³ | 453,600 g |
| 1 ton | yd³ | 907,185 kg |
| 1 long ton | acre ft | 1016,050 kg |

Tab. 6: US to SI-Units of mass

### 3.6.3. Units of energy and temperature

This chapter will illustrate the conversion process from °Fahrenheit, which is the commonly used unit for temperature in the US, to °Celsius and will also explain the British thermal unit, which is a unit to express energy.

Rule for °Fahrenheit to °Celsius:

*1°F = °C x 1.8 + 32* *or* *1°C = (°F - 32) x* $\frac{5}{9}$

*Example:* *10°F = (10 - 32) x* $\frac{5}{9}$ *= - 12.22°C*
*10°C = 10 x 1.8 + 32 = 50°F*

British thermal unit:

*1 BTU/h = 0.293 W/h*

### 3.6.4. U-Factor and R-Value

The u-factor is used to describe how well a product or a whole element conducts heat or the rate of heat in watts trough one square meter of a structure when on the inside and the outside temperature having a difference from one Kelvin. It is very important to convert the US-U-factor to the SI-U-factor, because the US-U-factor appears to be a lot stricter out of the SI-Units view. Furthermore the U-factor is the inverse of the R-Value, which is typically used to illustrate the insulation value of a single material. Accordingly the U-factor is usually used to provide whole elements insulation values. The US building codes typically use the U-factor just to rate glazing elements and the R-Value to rate insulation layers.

Following rule has to be applied to convert the US-u-factor to the SI-u-factor:

***1.h.ft².°F/BTU = 0,17611 W/m²K***

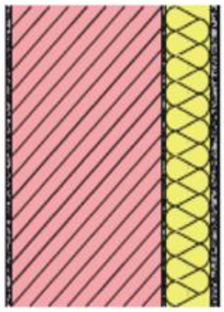
(Btu= British thermal unit, °F=grad Fahrenheit, ft²=square feet, h=hour)

***Simplified:*** $$\frac{\boldsymbol{US\ u{-}factor}}{\mathbf{0.17611}} = \boldsymbol{SI\ U - factor}$$

**Or using for single material R-Value:** ***US R-Value * 0.17611 = SI R-Value***

(*U-factor = 1/R-Value, R-Value = thickness [m] / thermal conductivity [*λ*]*)

Following example, approximated data is used, shall exemplify the calculation process of the U-value of a wall element.



| Layer | Thickness [m] | Lambda λ | R=d/ λ |
|---|---|---|---|
| Inside air layer | | | 0.130 |
| Interior plaster | 0.02 | 0.70 | 0.029 |
| Brick wall | 0.50 | 0.20 | 2.500 |
| Insulation layer | 0.20 | 0.04 | 5.000 |
| Exterior plaster | 0.02 | 0.70 | 0.130 |
| Outside air layer | | | 0.040 |
| | | $R_T$ = | 7.829 |
| | | U-Value=1/$R_T$ = | 0.1277 W/m²K |

Pic. 8: Wall - Composition example

Tab. 7: Calculation of a random u-factor

# 4. OVERVIEW OF THE LOCAL BUILDING CODES

Regarding to the building and construction laws there is a big difference from Austria to California. While Austria still has different building laws in some federal states, California has just one code which is effective right now.

The Austrian system of building laws is a little bit weird. While the Austrian institute of construction engineering works on an overall code named OIB, which has 6 parts and a few subtitles, each federal state has its own building law though. The federal states are allowed to anchorage the OIB in their federal building law, but they are not forced to. However, today seven out of nine federal states anchored the OIB in their local building law. On the other hand, California has just one building code called “California Standards Building Code” or “Title 24”, because it is the 24$^{th}$ title in the CA statute book, called Californian Code of Regulations.

## 4.1. California Standards Building Commission

The California Building Standards Code Commission consists out of 11 members. These members are directly appointed by the Governor of California and confirmed by the State Senate. Members of the BSC represent the public and are responsible for the building and construction industry as well as the local government.

The BSC meets quarterly. Members serve for four years and don't get paid for their serving. They see it as an honor to work for the BSC and just receive reimbursement for travel expenses.

In addition to the 11 main members there are 6 more code advisory committees which each are in charge for their own field and consists out of about 11 people. These people review their codes annually and provide recommendations to the Head Committee.

As the law tells the most important duties of the BSC are:

- "Reviewing and approving building Standards proposed and adopted by state agencies
- Codifying and publishing approved building standards
- Resolving conflicts and contradictions within building standards
- Coordinating and managing the code adoption process
- Ensuring coordination in the proposal of building standards
- Assisting in the development of building standards
- Resolving conflicting building standards situations" [14]

So in fact, the mission of the BSC is to produce usable building standard codes and regulations that help to use these standards and protect all Californians.

Their vision is to ensure that the statewide building code development, the process of growing, is efficient and effective. As well as they want to resolve conflicts and avoid contradictions within their codes.

That means, the overall goal of the BSC is to help the industry work more efficient, secure the citizens and create a homogenous compendium for all.

[14] CBSC California General Services: In URL: http://www.bsc.ca.gov (Sept 22nd, 2014)

## 4.2. California Standards Building Code Overview

The California Building Standard Code is the overall name for the rules of regulation regarding to buildings in California and is comparable to the OIB-Guidelines in Austria. It contents 12 parts, in fact there are 13 but the building code is divided by 2 and 2.5 and usually it counts as one part. It is directly subordinated to the California Code of Regulations (CCR). The Building Standard Code is title 24 within the CCR.

Regarding to CBSC Information sheets, "the CBSC is a compilation of three types of building criteria from three different origins:

- Building standards that have been adopted by state agencies without change from building standards contained in national model codes
- Building standards that have been adopted and adapted from the national model code standards to meet California conditions; and
- Building standards, authorized by the California legislature, that constitute extensive additions not covered by the model codes that have been adopted to address particular California concerns" [15]

Starting in 1989, BSC has published updated editions of the CBSC every three years. The Version of 2007 and the Edition of 2010 are almost available today. The current code was published in 2013 and contains 13 valid parts.

Part 1, 2, 2.5, 6, 8, 9, 10, 11 and 12 were published by the International Code Council (ICC), Part 4 and 5 were published by the International Association of Plumbing and Mechanical Officials (IAPMI). And part 3 was published by BNi Building News.

Additionally, almost every Part has an appendix which provides links to referenced standards which should be applied.

[15] CBSC California General Services: In URL: http://www.bsc.ca.gov (Sept 22nd, 2014)

Content of the Californian Standard Building Code:

Part 1: The California Building Standards Administrative Code

Part 2: California Building Code

Part 2.5: California Residential Building Code

Part 3: Electrical Code

Part 4: Mechanical Code

Part 5: Plumbing Code

Part 6: California Energy Code

Part 7: California Elevator Safety Construction Code

Part 8: California Historical Building Code

Part 9: California Fire Code

Part 10: California Existing Building Code

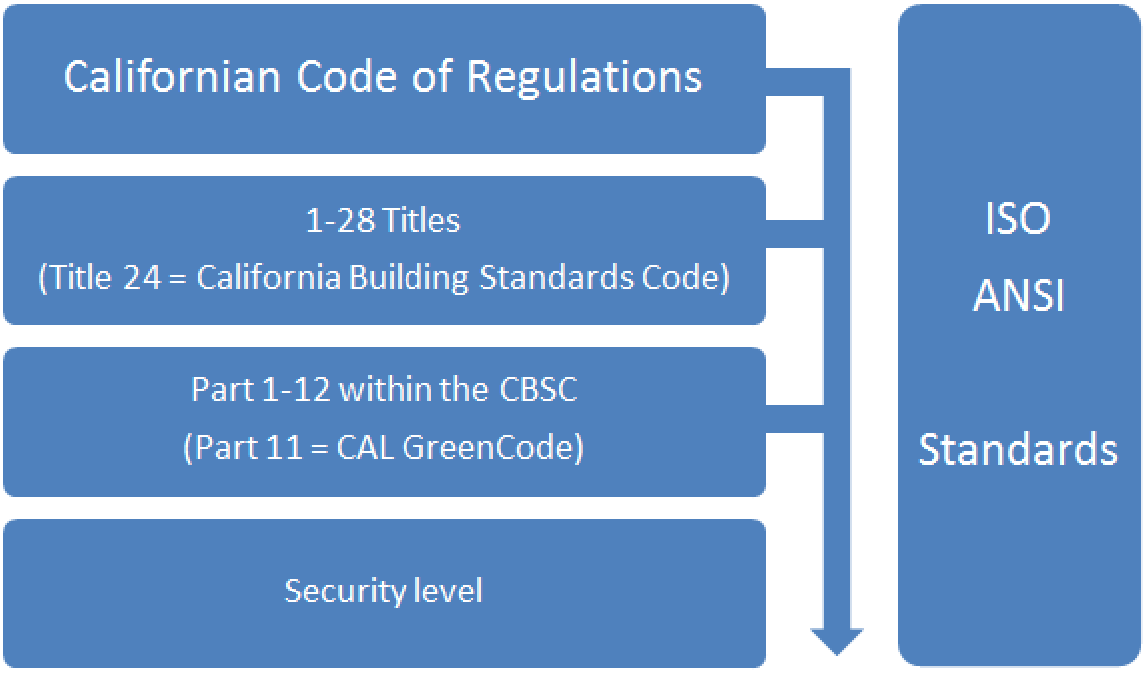
Part 11: California Green Building Standards Code

Part 12: California Reference Standard Code

Part 7 of the CBSC is no longer part of Title 24. At first, the code commission wanted to set up an own elevator safety and construction code. Then they changed their plans and integrated the elevator requirements into accessibility paragraphs of Part 2, 2.5 or 8. Part 7 is nowadays reserved and used as a placeholder for future ideas.

For detailed information about elevator construction and safety, Title 8 of the Californian Law – “Elevator Safety Orders”, set up by the California Department of Occupational Health and Safety, should be considered.

Further chapters of this thesis will contain detailed information about Part 6 and its additional energy certificate guide from Austria and Part 11 from California and therefore they are decisive to achieve the result of the case study in Chapter 8.




Position of the CBSC in the American law structure

### 4.3. Austrian Institute of Construction Engineering (OIB)

The Austrian Institute of Construction Engineering was founded in 1993 to represent the interests of Austria's government and construction industry within the European Union and also to create an overall Austrian building code which all federal states can use. Therefore the Austrian Institute of Construction Engineering works continuously on the Austrian building codes, which then can be used for whole Austria. They also decide about possibilities for using new materials, supervising the building industry market and serving as information centre for construction, law and material issues.

The federal states of Austria founded the Austrian Institute of Construction Engineering together to get rid of, or work on, the big differences between the local building codes of the federal states. Also a reason the construction industry in Austria needs the Austrian Institute of Construction is to make Austrian building products comparable and also able to evaluate within the European Union. The goal of the European Union is to achieve one overall standard to open the construction market. This is only possible if every country within the EU sticks to the comparable rules.

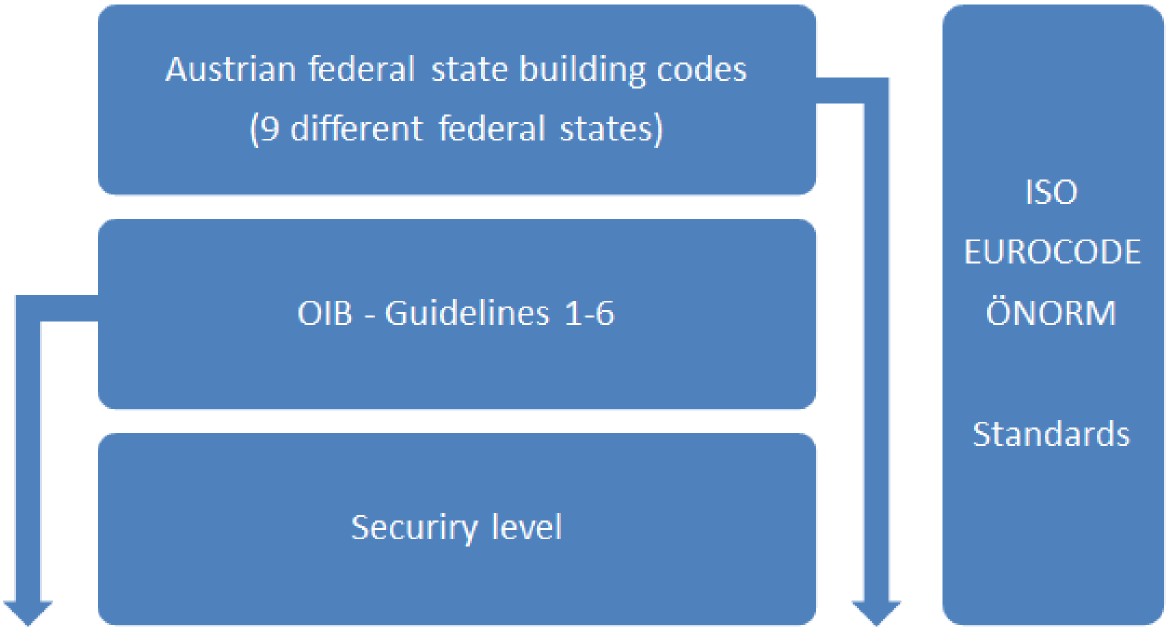
Within Austria, the Austrian Institute of Construction Engineering works also on the cut surface between law and construction requirements to keep the quality of the local building regulations high. Further they conserve these proceedings, make them available for the public and also try to anchorage the new knowledge within the Austrian building laws. This is possible because the Construction Institute serves as connection point between the nine federal states and has members and volunteers coming from everywhere in Austria to provide information about supply and demand regarding to the Austrian construction industry. The achieve its goals, the Austrian Institute of Construction works independent and prospectively together with experts to find solutions everybody is confident with.

The side-effects of having an overall building code for Austria is one of the benefits the Construction Institute aims on, high efficient buildings, safeguarding of resources and overall safety for humanity and nature trough executing the OIB-Guidelines. Even if Austria's federal states have individual conditions and the right to act individually, the OIB sees itself as a union, helping to create one output together. This is only possible with the help of knowledge from experts working in the different federal states of Austria.

To fulfill these goals the Austrian Institute of Construction Engineering is managed by one director. A management out of five experts above this director is installed for supervision and voting's regarding decisions within the OIB. Besides the assistance of the director, a controlling division and an information center, the Austrian Institute of Construction exists out of three main departments. These departments are working on individual building law proposals for the overall building law. The three departments are engineering construction, building physics and engineering on historic buildings/interior development/subsurface engineering. To change the OIB-Guidelines or adopt a new law within the OIB-Guidelines, the general assembly has to meet. This assembly consists out of members from each federal state. Though each federal state has his own building code, it is possible, or desired, to obligate the OIB-Guidelines within the local building code. This happened in seven out of nine federal state laws yet.

To complete the responsibilities of the Austrian Institute of Construction, here is what they announce as their goals and duties by themselves:

- “The issuance of European technical evaluations
- Granting of technical constructions
- The issuance of technical certificates
- Coordination and representation of Austria’s nine federal states within Austria and the European Union
- Managing of an index with all valid European technical evaluations
- Supervision and assistance of technical researches
- Coordination and publishing of the OIB-Guidelines
- Serving as product information center for the building industry” [16]




Position of the OIB- Guidelines in the Austrian law structure

[16] AUT Construction Institute: In URL: http://www.oib.or.at/de/ueber-uns/aufgaben (Oct, 2014)

## 4.4. OIB-Guidelines Overview

Due to the problem, that there was no general building law in Austria, the OIB-Guidelines harmonize the different federal state standards. Therefore, after the general assembly decided to adopt new requirements into the Guidelines, the federal states can embed them into their official building law.

Nowadays seven out of nine federal states have done this. Therefore a constructor has to stick to the OIB-Guidelines to realize his project. If the constructor wants to apply a not legalized or not proven method of the Austrian Institute of Construction, he or she has to prove that his or her way of construction is at least as efficient or safe as the OIB-Guidelines provide.

The rules are under free public access and the latest published version if from October 2011.

The OIB-Guidelines are grouped as following:

OIB-Guideline 1: Mechanical stability and structural safety

OIB- Guideline 2: Fire protection

OIB- Guideline 2.1: Fire protection within industry buildings

OIB- Guideline 2.2: Fire protection within garages and parking lots

OIB- Guideline 2.3: Fire protection within buildings (escape way > 22m)

OIB- Guideline 3: Hygiene, health and environmental protection

OIB- Guideline 4: Utilization safety and barrier-free accessibility

OIB- Guideline 5: Noise protection

OIB- Guideline 6: Energy efficiency and protection against heat losses

Further Chapters of this thesis will mainly deal with information that OIB-Guideline 6: Energy efficiency and protection against heat losses and its additional energy certificate guide contains. Eventually other OIB-Guidelines can be consulted and compared if analogies or comparable articles within the California Building Standards Code appear.

# 5. ENERGY EFFICIENCY BUILDING CODES

Any engineer or architect in California who wants to plan, design or execute a construction project has to be licensed by the professional engineer's board committee. There they license the applicant, if he or she meets all requirements of the board, officially for the state of California regarding to the Business and Professions Code. Applicants have to prove that they are skilled enough, for example with a degree, certificates or professional experience. Afterwards an exam has to be passed, which is held by the board. Within this exam different problems and questions have to be solved. Nowadays these questions have changed and so the board also asks the aspirants about the new energy efficient building rules in California as well.

These rules can basically be found in Title 24, Part 6: The California Energy Code, and partially in Part 11: The California Green Building Standards Code.

## 5.1. The California Energy Code

Part 6: The California Energy Code was published in 2008; the California Energy Commission adopted their old standards. The outcome was the California Energy Code. If nowadays, people submit applications for permits to build their houses, the 2008 standards must be met. The Energy Code has following purposes:

1. To respond to the global warming solution act of 2006, this mandates that California must reduce its greenhouse gas emissions by 20%.
2. To make aware, that energy efficiency is the first step to protect resources
3. To reduce nevertheless greenhouse gas emissions, but also water needs.
4. To accord to the West Coast Governors Global Warming Initiative which implies that energy efficiency standard changes have to be described in California's Building Standard Codes to increase energy efficiency in all type of buildings.[17]

[17] Wikipedia Article "California Energy Code": http://en.wikipedia.org/wiki/California_Energy_Code

Part 6 is separated into 9 subchapters, which were all set to provide requirements of energy efficiency standards for different kinds of buildings like high-rise constructions, hotels, motels, offices, factories, industrial constructions and also low-rise buildings.

Therefore, the volume of building requirements is very high. For further research all chapters, anyhow in charge for low-rise residential buildings, will be illustrated and compared with a convenient Austrian law if there is such a law.

## 5.2. Analogy in Austria

To execute, plan or design different types of construction, the requirements in Austria are very similar to the Californian ones. Austrian engineers or architects also have to pass a governmental exam. They also have to prove that they are skilled enough, for example with a degree, certificates or professional experience and afterwards they can do the exam. And also in Austria, different problems and questions regarding to construction techniques have to be solved within this exam. In Austria, degree holders of this governmental exam are called “master builders”, while those in California are called “official licensed engineer/architect”. Operating, respectively build in Austria, requires being familiar with the local rules. As we learned, OIB-Guidelines are the Austrian overall building standards, comparable to Title 24 in California.

Within the OIB-Guidelines, OIB-Guideline 6: Energy efficiency and protection against heat losses seems to be the most qualified building law to be compared to Part 6: The California Energy Code.

## 5.3. Energy Efficiency building paragraphs

The objective of this chapter is to provide the reader with all necessary as well as mandatory requirements of the Californian Energy Code regarding to low-rise residential buildings. Further, Austrian analogies will be illustrated and both countries requirements will be compared. These elaborated requirements are building the basis and will be used for the following case study of this thesis.

Following table refers to and contains information out of Part 6: The California Energy Code and shows the relevant sections to achieve the object of this thesis.

These sections will be consulted for further comparisons:

| Occupancies | Application | Mandatory |
|---|---|---|
| Low-Rise Residential | Envelope | 110.6, 110.7, 110.8, 150.0 (a-d,g,l,q) |
| | HVAC | 110.2, 150.0 (h,i,m,o) |
| | Water Heating | 110.3, 150,0 (j,n) |
| | Indoor lightning | 110.9, 150.0 (k) |
| | Outdoor lightning | 110.9, 150.0 (k) |
| | Pool and spa systems | 110.4 |
| | Solar ready buildings | 110.10 |

Tab. 8: Relevant energy efficiency sections for low-rise residential buildings[18]

### 5.3.1. Building envelope requirements in California

Californian building envelope requirements are generally located in sections:

110.6, 110.7, 110.8, 150.0 (a-d, g, l, q)

These sections contain information about the thermic quality of walls, roof, windows, doors and ceiling requirements.

*110.6:* Mandatory requirements for fenestration products and exterior doors:

*(a)* Manufactured fenestration products and exterior doors are only allowed to install if they meet the requirements of the following:

*1. Air leakage*: a maximum of 0.3 $cfm/ft^2$ is allowed for window and door area of residential windows/doors at a tested pressure from 75 Pascal. [19]

[0.3 $cfm/ft^2$ = 1.5 $L/s\ m^2$]

[18] Title24: The California Energy Code, Section 100.0 – SCOPE, Page 43
[19] Title24: The California Energy Code, Section 110.6, Page 96

*2. U-factor*: The fenestration products U-factors shall be rated in accordance with the applicable U-factor set forth in following table out of section 110.6-A.

| Frame | Product type | Single pane U-factor | Double pane U-factor | Glass block U-factor |
|---|---|---|---|---|
| **Metal** | Operable | 7.3 | 4.5 | 4.95 |
| | Fixed | 8.75 | 4.03 | 4.08 |
| | Greenhouse/ Garden windows | 12.83 | 7.95 | N/A |
| | Doors | 7.0 | 4.37 | N/A |
| | Skylight | 11.243 | 7.38 | N/A |
| **Metal, thermal brake** | Operable | N/A | 3.74 | N/A |
| | Fixed | N/A | 3.12 | N/A |
| | Greenhouse/ Garden windows | N/A | 6.36 | N/A |
| | Doors | N/A | 3.35 | N/A |
| | Skylight | N/A | 6.30 | N/A |
| **Nonmetal** | Operable | 5.62 | 3.29 | 3.40 |
| | Fixed | 5.90 | 3.12 | 3.23 |
| | Doors | 5.61 | 3.0 | N/A |
| | Greenhouse/ Garden windows | 11 | 6 | N/A |
| | Skylight | 8.35 | 4.77 | N/A |

Tab. 9: Required fenestration products minimum u-factors [20]

U-Factors are already converted into SI-Units, regarding to Chapter 3.6.4. Therefore they are directly comparable with the OIB-Guideline U-factors. But attention, these U-factors are the generally allowance for all fenestration products

[20] Title24: The California Energy Code, Section 110.6-A, Page 98

in all kinds of buildings. For low-rise residential buildings, the requirements of section 150.0 (q) have to be met as well.

*3. Solar heat gain coefficient:* The fenestration products solar heat gain coefficient (SHGC), shall be rated in accordance with the following applicable table out of Section 110.6-B. This factor is the US-Unit for our G-Factor, which describes the solar energy which can interfuse the glazing. This factor is always given in a percentage number, therefore directly comparable. Following table illustrates the Californian SHGC requirements. [21]

| **Frame Type** | **Product** | **Glazing** | **Fenestration Product** | | |
|---|---|---|---|---|---|
| | | | **Single** | **Double** | **Block** |
| **Metal** | Operable | Clear | 0.80% | 0.70% | 0.70% |
| | Fixed | Clear | 0.83% | 0.73% | 0.73% |
| | Operable | Tinted | 0.67% | 0.59% | N/A |
| | Fixed | Tinted | 0.68% | 0.60% | N/A |
| **Metal, thermal break** | Operable | Clear | N/A | 0.63% | N/A |
| | Fixed | Clear | N/A | 0.69% | N/A |
| | Operable | Tinted | N/A | 0.53% | N/A |
| | Fixed | Tinted | N/A | 0.57% | N/A |
| **Nonmetal** | Operable | Clear | 0.74% | 0.65% | 0.70% |
| | Fixed | Clear | 0.76% | 0.67% | 0.67% |
| | Operable | Tinted | 0.60% | 0.53% | N/A |
| | Fixed | Tinted | 0.63% | 0.55% | N/A |

Tab. 10: Minimum SHGC for fenestration products [22]

*4. Visible Transmittance (VT):* The fenestration product's *VT shall be rated in ac*cordance with NFRC 200* or ASTM E972*, for skylights NFRC 203

**Different US-Standard and Rating Codes which provide requirements for building materials*

[21] Title24: The California Energy Code, Section 110.6, Page 96
[22] Title24: The California Energy Code, Section 110.6-B, Page 99

*5. Labeling:* Fenestration products shall have a temporary label for manufactured fenestration products or a label certificate when it is site-built. These labels must list u-factor, SHGC, VT. They shall not be removed before inspection by the official governmental agency. [23]

*6. Fenestration Acceptance:* Manufactured fenestration is only allowed to be used when they meet obligatory requirements above. They have to be labeled and can be tested by the official governmental agency if needed.

*(b)* Field-fabricated fenestration products and exterior doors are only allowed to install if the compliance documentation has demonstrated compliance with u-factor, SHGC and VT tables from above and also shall be weather-stripped. [24]

110.7: Mandatory requirements to limit air leakage:

All joints, penetrations and other openings in the building envelope that are potential sources of air leakage shall be caulked, weather stripped or otherwise sealed to limit infiltration and exfiltration. [25]

110.8: Mandatory requirements for insulation, roofing products and radiant barriers:

*(a) Insulation certification by manufacturers*: Any insulation shall be certified by Department of Consumer Affairs, Bureau of Home Furnishing and Thermal Insulation that the insulation conductive thermal performance is approved pursuant to the California Code of Regulations, Title 24, Part 12, Chapters 12-13, Article 3, “Standards for Insulation Material”. [26]

*(b) Installation of Urea Formaldehyde Foam Insulation:* Urea formaldehyde foam insulation may be applied for installed only if:

1. It is installed in exterior side walls; and
2. A four-mil-thick plastic polyethylene vapor retarder or equivalent plastic

[23] Title24: The California Energy Code, Section 110.6, Page 96
[24] Title24: The California Energy Code, Section 110.6, Page 97
[25] Title24: The California Energy Code, Section 110.7, Page 99
[26] Title24: The California Energy Code, Section 110.8(a), Page 100

sheathing vapor retarder is installed between the foam insulation and the interior space in all applications.[27]

*(c) Flame spread rating of insulation:* All insulating material shall be installed in compliance with the flame spread rating and smoke density required in CBC.

*(d) Installation of insulation in existing buildings:* Insulation installed in an existing attic, shall comply with the applicable requirements of subsection 1 below. If a contractor installs the insulation, the contractor shall certify to the costumer, in writing, that the insulation meets the requirements.

1. If insulation is installed in the existing attic of low-rise residential building, the R-value of the total amount of insulation, including the amount already in the attic, shall meet the requirements of section 150.0 (a). [28]

*(e) Insulation placement on roof/ceiling*: Insulation installed to limit heat loss and gain through the top of conditioned spaces shall comply with the following:

1. Insulation shall be installed in direct contact with a continuous roof or ceiling which is sealed to limit infiltration and exfiltration. This includes, but not limits, to place insulation either above or below the roof deck or on top of a drywall ceiling.

2. Insulation shall be installed below the roofing membrane or layer used to seal the roof from water penetration unless the insulation has a maximum water absorption of 0.3percent by volume.[29]

*(g) Insulation requirements for heated slab floors (foundations with floor heating):* Heated slab floors shall be insulated according to the requirements in following table 110.8-A.

<u>1. Insulation materials in ground contact must:</u>

A. Comply with the certification requirements of Section 100.8 (a); and

B. Have a water absorption rate for the insulation material alone without facing that are no greater than 0.3 percent within the 24hours test, described in ASTM C272*.

[27] Title24: The California Energy Code, Section 110.8(b), Page 100
[28] Title24: The California Energy Code, Section 110.8(c), Page 100
[29] Title24: The California Energy Code, Section 110.8(e), Page 100

2. Insulation installation must:

A. be covered with a solid guard that protects against damage from ultraviolet radiation, moisture, landscaping operations and wind; and

B. Include a rigid plate, which penetrates the slab and blocks the insulation from acting as a conduit for insects from the ground to the structure above the foundation. [30]

Table 110.8-A: Slab insulation requirements regarding to the different climate zones in California:

| Insulation Location | Insulation Orientation | Requirements | Climate Zone | Insulation R-Value | Insulation u-factor |
|---|---|---|---|---|---|
| Outside edge of heated slab, either inside or outside the foundation | Vertical | From the level to the top of the slab, down 16 inches [=40cm], or to the frost line, whichever is greater. | 1-15 | US: 5<br>SI:0.8805 | US: 0.2<br>SI: 1.13 |
| | | | 16 | US: 10<br>SI: 1.7611 | US: 0.1<br>SI: 0.56 |
| Between heated slab and outside wall | Vertical and Horizontal | Vertical insulation from top of slab at inside edge of outside wall down to the top of the horizontal insulation. | 1-15 | US: 5<br>SI:0.8805 | US: 0.2<br>SI: 1.13 |
| | | | 16 | US: 10 vertical<br>SI: 1.76 vertical<br>US: 7 horizontal<br>SI: 1.23 horizontal | US: 0.1 vert.<br>SI: 0.56 vert.<br>US: 0.14 horiz.<br>SI: 0.81 horiz. |

Tab. 11: Heated Slab insulation requirements [31]

* Different US-Standard and Rating Codes which provide requirements for building materials

[30] Title24: The California Energy Code, Section 110.8(g), Page 101
[31] Title24: The California Energy Code, Section 110.6-B, Page 99

150.0: General mandatory requirements for newly constructed low-rise residential buildings:

*(a) Ceiling and rafter roof insulation:* Ceilings, separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Item 1 or 2 below:

1. Ceiling and rafter roof shall be insulated between wood-framing members with insulation resulting in an installed thermal resistance of R-30 (US R-value= 30, SI R-value= 5.28) or greater for the insulation alone. The attic access shall be gasketed to prevent air leakage. This means an insulation u-factor from 0,190 for ceiling insulation material which separates conditioned space to unconditioned space.

2. The weighted average overall u-factor of the ceiling shall not exceed [US] 0.031or [SI] 0.176. [32]

*(b) Loose-fill insulation*: When loose-fill insulation is installed, the minimum installed weight per square foot has to confirm with the insulation manufacturer's installed design weight per square foot to achieve the labeled R-value. [33]

*(c) Wall insulation:* Insulation installed in grade framed walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Items 1, 2 and 3 below:

1. Walls shall be insulated between framing members with insulation having an installed thermal resistance of not less than R-13 in 2x4* inch framing, or the u-factor shall not exceed [US] 0.102 or [SI] 0.579; or

2. Walls shall be insulated between framing members with insulation having an installed thermal resistance of not less than R-19 in framing 2x6* inch or greater, or the u-factor shall not exceed [US]0.074 or [SI] 0.420; and

3. Bay Window roofs and floors shall be insulated to meet the wall insulation requirements as well.[34]

[32] Title24: The California Energy Code, Section 150.0(a), Page 214
[33] Title24: The California Energy Code, Section 150.0(b), Page 214
[34] Title24: The California Energy Code, Section 150.0(c), Page 214

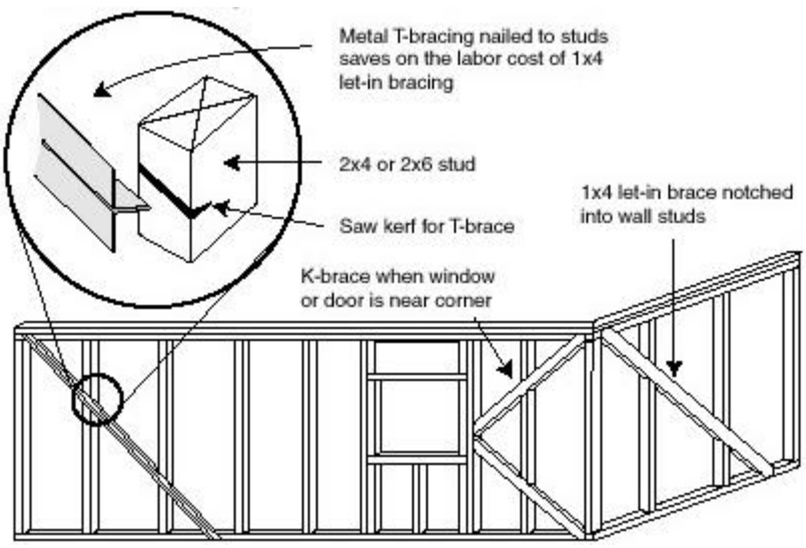
*Explanation of wall construction out of framing members 2x4 inch / 2x6 inch:

The typical Californian low-rise residential building is built with wooden girders. Usually, there are two different sizes of girders, out of which the walls are built.

Therefore Californian constructors use 2x4 or 2x6 inch girders, which basically are 5x10 cm or 5x15 cm supporting beams. The longer side is used to provide empty space and volume for the insulation between the framing members and also strengthens the wall against wind or other horizontal loads. Therefore as more space there is between those framing members, as thicker the insulation can be and as better the insulation will be in the end.

Usually 2x6 walls are built in the colder, more Mediterranean or subarctic areas of California, to achieve higher insulation factors.

Following construction example explains the construction type the best and illustrates how these 2x4 and 2x6 wooden beams are installed:



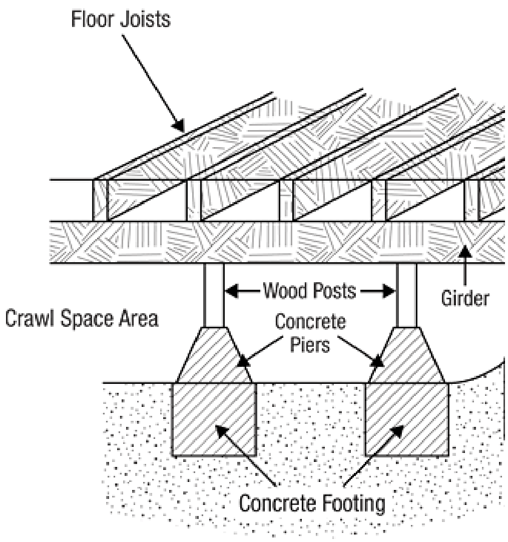

Pic. 9: Wall - Composition example of 2x4 / 2x6inch walls

*(d) Raised floor insulation*:* Raised floors separating conditioned space from unconditioned space or ambient air shall meet the requirements of 1 or 2 below:

1. Floors shall be insulated between wood-framing members with insulation having an installed thermal resistance of R-19 or greater.

2. The weighted average u-factor of floor assemblies shall not exceed [US] 0.037 or [SI] 0.210.[35]

*Raised floors are a typical construction type in California. Houses are usually having strap foundations. On these foundations wooden posts are fixed. Further a secondary construction out of wooden beams is used to provide a higher ground floor. This is a) used for to provide a firm ground, b) all kind of conducts, cords and electric cables can be installed there efficient and cost-saving and c) it is very resistant against earthquakes, therefore it provides high security against collapse.




Pic. 10: Raised floor construction detail

This structure is very typical, especially used when buildings have no basement, which is also very typical for California.

The picture on the left shows a raised floor construction detail. The generated crawl space area is rear ventilated, therefore the insulation material, described in 150.0(d) has to be installed between the wooden posts, the girders or at least between the wooden floor joists.

*(g) Vapor retarder:*

1. In climate zone 14 and 16 a Class II vapor retarder shall be installed on the conditioned space side of all insulated in all exterior walls, vented attics, and unvented attics with air-permeable insulation; and

[35] Title24: The California Energy Code, Section 150.0(d), Page 214

2. In climate zone 1-16 with unvented crawl spaces the earth floor of the crawl space shall be covered with a Class I or Class II vapor retarder; or

3. If a vent is installed in the crawl space, a Class I or Class II vapor retarder shall be installed to reduce moisture entry and protect insulation from condensation. [36]

*(l) Slab edge insulation:* As started to describe in 110.8 (g), slab edges shall additionally meet the following:

1. Water absorption rate for the insulation material alone without facings is not allowed to be greater than 0.3 percent.

2. Concrete slab perimeter insulation shall be protected from physical damage and ultraviolet light deterioration.[37]

(q) Fenestration products: As mentioned on page 32, low-rise residential fenestration requirements are separated from the default factors. Therefore, low-rise residential fenestration products separating conditioned space from unconditioned space or outdoors, shall meet the requirements of either Item 1 or 2 below:

1. Fenestration, including skylight products, must have a maximum overall u-factor of [US] 0.58 or [SI] 3.293

2. The weighted average u-factor of all fenestration, including skylight products, shall not exceed [US] 0.58 or [SI] 3.293.

Therefore, regarding to table 9 on page 32, not every product type is applicable for low-rise residential buildings. [38]

### 5.3.2. Comparable values of building envelope requirements

<u>Comparable Austrian requirements are basically located in OIB-Guideline 6:</u>

The OIB-Guideline 6, Chapter 3 contains information about the Austrian thermic requirements of walls, roofs, windows, door, ceiling and other decisive building

[36] Title24: The California Energy Code, Section 150.0(g), Page 215
[37] Title24: The California Energy Code, Section 150.0(l), Page 220
[38] Title24: The California Energy Code, Section 150.0(q), Page 225

envelope requirements. Therefore it contains the important information to be compared to the illustrated Californian building laws above.

The following table illustrates all comparable u-factors regarding to building envelopes the Californian law provides for climate zone 16 compared with the requirements of OIB-Rule 6:

| **Product / Location** | **California** | **Austria** |
|---|---|---|
| Exterior walls | 0.397 W/m²K | 0.35 W/m²K |
| Interior walls | 0.750 W/m²K | 0.90 W/m²K |
| Exterior Basement walls | 0.301 W/m²K | 0.40 W/m²K |
| Interior Basement walls | 0.375 W/m²K | 0.60 W/m²K |
| Ceilings against unconditioned space | 0.142 W/m²K | 0.20 W/m²K |
| Interior ceilings | 0.579 W/m²K | 0.90 W/m²K |
| Foundation | 0.522 W/m²K | 0.40 W/m²K |
| Windows | 3.293 W/m²K | 1.4 W/m²K |
| Doors | 3.0 W/m²K | 1.4 W/m²K |
| Roof | 0.19 W/m²K | 0.2 W/m²K |

Tab. 12: Decisive building envelope u-factors from California compared to Austria

As illustrated, the differences between the decisive u-factors are not very big. In fact, apart from the fenestration products they are pretty similar. What difference these differential u-factors within the fenestration products will cause, will be break even in the case study.

Allowed air leakage: Example for a 15 m² room (h=2.5 m) CEC and OIB-6:

| **Code** | **CEC:** | **OIB-6:** |
|---|---|---|
| Maximum air leakage | 135 l/h at 75Pascal | 112.5 l/h at 50Pascal |
| Comparable leakage | 90 l/h at 50Pascal | 112.5 l/h at 50 Pascal |

Tab. 13: Air leakage allowance comparison between CEC and OIB6:

The following sections contain information about heating, venting, air conditioning, water heating indoor-, outdoor lightning and other requirements and therefore they are decisive for the energy efficiency in general as well.

The author reserves the right to focus and illustrate only important requirements which seem important for civil engineering needs. It can occur that there are not comparable OIB-Guidelines. Therefore it can appear that there will be no comparisons to the Austrian OIB-Guidelines of these sections. The provided information is basically needed to achieve fine adjustments for the case study needs and because of completeness.

#### 5.3.3. Heating, venting and air conditioning (HVAC)

HVAC requirements are located in sections: 110.2, 150.0 (h,i,m,o).

110.2: Mandatory requirements for space conditioning equipment

*(c) Thermostats:* All unitary cooling and heating system, including heat pumps not controlled by a central energy management control system in new residential low-rise buildings shall have a setback thermostat. All thermostats shall be able to be at least set for four periods a day. [39]

*(d) Gas- and oil fired furnace loss controls:* All furnaces with input ratings >225.000 BTU/h (about 65 kW), including electric furnaces that are not located within the conditioned space (as basement) shall have jacket losses not exceeding 0.75percent of the input rating.

Furthermore Section 102.2-K provides following requirements for low-rise residential furnace efficiency:

| **Equipment type** | **Sub category** | **Size input** | **Efficiency factor AFUE*** |
|---|---|---|---|
| Hot-Water boiler | Gas-Fired | < 300.000BTU/h | *82%* |
| | Oil-Fired | < 87 kW | *84%* |

Tab. 14: Furnace energy efficiency requirements for low-rise residential buildings[40]

*AFUE means Annual fuel utilization efficiency, and shows the efficiency factor with a percentage of how much input of the fuel type is converted into output.

[39] Title24: The California Energy Code, Section 110.2(c), Page 78
[40] Title24: The California Energy Code, Section 102.2-K.0(d), Page 91

Following table shows a comparison of hot water boiler efficiency possibilities:

| Fuel | Class | AFUE |
|---|---|---|
| Oil-Fired | Pre-1970 | 60% |
| | Middle class | 83-89% |
| | High class | 89-93% |
| Gas-Fired | Conventional | 55-65% |
| | Middle class | 78-84% |
| | High class | 90-97% |

Tab. 15: Furnace energy efficiency possibilities nowadays

150.0: Mandatory features and devices:

*(h) Space conditioning equipment:* Building, cooling and heating loads are important for the purpose of designing the HVAC systems. Therefore the average inside design temperatures shall be a minimum of 68°F (20°C) for heating and 75°F (23°C) for cooling purposes.

*(m) Duct and ventilation systems requirements*: HVAC duct constructions (heating, cooling and ventilation) shall have a minimum insulation of R6 or any higher level. (R6 = insulation material US R-Value: 6, SI R-Value: 1.05, SI U-factor: 0.946 W/m²K). This R-Value shall be based on insulation material only, excluding air-films, vapor retarder or other duct components. Insulation shall also be protected against damage, including sunlight, moisture, maintenance or wind. For example with aluminum, sheet metal or plastic covers.

If the mechanical system that supplies air to a room trough ductwork exceeds a length of 10 ft (3 m) it shall be provided with an air filter in accordance to following:

1. The system shall be designed that every recirculated air and all outdoor air is filtered before passing through the system’s thermal conditioning components.

2. All system air filter devices shall be located and installed to allow access and regular service by the owner.

*(o)Ventilation for indoor air quality:* In order to meet the requirements of indoor air quality in low-rise residential buildings ventilation has to be installed. Window operation is not a permissible method of providing the whole building with the required air flow. [41]

### 5.3.4. Water heating

Water heating requirements are generally located in sections: 110.3, 150.0 (n,j)

110.3: Mandatory requirements for service water heating systems and equipment

*(c)* The controls of any lavatory water outlet shall limit the outlet temperature to 110°F (44°C).

Insulation of unfired service water heating storage tanks and backup tanks for solar-heating systems shall have an external insulation minimum of at least US R-value: 12 or SI R-value 2.11 or SI u-factor: 0.47. The overall insulation, internal and external compared, shall be at least US R-value: 16 or SI R-value: 2.81 or SI u-factor 0.354.[42]

150.0: Mandatory features and devices:

*(j)* This section provides data for minimum water pipe insulation requirements as following table show for average low-rise residential needs in California:

| ***Water Temperature*** | ***Nominal pipe diameter*** | | | | |
|---|---|---|---|---|---|
| | *<2.5 cm* | *2.5-3.8cm* | *3.8-10 cm* | *10-20 cm* | *>20 cm* |
| | ***Insulation thickness (with US-R16, SI-R 2.82)*** | | | | |
| *60-90°C* | *3.8 cm* | *3.8 cm* | *5 cm* | *5 cm* | *5 cm* |

Tab. 16: Required service water pipe insulation thicknesses [43]

[41] Title24: The California Energy Code, Section 150.0(m,o), Page 220
[42] Title24: The California Energy Code, Section 110.3, Page 92
[43] Title24: The California Energy Code, Section 120.3-A, Page 120

*(n)* Solar heating system collectors for warm water supply shall be certified and rated by the Solar Rating and Certification Corporation (SRCC) or by a testing agency approved by the governmental building agency. [44]

Comparable Austrian requirements are basically located in OIB-Guideline 6:

The OIB-Rule 6, Chapter 6 contains information about the Austrian thermic requirements of service device requirements. Therefore it contains the important information to be compared to the illustrated Californian building laws above.

The following table illustrates all comparable hot water supply insulation requirements between California and Austria.

| | ***Nominal pipe diameter*** | | | | |
|---|---|---|---|---|---|
| | *<2.5cm* | *2.5-3.8cm* | *3.8-10cm* | *10-20cm* | *>20cm* |
| | ***CEC requires insulation thickness of (SI R=16)*** | | | | |
| *CEC: conditioned and unconditioned space* | *3.8cm* | *3.8cm* | *5cm* | *5cm* | *5cm* |
| | ***OIB6 requires insulation thickness pf (SI R=28)*** | | | | |
| *OIB6: unconditioned space* | *1.6cm* | *2.5cm* | *6.5cm* | *10cm* | *10cm* |
| *OIB6: conditioned space* | *0.8cm* | *1.25cm* | *3.3cm* | *5cm* | *5cm* |

Tab. 17: Compared insulation thickness requirements of CEC and OIB6

The California Energy Code does not separate different locations of water supply pipes. Therefore the comparison illustrates the compared requirements for water supply insulation within Californian low-rise residential buildings and the Austrian requirements, coming out of the OIB-Guideline 6: Chapter 6, are separated in conditioned and unconditioned space.

This will be decisive for the case study because the energy certificate includes the insulation thicknesses for water supply pipes within conditioned and unconditioned spaces within low-rise residential buildings.

[44] Title24: The California Energy Code, Section 150.0(n), Page 220

#### 5.3.5. Indoor and outdoor lightning requirements

Indoor and outdoor lightning requirements are generally located in sections: 110.9, 130.0, 150.0(k)

110.9: Mandatory requirements for lightning control devices and systems

*(b) [...]…Automatic outdoor and indoor lightning control:*

A. These shall have sunrise and sunset prediction accuracy within +/-15 minutes and timekeeping accuracy within five minutes per year; and

B. Have the ability to setback or turn off at lightning at night of require… […] [45]

*(e) Residential high efficiency lightning:* To qualify as high efficiency for compliance with the residential lightning standards, a residential luminaire or LED light shall be certified by the Energy Commission. Other luminaire or LED shall be certified as low-efficiency lightning. Lightning not certified to the Energy Commission shall be automatically classified as low efficiency. Residential lightning has to be certified to the Energy Commission. Nonresidential lightning must not be certified. [46]

150.0: Mandatory features and devices

*(k) Luminaire requirements:*

*1. A:* Installed luminaires shall be classified by the Energy Commission as high-efficiency or low-efficiency. Not certified luminaires are not allowed to be installed. High-efficiency luminaires shall be switches separately from low-efficiency luminaires.

*1. E:* Permanently installed night lights and night lights integral to installed luminaires or exhaust fans shall be rated to consume no more than five watts of power per each luminaire or exhaust fan.

*3. A:* A minimum of 50 percent of the total rated wattage of installed lightning in kitchens shall be high-efficacy. This includes all permanently

[45] Title24: The California Energy Code, Section 110.9(b), Page 104
[46] Title24: The California Energy Code, Section 110.9(e), Page 106

installed lightning in the kitchen except for lightning that is internal to cabins and cabinets for the purpose to luminaire only the inside of the cabinet or cabin.

*5. A:* A bathroom shall have a minimum of one high-efficiency luminaire installed; and

*5. B:* all other luminaires shall be controlled by vacancy sensors or high-efficiency luminaires have to be installed as well.

*6.* Lightning in garages, laundry rooms and utility rooms shall be high efficiency rated and controlled by vacancy sensors as well.

*7.* In every type of room not listed above, installed lightning shall be rated as high-efficiency luminaires or shall be controlled by either dimmers or vacancy sensors.

*EXCEPTIONS:* Luminaires in closets less than 70 $ft^2$ (=6,5 $m^2$) and luminaires in detached storage buildings less than 1000 $ft^2$ (=92 $m^2$) located on a residential site.

*9.* Residential outdoor lightning for single family residential buildings permanently mounted to a residential building or other buildings on the same lot shall be rated as high efficiency or may be low efficiency rated if it meets all of the following requirements:

*A.* Controlled by a manual on and off switch; and

> *B.* controlled by a motion sensor, not having a bypass switch that disables the motion sensor but the motion sensor shall automatically reset within every six hours.

*10.* Internally illuminated address signs shall consume no more than 5 watts of power. [47]

[47] Title24: The California Energy Code, Section 150.0(k), Page 217-220

### 5.3.6. Pool and spa system requirements

Pool and spa systems requirements are generally located in section: 110.4

110.4: Mandatory requirements for pool and spa systems and equipment:

*(a)* Any pool or spa system or equipment may be installed only if the manufacturer has certified that the system or equipment has the following:

1. A thermal efficiency that complies with the efficiency regulation of pool and spa systems.
2. An on-off switch, readily accessible, mounted on the outside of the heater that allows shutting off the heater without adjusting thermostat settings; and
3. A permanent, easily readable and waterproof plate or card that gives instructions for the energy efficient operation of the pool or spa heater and for the proper care of pool or spa water when a cover is used. [48]

*(b)* Additionally, any pool or spa system or equipment shall be installed with the following:

1. At least 36 inch of pipe shall be installed between the filter and the heater to allow the future addition of solar heating equipment.
2. A cover for outdoor pools or outdoor spas that are not operated with solar power.
3. A time-switch or similar control mechanism shall be installed to control the water circulation and to make sure that will allow all pumps to be set or programmed to run only during the off-peak electric period and for the minimum time necessary to maintain the water in the condition required for the health standards. [48]

[48] Title24: The California Energy Code, Section 110.4(a,b), Page 94

#### 5.3.7. Solar component requirements

Solar component requirements are generally located in section: 110.10

While in Austria, the owner can decide on his own where and how big he installs a solar panel, the Californian Energy Code provides the following required direction and the minimum size of the solar facilities in California.

110.10: Mandatory requirements for solar ready buildings and solar components.

*(b) Minimum requirements of solar zones on low-rise residential buildings:*

> A. If thermos-solar panels or photovoltaic panels are going to be installed, the solar zone shall be located on the roof or overhang of the building or the overhang of another structure (like a covered parking) and have a total area of no less than 250 ft² (=23 m²) or no less than 15% of the total roof area excluding any skylight area.
>
> B. All sections of the solar zone located on roofs shall be oriented between 110° and 270° true north.
>
> C. No obstructions, including vents, chimneys, architectural features and roof mounted equipment, shall be located in the solar zone or shall project the surrounding solar zone. Except all north orientated obstructions.[49]

Usually it is advisable to contact an expert for solar devices before installing any kind of solar unit. But adopting some minimal requirements within the law, like in California, makes a lot of sense. They prevent ordinary persons from making mistakes and serve as unification as well.

This system is definitely very well-engineered nowadays. So it is a very efficient way to use solar energy. Therefore the Austrian legislator should consider adopting some basic requirements for solar panels in the OIB-Guidelines to advance the development of using this sustainably energy source.

[49] Title24: The California Energy Code, Section 110.10(b), Page 109

## 5.4. Process of approving and getting a building permit

After applying energy efficiency requirements into the planning process of the low-rise residential building, the next required step would be to get a building permit. Following main steps in the process of a building permit in California and Austria are needed to be done.

The Californian government grants building permits within their different counties. Therefore it can appear that the counties itself could have different ways of granting building permits. The following approach for getting a building permit is decisive for the Californian county San Luis Obispo, which is located on the central coast of California.

After buying the lot where the building is planned to be built, the owner has to apply for a land use permit, which is usually included at the purchase and already granted before and basically confirms that the lot is approved to be built on. The local governmental planning, construction and landscape service department grants these land use permits and therefore they confirm that the building is in accordance with the local landscape planning.

Afterwards the basic steps in the construction permit process in California are:

1. <u>Filing and handing in the application:</u> Construction permit applications are available at the permit centers or on the planning department's website. (An example is located within the appendix A.2 on the end of this paper.) Within this application the owner should hand in following documents:
    a. Property and project layout
    b. Three complete sets of construction plans (copies)
    c. Verification of water, sewer and fire services
    d. The plan review fee has to be paid at the moment the application is handed in the balance is to be paid at the time the permit is issued. Fees for single family homes vary between 9.000 and 13.000 $ and

are dependent on size and difficulty of the planned residential building.

2. Plan Check Review: A plans examiner will review all the handed in plans to make sure they comply with the California Building Standard Code.
3. Review by other Agencies: The local planning department will send other plan sets to relevant agencies such as the County Public Works department in order to approve certain different aspects of the plans.
4. Correction Letter: The applicant will receive a letter of corrections. This letter will contain building, planning and public works issues that must be resolved before the construction permit can be issued. After applying these corrections, this has to be registered at the planning department, the balance has to be paid and therefore the building permit will be granted. This process takes usually two months and is allowed to take 75 days*. The valid time of the building permit depends on the size and cost of the project and will be defined by the local planning department.
5. During Construction: Therefore the construction process can be started. It will happen that, at certain stages in the construction process, an inspection will take place. The inspector has to announce his visit one day in advance.
6. Final building inspection: The building owner has to schedule a final building inspection. This is necessary to check if the project has met all required conditions. If any conditions have not been met, the owner will receive a written statement explaining what must be done before the project can be given final approval.

   Once all conditions have been met, the project passes the final inspection and the inspector will hand the owner the final approval. [50]

*If the owner is not able to fulfil his duties to complete the application within 360 days, the application and the paid fees are going to expire. A 180 days extension can be requested.

[50] San Luis Obispo government In URL: http://www.slocounty.ca.gov/planning.htm (Nov,2014)

To apply and achieve a building permit in Austria, it is also necessary to contact the local building authority.

The department for building issues in Vienna is called building police and is therefore responsible for all construction and planning activities in Vienna.

If the purchased land where a citizen wants to build is already dedicated for residential buildings, which can be verified online, the owner has to apply for a building permit.

Therefore the future building owner has to hand in an application and following documents:

- Necessary plans for the construction process
- Letter of agreement of the person who is listed in the land charge register that he/she agrees with the building
- Structural pre-analysis of the building
- Energy certificate of the planned building
- Proof that sustainable supply systems are applied or at least tried to be applied but are not economic

Further steps are pretty much the same, respectively not really different as in California. Therefore they will not be explained again.

Interesting points are: The estimated costs for receiving a building permit depends on the project size as well, but is approximately outlined with 100 - 200 € from the building authority, which is a very big difference to California. Although the Viennese building authority charges a couple of fees in addition to this basic fee of 100 - 200 €, the amount of 9.000 -13.000 $ will never be reached. The estimated time to achieve a building permit in Vienna is announced within eight weeks, which is probably also pretty similar to California (2 months - 75 days). The valid time of a building permit in Vienna is four years.

# 6. BUILDING RATING SYSTEMS

The goal of energy efficient buildings is to reduce the bad impact in form of $CO_2$ on the nature and to protect our resources. The needed heating energy demand is outlined in the form of kWh/m² and year and makes it possible to compare different buildings. Nowadays we use building rating systems to indicate how energy efficient buildings are. These rating systems differ from continent to continent and even from country to country, dependent on the local building standard codes and requirements.

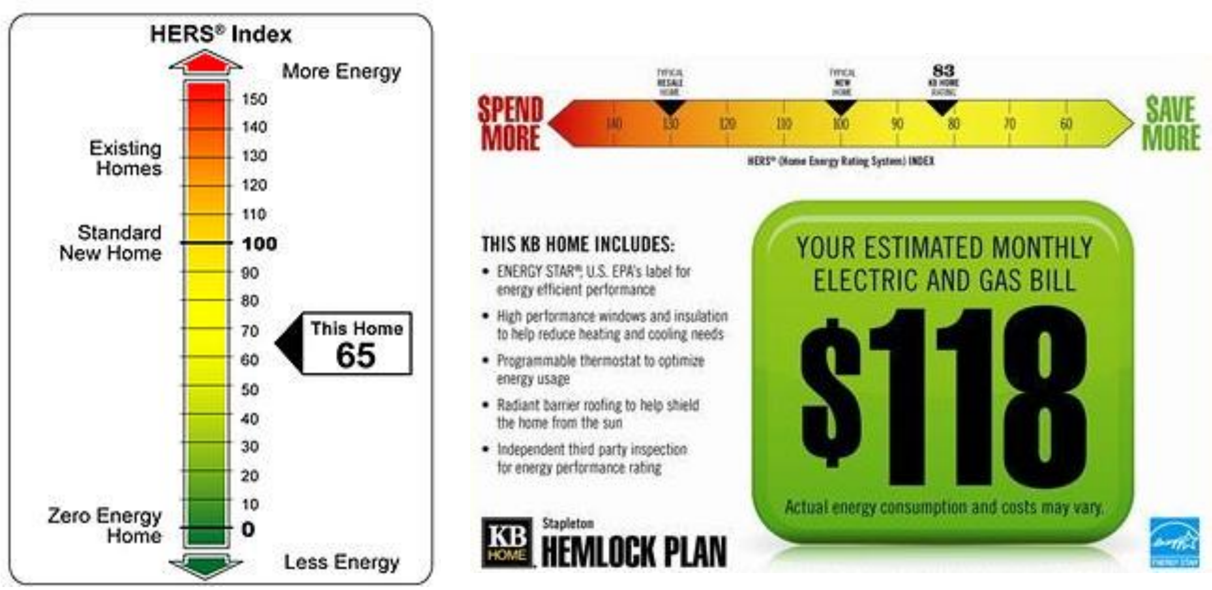
While Austria has an obligatory energy certificate for every new building, California has not. Although they have two very established rating systems, but the government hasn't made it mandatory yet. Anyways, people use it for different reasons. Some people want to know how energy efficient their buildings are, some want to use a good certificate as a status symbol and others just want to see where they can improve or renovate their buildings.

## 6.1. HERS (California)

The Home Energy Rating Systems, short HERS, is mainly used for low-rise residential buildings. A home energy rating of a home before construction is called projected rating, for which HERS can also be used for. Otherwise it is used to determine a home's current efficiency rating, which would be called confirmed rating. People mainly use it to know about their home's utility costs before buying or building it. The final report outlines the energy features of the home and the expected costs of utility bills.

How does it work? The HERS Index score, relates to a reference low-rise object built in 2008 regarding to the building requirements at that time. The lower the number on the score, the more energy efficient is the building. The U.S Department of Energy has published, that a typical resale home in the U.S nowadays has a HERS score of about 120-130. While a home built to the 2008 score has a rating of 100.

Of course the goal is to achieve the lowest score possible, while keeping in mind that future zero net energy homes will have a score of zero, low-rise residential buildings  built regarding to 2014 requirements will have a score between 90 - 70.




Pic. 11: Final HERS rating example including estimated utility costs

Only certified HERS raters are allowed to do an official HERS energy rating on a building. This person will then compare the data against the reference home of the same size and shape and the final outcome will be similar to the graphic above.  A HERS rating costs about 500 to 800 $ per low-rise residential building.

Following data is integrated and used to achieve the final HERS rating:

- All exterior walls (above and below grade)
- Floors over unconditioned spaces (garages, basements)
- Ceilings and roofs
- Attics, foundations and crawlspaces
- Windows, doors, vents and ducts
- HVAC system, water heating system
- Air leakage of the home
- Leakage in the heating / cooling system

## 6.2. LEED (California)

Another big rating system in the United States, also used in California is called LEED, which means Leadership in Energy and Environmental Design. LEED is mainly used for big offices, schools, healthcare buildings or whole residential neighborhoods. There is also a LEED for Homes rating, but it differs from the actual LEED v3 and is not really used often. Although it is very important in the U.S, it is internationally not very well established. Just a few buildings out of the U.S are LEED rated. Basically because the system is based on U.S building standard codes.

The actual version "LEED v3" was published in 2009 and makes it able to gain 110 points for a building. 100 points are possible base points, distributed across six credit categories:

1. ***Sustainable sites*** (rewarding the chosen location of the building)
2. ***Water efficiency*** (rewarding water management within the building)
3. ***Energy and Atmosphere*** (Efficiency and impact on the atmosphere)
4. ***Materials and Resource*** (efficiency of used materials and resources)
5. ***Indoor Environmental quality*** (using quality inside the building)
6. ***Innovation and Design*** (new building methods, architectural aspects)

The 10 remaining points can be earned within aspects of regional priority and additional points for innovation and design.

A collection of reference objects is used to quantify the environmental impacts of the test object regarding to the reference objects. Then the data regarding actual impacts on environmental and human health are used to assign points to the individual categories above. The overall goal is, of course, provide a possibility to measure the energy efficiency of the rated building and make it comparable to other objects. In the end the building gets rated by the Green Building Certification Institute. A fee is required to register the building and get rated by the Institute. This fee depends on the size of the project. It starts at 2900 $ and can increase up to 1.000.000 $ and above for large projects. In percentage it is usually an additional amount of 1 to 6% of the total project cost.

After investigation of the project and assigning the points by the Green Building Certification Institute the LEED v3 rating looks as following graphic shows:


Pic. 12: Different final LEED rating example tiers

## 6.3. Energy Performance Certificate (Austria)

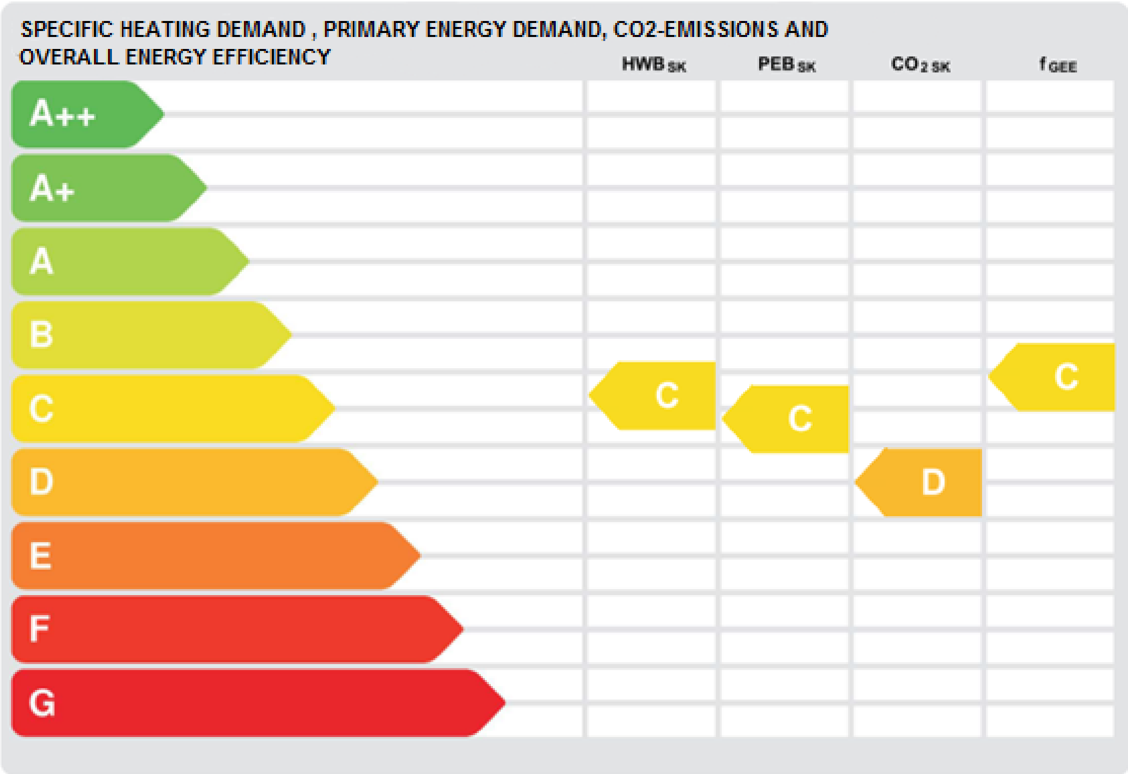
The Austrian Energy Performance Certificate is a mandatory feature to measure the energy efficiency for every kind of building. Owners or sellers have to provide the energy certificate to the government within the applying process for the building permit for new buildings. This rating system is very similar to the HERS rating and also contains similar aspects of the building. It uses different kinds of energy demands each square meter and year and ranks the building regarding to them. For an average low-rise home the Certificate is about 300 – 500 €.

To calculate the energy demand per square meter the system uses data from:

- All exterior walls (above and below grade)
- Proportion heated gross volume to envelope area (= l/c–value)
- Floors over unconditioned spaces (garages, basements)
- Ceilings, roofs and building orientation
- Attics, foundations and crawlspaces
- Windows, doors, vents and ducts

- HVAC system, water heating system
- Air leakage of the home
- Insulation of the pipe and duct system

The parameters above are decisive for the Austrian Energy Certificate. The final document contains a lot more information but the basic rating usually looks like the following image.




Pic. 13: Austrian energy certificate rating example

The different colored levels are showing the energy demand per year and the efficiency itself. As higher the levels, as higher the efficiency and as lower is the energy demand. The different columns are showing different aspects of energy needs.

<u>*HWB = Heating Demand:*</u> The heating demand describes how much energy in form of heat, is needed to heat up all rooms of the building to the preferred temperature. The current maximum for new buildings is 66,5 kwh/m² and year.

*PEB = Primary Energy Demand:* The primary energy demand factor describes how much energy the building generally needs. That contains aspects of the different used energy sources, how much energy it is needed to prepare them and make them ready to use and how much impact these primary energy sources have on the environment.

*$CO_2$ = $CO_2$-Emissions:* This column describes the annual $CO_2$-Emissions, caused by the end energy demand of the building.

*$f_{GEE}$ = Final Energy Efficiency Factor:* The Final Energy Efficiency Factor compares the whole energy demand situation with a reference building.

The different levels are distributed as following table shows:

| | |
|---|---|
| A++ | ≤10 kwh/m² and year |
| A+ | ≤ 15 kwh/m² and year |
| A | ≤ 25 kwh/m² and year |
| B | ≤ 50 kwh/m² and year |
| C | ≤ 100 kwh/m² and year |
| D | ≤ 150 kwh/m² and year |
| E | ≤ 200 kwh/m² and year |
| F | ≤ 250 kwh/m² and year |
| G | > 250 kwh/m² and year |

Tab. 18: Austrian Energy Certificate tiers

In average, usual houses, built in the last 10 -15 years without any special focus on energy efficiency have a rating of C or D. Houses which are focused on low energy demand, called low energy houses and are built to lower the heating demand dramatically, usually need 50 kwh per m² and year and therefore these buildings usually are rated between tier A and B. Passive houses, which are built without any heating system have to have a heating demand of 15 kwh per m² and year or lower. A zero net energy demand building should have a rating of A++.

### 6.4. Rating systems conclusion

Apparently the U.S HERS Certificate and the Austrian Energy Certificate appear to be very similar. The biggest difference is that Austria made its certificate mandatory, California has not. Although it appears to be very similar the two systems have a few differences which are summarized and illustrated again in following table.

| | **HERS Certificate** | **Austrian Energy Certificate** |
|---|---|---|
| Mandatory at all | NO | YES |
| Air leakage | YES | YES |
| Envelope u-factors | YES | YES |
| Fenestration u-factors | YES | YES |
| HVAC System | YES | YES |
| Pipe insulation | YES | YES |
| Building orientation | NO | YES |
| Leakage in the heating/cooling system | YES | NO |
| Includes estimated price for utility needs | YES | NO |
| Cost | 500-800$ | 300-500€ |

Tab. 19: Austrian Energy Certificate compared to U.S HERS Certificate

Obviously the prices are very vague, and of course they depend on the size of the project and on the rates of the executing company, but average low-rise homes can be roughly indicated within the illustrated ranges above. Also very interesting and useful is the estimation of the future utility costs of the building which the HERS rating provides. This would be a useful feature in the Austrian Energy Certificate as well. Usually people are not interested in energy key data, but they are interested in how much money they have to pay for energy and how they could save money. The HERS rating shows both, and makes it easier for the costumer to get an idea about energy.

# 7. ZERO NET ENERGY HOMES (ZNE)

Many of our environmental problems are a product of our energy consumption in private single households. The overall amount of heating and the loss of warmth and energy are leading to $CO_2$ emissions. This is why the construction industries and the governments internationally focus on reducing the emissions by lowering the heating energy demand or heat losses and increase the energy efficiency in single homes.

While having in mind, that our actual building codes are just representing the actual average state of the art, engineers are developing house models which have a neutral energy demand when considering the whole annual needs. These house models are the future, currently very expensive and not perfected, but in the nearer future house models like these will be the usual new low-rise construction types. They will save energy on the one hand, and provide the same living comfort with a higher efficiency grade on the other.

*So what is a Zero Net Energy Home (ZNE) exactly?*

To define a ZNE, the first and most important step to think about is how to lower the annual energy demands of the building to a minimum which is usually lower or about 15 W/m²K for the heating demand per square meter and 120 kwh/m² and year (or lower) for the primary energy demand of the whole building needs (heating, warm water, electricity). After finding the lowest demand possible, the second step would be to focus on how to regain these needs with renewable energy sources directly on site. That means that the annual energy demands of the ZNE should be covered by totally renewable energy sources such as wind, water, geothermal energy or solar power.

But it also has to be told that a ZNE does not certainly mean that the building is energy independent at all. It needs certain energy sources to fulfil the user's needs when renewable energy sources cannot reach the whole demands. Most of the time that means that the building is still connected to the public electricity grid, supplying electricity when the renewable sources on site cannot fulfill the demands, or supplying electricity even at times when there is no access to a renewable energy source like in night (no solar power) or on a calm, windless day.

There are a few tools or characteristics engineers can affect to create these totally sustainable homes and when put together in the right magnitude, the home is not only totally energy neutral, it provides also a very comfortable living space for a whole family.

*Building envelope and U-factor goals*

The building envelope would be the first characteristic to work on to lower both, the heating demands and heat losses. In this juncture usually highly developed insulation materials attached to the nontransparent envelope materials (foundation, exterior basement walls, exterior walls and roof) with u-factors less than 0,15 W/m²K are installed or tried to be achieved. The fact that the construction industry has worked a lot on these insulation materials in the past makes that fact not as hard to achieve. Therefore it is a solid, well developed basic to equip the building in that way.

Furthermore, maybe the most important or at least very important parts of the building envelope are the fenestration products. Improving windows is expensive and a lot of people underestimate the potential very well developed windows have. Not only a lot of energy is lost through glazing, but also windows have a huge potential to gain and store solar power. Usually as lower the u-factor of the window is, as higher the insulation and as lower the solar gains of the building are. Nowadays experts have worked on highly developed fenestration products which can affect the energy balance of a building a lot and combined insulation with solar gains. While speaking about the European area an overall window U-factor under or about 0.8 W/m²K counts to the high-class products.

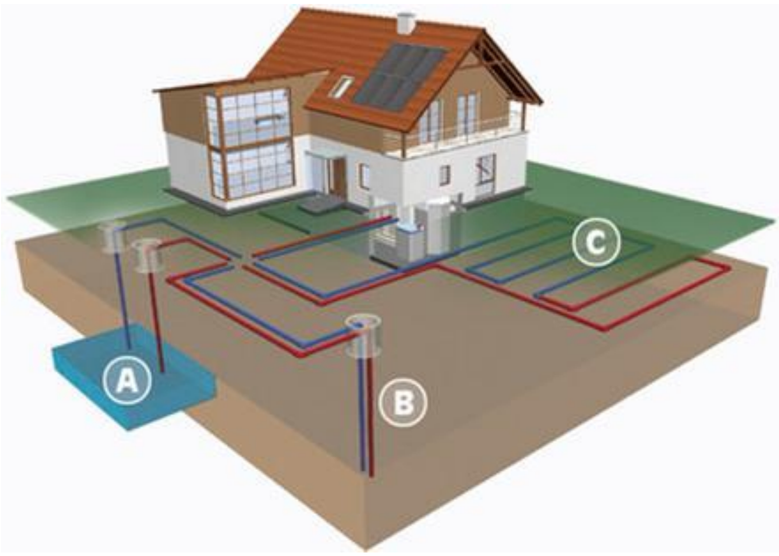
Talking about the U.S area, where glazing products are a little behind our standards, an overall windows u-factor of 1.7 W/m²K does count as high class. The fact that the actual Austrian OIB-Guidelines require a minimum of 1.4 W/m²K for glazing products makes the U.S standards almost average.

To achieve such a low u-factor (0.8 W/m²K) usually a couple of glass layers, about two or three, are connected to a very well developed framework while filling the spaces between the glass layers with an insulating gas or vacuum. At last, most of the windows should be installed on the south facing side of the building to guarantee their high efficiency.

*HVAC system and energy recovery to cover the demands*

A Zero Net Energy home does not have a conventional heating system. Besides storing the indirect given heat energy from humans or machines, it usually uses a modern heat pump to create an enjoyable living area. The heat pump gains its needs (heat in winter, cooling in summer) either from solar power and/or from geothermal energy.

This works as following, that the heat pump is connected to a pipe system which is installed on the same site as the house is. This pipe system collects warmth from the ground water or the surrounding soil in winter or the other way round in summer and delivers the energy to the heat pump which converts it into warm air and/or warm water. Combined with solar thermal panels, usually installed on the roof to heat up the use water, is this the state of the art heating/cooling system nowadays.




Pic. 14: Different Heat pump types [51]

[51] Heat Pump types In URL: http://www.j-baumann.at/waermepumpe-Dateien/image005.jpg (2014)

Usually one of these three systems is used:

“*Type A*” uses a system which is connected to a groundwater source which supplies the pipe system with the needed energy.

“*Type B*” uses a system which is connected to the deep surrounding soil which supplies the deep tubes with the needed energy.

“*Type C*” uses a system which is widespread in area, easier to install as A or B and gets its energy also from the surrounding soil.

Afterwards the heat pump converts the energy, gained from soil or water, into the finally needed energy state and provides it to the room heating system which can either be run by warm water (radiators) or air (ventilation).

Additionally these heat pumps are that high efficiency that they also cover the whole fresh air demands, which means the take over the whole ventilation system and mix up the heated air with needed fresh air in the exactly needed amount.

*Indoor and Outdoor lightning*

During the day, most of the illumination is provided by sunlight. This is achieved by using a well-developed grade of natural light exposure by the fenestration products, but also by using high efficiency skylights.

At nighttime illumination is typically provided by fluorescent systems or/and LED lightning. These systems are more efficient than traditional illumination which means that they do not dispense a lot of heat and use less than 1/3 electricity.

*Electricity recovery to cover the demands*

To cover the electricity demands of a ZNE, typically engineers use solar or wind power in form of photovoltaic panels or/and a little wind wheel. For real independency, a little block heat and power station run by biogas or biomass can be used to provide the building with electricity without connecting it to the grid or without take energy from the grid. Excessive energy can be stored or reverted into the grid.

To be a pioneer always has some advantages and disadvantages, but without pioneers we would be stuck and cannot make steps forward. Of course buying or building a Zero Net Energy Building comes with a couple of negative and positive points, following are illustrated from the author’s point of view:

*Advantages*

- Being independent from electricity and other energy source prices
- Reducing general annual supply costs of living
- Very high resale value
- Future restrictions regarding to $CO_2$ Emissions does not affect you
- Playing an active role in lowering the countrywide $CO_2$ Emissions

*Disadvantages*

- High initial costs for building and purchasing the equipment
- Probably dealing with some issues based on immatureness
- While having an annual energy demand of zero, it could happen that the building also needs energy when public peak demand occurs which would lead to unexpected one-time costs
- The building is dependent from the environment, shaded areas due to mountains or woods are not qualified
- In order to apply on of the listed heat pumps systems, soil investigation is necessary

Although today the disadvantages may be still enough to decide to build the average, well developed way, it would be a great investment for the future. The energy change has to get in our minds and by increasing the market requests the supply will also increase. Regarding to our market standards, this will lower the price which usually makes products more interesting for the populace and this again will increase the developing rate of the Zero Net Energy Building Standard.

# 8. CASE STUDY

The following case study will combine the researched topic of the different energy efficiency building standard requirements, located in Chapter 5, with a theoretical example to illustrate the energy demands, in form of an, on the Austrian OIB-Guidelines based, energy certificate, of a building with the applied minimal requirements. On the one hand the Californian Energy Code will be used and the requirements will be applied on a building theoretically placed in the north of California and on the other hand the Austrian OIB-Guideline 6 will be decisive for the same building, with the Austrian requirements but located in Austria, Vienna.

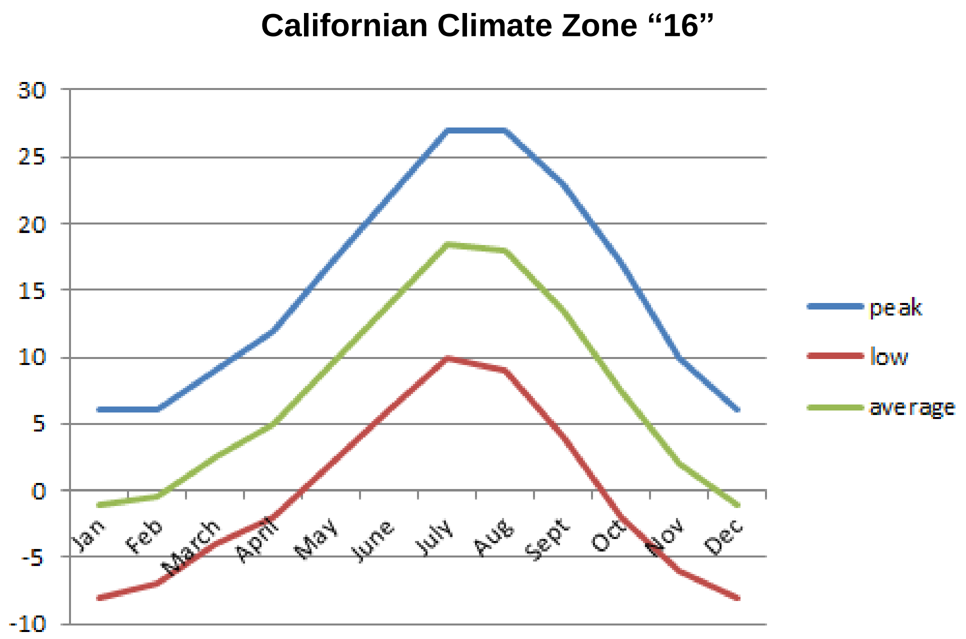
Therefore the goal is to illustrate the result of the different requirements from California and Austria, not only on a theoretical basis, but on an example which makes it easier to understand where the impacts of these requirements take place. Furthermore it makes it easier to explain where opportunities are and where the different building standards could “learn from each other”, which is the purpose of this chapter, connects theory with praxis and will complete the overall aim of this thesis.

## 8.1. Applied climate situation

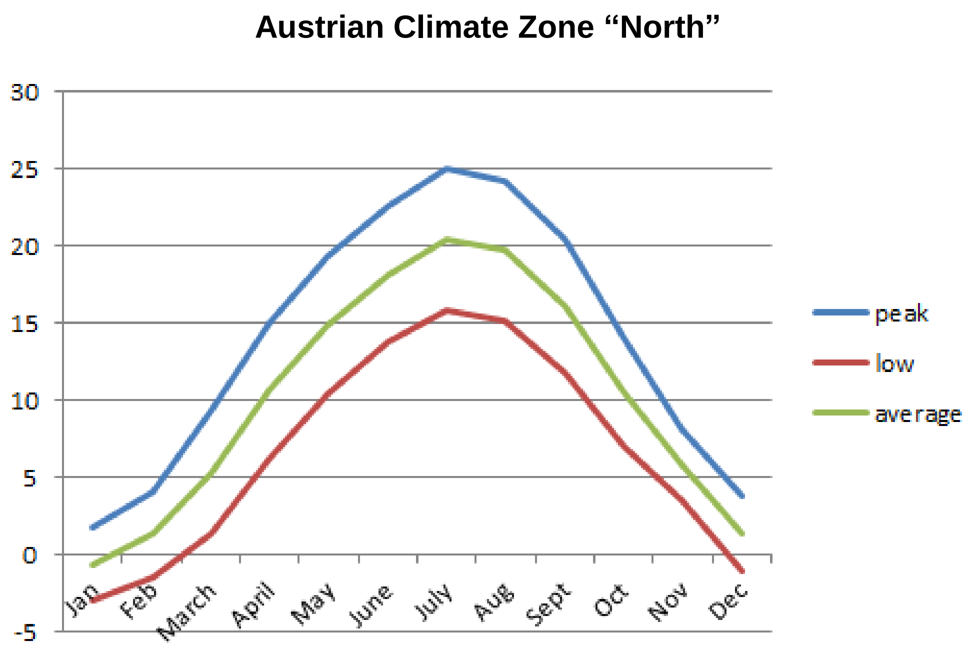
As further chapter explained, both countries have different climate zones within their area and therefore the building codes provide different climate data with different requirements for buildings located in those. This climate information is one of the most important information to calculate energy needs of a building. California is widespread from north to south and therefore, in the north the climate is comparable to the eastern Austrian climate. The following comparison shows the analogy of Californian climate zone Nr.16 and Austrian climate region “North”. These climate regions are pretty similar, as the graphs show, and therefore they make it possible to compare buildings in their actual location, connected with the actual decisive requirements for those locations. The fact, that this case study doesn’t deals with a theoretical reference climate in which both buildings could be located , makes the comparison even more realistic, because it represents the actual needs, which are originating from the real local requirements in exactly both places.

Although comparisons of different locations can, and will never be 100 % accurate, we can try to reach the highest comparable stage to make studies very significant. After long and exact studies on the different climate situations, following climate zones were found as the most similar. Therefore, the requirements of these climate zones are the most comparable ones and will lead to the highest accurate output. Even if engineers are no weather forecasters or meteorologists, when we take a look at the following graphs, it is easily recognizable that the average temperatures, which are represented from the green graphs, appearing very similar, which means it can serve as the most accurate common ground for further steps.

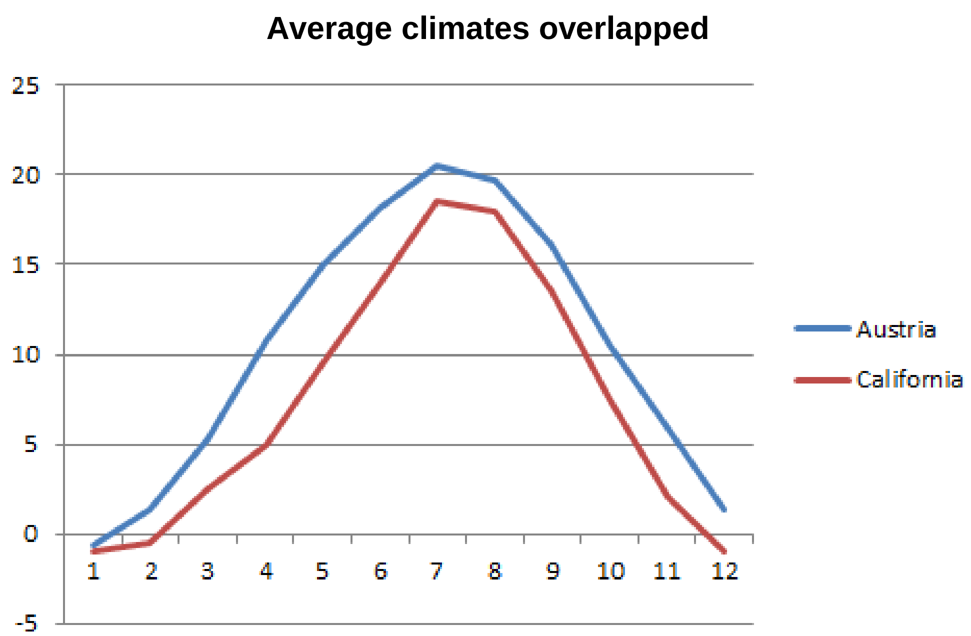
Following data, illustrated in °C, was used for the calculations and has been provided by the different local governmental meteorological offices.




Pic. 15: Californian Climate Zone -16




Pic. 16: Austrian Climate Zone –North




Pic. 17: Average climate graphs overlapped

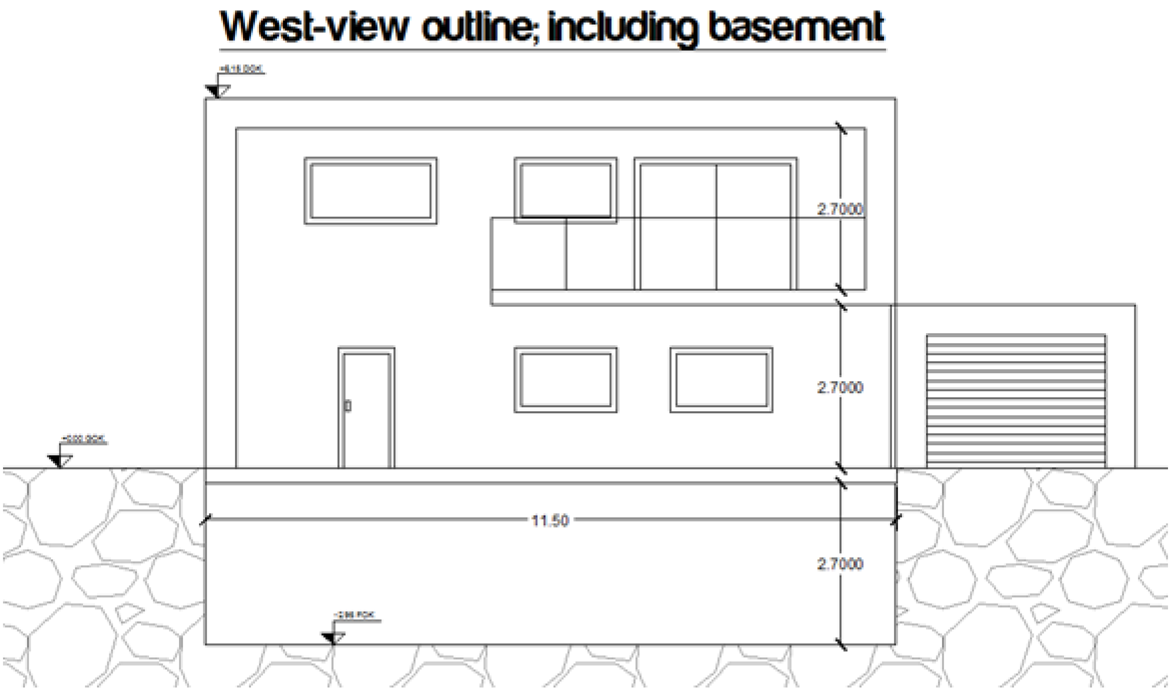
The average climate is decisive to calculate the average heating demand days. This again is part, therefore needed, of the calculation of the whole energy demand of a building. As we can see, both average graphs are very similar and have a maximum difference of 3.5°C, which is accepted as adequate enough.

## 8.2. Test object

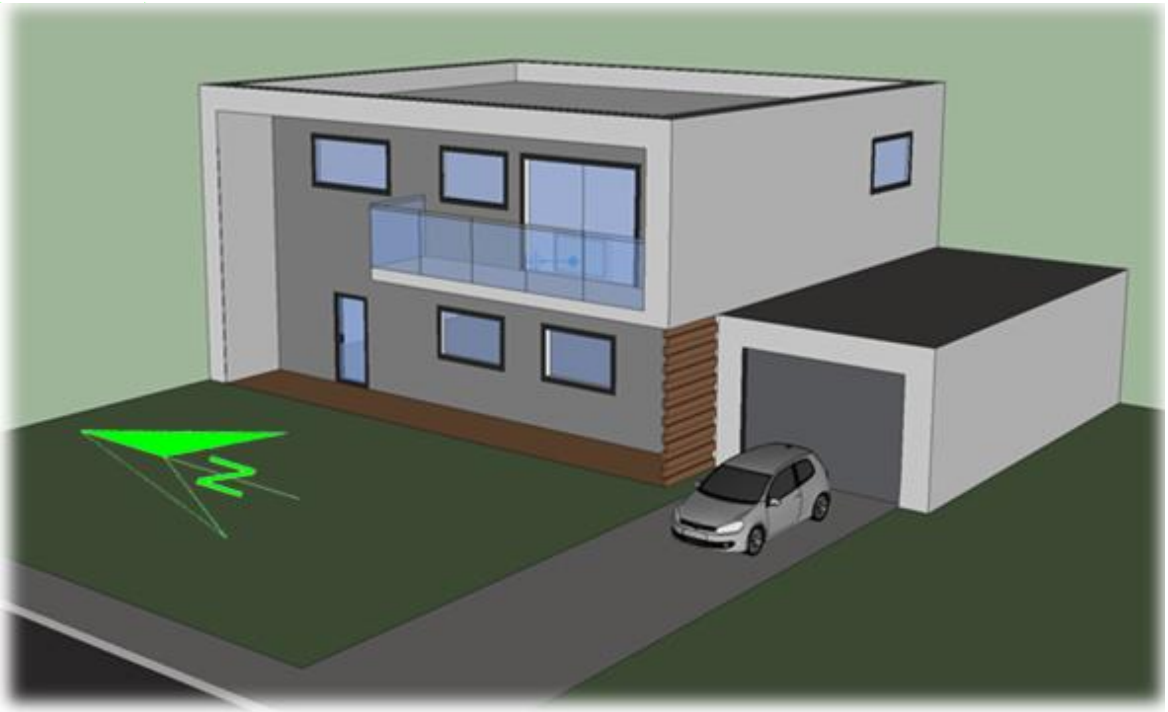
The test object is a theoretical self-outlined low-rise residential building in modern architectural construction style. To complete the research of this thesis, the test object is used for benchmarking the different aspects of energy efficiency of the building standard codes. On the one hand it will get all Californian minimum requirements, regarding to the California Energy Code. On the other hand, the building will get equipped, regarding to the Austrian OIB-Guideline 6.

The object is east-west orientated, is 11.50 m to 9 m large and has therefore about 205 m² split on two floors with a height of 2.7 m each floor. The whole building has a basement which is the same size in length and width as the first and second floor. The basement is basically used as unconditioned space, providing area for the HVAC system and storage space. The attached garage provides place for two cars in a row, the adjacent walls from the garage to the building exceeds the u-value of the exterior wall in this area.

The following illustrated drawings shall give a slight imagination of the theoretical object. These drawings are technical not relevant nor for any other purpose than imagination. They just make it easier for the reader to envision the object.




Pic. 18: West-view outline of the theoretical case-study object



Pic. 19: Scheme of the theoretical case-study object

Because this case study is just dealing with the energy efficiency of this building, the different wall mountings are not really decisive. Instead of applying different wall compositions, whole element u-factors will be used.

The each different requirements of the local building codes have been applied on the object to create a „Californian” and an „Austrian” object and will be described differentiated in the following chapters.

For the calculation of the Energy Certificates, the calculation tool GEQ was used, which is a well-known tool in Austria for modeling Energy Certificates.

## 8.3. Energy Performance Certificate „Austria, North“

The Austrian test object is located in the climate zone north, in the suburbs of Vienna, close to the lower Austrian border. This region in Austria, close to the capital city is well-known for low-rise residential buildings and connected with the fitting climate zone the perfect theoretical spot for the case study.

The following chapters will describe the different characteristics which are applied to the test object “Austria, North”.

#### 8.3.1. Building envelope

The building envelope contains all room-creating elements and is therefore very important to calculate the energy loss through walls, roofs, ceilings and the foundation. At first it is important to know about the decisive dimensions and the size of the building to calculate the floor area and the volume which has to be heated or cooled. The following data was assumed out of the theoretical model and was applied as following:

Width of the whole building.......................................................................11.50 m

Length of the building ...............................................................................9.00 m

Floor height ..............................................................................................2.70 m

After the decisive dimensions and the numbers of the floors were determined, the applicable u-factors have to be found and added to the fitting materials. Following u-factors, out of the Austrian OIB-Guideline 6, were used for this step.

Exterior walls ..........................................................................0.350 W/m²K

Basement walls ........................................................................0.400 Wm²K

Roof..........................................................................................0.20 W/m²K

Foundation ..............................................................................0.40 W/m²K

Ceiling against conditioned space ...........................................0.40 W/m²K

#### 8.3.2. Fenestration and door

Moving on, creating the Energy Certificate, fenestration and door products have to be chosen. This is also important because of the components within the fenestration and door products and their energy behavior. This usually means, as more glazing there is, as more energy loss is created at the same time. Of course there are some high-end products which lower the energy loss significantly, but talking about the standard products which are determined in the building codes of today this rule is still valid. Regarding to the Austrian OIB-Guideline 6, following minimum requirements have to be met within fenestration and door products, which were also applied to the test object.

The Type names are self-created and refer to the object [Door, Window], the size [1, 2, 3] and the location [A=Austria]. The following u-factors are the minimum requirements of the OIB-Guideline 6.

“Door 1A”……………………1.00 m x 2.00 m.........................U-factor = 1.4 W/m²K

“Window T1A”………………1.50 m x 0.90 m.........................U-factor = 1.4 W/m²K

“Window T2A”……………… 2.00 m x 0.90 m.........................U-factor = 1.4 W/m²K

“Window T3A”………………2.50 m x 2.50 m.........................U-factor = 1.4 W/m²K

Regarding to the calculation rules of the Austrian Energy Certificate, it is also important which window is located on which side of the building. This is because the calculation process also involves heat gains due to sunlight and also warns for overheating in summers. Therefore following table shows which type of window faces which geographic direction of the object and is therefore also decisive for the calculation process and the case study.

| **Type** | **1.OG North** | **1.OG East** | **1.OG South** | **1.OG West** |
|---|---|---|---|---|
| Door 1A | | | | 1 |
| Window T1A | 1 | 1 | | 2 |
| Window T2A | | | | |
| Window T3A | | | | |
| **Type** | **2.OG North** | **2.OG East** | **2.OGSouth** | **2.OGWest** |
| Window T1A | | 1 | 1 | 1 |
| Window T2A | | | | 1 |
| Window T3A | | | | 1 |

Tab. 20: Number and orientation of windows and doors in “Austria, North”

As we can see, the object is west orientated, which means that the most fenestration products and the main door are on the west side of the building. This was chosen to protect the building against significant overheating in the summer and also to make the yard enjoyable during the day. As we can see, the north side, which usually doesn’t provide any heat or light gaining’s due to sunlight has just one window. The north side is also the back side of the building and usually contains rooms as such like bedrooms or rooms for children which are very comfortable to sleep in when not overheated during the day.

#### 8.3.3. HVAC System

The HVAC system, which basically deals with heating, ventilation and air conditioning and therefore contains all the needed equipment to keep the air conditions enjoyable for humans, also have a lot of potential to lose energy and is therefore a decisive part for the calculation of the energy efficiency and the Energy Certificate.

The first step is to determine the type of warm water provision. Usually, warm water is provided by a tank located in the central basement of the building which is filled with warm water by the main heating system of the house. This means, that the room heating system also supplies the warm water tank. Therefore we call the system “combined, indirect heated tank, located in the central basement”

Our tank has a volume of about 300 liters, which theoretically could serve for about four to five 10minutes of showering a day if we decide to reheat the whole tank once a day.

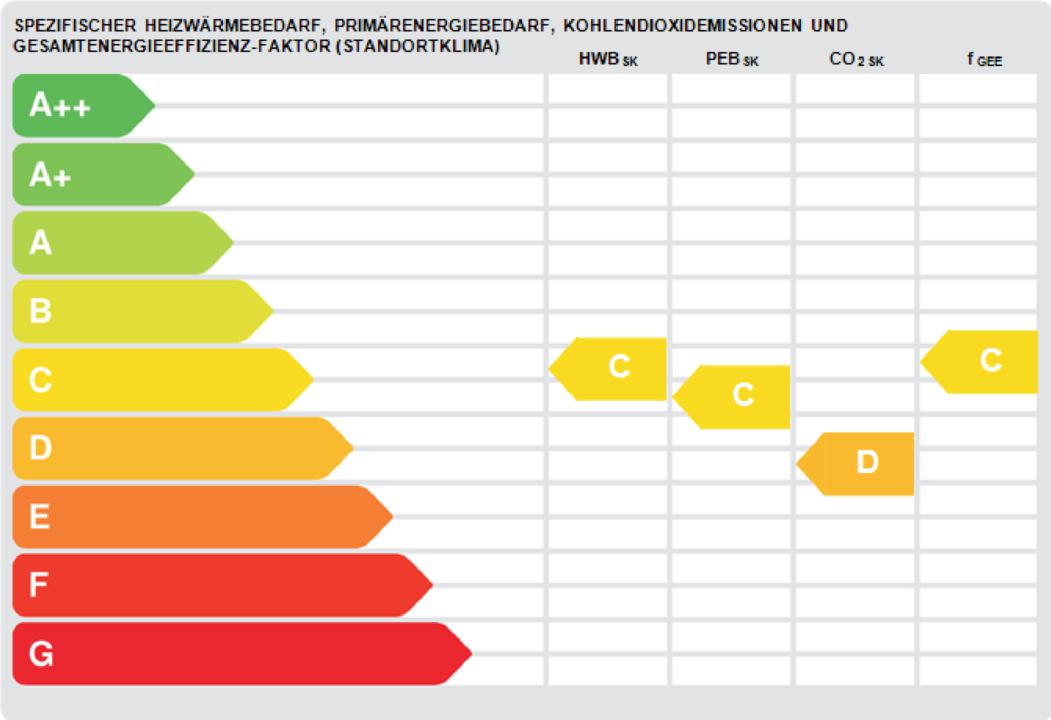
The next step is to determine the main heating device. Usually Austrian low-rise residential buildings are heated by single room heaters, supplied by warm water. The main heating device for “Austria, North” has 17 kW, is located in the unconditioned basement and is fired with light fuel oil. The efficiency grad of this system has a theoretically grade of 85%.

No heat pump is installed and ventilation is provided by manual fenestration openings. All pipes used for the HVAC systems are insulated by a grade of 2/3.

These requirements were also provided by the OIB-Guideline 6 and altogether should lead to the minimal HWB requirement of 66.5 kwh/m² and year.

### 8.4. Intermediate result for „Austria, North“

When applying all the earlier mentioned requirements and calculating the Energy Certificate for „Austria, North“, following intermediate result was achieved.




Pic. 20: Energy Certificate result for “Austria, North”

This graphical result basically means that the planned building accords to the minimal requirements of the Austrian building codes. This chapter shall just give a brief overview of the intermediate result. Interpretations, improvements and the comparison to the result out of the Californian Building Standards will be located in Chapter 8.7 respectively 8.8.

Nevertheless the most important basic characteristic results, which are explained on page 57 and 58, will be given right now as well:

$HWB_{SK}$ ........................................ 65.6 kwh/m² a

$PEB_{SK}$ ........................................ 204.8 kwh/m² a

$CO_{2SK}$ ........................................ 47.2 kg/m² a

$F_{GEE}$ ........................................ 1.15

## 8.5. Energy Performance Certificate „California, 16"

The Californian test object is located in the climate zone 16, in the northern part of California. After intensive studies, this region in California shows the closest findable climate to the situation in Austria and so it is the perfect theoretical spot for the counterpart of this case study. Technically the same basic information which was used for "Austria, North" will be used for again for "California, 16". For completeness and easier understanding reasons it could occur that some information is listed again.

The following chapters will describe the different characteristics which are applied to the test object "California, 16" to create the Energy Certificate.

### 8.5.1. Building envelope

The building envelope contains all room-creating elements and is therefore very important to calculate the energy loss through walls, roofs, ceilings and the foundation. At first it is important to know about the decisive dimensions and the size of the building to calculate the floor area and the volume which has to be heated or cooled. The following data was assumed out of the theoretical model and was applied as following:

Width of the whole building........................................................................11.50 m

Length of the building ...............................................................................9.00 m

Floor height ..............................................................................................2.70 m

After the decisive dimensions and the numbers of the floors were determined, the applicable u-factors have to be found and added to the fitting materials. Following u-factors, out of the Californian Building Standards Code, were used for this step.

Exterior walls ..................................................................................0.397 W/m²K

Basement walls .................................................................................0.301 Wm²K

Roof.................................................................................................0.19 W/m²K

Foundation ........................................................................................ 0.522 W/m²K

Ceiling against conditioned space ...................................................... 0.142 W/m²K

### 8.5.2. Fenestration and door

The Type names are self-created and refer to the object [Door, Window], the size [1, 2, 3] and the location [C=California]. The following u-factors are the minimum requirements of the Californian Building Standards Code.

"Door 1C"……………………1.00 m x 2.00 m ...................... U-factor = 3.00 W/m²K

"Window T1C"………………1.50 m x 0.90 m ...................... U-factor = 3.29 W/m²K

"Window T2C"……………… 2.00 m x 0.90 m ...................... U-factor = 3.29 W/m²K

"Window T3C"………………2.50 m x 2.50 m ...................... U-factor = 3.29 W/m²K

Moving on as exactly the same as for the Austrian part, the orientations of the windows and the door is the next step and the information is again illustrated in the following table:

| **Type** | **1.OG North** | **1.OG East** | **1.OG South** | **1.OG West** |
|---|---|---|---|---|
| Door 1C | | | | 1 |
| Window T1C | 1 | 1 | | 2 |
| Window T2C | | | | |
| Window T3C | | | | |
| **Type** | **2.OG North** | **2.OG East** | **2.OGSouth** | **2.OGWest** |
| Window T1C | | 1 | 1 | 1 |
| Window T2C | | | | 1 |
| Window T3C | | | | 1 |

Tab. 21: Number and orientation of windows and doors in "California, 16

The differences here are the decisive u-factors which determine the energy loss and heat gains of the different fenestration products. As we can see the Californian u-factors are significant higher numbers than in Austria, which means the u-factor is lower and therefore the energy losses are higher as well.

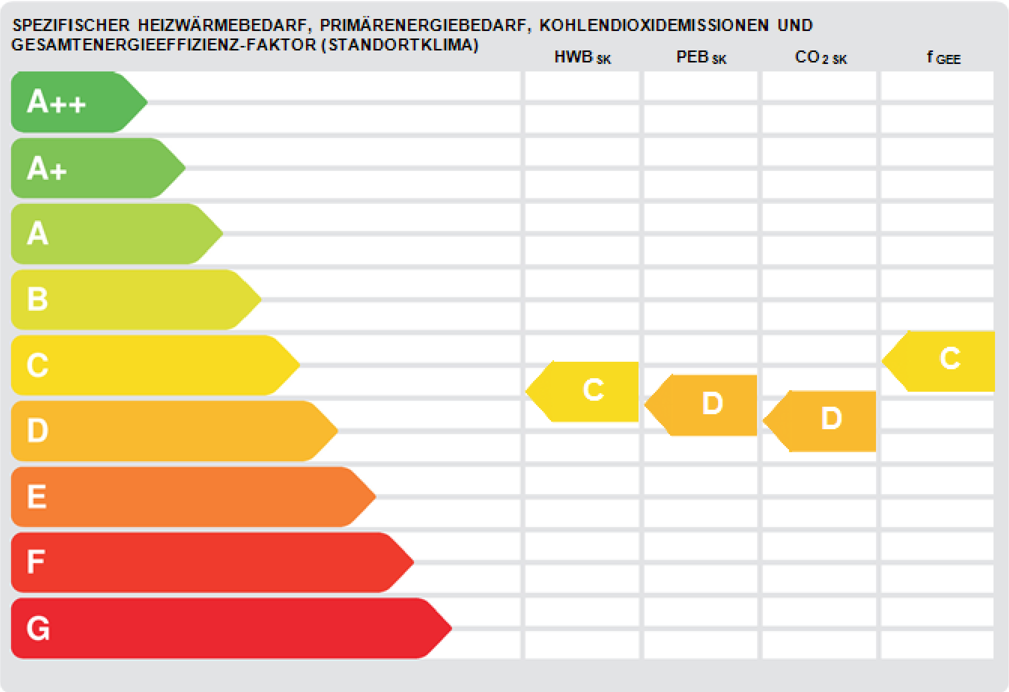
### 8.5.3. HVAC System

The HVAC system applied to the Californian test object „California, North“, is based on a small field study of the author connected with the requirements of the Californian Building Standards Code. After the investigation of a couple of average Californian low-rise residential homes following setup was chosen as “average” and therefore applicable to this part of the case study.

The main used fuel is natural gas. Therefore average houses use a central heating device supplied by natural gas. Usually these devices are not connected to a tank. This means that the warm water supply is guaranteed by an instant boiler which heats up the water while needed. This system is also used for space heating. All pipes, regarding to the Californian Building Standards Code, are insulated by a grade of 1/3.

Thus the CBSC does not allow ventilation by manual window operation, ventilation has to be installed. Therefore a simple ventilation system without heat recovery was chosen and the maximum of 1.5 L/s m² air leakage was applied.

## 8.6. Intermediate result for „California, 16“




Pic. 21: Energy Certificate result for “California, 16”

After analyzing the graphical output, the Energy Certificate for “California, 16” shows following result in numbers:

$HWB_{SK}$ ........................................................................................ 95.3 kwh/m² a

$PEB_{SK}$ ........................................................................................ 225.5 kwh/m² a

$CO_{2SK}$ ........................................................................................ 43.6 kg/² a

$f_{GEE}$ ........................................................................................ 1.32

## 8.7. Comparison

As expected, the differences are not that big. Both test objects got ranked between classes C to D within the decisive characteristics. This was kind of foreseeable because of the very similar requirements.

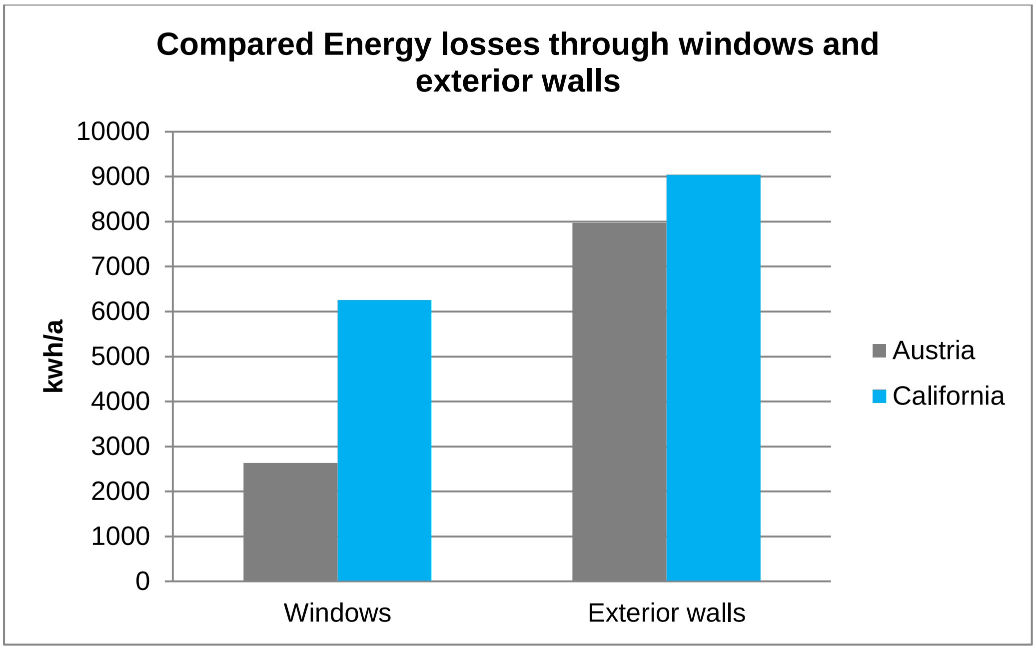
Following important results have been achieved during the case study, illustrated in this table:

| | **Austria, North** | **California, 16** |
|---|---|---|
| $HWB_{SK}$ | 65.6 kwh/m² a | 95.3 kwh/m² a |
| $PEB_{SK}$ | 204.8 kwh/m² a | 225.5 kwh/m² a |
| $CO_{2SK}$ | 47.2 kg/m² a | 43.6 kg/m² a |
| $f_{GEE}$ | 1.15 | 1.32 |

Tab. 22: Comparison of “Austria, North” and “California, 16” energy demand results

As we can see the heating demand per square meter ($HWB_{SK}$) of “Austria, North” is 65.6 kwh/m² and year, which exactly reflects the minimum requirement of the Austrian OIB-Guideline these days. On the other hand, the $HWB_{SK}$ of “California, 16” is 95.3 kwh/m² and year. This is difference from about 45 %. That basically means that, by applying the OIB-Guideline compared to the Californian Building

Standards at the exact same building, lead to a 45 % lower energy demand per square meter. This is probably caused by the low required u-factor values from fenestration and door products. This lack leads to a very high loss of energy trough different materials which we can see in the following figure.

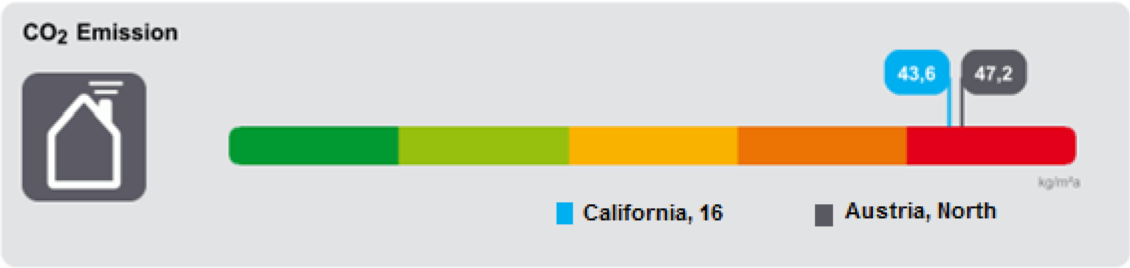



Pic. 22: Compared energy losses of windows and exterior walls

The diagram expresses the two highest energy loss sources. We can clearly see that the lower u-factor value of the windows, found in the Californian Building Code leads to an enormous difference.

The primary energy demand ($PEB_{SK}$) is directly connected with the type of energy source. Therefore we can see, although the $PEB_{SK}$ from "California, 16" is slightly higher than the $PEB_{SK}$ from "Austria, North", it is not in the same proportion as the $HWB_{SK}$. That tells us, while knowing that gas and light oil have a similar energy output that gas is easier to prepare than oil, which means it needs less energy to prepare gas to be used as combustible material than raw oil. The problem with using gas is that there has to be a highly developed pipeline network, which is very expensive and Austria does not really have this type of infrastructure in the suburbs. This is also why most of the people, who live in a low-rise residential building in Austria, are using oil as combustible.

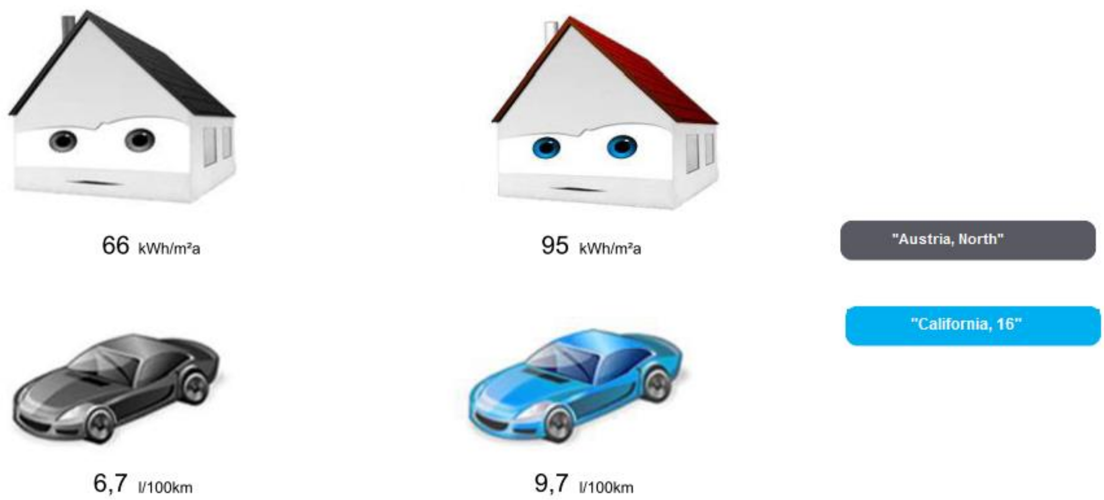
The $CO_{2SK}$ value is directly connected with the type of heating device and the used combustible. The value is almost equal at both test objects, which proofs that using oil as combustible material causes more exhaust and more emissions than using gas.




Pic. 23: $CO_2$ Emissions directly compared and ranked

While the “Austria, North” shows an amount of 9766 kg of $CO_2$ emissions per year, “California, 16” has only 9020 kg a year. To make it easier understandable the similar amounts are caused by an average diesel car which needs about 8 liters per 100 kilometers and is driven 50.000 km a year.

Summing up the demands and continuing the comparison to a car, both houses could be compared to each other and to cars like the following graphic shows:




Pic. 24: “Austria, North” and “California, 16” compared to each other and to their car equivalents

## 8.8. Case study résumé

Even though the numbers look very close to each other on the first sight, we should not forget that these numbers are decisive for one square meter per year. That means that the "real" energy demand for the whole building rises with every square meter of the house (207 m²).

Therefore, the "real" demands, losses and gains are shown in the following table:

| | **Austria, North** | **California, 16** |
|---|---|---|
| $HWB_{SK}$ | 65,68 kwh/m² and year | 95,31 kwh/m² and year |
| Annual energy demand for heating purposes | 13.721 kwh per year | 19.842 kwh per year |
| Annual heat loss through exterior walls | 7.973 kwh per year | 9.044 kwh per year |
| Annual heat loss through windows | 2.673 kwh per year | 6.255 kwh per year |
| Annual overall heat loss | 20.790 kwh per year | 27.717 kwh per year |
| Annual solar gains | 2.646 kwh per year | 3.047 kwh per year |

Tab. 23: "Real" annual demands, losses and gains of both test objects

The annual solar gains are connected to the different u-factors of the buildings. That means that the higher u-factor value of the installed windows in "Austria, North" automatically reduces the solar gains. On the other hand, the lower U-factor values of the installed windows in "California, 16" are leading to solar gains.

As we can see, the Californian Building Standards Code is leading continuously to higher demands and therefore higher losses. Summed up, the biggest part of the differences is a result of the different u-factors of the fenestration products, which is very impressive and should illustrate that, when thinking about buying windows, there is a very high potential savings amount in energy costs.

Another important fact which should be considered is that these requirements are the absolute minimum of each building code and therefore this study might represent the differences in each building codes regarding to the chosen climatic areas, but eventually not the average reality regarding to the whole countries.

## 9. Conclusion

Concluding, the purpose of the paper is reached and hopefully showed a widespread topic of Austria's and California's energy demands, how engineers are dealing with these issues today to provide efficient housing situations and the future possibilities we have to lower and control our emissions to make our environment cleaner and to act more sustainable in the same way regarding to and focused on California's and Austria's building standards.

When thinking back about the different rating systems, we can see that the international work on benchmarking energy efficiency is very well developed these days. Both systems, from The Unites States and Austria's are pretty similar and both contain the most important features.

At the end, using the results from the case study, combined with the analysis of the particular building standards regarding to energy efficiency, the current differences and, more important, their impacts on low-rise residential buildings has been explained and illustrated. The main differences and their effects are clear and maybe we can learn from each other based on these perceptions.

The overall result tells us that the people in charge are very aware of the topic. But energy efficiency is, by far, not at its end. Engineers will always work harder to achieve better results. We are on a very good way these days, more aware than ever and some of our reformations within guidelines and laws are changing faster than ever.

Maybe someday every low-rise residential building will be a Zero Net Energy Home and living itself will not affect the environment more than it has to.

# Terms and definitions

This summary of shortcuts should serve as repetition, reference book for terms and definitions to be able to look up their meaning fast and clearly arranged.

*[BTU] ..................... British thermal unit*

The British thermal unit is a unit of energy. The shortcut is “BTU”. A BTU is defined as the amount of needed energy to heat a pound of water up for 1 °F.

*[°F]......................... degree Fahrenheit*

Degree Fahrenheit is a unit to measure temperature, mainly developed to avoid negative numbers on the temperature scale.

*[λ] .......................... Lambda-Value*

The Lambda-Value is a unit less number to express heat loss abilities of materials.

*[R].......................... R-Value*

The R-Value is also a unit to express heat loss abilities of materials. The difference is that it connects the Lambda-Value with the thickness of the specific material. The exact definition of the R-Value is located on page 21 of this thesis.

*[U].......................... U-factor*

The u-factor is a unit to express insulation abilities of materials. The exact definition of the u-factor is located on page 21/22 of this thesis.

*[SHGC] .................. Solar heat gain coefficient*

This factor is the US-Unit for the European G-Factor, which describes the solar energy which can interfuse the glazing. This factor is always given in a percentage number, therefore directly comparable.

*[HERS] .................. Home Energy Rating System*

HERS is also an U.S building rating system, but mainly focused on low-rise residential buildings. The description can be found on page 53/54 of this thesis.

*[LEED]................... Leadership in Energy and Environmental Design*

LEED is an U.S building rating systems. It is mainly used for business and office buildings. The description can be found on page 55/56 of this thesis.

*[ZNE] ..................... Zero Net Energy Home*

A new building standard with an annual zero energy demand.

*[HWB]................... Heating Demand*

The heating demand describes how much energy in form of heat, is needed to heat up all rooms of the building to the preferred temperature.

*[PEB] ..................... Primary Energy Demand*

The primary energy demand factor describes how much energy the building generally needs. That contains aspects of the different used energy sources, how much energy it is needed to prepare them and make them ready to use and how much impact these primary energy sources have on the environment.

[$f_{GEE}$]....................... *Final Energy Efficiency Factor*

The Final Energy Efficiency Factor compares the whole energy demand situation with a reference building. Therefore this number makes the building easier comparable to others regarding to one factor.

# Appendices

## A1. Californian envelope requirements for all climate zones

Page 234 2013 Building Energy Efficiency Standards

*TABLE 150.1-A COMPONENT PACKAGE-A Standard Building Design*

| | | | Climate Zone | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Building Envelope – Insulation[1] | Roofs /Ceilings | | U 0.025 R 38 | U 0.031 R 30 | U 0.031 R 30 | U 0.031 R 30 | U 0.031 R 30 | U 0.031 R 30 | U 0.031 R 30 | U 0.031 R 30 | U 0.031 R 30 | U 0.031 R 30 | U 0.025 R 38 | U 0.025 R 38 | U 0.025 R 38 | U 0.025 R 38 | U 0.025 R 38 | U 0.025 R 38 |
| | Walls – Above Grade | 2x4 Framed[2] | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U-0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 | U 0.065 R 15+4 or R 13+5 |
| | | Mass Wall Interior[3] | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.059 R 17 |
| | | Mass Wall Exterior[3] | U 0.125 R 8.0 | U 0.125 R 8. | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.125 R 8.0 | U 0.1025 R 8.0 | U 0.125 R 8.0 | U 0.070 R 13 |
| | Walls – Below Grade | Below Grade Interior[3] | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.070 R 13 | U 0.066 R 15 |
| | | Below Grade Exterior[3] | U-0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.200 R 5.0 | U 0.100 R 10 | U 0.100 R 10 | U 0.053 R 19 |
| | Floors | Slab Perimeter | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | U 0.58 R 7.0 |
| | | Raised | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 | U 0.037 R 19 |
| | | Concrete Raised | U 0.092 R 8.0 | U 0.092 R 8.0 | U 0.269 R 0 | U 0.269 R 0 | U0.269 R 0 | U 0.269 R 0 | U 0.269 R 0 | U 0.269 R 0 | U 0.269 R 0 | U 0.269 R 0 | U 0.092 R 8.0 | U 0.138 R 4.0 | U 0.092 R 8.0 | U 0.092 R 8.0 | U 0.138 R 4.0 | U 0.092 R 8.0 |
| Building Envelope | Radiant Barrier | | NR | REQ | REQ | REQ | REQ | REQ | REQ | REQ | REQ | REQ | REQ | REQ | REQ | REQ | REQ | NR |
| Building Envelope – Roofing Products | Low-sloped | Aged Solar Reflectance | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0.63 | NR | 0.63 | NR |
| | | Thermal Emittance | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0.75 | NR | 0.75 | NR |
| | Steep Sloped | Aged Solar Reflectance | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | NR |
| | | Thermal Emittance | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0. 75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | NR |
| Building Envelope – Fenestration | Maximum U-factor[4] | | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| | Maximum SHGC[5] | | NR | 0.25 | NR | 0.25 | NR | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | Maximum Total Area | | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| | Maximum West Facing Area | | NR | 5% | NR | 5% | NR | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% |

*SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR NEWLY CONSTRUCTED RESIDENTIAL BUILDINGS*

## A2. Californian construction permit application

# CONSTRUCTION PERMIT APPLICATION

PLANNING & BUILDING DEPARTMENT • COUNTY OF SAN LUIS OBISPO
976 OSOS STREET • ROOM 200 • SAN LUIS OBISPO • CALIFORNIA 93408 • (805) 781-5600

**PROPERTY INFORMATION**

Assessor Parcel Number(s): ________________ Project Address: ______________________________________

**APPLICANT / PROFESSIONAL INFORMATION** (*Check ☐ contact person. Agents must fill out Authorization of Agent.*)

☐ Landowner Name__________________________________________ Daytime Phone: __________________
Mailing Address______________________________________ City:________________________ Zip: _______
Email Address__________________________________________
☐ Licensed Professional In Charge of Project __________________________________ Phone: ______________
Mailing Address______________________________________ City:___________________ License:_________
Email Address__________________________________________
☐ Licensed Contractor ____________________________________________________ Phone: ______________
Mailing Address______________________________________ City:___________________ License:_________
Email Address__________________________________________
☐ Agent for ☐ Contractor ☐ Owner _______________________________ Phone: ________________________
Mailing Address______________________________________ City:________________________ Zip: _______
Email Address__________________________________________

**PROJECT INFORMATION** (*please fill out this section completely*)

Scope of Work: ______________________________________________________________________________
______________________________________________________________ Valuation: $_________________

- Structure Info - Conditioned Area _____ sq. ft. • Unconditioned Area _____ sq. ft. • Deck/Porch/Patio _____ sq. ft. Retaining Wall Length _____ lin. ft. • Bedrooms _____ • Bathrooms _____ • Stories____ • Roof Height ______ft.
- Utilities - ☐ Well ☐ Septic ☐ Public - agency or company for water/sewer __________________________
- Grading - Cut______c.y. Fill:______c.y. Total _______c.y. Slope: _______ Area of disturbance ________ ac.
- Impervious surface area _______ sq. ft. (*May require separate Stormwater Control Plan Application*)
- Solar - ☐ Grid tied ☐ Off Grid Total KW _______ ☐ New Electric Meter ______ Amps

**WASTE MANAGEMENT - RECYCLING PLAN**

**Are you planning to**

☐ **A**) use an Integrated Waste Management Authority (IWMA)-certified construction and demolition waste recycling facility? **or**
☐ **B**) use other recycling and disposal facilities? (*complete Detailed Recycling Form*)

**BY MY SIGNATURE BELOW, I CERTIFY TO EACH OF THE FOLLOWING:**

☐ I am the property owner, contractor, or am authorized to act on the property owner's behalf, and the information I have provided above is correct. I acknowledge that I have read and understand the information contained herein.
☐ I agree to comply with all applicable city and county ordinances and state laws relating to building construction.
☐ I authorize representatives of this city or county to enter the above-identified property for inspection purposes.
☐ My construction permit application is public record and is therefore published in the weekly reports on the San Luis Obispo County Planning and Building Department's website, as well as in the public information area. All references to names, addresses, telephone numbers, and project information will be part of this public record. All applications must be filed under the property owner's name and address; however, I may use an alternate contact address and telephone number.
☐ I acknowledge **my application will expire after 6 months (2 months for Code Enforcement)**, if not issued by that time.

______________________________________________ ______________________________
**Signature of Owner / Authorized Agent** Date

*I hereby affirm under penalty of perjury that I am licensed under provisions of Chapter 9 (commencing with Section 7000) of Division 3 of the Business and Professions Code, and my license is in full force and effect.*

**Contractor Signature** ____________________________________________ Date____________________

CONSTRUCTION PERMIT APPLICATION PAGE 1 OF 2
SAN LUIS OBISPO COUNTY PLANNING & BUILDING APRIL 15, 2014
SLOPLANNING.ORG PLANNING@CO.SLO.CA.US

**DISCLOSURES** *(please initial 'yes' or 'no' for each)*

☐ Yes **I have signed and completed the required Hazardous Waste and Substances Statement Disclosure.**
☐ Yes ☐ No This project requires me to obtain a D.O.S.H. Hazardous Activities Permit.
☐ Yes ☐ No I hereby affirm under penalty of perjury that there is a construction lending agency for the performance of the work for which this permit is issued (Section 3097, Civil Code).

Name & Address of Lender: ____________________

**OWNER-BUILDER DECLARATION**

I hereby affirm under penalty of perjury that I am exempt from the Contractors' State License Law for the reason(s) indicated below by the checkmark(s) I have placed next to the applicable item(s) (Section 7031.5, Business and Professions Code: Any city or county that requires a permit to construct, alter, improve, demolish, or repair any structure, prior to its issuance, also requires the applicant for the permit to file a signed statement that he or she is licensed pursuant to the provisions of the Contractors' State License Law (Chapter 9 (commencing with Section 7000) of Division 3 of the Business and Professions Code) or that he or she is exempt from licensure and the basis for the alleged exemption. Any violation of Section 7031.5 by any applicant for a permit subjects the applicant to a civil penalty of not more than five hundred dollars ($500).):

☐ I, as owner of the property, or my employees with wages as their sole compensation, will do ☐ all of or ☐ portions of the work, and the structure is not intended or offered for sale (Section 7044, Business and Professions Code: The Contractors' State License Law does not apply to an owner of property who, through employees' or personal effort, builds or improves the property, provided that the improvements are not intended or offered for sale. If, however, the building or improvement is sold within one year of completion, the Owner-Builder will have the burden of proving that it was not built or improved for the purpose of sale.).

☐ I, as owner of the property, am exclusively contracting with licensed Contractors to construct the project (Section 7044, Business and Professions Code: The Contractors' State License Law does not apply to an owner of property who builds or improves thereon, and who contracts for the projects with a licensed Contractor pursuant to the Contractors' State License Law.).

☐ I am exempt from licensure under the Contractors' State License Law for the following reason:

____________________

☐ I have signed and completed the **Owner-Builder Notice to Property Owner** form

By my signature below I acknowledge that, except for my personal residence in which I must have resided for at least one year prior to completion of the improvements covered by this permit, I cannot legally sell a structure that I have built as an owner-builder if it has not been constructed in its entirety by licensed contractors. I understand that a copy of the applicable law, Section 7044 of the Business and Professions Code, is available upon request when this application is submitted or at the following website: http://www.leginfo.ca.gov/calaw.html.

**Signature of Owner/Authorized Agent** SIGN HERE ____________________ **Date:** ____________

**WORKERS' COMPENSATION DECLARATION**

**WARNING**: Failure to secure workers' compensation coverage us unlawful, and shall subject an employer to criminal penalties and civil fines up to one hundred thousand dollars ($100,000), in addition to the cost of compensation, damages as provided for in section 2706 of the Labor Code, interest, and attorney's fees. I hereby affirm under penalty of perjury one of the following declarations:

____ I have and will maintain a certificate of consent to self-insure for workers' compensation, issued by the Director of Industrial Relations as provided for by Section 3700 of the Labor Code, for the performance of the work for which this permit is issued.
Policy No. ____________________

____ I have and will maintain workers' compensation insurance, as required by Section 3700 of the Labor Code, for the performance of the work for which this permit is issued. My workers' compensation insurance carrier and policy number are:
Carrier ____________ Policy Number ____________ Expiration Date ____________
Name of Agent ____________________ Phone # ____________

____ I certify that, in the performance of the work for which this permit is issued, I shall not employ any person in any manner so as to become subject to the workers' compensation laws of California, and agree that, if I should become subject to the workers' compensation provisions of Section 3700 of the Labor Code, I shall forthwith comply with those provisions.

**Signature of Owner/Authorized Agent/Contractor** SIGN HERE ____________________ **Date:** ____________

**NOTE:** Applications will become null and void if not issued within 6 months (2 months for Code Enforcement applications), and applicant will need to resubmit and repay fees.

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## Images and Pictures

## Tables

## Required software

### GEQ

Energy certificate software for Austrian purposes. Version 2013, 110705.

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Mailto: office@geq.com , In URL: www.geq.at or www.berechner.at

### AutoCAD 2013

CAD software for engineering purposes. Version 2013 of Autodesk, Inc.

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San Rafael, CA 94903 In URL: www.autodesk.com

### GOOGLE SketchUp

3D Modeling software for all purposes. Version 2013, 13.0.4812

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