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Doing Well by Doing Good - An economic analysis of energy-efficient buildings in Austria

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To my Grandfather

Eidesstattliche Erklärung

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I declare that I have authored this thesis independently, that I have not used other than the declared sources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

This paper was not previously presented to another examination board and has not been published.

Special thanks to my supervisor, Univ.-Prof. Dr. Franz Wirl. I am also grateful for the suggestions of others who helped me in writing this master thesis.

Vienna, 04.07.2017

Signature
(Armilda Lackaj)

Table of Contents

List of Figures

List of Tables

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAR	Beste Aussichten Real Property Trustee
bn.	billion
BPIE	Buildings Performance Institute Europe
BREEAM	Building Research Establishment Environmental Assessment Method
CSR	Company Social Responsibility
CO_2	Carbon Dioxide
DGBN	Deutsche Gesellschaft für Nachhaltiges Bauen
DIFNI	Deutschen Privaten Institut für Nachhaltige Immobilienwirtschaft
EAA	Environmental Agency Austria
EPA	U.S. Environmental Protection Agency
EPBD	Energy Performance of Buildings
EPCs	Energy Performance Certificates
EU	European Union
EUR	Euro
GB	European Green Building Programme
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HVR	Ventilation system through heat recovery
IBO	Österreichisches Institut für Bauen und Ökologie GmbH
IPD	Investment Property Databank
kWh	kilowatt-hour
kWp	kilowatt-peak
LEED	Leadership in Energy and Environmental Design
m.	Meter
MAR	Missing at Random
MSCI	Modern Index Strategy Indexes
PV	Photovoltaic
OIB	Österreichisches Institut für Bautechnik
sqm.	Square meter
ÖGNI	Österreichische Gesellschaft für Nachhaltige Immobilienwirtschaft
TQ	Total Quality
TQB	Total Quality Building
TBV	Technische Bauvorschriften 2008
U.S.	United States
USGBC	US Green Building Council
WUSKEA	Wiener unabhängiges Kontrollsystem für Energieausweise

Executive Summary

Die Einführung des Energy Performance Certificate (EPC) durch die Europäische Union entfachte den Trend zur Zertifizierung sowie führte zur Anpassung der staatlichen Nachhaltigkeitsstrategie. Da mehr als 40% des Energieverbrauches auf Gebäude entfallen, bedeutet das, dass der Immobiliensektor davon besonders betroffen ist. Im Ergebnis heißt es, dass die Bereitschaft zur Zahlung des erhöhten Mietpreises gestiegen ist, nicht zuletzt, weil auch das Niveau des Umweltbewusstseins gestiegen ist.

Da es in Österreich sehr wenige beziehungsweise nur sporadische Nachweise des Einflusses der grünen Zertifizierung auf die Preisgestaltung am Immobilienmarkt gibt, war der Fokus dieser Masterarbeit auf dem Bürosegment gerichtet um das Verhältnis zwischen Investitionen unter Bedachtnahme auf die Nachhaltigkeit der Energienutzung in neue und renovierte Räumlichkeiten einerseits und dem Mietzins andererseits festzustellen.
Dass es sich um einen für Österreich neuen Trend handelt, erklärt die Anzahl der Zertifizierungsschemen in Verbindung mit dem Nichtvorhandensein von Informationen das Fehlen von Analysen beziehungsweise Studien über das Land. Daher sind die Ergebnisse dieser Masterarbeit von großer praktischer Bedeutung und Relevanz, da diese nicht nur einen Einblick in das Thema gewähren, sondern auch unter anderem eine Grundlage für spätere Vergleiche und Verweise herangezogen werden können.

Zu Beginn wurde eine Auswahl von 118 Gebäuden getroffen, welche ein grünes Zertifikat von einer der fünf Rating-Agenturen erhalten haben. Die Daten wurden einzeln erfasst und verarbeitet, in der Folge wurde eine Gesamtanalyse durchgeführt. Weiteres wurde eine Untergruppe bestimmt, welche 31 Immobilienobjekte umfasste, basierend auf den Baueigenschaften und Informationen über die Zusammensetzung des Mietzinses. Im zweiten Schritt wurde eine Kontrollgruppe ausgewählt, welche aus Objekten bestand, welche eine Verbindung mit der grünen Untergruppe aufweisen – die Bereitschaft zur Zahlung wurde an Hand des hedonistischen Preismodells geschätzt.

Regressive Daten haben ergeben, dass es eine Verbindung zwischen dem Mietzins und bestimmten hedonistischen Eigenschaften gibt. Dennoch werden sich diese Ergebnisse in der Zukunft verändern, insbesondere wegen der Marktgröße, Größe des Staates sowie der hohen Konzentration von grünen Gebäuden innerhalb einer Region. Jedoch zeigt die durchgeführte Analyse, dass es eine negative Korrelation zwischen dem Mietzins und dem Heizwärmebedarf gibt. Weiter unterscheiden sich die Ratings der verschiedenen Agenturen. Das ist ein stichhaltiger Beweis, welcher gewisse Parallelen zu den internationalen Studien herstellt und bestätigt, dass die Zertifizierung einen erhöhten Marktwert schafft, statt bloß einen nicht messbaren Kennzeichnungseffekt darzustellen.

Executive Summary

The introduction of Energy Performance Certificates (EPCs) across the European Union encouraged the trend of certification labels and government changes in sustainability policies. Since more than 40 percent of the final energy consumption occurs from buildings, the real estate sector occupies a significant part share. As a result, the willingness to pay a price that is conceivably higher in view of a growing level of environmental awareness has increased.

Concerned by little to no evidence of the green certification impact in rental prices of environmentally sustainable buildings in the Austrian real estate market, the aim of this study is to focus on office buildings and investigate the relationship between energy efficiency investments for new and refurbished green buildings and effective rent.

Since this is a new trend in Austria, the numerous labelling schemes combined with the inaccessibility of data explain why there is an absence of analysis or studies related to Austria. Therefore, the analysis presented in this thesis is of significant importance as it provides new insights and findings that can be used for future references and comparisons.

To begin, a national sample of 118 office buildings, that have been labelled as green buildings by at least one of five rating agencies, was assembled. The data was processed individually although aggregate analysis was used. Furthermore, a subsample of 31 buildings is identified based on information about building characteristics and monthly rent available. In the second part, a control sample of nearby office buildings is attached to the green subsample and the willingness to pay is estimated by using the hedonic rent model.

Moreover, regression data reveals a link between rental prices and hedonic characteristics. Nonetheless, because of the market size, country size and the high concentration of green buildings in one region, the results are a matter of change. However, the analysis carried out in this research study reveals a negative correlation between rent prices and heating demand, as well as the relationship differs between rating agencies. This is solid evidence added to the international studies concerning green certification which affirms its augmented market value attributing to it more than an intangible labelling effect.

I. Introduction

1. Background Information

One of the three pillars of sustainability, is environmental sustainability. Its significant importance is reflected in the fading effect of the social and economic pillars while considering their dependency on the greater system they live in, which is the environment. Because of its descriptive characteristics in production and consumption methods, and more importantly capital investment, awareness towards environmental sustainability has experienced cognitive and social changes. The real estate sector occupies a significant part share, where more than 40 percent of the final energy consumption occurs from buildings, thereby contributing a projected rate of 56 percent of CO_2 emissions globally. (World Economic Forum (WEF), 2016) Because of this, there is an increase in the willingness to pay a conceivably higher price as the awareness for environmental impacts has also increased. In response to market demand, independent third parties have established certification labels. (Miller, et al., 2008) Since there is an interest in the production of favourable environmental outcomes the parties involved in this process come from two different backgrounds. From one side, governmental policies contribute through regulations and standards, as well as through financial incentives and educational supports. (Gabay et al., 2014) On the other side, building owners and managers are placed based on their financial interests. (Wetering & Wyatt, 2011)

In the European Union, the development of energy and climate policy overall has gained increasing attention. This is also reflected from the Austrian Government which in the last decade has continuously established energy policies. In 2012, Austria introduced Feed-in tariff, a support scheme for renewable energy sources used for electricity, heating and cooling and transport, (Ökostromgesetz 2012 – ÖSG 2012, 2012)**,** as well as an investment subsidy of 40 percent of the investment costs (EEA, 2012) up to EUR 375 per kWp for Photovoltaic (PV) installation of buildings. (Jirous, 2012) Despite the measures taken, Austria was sued in 2014 from the EU Commission for incomplete transposition into national law of the directive on energy performance of buildings (European Commission, 2014). However, according to the Environmental Agency Austria (EAA), the total greenhouse gas (GHG) emissions produced from households and occupied living spaces was reduced despite the growing numbers in this sector (Figure 1). As the building sector consumes 30 percent of the end energy in Austria (Austrian Energy Agency, 2017)**,** the lever for a potential reduction is based on switching into renewables and introducing innovative programmes that support building renovations and establish requirements for new buildings (related to the mandatory category ‘nearly-zero-energy buildings).

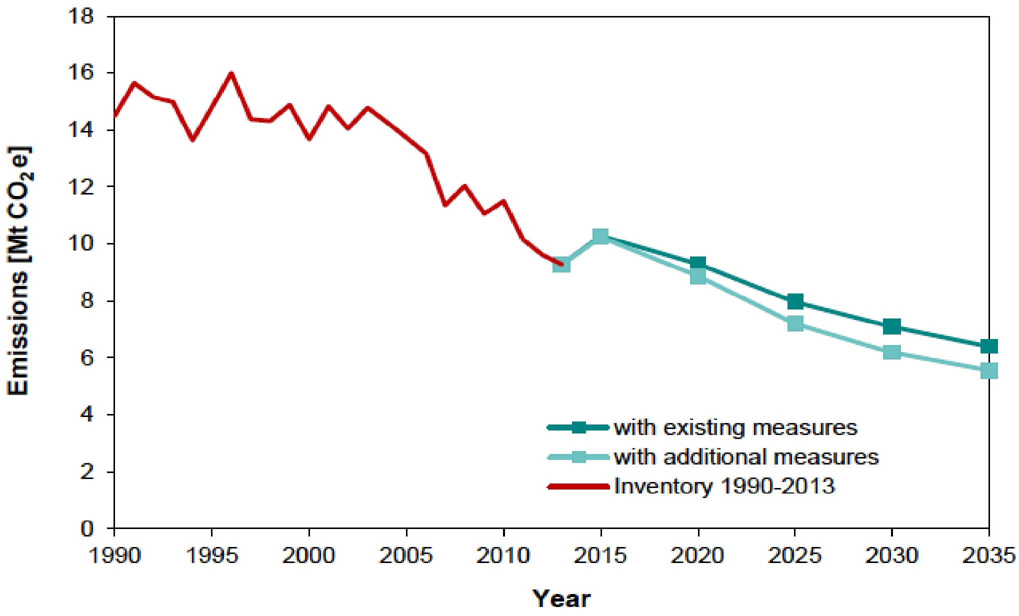

Figure 1: Past trend and scenarios (2014–2035) GHG emissions (incl. sectors Residential, Commercial/ Institutional and Agriculture/ Forestry/ Fishing sectors and military transport sector

(Source: (Anderl, et al., 2015)***)***

The introduction of Energy Performance Certificates (EPCs) from the European Union encouraged the trend of certification labels and the change of sustainable policy agenda for governments. However, in the Austrian real estate market there is little evidence of their impact.

Despite the fundamental role of energy costs and the growing awareness on energy saving, there is a scarcity present in quantitative evidence on the “green stock market” across European countries, particularly in Austria. This research study examines the presence of certified green buildings in the Austrian real estate market by focusing on commercial and rental prices. Furthermore, an analysis on the economic significance of this trend compares rental prices and hedonic characteristics of eco-certified buildings by identifying a control sample of nearby non-certified office buildings.

1. Green Building Initiative: Why certify? Source?

The concept of green buildings tends to lead into a more sustainable building and construction able to preserve the environment. Limiting it to energy efficiency will undress it from different features and characteristics that are determinants that inter-relate with other aspects. From a historical prospective, the European and U.S market driving forces are in striking contrast. The European driving forces such as climate, culture, politics and economics have highly influenced the real estate market.

Climate: The cold climate of northern Europe has significantly influenced the interest of these countries in investing and supporting innovative technologies contributing to the well-being of occupants. Europeans are less vulnerable to constant temperatures (air-conditioning) considering the four-season climate and the continuous temperature fluctuations. (Yudelson, 2012)

Culture: Since Europeans tend to build permanently, this is also related to the climate (the absence of natural catastrophes and disasters such as hurricanes, tornados, tsunamis and other geologic processes) the tendency is to be efficient in both architectural and operational approaches. Also, fresh air and natural light is part of the Austrian building regulations based on The Health and Safety at Work Act enacted in 1994. (Yudelson, 2012)

Policies and regulations: Simultaneously, policies, regulations and directives of European Union and Energy Performance of Buildings Directive (EPBD) are constantly supporting and monitoring different influential environmental aspects and goal reaching factors across European countries, i.e. GHG/Kyoto Protocol. (Yudelson, 2012)

Cost saving: Quantifying the economic value of green buildings helps in understanding the importance of investments. Since this has become a cost-perception issue, research at academic levels has contributed by analysing it via different perspectives. (Yudelson, 2012)

Resource scarcity: Green architects distinguish between two phases (1) reduction of energy consumption at the initial starting point and (2) transition to renewables. From an economic point of view, reducing energy consumption at the time of construction will translate into saving resources and insuring against future energy price increases. Also, new technological improvements, i.e. insulation may result in lower operating costs. (Brounen & Kok, 2011)**,** (Mathiessen & Morris, 2007)

Image and reputation: Green investments seek to influence and improve the environmental performance of a corporate, thereby affecting its image and reputation. (Schueth, 2003)**,** (Graf & Wirl, 2014) As such, the willingness to pay at tenants end will be higher (Pivo & Fisher, 2010) enabling investors to charge higher rent and rental premium. The image created through the Company Social Responsibility (CSR) can attract a better workforce (Gond, et al., 2007) and might result in higher employee productivity which because of its complex nature is difficult to quantify in financial terms. (Eichholtz, et al., 2010)

Furthermore, (Albuquerque, et al., 2015) provides evidence that the CSR level of activities affecting systematic risk and the environment has the strongest association to it. Eichholtz et al. (2010) go further and discuss that the long economic life of a building stabilizes the market value; it reduces the price fluctuation of properties therefore resulting in lower capital cost and higher building evaluation.

Besides the economic benefits, the discussion continuous to remain open considering the inconvertible facts which make them questionable. There is empirical evidence that construction costs increase by 5 percent when it is green. Higher premium rents in Singapore and selling prices in Malaysia (Addae-Dapaah, et al., 2009) (Isa, et al., 2013) have a crucial effect on renting or buying decision -

making processes, forcing tenants to move towards conventional buildings. Moreover, various authors ((Anderson, 2008), (Morri & Soffietti, 2013), (Reed, et al., 2009)) discuss the additional costs involved in the certification process, depending on the building's certificate and construction phase. Both advocacies have their evidences but being able to define the criterion for "worthiness" it is possible only if the pay-off from the investment convinces the developers, investors, and tenants.

2. Market situation and Global Growth

i. Real Estate Market in Europe

This section provides the European building situation at a glance and brings facts and figures related to environmental and energy performance indicators. The main data source has been extracted from the Eurostat 2017, European Building Stock Observatory- a public data portal launched for the first time in the third quarter of 2016, and various Real Estate Companies present in Austria. Also, by collecting more detailed information about the Austrian real estate market and focusing on office buildings, as one's behaviour is to some extent related to the other, this will help summarize the current situation and outline the evolution of the green stock market. As the first study in the Austrian green stock market, the information concerning green buildings and in particular green office buildings has been collected and processed individually although aggregate analysis have been used.

According to the European Building Stock (2016), 25 bn. sqm of floor space in the EU27, Switzerland and Norway is useful from which half of it is located in the northern and western Europe. The other part is situated in South and Central& East regions, respectively 36 and 14 percent. From this, the residential building stock occupies 75 percent of the share, peaking with Italy (89 percent). (Figure 2)

We can distinguish three representative age bands among the buildings: Old (up to 1960), Modern (1961-1990), Recent (1991-2010). (BPIE, 2011) Categorized by region, buildings located in South Europe were mainly built during 1961 and 1990. UK, Denmark, Sweden and France make up the highest number of old buildings, with Cyprus leading with the highest percentage of recent buildings (28,96 percent). According to estimations, central and eastern European countries have been building less residential spaces in the last 20 years. (European Commission , 2017)

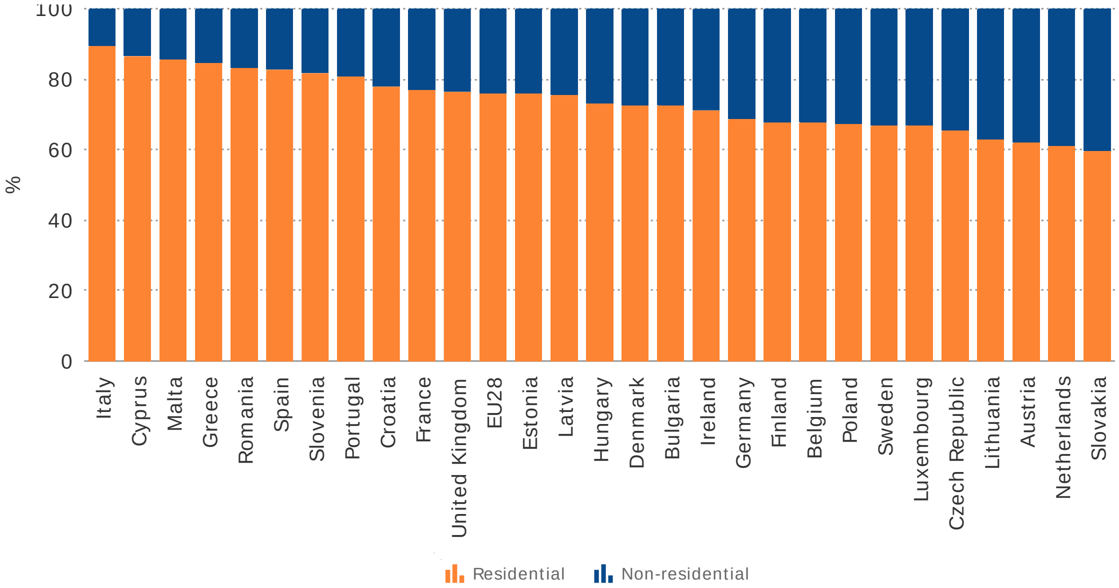

Figure 2: Breakdown of building floor area (2013)
Source: EU Buildings Observatory/EU Commission (2016)

The highest residential density is observed in Malta with 89,5 percent, whereas per Eurostat 2010**,** Greece, Finland and Austria result with the highest building density (buildings per 1,000 inhabitants). The latter one might be because of a higher density in non-residential buildings. Figure 2 portrays the breakdown of building floor area by country.

Due to missing data, outdated ones or rarely harmonized, it is impossible to sum up a total number of non- residential buildings around the European Union. As such, this part will consist of a general conspectus, rather than an analysis of economic indicators and characteristics of the non-residential building sector.

> *“A building is regarded as a non-residential building when the minor part of the building (i.e. less than half of its gross floor area) is used for dwelling purposes”. (United Nations, 1997)*

The challenge of non-residential buildings consists in the diverse nature of the subsectors. Considering the functionality and/or purpose of the building and referring with the same term to different typology, confusions might evoke. According to Buildings Performance Institute Europe (BPIE), non-residential buildings are separated into the following subsectors: offices, wholesale & retail, hotels & restaurants, hospitals, sport facilities, education and others. BPIE study reviews that offices belong to the private and public sectors (company and state, regional, administrative buildings) occupying 23 percent of the non-residential sector. The wholesale & retail subsector, with its 28 percent of the share include a wider range of buildings such as shops (detached and in shopping centres), retail (large and small), services (hair dressers, laundry, gas stations), fair and congress buildings, etc. Educational buildings (17 percent), include mainly schools (primary, secondary, high schools and universities) as well as spaces with a specific purpose such as laboratories. Hotels & restaurants (pubs and cafés included) and others (warehouses, garage, and garden buildings) occupy 22 percent each. Furthermore, hospitals and sports facilities occupy respectively 7 and 4 percent. Figure 3 combines the distribution of non- residential floor area by country. (BPIE, 2011)

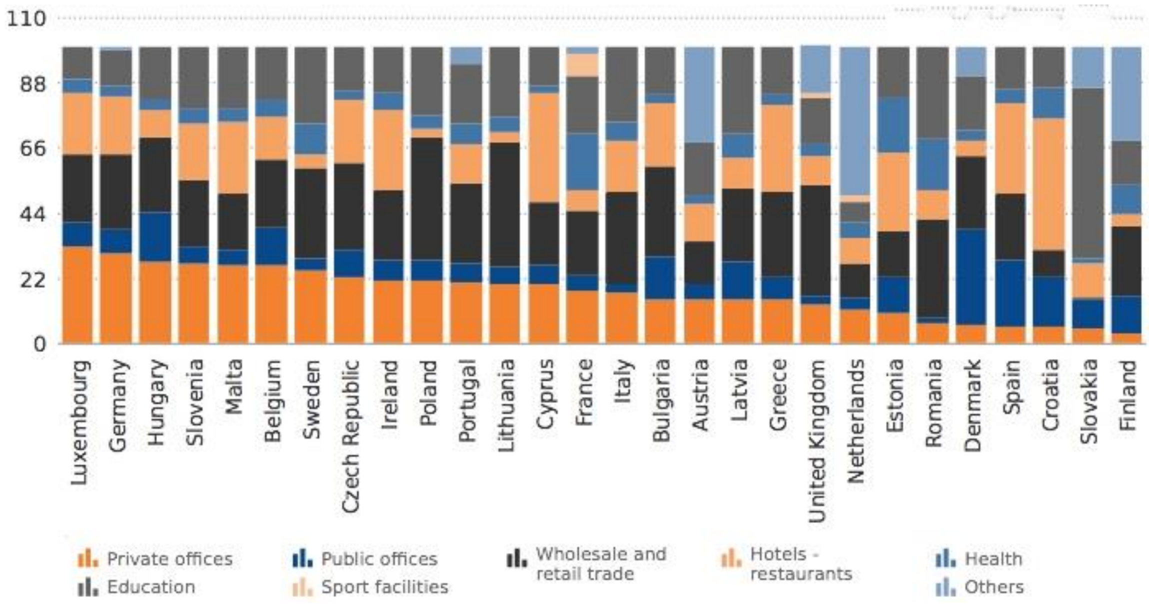

Figure 3: Distribution of non-residential floor area by area of use (2013)
Source: EU Buildings Observatory/EU Commission (2016)

Considering the purpose of this study, emphasis is placed on offices (private and public offices). An office building is:

> *"A building whose primary function is to provide space for administrative, financial, professional or customer services. The office area must make up a significant majority of the total building's gross area. The building may also comprise other type of spaces, like meeting rooms, training classrooms, staff facilities, or technical rooms" (Dodd, et al., 2016).*

where the term "significant" it is country specific (50-80 percent of the building). The share of offices in non-residential buildings does not exceed 43,9 percent (Hungary) and goes down to 8 percent in Rumania (Figure 4). It is observed that countries like Poland, UK and Italy have more offices, including private offices. France and Germany have been facing a constant growth from 2010 to 2013 in office space, meanwhile the number of private office space has been decreasing in Italy, Greece and Spain (Figure 5).

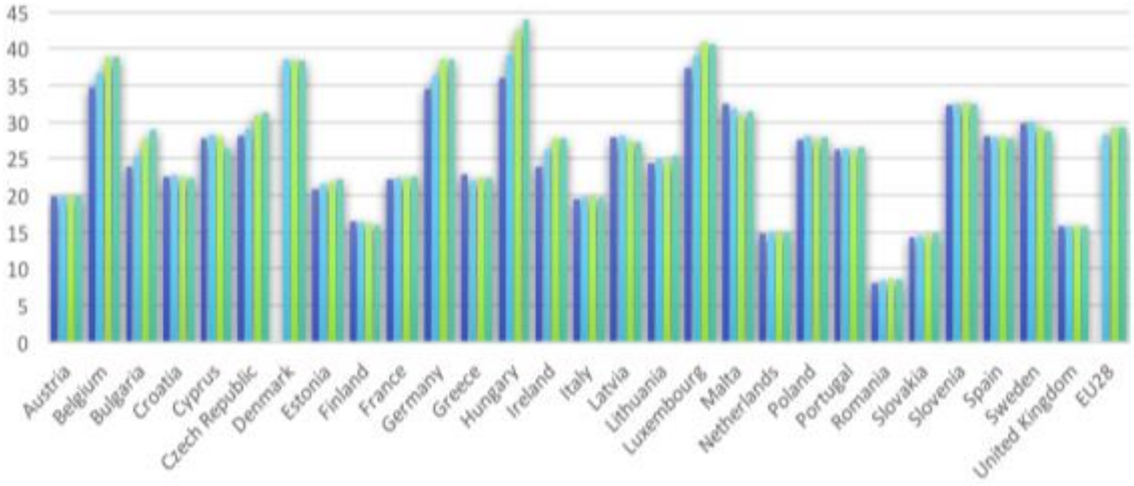

Figure 4:Share of offices in non-residential (Unit %) (2010-2013)
Source: EU Buildings Observatory/EU Commission (2016)

The 'Made-in-the-USA crisis' began in 2007-2008 and affected/spread in the European Union by the end of 2009 leading to a housing bubble boom. Since this relationship holds for the whole real estate sector, the below charted countries reflect it in numbers.

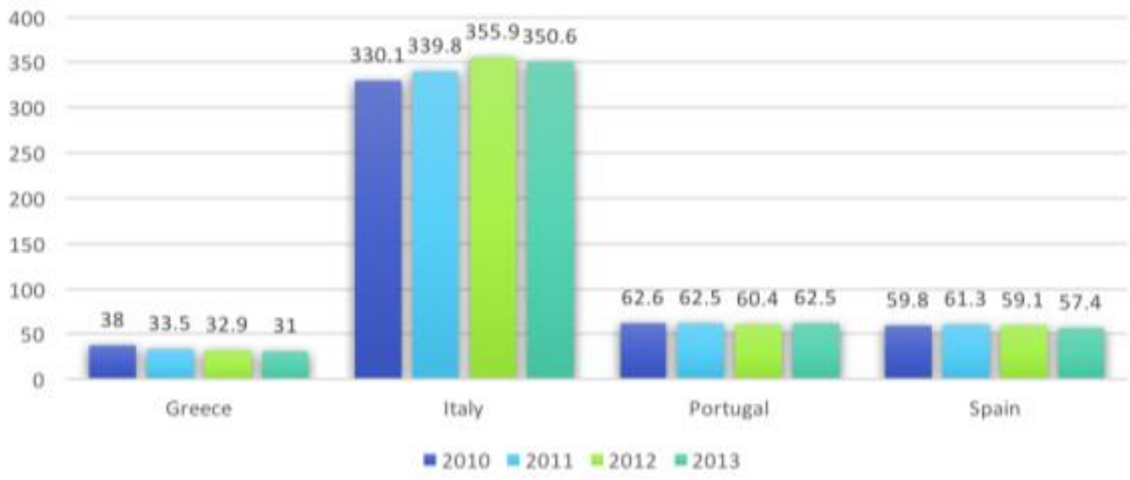

Figure 5: Countries with decreasing number of private offices
Source: EU Buildings Observatory/EU Commission 2016

The global crises that we are experiencing, predicted to be ongoing until 2045, started in the real estate market and affected global wealth stability crucially. (Streissler, 2012) To forecast this highly volatile market and understand its developments, it has become challenging. The importance of the real estate market relies in the identification of an interface of real estate industry with other industries in order to build an integrated view that may help us determine an appropriate strategy towards a sustainable and 'stress resistant' financial market. (Hilbers, et al., 2001) (ESRB, 2015)

ii. Real Estate Market in Austria

Real estate has become an increasingly attractive asset in recent years. Compared to equities, direct real estate investments are rising considerably well. Despite the volatility of price development, real estate prices are significantly lower than that of equities. Large institutional investors, sovereign and other funds, which have high investment requirements, have notably/ particularly increased the proportion of properties in their portfolios. Moving toward the Austrian real estate market, from 2001 to 2011, we can observe an increment in the number of buildings by 7,1 percent, with a total number of 2,191,280 buildings. (Statistics Austria, 2014). Recalling the age bands set for the European buildings, in Austria 42 percent of the buildings were built during 1961-1990, 33 percent before the '60s and the rest, 25 percent was built within the last 20 years (1991-2011). (Figure 6). The office building market has experienced the same fluctuation. In the last 20 years (1991-2011) there is a decrement in their share (Figure 7) (Statistics Austria, 2014).

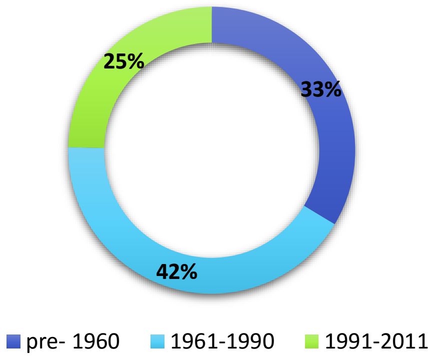

Figure 6: Age-Share of office buildings in Austria
Source: Statistic Austria (2014)

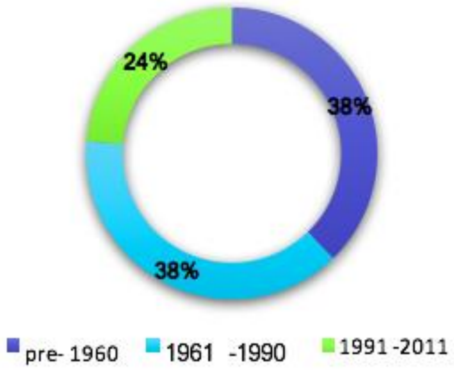

Figure 7: Age-Share of buildings in Austria
Source: Statistic Austria (2014)

According to (Statistics Austria, 2014), non–residential buildings sub-categorize as below (Figure 8). It is observed that industry and warehouse buildings dominate through non-residential buildings, except for Tirol and Salzburg where the influence of tourism is reflected in the number of hotels and similar buildings. Since Vienna is an economic powerhouse of numerous businesses, the number of office buildings exceeds 4,500.

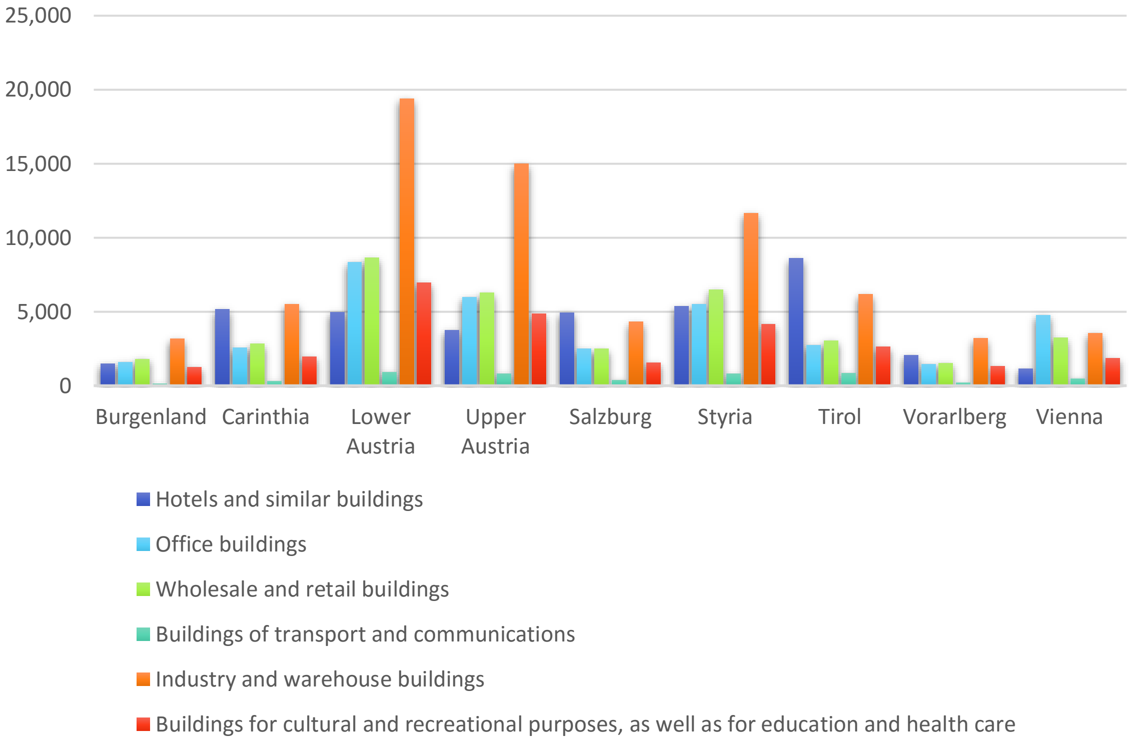

Figure 8: Number of non-residential buildings
Source: Statistic Austria (2014)

Office buildings are mainly found in Lower and Upper Austria (respectively 24 percent, 17 percent), Styria (16 percent) and Vienna (13 percent) whereas the rest of the federal states occupy 30 percent of the share overall (Figure 9).

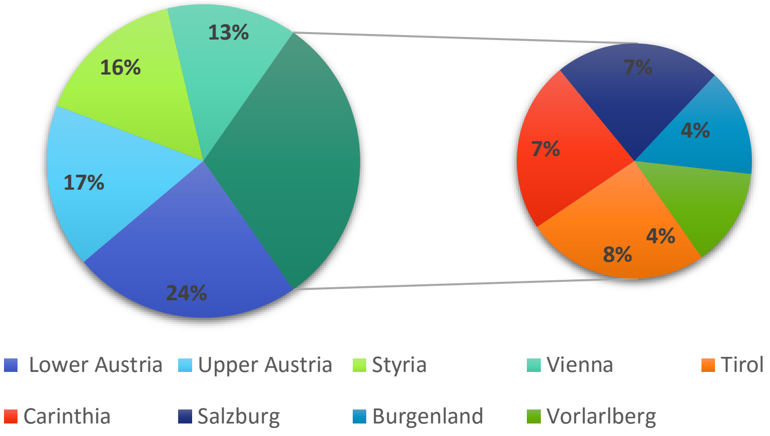

Figure 9: Share of buildings according to Federal States
Source: Statistic Austria (2014)

From 1961 until 1990, Austria faced an (office) building boom that went considerably down in 2009 (Figure 10). After this year, investment on commercial buildings started to take off again and by the end of 2015 investments peaked at approx. EUR 3,9 bn. decreasing again in 2016 to EUR 2,9 bn.**.** (CBRE GmbH, 2017).

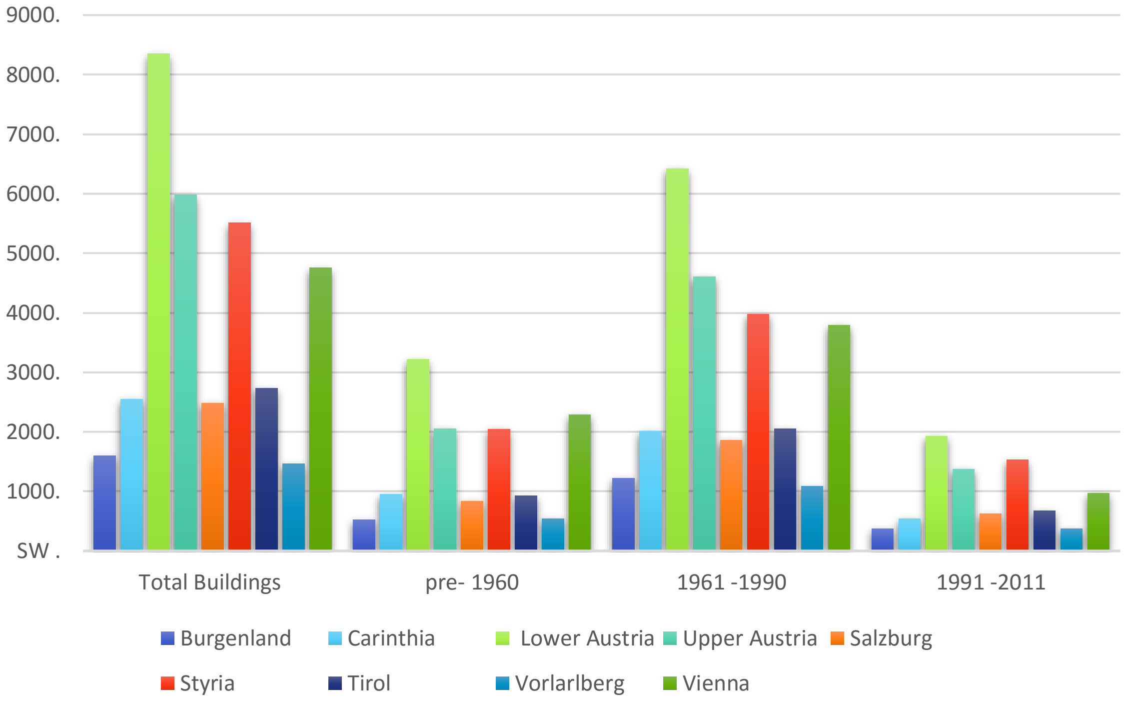

Figure 10: Number of office buildings in Austria
Source: Statistic Austria (2014)

The tight supply and the high demand drove real estate prices to rise considerably. By consequence, hardening yields are present unless the rent is not increasing. A strong demand for real estate and the lack of sufficient alternatives trigger a greater risk, the price correction.

In the yearly report from EHL Real Estate Group for 2016, the outlook for 2017 tends to show an increase in deliveries and average rent by 4 percent during 2016 raising to EUR 15 and 20/sq./m. (EHL Real Estate Group, 2016) Moreover, according to IPD (Investment Property Databank) Austria Annual property index, the average annual total return over three and ten years is 5,7 percent signing like this the stability in the Austrian real estate market. (MSCI , 2015) Furthermore, the growth forecast of Austrian economists in 2016 with a plus of 1.5 percent in real terms is well above the real GDP (Gross Domestic Product) growth of 1.0 percent. (Ragacs & Vondra, 2016) Also, the positive signals coming from the economic indicators and an increasing interest from foreign investors in the Austrian real estate market who are particularly interested in large transactions are promising for an upturn.

In the recent years, various aspects of green building evolution have triggered the interest of not only investment banks and private institutions, but also that of researchers who are constantly investigating green buildings from an economic and social point of view. Thus, the importance of the real estate market in the economy, its impact on economic stability and the importance for institutional investors, has positively triggered an academic interest. (Kao & Sung, 2016) This in turn has played a significant role by establishing in-depth market observations, analyses and forecasting. Taking hint from the definition and characteristics of green buildings as a mixture of sustainability and energy efficiency, the intertwining of real estates and energy markets will result in a hybrid product.

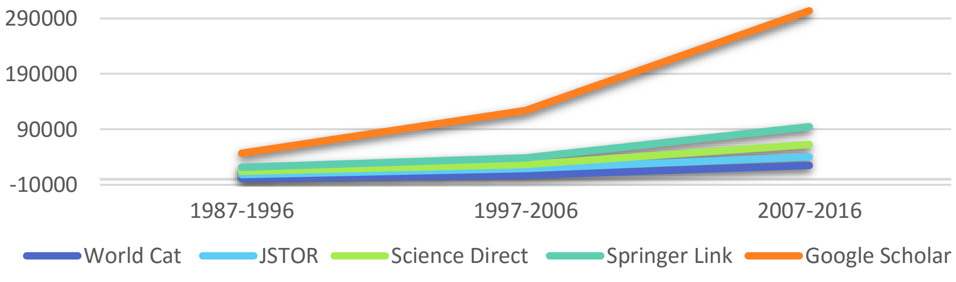

Figure 11: Academic interest - Search text: Green Office Buildings

Without wanting to discuss their essential quality or their contribution, the number of annotated bibliography of academic and scholar search engines and sources related to green buildings, commercial office spaces, green energy etc., has increased because of the raising awareness of topic engagement and its implication with the environment, energy and health sectors. As presented in Figure 11, the academic contribution relevant to sustainability has faced a rapid development particularly in the past decade.

2. Green Buildings

1. Green Buildings

Green building is constantly an evolving concept and definition. Different variations are quoted among countries, institutions, agencies and researchers. One definition offered by the U.S. Environmental Protection Agency (EPA)[1] is:

> *"...the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building.*

Similarly, the U.S. Green Building Council (USGBC) offers a useful working definition:

> *"... a holistic concept that starts with the understanding that the built environment can have profound effects, both positive and negative, on the natural environment, as well as the people who inhabit buildings every day. Green building is an effort to amplify the positive and mitigate the negative of these effects throughout the entire life cycle of a building."*

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[1] The Environmental Protection Agency mission is to protect human health and environment. Established in the US, the EPA started its operation in 1970, with its headquarter in Washington, D.C. and 10 regional offices around the country, creating and enforcing the environmental policy of the United States. After Mr. Trump elected President, US EPA is one of the most controversial issues in the press, considering the recent happenings regarding the budget and workforce cuttings Mr. Trump is planning to introduce this year.

Obviously for the U.S. market, the most important element remains *the efficient use of energy*. Whether green buildings or high performance buildings fulfil their purpose or not despite the energy usage reduction, this remains still a debatable topic (Glaeser & Kahn, 2010) (Eichholtz, et al., 2013). Whereas, Europeans relate to green as sustainable by bringing together Europe 2020 strategy and Kyoto Protocol. On the one hand, there is an improvement in energy efficiency and in CO_2 emission reduction. On the other hand, they should both contribute towards promoting sustainability as an organic process, instead of imposing it. Following this concept, the European Union has introduced a new term, "nearly zero-energy buildings" (European Parliament and Council of the EU, 2010). This gives member states the possibility to appoint the definition on a national level based on local and regional circumstances, and by also setting their targets independently. According to Article 9 (5) on EPBD, the Commission will prove the targets every three years and by the end of 2020 (1a) "all *new* buildings are nearly zero-energy buildings".

> *"…nearly zero-energy building' means a building that has a very high energy performance, as determined in accordance with Annex I[2]. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby; (European Parliament and Council of the EU, 2010)*

2. Green Office Buildings

Referring to the previous assumption, in this part I will attempt to add another aspect to the buildings other than a product. Earlier definitions of buildings and offices are applied to both despite their differences. These are reflections of their complex implications in property markets when moving from one market transformation to another (Killip, 2011a). Relating this to the environmental movement, with 1960s as a starting point and enhancing after the oil crises in the 1970s, green office buildings refer to energy efficient structures integrated with the

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[2] Annex 1: Common general framework for the calculation of energy performance of buildings published under 'Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings'

recycled content and material (recycled coal products, foundry sand and demolition debris). All other green characteristics such as energy conservation, pollution reduction and healthy environments remain unchanged (Mao, et al., 2009). However, the presence of detrimental aspects such as the lack of noise, are present. The construction material used for buildings tends to make buildings less noisy and as such employees lose their sense of privacy.

3. Energy Performance Certification

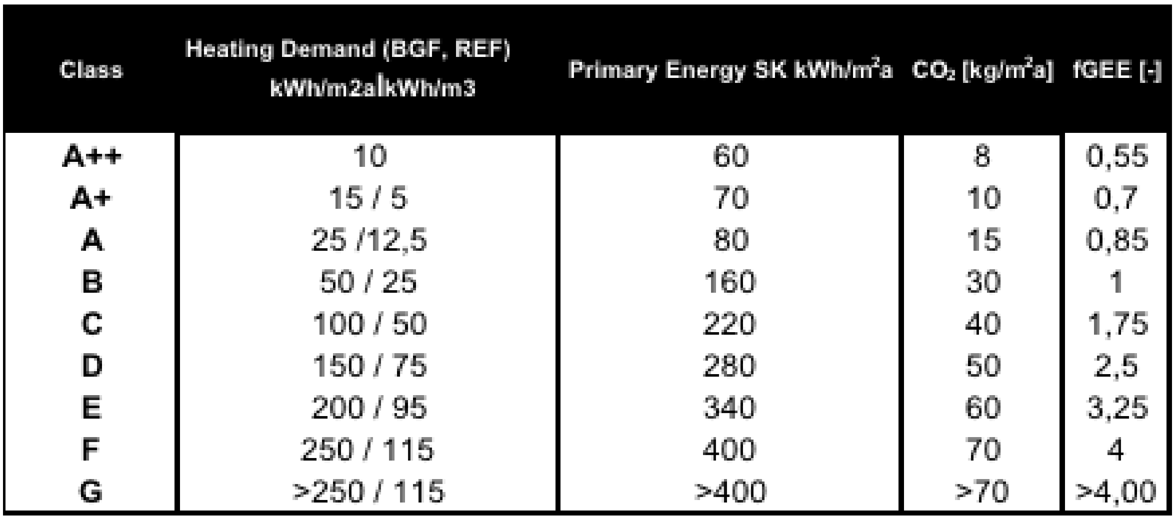
i. Energy Performance Certification Scheme

In Austria, the scheme came into force in 2008, excluding public buildings and one year later, in 2009 including all segments of the property markets. (Jilek, 2011) The implementation happened on a federal and regional level. However, the already issued EPCs (in 2008) were not separate for residential and non-residential buildings. (BPIE, 2010) As such the new EPCs for residential and non-residential buildings were revised, and it became mandatory (where the seller should provide it to the buyer within 14 days – additional time at regional level- *after* singing the contract) and was agreed to include the primary energy and CO_2 emission, as well as introduce specific labelling for thermal heating demand. (Mudgal, et al., 2013)

Additionally, non-residential buildings EPCs should contain (Österreichisches Institut für Bautechnik, 2015)**:**

- Heating demand of the building and the comparison to reference value
- Cooling demand of the building
- Energy demand (Loss) of domestic appliances separately for heating, cooling, mechanic ventilation and lighting of the building
- Final energy demand of the building
- Recommendation of measures (new buildings excluded) whose implementation reduce final energy demand of the building and are technically and economically suitable/ achievable.

The following table is a summary of the class limits presented in the first page of the EPCs.



Class	Heating Demand (BGF, REF) kWh/m2a|kWh/m3	Primary Energy SK kWh/m^{2}a	CO_2 [kg/m^{2}a]	fGEE [-]
A++	10	60	8	0,55
A+	15 / 5	70	10	0,7
A	25 /12,5	80	15	0,85
B	50 / 25	160	30	1
C	100 / 50	220	40	1,75
D	150 / 75	280	50	2,5
E	200 / 95	340	60	3,25
F	250 / 115	400	70	4
G	>250 / 115	>400	>70	>4,00

Table 1: Energy efficiency scale according to OIB -Richtlinie 5
Source: (Österreichisches Institut für Bautechnik, 2015)

Based on this graphical representation of energy efficiency in Austria buildings are classified as follows:

A++: Passive house: Passive House is a standard building conceptualized to be energy efficient, comfortable and affordable. Other characteristics regarding heating and cooling refer to the saving ability (75-90 percent building related). Depending on the heating fuel, a passive house uses less than 1,5 l of oil and 1,5cbm of gas/sqm/ a. Passive cooling and a ventilation system help living or working in a comfortable environment. (Passivhaus Institute, 2015)

A+; A: Nearly zero-energy buildings: As previously mentioned, referring to the orientation and implemented strategies of the European Union, nearly zero-energy buildings are in trend and by 2020 they will become known to all the member states. (European Commission, 2016)

B: Low Energy House: In order to provide a conceptual definition of these types of buildings and not confuse it with other buildings in the same family, it is necessary to focus mainly on design. As a practice that can be applied to both newly built houses and renovated ones, design can enable low energy demand through insulating materials, renewable energy used (energy efficiency) and low energy technology. (European Comission, 2009)

C: Buildings built according to the technical specification (Technische Bauvorschriften - TVB) of 2008. With the new EU regulation of 2015, technical specifications have been adjusted so that they align with the other member states.

D; E; F; G: Under this category fall all old and not renovated buildings.

To conclude, being an integral part of EPBD, EPCs should ensure that minimum energy performance requirements for buildings or building units are set. Also, the positive impacts that EPCs might introduce in the real estate market provide a more comprehensive overview for owners, occupiers and real estate actors.

Notwithstanding to Austrian standards, the application of EPCs has come into force in 2008 for sale, rent and leasing buildings. However, as other member states, Austria is struggling with public acceptance and data access is not possible. The national database of Statistics in Austria possesses currently no available data. Since 2015, the city of Vienna is providing an energy-proofing database (Vienna's independent control system for energy certificates Wiener unabhängiges Kontrollsystem für Energieausweise (WUKSEA)), for the quality-assured registration of energy certificates for Viennese buildings. However, these databases are not publicly available. In order to extract these data, the federal states should be contacted individually and the quality of the entries is assumed to be poor.

ii. Energy Performance Certification Impact on Rent

The purpose of EPCs is to raise awareness. If we will refer to buildings as a product, our understanding should perceive them as a bundle of characteristics (Lancaster, 1971). The dimensions of the products are levelled from labelling schemes in which in our example EPCs play the role of an energy and environmental label. The purpose of labelling schemes is to compare these products (buildings). (European Commission, 2016)

Here, some of the difficult aspects are to understand, read the label and trust it. As for the builders and owners, this should not imply any issues when referring to the buyers or tenants by considering their interests and the importance of energy usage which may pose a novel problem. (Mudgal, et al., 2013)

However, the focus of this thesis implicates that buyers/tenants have gained the understanding and readiness to be involved in the greening process and furthermore aim for an EPC. It also tries to find out if this does entail a change in selling or renting price based on the energy performance of the building.

A large number of cross sectional studies report the positive impact of labelling in the sales and rent value. In 2011, Fuerst and McAllister reported a link between environmental performance certification and the sales value of commercial property in the US. For the Austrian market, there does exist a location-specific effect as well as differences in sales and rental markets (Mudgal, et al., 2013). Data from this same report identified an average of 8 percent increase in prices in case of an improvement in energy efficiency. Moreover, the location- specific effect contributes in higher premium prices in Vienna (10 percent to 11 percent) compared to Lower Austria. Several lines of evidence demonstrate the same effect in rent but slightly lower than sales premiums. However, the result report only about housing market and this is very limited. Whereas regarding rental and sales premiums of commercial/ non-residential buildings, there is no available data or reports so far.

4. Motivation and Barriers of EPCs

In recent years, there has been an increasing amount of literature on green buildings emphasizing the profitability of environmentally friendly buildings. (Miller, et al., 2008) (Eichholtz, et al., 2013) (Fuerst & McAllister, 2011a) Unable to cover a big dataset, researchers and their studies rely on a small number of data sources and they are very specific in time, countries and property markets. As such a generalization of the impact and effects of EPC will be possible in case of continuous contribution from different sectors, lying into different timeframes around the world and avoiding limitations.

During 2008, 2009 and 2011, with the initiative of the EU the same surveys were conducted to understand the motivation and barriers in the European Green Building Programme (GB). Applying the same questionnaire with slight modifications, the key results from the nine countries indicate energy cost reductions and environmental considerations as the main reasons for being part of the project. Interestingly, from 2008 to 2011 there was an increment in the number of participants sharing the same motivation (70,4 percent) whereas the other would reason it by the increasing value of the property (37 percent). These results match to the main benefit, cost saving (32 percent), which companies have experienced after the implementation of GB project, which again based on the

survey more than the half of the participants (68 percent) have verified the energy saving and reported calculated savings. (Bertoldi & Elle, 2012)
One last remark presented in this report on the survey refers to EPCs and rising number. In 2009, the number of participants who answered to 'Did your building have an EPC issued' was not satisfactory, whereas in 2011 more than 80% answered to the query and 63 percent delivered a confirming answer.

The intrinsic value of the survey is mainly for the identification of the motivation and benefits of the project rather than the results. Accompanied by the driving factors elaborated in the introduction part, we can create a complete picture of how social and economic factors impact the market. Also, it is significant to understand the importance of harmonized studies in time and place.

5. Rating systems

i. International Rating Agencies

Along with the green building movement and the crisis in the real estate market, certification led to a new understanding of quality in buying and/or maintaining. To improve knowledge regarding the level of sustainability, many countries worldwide have developed various green rating systems. From a financial point of view, it is possible to have building comparisons all around the word. Introducing in this equation sustainability factor, calculating and analysing the value of a building becomes a complex approach, simplified throughout the rating tools in industrialized countries. Reed, et al., 2009 discuss the necessity and benefits from the multi-criteria of the rating tools among the countries and express their concern regarding different assessment methods.
Furthermore, Winward, et al., 1998 differentiate between endorsements and comparison rating tools. The first category recognizes only two subcategories: either the building meets the specified criteria and qualifies or it doesn't. Whereas, comparison rating tools compare and rate buildings from "better" to "worse".
Internationally, there are several rating agencies: LEED (US), Green Stars (Australia), BREEAM (UK), HQE(FR), DGBN (DE), the Swiss Minergie, CASBEE (JP) etc. However, despite their international aspect, specific EPC schemes (elaborated in the previous subchapter) facilitate cross-country comparisons.

ii. Green Labels in Austria[3]

In Austria, green building trends and their certifications from several rating agencies started in the 2000s. Meanwhile, their popularity is growing proportionally to their number, the question of which certificate is best suited to evaluate the development of projects, as well as the quality of stock portfolio in the market remains unanswered.

International rating agencies such as BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environmental Design) and DGBN (Deutsche Gesellschaft für Nachhaltiges Bauen) are widely active in the Austrian market. (Terbut & Schrattenecker, 2016) Despite the differences in content, which are mutually complementary, the main evaluation criteria (ecological, socio cultural and functionality) remain the same.

BREEAM is the pioneer rating agency for sustainable buildings. The system with the most experience in the market, started in 1990 with the goal to develop a customized system for every country and type of building. (BREEAM, 2016)

LEED (2009) coming from the USA, is the only rating agency internationally comparable. As such, LEED does not consider the national building standards but have their own standardized reference building. (USGBC, 2016)

DGNB incorporates two further aspects: economic quality (comprising of lifecycle cost analysis) and value of retention. It also examines exclusively socio-cultural quality in terms of land efficiency and public access to the building. Moreover, the technical quality, meaning ease in maintaining and recyclability, are aspects checked and evaluated only by DGNB. (DGNB, 2016)**.**

ÖGNI (Österreichische Gesellschaft für Nachhaltige Immobilienwirtschaft/ Austrian Sustainable Building Council) founded in 2009, is the Austrian version of DGNB. The goal of ÖGNI/DGNB is to spread a comprehensive and high-quality assessment system of sustainable buildings that is internationally comparable to its sister labs. Due to the different building regulations, it is not in ÖGNI's concept of buildings to be one hundred percent comparable. An attempt is made to keep as many records as possible, uniformly throughout the country. (ÖGNI, 2016)

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[3] All the information and data presented under this subchapter has been extracted from the websites of respective rating agencies (BREEAM, LEED, DGNB, ÖGNI, klima:aktiv) . This information is accessible to everyone.

Beside the international rating systems, in 2006 the Austrian Federal Ministry of Agriculture, Forestry, Environmental and Water Management developed a new project, *klima:aktiv* with the purpose of climate protection and reduction of CO2 emissions. Based on a self-declaration system and zero-cost plausibility test, the tool is meant to be streamlined. Later on, klima:aktiv criteria were integrated to *TQB* (Total Quality Building) system, an outsource of Total quality (TQ) and IBO system established in 2010. According to TQB, an open source system helps facilitate access to a check-list for sustainable construction and to disseminate the rating system (klima:aktiv, 2016)**.**

Green Building Programme was also part of the rating and certification tools active in Austria but in 2014 the Joint Research Centre decided to close down the programme after achieving their data collection target from over 1000 buildings.

Weighting the overall assessment, (Table 3) we can distinguish two different tendencies among the rating tools, one focusing on sustainability and economic aspects (TQB, DGNB/ ÖGNI) and the other on ecological and energy efficiency (klima:aktiv, LEED, BREEAM). Certain criteria such as fire protection, convertibility and accessibility for users are proved only by certain agencies such as TQB, DGNB and BREEAM. Exclusively, BREEAM enquiries specific information concerning the energy efficiency of the elevators and escalators separately whereas both, LEED and BREEAM appreciate innovative ideas towards the defined criteria and award them with extra points. Both rating agencies assure through a pre-contractual agreement an independent specialist who assists in the process from planning until initial/utilisation phase. (BREEAM, 2016) (U.S. Green Building Council -LEED, 2005)

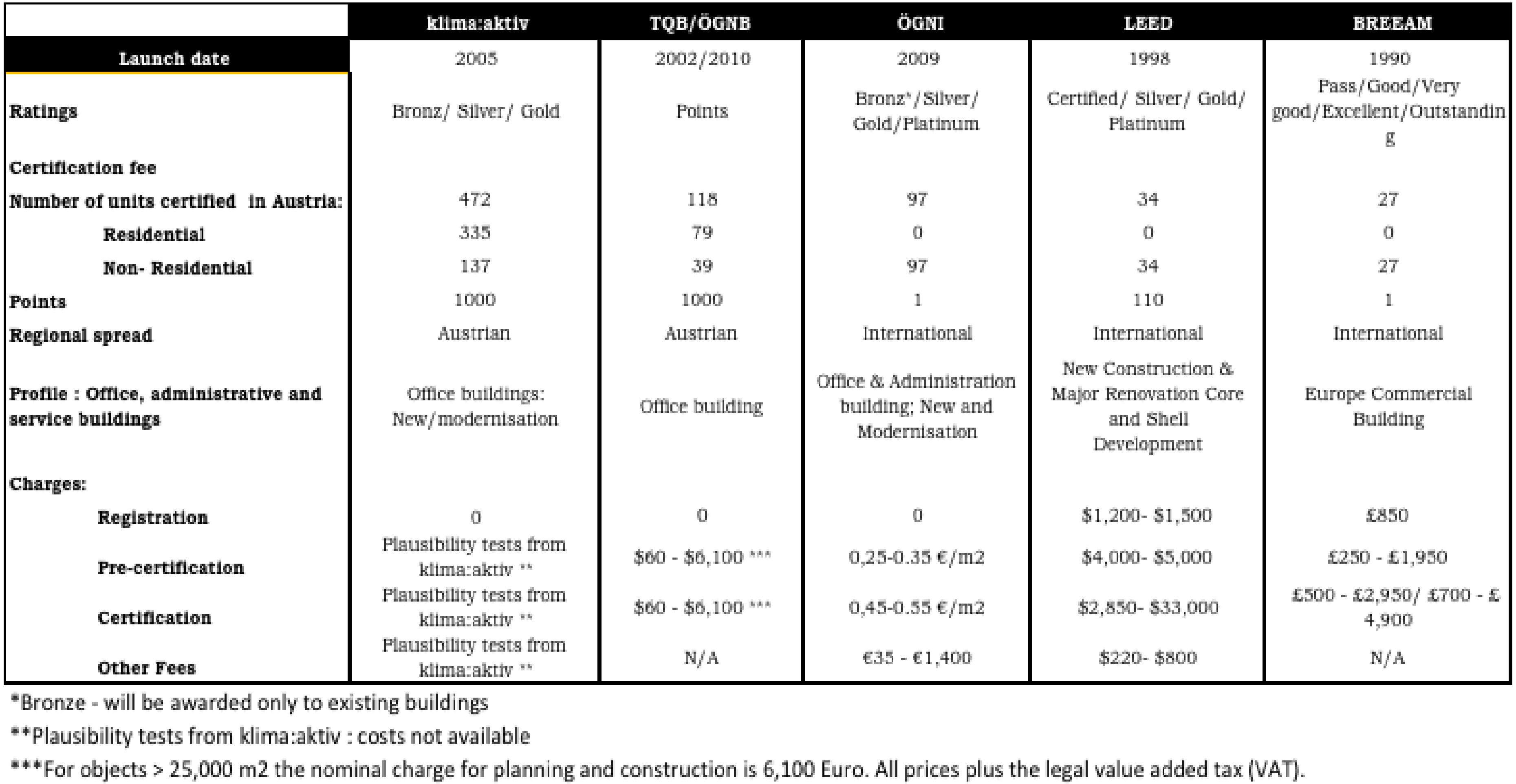
Regarding BREEAM, the tool has been introduced in the German speaking countries via DIFNI (Deutschen Privaten Institut für Nachhaltige Immobielienwirtschaft). Differently from LEED, BREEAM recognizes country specific standards and can be used internationally and regionally. (BREEAM , 2016)

All rating systems enable the certification of new construction, expansion and renovation. The phase in which the certification process starts defines certification costs. It is important to emphasize that the commitment of all parties is established and respected in each step of the process. Evaluation procedures during the process of planning and its implementation are constantly conducted to assure high sustainability.

klima:aktiv operates only nationally and is a leader among the rating agencies in the Austrian market, with the highest number of certified buildings. klima:aktiv assessment might be the appropriate rating tool when the main focus of the project resonates in energy efficiency and at least one low energy standard is achieved. (klima:aktiv, 2016) The other four rating tools have the same scope and size, a characteristic that makes rating tools comparable. However, LEED attempts to stimulate an international approach fail applying the US-American standards of the ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) engineering association to check the energy efficiency of European designs of the building technology. (USGBC, 2016)

If the international aspect does not weight, then ÖGNI and TQB are the best alternatives considering their mid-European understanding of the planning procedures and quality description. TQB is practically smaller than ÖGNI, albeit with its counterparts in Germany and other countries establish a relatively larger network.

As we can see in Table 2, the rating systems attach great importance to the economic aspect of sustainability.



	klima:aktiv	TQB/ÖGNB	ÖGNI	LEED	BREEAM
Launch date	2005	2002/2010	2009	1998	1990
Ratings	Bronz/ Silver/ Gold	Points	Bronz*/Silver/ Gold/Platinum	Certified/ Silver/ Gold/ Platinum	Pass/Good/Very good/Excellent/Outstanding
Certification fee					
Number of units certified in Austria:	472	118	97	34	27
Residential	335	79	0	0	0
Non- Residential	137	39	97	34	27
Points	1000	1000	1	110	1
Regional spread	Austrian	Austrian	International	International	International
Profile : Office, administrative and service buildings	Office buildings: New/modernisation	Office building	Office & Administration building; New and Modernisation	New Construction & Major Renovation Core and Shell Development	Europe Commercial Building
Charges:					
Registration	0	0	0	$1,200- $1,500	£850
Pre-certification	Plausibility tests from klima:aktiv **	$60 - $6,100 ***	0,25-0.35 €/m2	$4,000- $5,000	£250 - £1,950
Certification	Plausibility tests from klima:aktiv **	$60 - $6,100 ***	0,45-0.55 €/m2	$2,850- $33,000	£500 - £2,950/ £700 - £ 4,900
Other Fees	Plausibility tests from klima:aktiv **	N/A	€35 - €1,400	$220- $800	N/A

*Bronze - will be awarded only to existing buildings

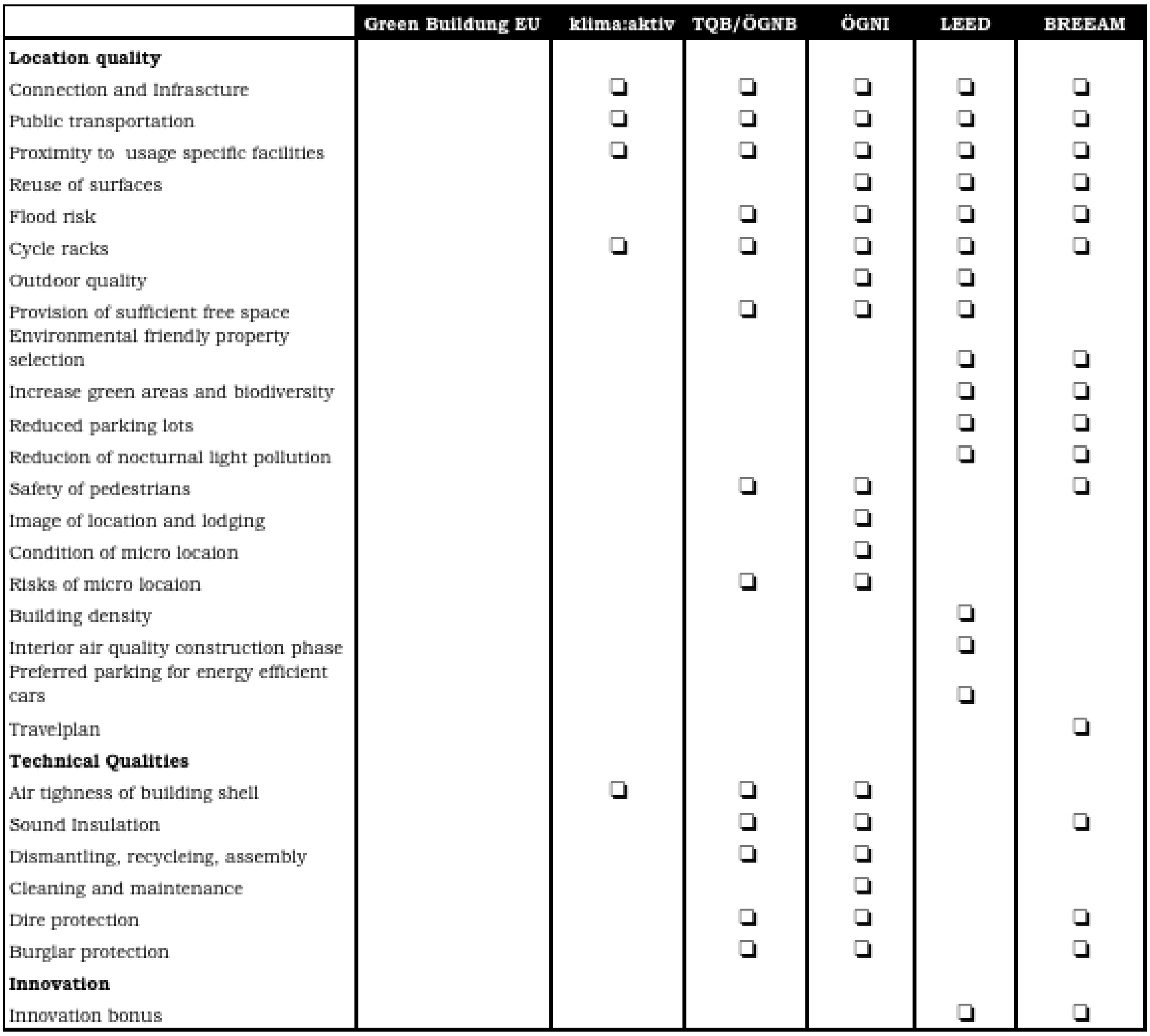
**Plausibility tests from klima:aktiv : costs not available

***For objects > 25,000 m2 the nominal charge for planning and construction is 6,100 Euro. All prices plus the legal value added tax (VAT).

Table 2: Rating tools characteristics

	Green Buildung EU	klima:aktiv	TQB/ÖGNB	ÖGNI	LEED	BREEAM
Planning Process						
Integral planning		☐	☐	☐		☐
Construction progress			☐	☐	☐	☐
Prevention of pollution through construction site activities			☐	☐	☐	☐
Construction waste management concept				☐	☐	☐
Systematic commissioning			☐	☐	☐	☐
Measurement and monitoring concept		☐	☐	☐	☐	☐
Waste concept for the utilization phase				☐	☐	☐
Integral planning			☐	☐		
Building pass				☐		
Property documentation				☐		
Floor covering						☐
Quality of excutive companies				☐		
Code of conduct of construction company						☐
Avoidance of private transportation		☐	☐	☐	☐	☐
Facility Management			☐	☐		
Economic Quality						
Life cycle costs		☐	☐	☐		☐
Value stability				☐		
Third - party questions			☐	☐		
Ecological Quality						
Ecological product		☐	☐	☐	☐	☐
Water efficiency	☐		☐	☐	☐	☐
Water savings			☐	☐	☐	☐
Water savings for irrigation					☐	☐
Rainwater utilization			☐	☐	☐	☐
Energy effiency	☐	☐	☐	☐	☐	☐
Energy effiency for lifts						☐
Renewable energy	☐	☐	☐	☐	☐	☐
Energy monitoring and building operation	☐	☐	☐	☐	☐	☐
Energy concept				☐	☐	☐
Green electricity		☐	☐	☐	☐	☐
Ecobilance		☐	☐	☐		☐
Wood products utilization				☐	☐	☐
Reduction of Albedo				☐	☐	
Coolant management					☐	☐
Socio-cultural quality						
Comfort criteria	☐	☐	☐	☐	☐	☐
Security			☐	☐	☐	☐
Thermic comfort		☐	☐	☐	☐	☐
Possibility of influencing the user - Thermal comfort			☐	☐	☐	☐
Line-of-sight				☐	☐	☐
Daylight availability	☐		☐	☐	☐	☐
Indoor air quality	☐		☐	☐	☐	☐
CO2 control				☐	☐	☐
Luminous intensities in- and outdoor	☐				☐	☐
Natural ventilation					☐	☐
Sun/glare protection	☐		☐	☐		☐
Acoustic comfort	☐		☐	☐		☐
Space efficiency				☐		
Usability			☐	☐		
Public access				☐		
Accesability			☐	☐		
Smoke free environment					☐	
Ventilation rate					☐	
Architecture and Art				☐		

Table 3: Selection Criteria for all present rating tools in Austria



	Green Buildung EU	klima:aktiv	TQB/ÖGNB	ÖGNI	LEED	BREEAM
Location quality						
Connection and Infrascture		☐	☐	☐	☐	☐
Public transportation		☐	☐	☐	☐	☐
Proximity to usage specific facilities		☐	☐	☐	☐	☐
Reuse of surfaces				☐	☐	☐
Flood risk			☐	☐	☐	☐
Cycle racks		☐	☐	☐	☐	☐
Outdoor quality				☐	☐	
Provision of sufficient free space			☐	☐	☐	
Environmental friendly property selection					☐	☐
Increase green areas and biodiversity					☐	☐
Reduced parking lots					☐	☐
Reducion of nocturnal light pollution					☐	☐
Safety of pedestrians			☐	☐		☐
Image of location and lodging				☐		
Condition of micro locaion				☐		
Risks of micro locaion			☐	☐		
Building density					☐	
Interior air quality construction phase					☐	
Preferred parking for energy efficient cars					☐	
Travelplan						☐
Technical Qualities						
Air tighness of building shell		☐	☐	☐		
Sound insulation			☐	☐		☐
Dismantling, recycleing, assembly			☐	☐		
Cleaning and maintenance				☐		
Dire protection			☐	☐		☐
Burglar protection			☐	☐		☐
Innovation						
Innovation bonus					☐	☐

Table 3 (continued): Selection Criteria for all present rating tools in Austria[4]

There are six criteria (Table 3) that comprise building certification except for BREEAM and LEED which have an additional one:

- Ecological Quality
- Economical Quality
- Social- Cultural & Functionality
- Technical Quality
- Process Quality
- Location Quality
- Innovation (BREEAM and LEED)

The rating tools have developed various certification-versions covering different building types:

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[4] The information needed to compile Table 2 and Table 3 was extracted from the rating agencies (BREEAM, LEED, DGNB, ÖGNI, klima:aktiv). This information is accessible to everyone.

Klima:aktiv: office buildings (new and modernisation), historic preservation renovation, educational institutions (new and modernisation), geriatric centres (new), hotel and accommodation (new and renovation), food supermarkets. (klima:aktiv, 2016)

TQB: residential construction, office buildings, commercial buildings, hotel industry, industrial buildings, education. Certification is possible for all building types both new and existing. (ÖGNB, 2016)

ÖGNI/DGNB: (new buildings): education, office and administrative buildings (refurbished and/or existing buildings), health care, commercial quartiers, retail buildings (building modernisation), hotels, industrial buildings, multi-purpose building, parking garages, sport venues, urban districts, venue assembly, residential buildings, leasehold improvements, series certification. Here, an interesting concept is the introduction of blueCARD which enables large real estate portfolios certification. The blueCARD covers all relevant sustainable topics by reducing the audit and valuation methodology. (ÖGNI, 2016)

LEED: new construction, existing buildings, commercial interiors, core and shell, homes neighbourhood development, schools, retail. (USGBC, 2016)

BREEAM: Court rooms, EcoHomes, industrial buildings, offices, healthcare buildings/spaces, prisons, retail spaces, education buildings, multi-residential. (BREEAM), 2016)

Existing buildings are another building category that can be certified. Rating system such as TQB, ÖGNI, and LEED apply the same practice regarding existing buildings so that a comparison might be possible for all buildings. ÖGNI /DGNB certify existing buildings with bronze certificates. (ÖGNI, 2015)

Also, BREEAM applies a similar concept for existing buildings in Austria and Germany (DIFNI). The online system combines the simplicity of the evaluation methodology and the most important test criteria (3 parts questionnaire) related to building operation making the rating tool customized to the distinctive interests of the building, its maintenance and its technical management. (BREEAM), 2016) Deciding among the rating tools is a process which usually implicates the collected data, their further utilization and the sustainability certificate. Despite the various possibilities offered, the difficulty for certification of existing buildings lies/remains in the high expenditures that they might bring.

6. Cost and Benefits of Green Buildings

The certification process involves expenditures and costs which fluctuate based on the rating tool and certification level. The perception that the cost of green buildings is higher compared to conventional buildings has affected its growth and development. (Simpeh & Smallwood, 2015) (Zhang, 2014)

Pearce (2008) considers the expected cost premium as a barrier which might even filter projects out of consideration.

Mainly, academic research papers focus on initial costs where the initial impact on construction costs is likely to increase. Several studies in China confirm higher cost premiums. When introducing green systems, construction costs will increase by 10,77 percent (Hwang & Tan, 2012) whereas for green management (including building design, construction techniques and methods) there is a reported increment of about 2 percent of the total investment on average, translating into 5-10 percent more than conventional building costs. (Kim, et al., 2014) Moreover, green certifications are expected to have their impact on cost premiums varying on rating tools, certification level and nature of building. (Tatari & Kucukvar, 2011)

In Australia, depending/based on the level of certification there is an increase of construction costs of 3-5 percent. Other than initial costs, Bond (2011) identifies lack of consumer information about benefits and savings from incorporating energy efficient and water saving devices and features in Australia and New Zealand. Simpeh & Smallwood (2015) recognize similar critical factors regarding South African construction industry, among them lack incentives for promoting green building, inadequate information regarding the financial and economic benefits and opportunities of green buildings and inadequate cost data for greening existing buildings.

Liu, et al., 2014 discuss that regardless of the large share incremental costs of the energy efficiency technology application occupy in total incremental costs of green buildings, the incremental economic and environmental benefits pay off. Historically seen, economic crises and the volatile demand for oil and natural gas as well as their fluctuating price, savings in energy supported by green buildings help to increase the building value and lower the operational costs of occupants.

Ries, et al., (2006) quantifies further intangible economic savings such as improving employee productivity by 25 percent, increasing benefits from improvements in health and safety, and providing savings from energy (energy usage decrease by about 30 percent), operational, and maintenance cost (decrease by 13 percent). (Fowler & Rauch, 2006) Moreover, green buildings can qualify for financial benefits regarding properties. In terms of financial incentives, investors can use these opportunities to lower their construction and maintenance costs.

Several reports investigating rental rates and sales premiums provide indications regarding higher selling and rental prices. Moreover, Miller & Pogue, (2009) found that in ten markets across U.S., green buildings average rental rates are by 13 percent higher than the market. According to CBRE, (2012) “LEED certified buildings routinely commanded the highest rents and sales prices.”

In their working paper, Bond & Devine (2016) observe rental prices for green multifamily properties and demonstrate 8.9 percent rental rate premium associated with LEED apartments. Other studies support these findings and confirm that green buildings not only cost roughly more but their vacancy rate is 4 percent lower than for non-green properties (Herceg & Ranade, 2015)**.**

Consisting in higher rental prices and higher occupancy rate, green certified buildings are under this mean more profitable for investors and their interest has increased. (Isa, et al., 2013) (O'Mara & Sh., 2012) Albeit, there is still an undertone of scepticism coming from conservative investors. In this regard, green certification serves to prove and confirm the green features (i.e. energy efficiency) the owners and builders allege to it. (Richardson & K., 2007) Green and sustainable trends are desirable not only for individuals but they aspire ideas for futuristic eco-cities. Companies, investors and builders plan and advertise their green rhetoric constantly to impact and influence the market and boost sales. (Bond & Devine, 2016) (Kok and Kahn, 2012) The primary role of green certification is to avoid any green washing. Because the “green image” plays a crucial role towards investors who value quality, rating agencies accredited to complete the quality assurance of the buildings and their certification are helpful in this concern. (Cooremans 2011) It also creates accurate rating standards assuring the certification holder an incontrovertible proof. As a guarantee for buildings performance, including here the avoidance of possible maintenance issues (lower operating costs), green certification can be considered a partner. (Kats & Capital(2003)

To conclude, the investigated literature demonstrates a wide range of empirically based green building costs and benefits. To identify and quantify its value for further implications, investors might consider life cycle cost analysis, an economic assessment calculating all the significant costs (initial, financing and operational costs) in the long term, to evaluate the certification.

3. Data and Methodology

1. Data

i. The Study Area

The study area is Austria situated in centre of Europe with a population of 8.629.519 (2015 est.). Austria as a federal republic, is divided into 9 provinces: Burgenland, Carinthia, Lower Austria, Salzburg, Styria, Tyrol Upper Austria, Vorarlberg and Vienna, its capital. According to Labour Market Statistic data for the third quarter of 2016, 7 out of 10 people are employed. The Micro Census records 4,1 percent of the working population is employed in the financial and insurance, and real estate sector. Clerical support workers occupy 10 percent of the major group shares (ISCO-08).

Lower Austria dominates with the highest number of office buildings. Its size and geographic contiguousness to Vienna has a positive influence on the regional economy. However, as Vienna profits from its good underlying position, it also attracts many foreign enterprises from different sectors and is now the ideal hub for many headquarters of multinational enterprises or their foreign subsidiaries aiming to build East- West business relations.

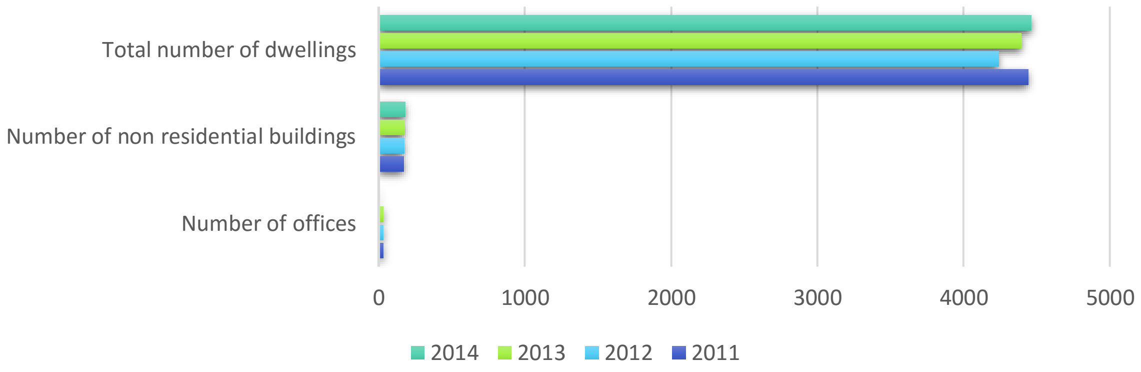


Figure 12: Building stock in Austria (2011-2014) (in 1000)
Source: EU Buildings Observatory/EU Commission 2016

The existing office space of about 10,95 Mio. sqm in the Viennese office market has increased in leased space by 45 percent (290,000 sqm) compared to the total rental office space in 2015 (approx.. 200,000 smq). (EHL Real Estate Group, 2017)

Still the negative interest rates are affecting the current situation in the real estate market and driving yields lower than expected. According to BAR (Beste Aussichten Real Property Trustee) during the past three years due to the high demand, the prime yield in long term leased core office properties with tenants with high credit ratings has been falling constantly from 4.55 percent (in 2014) to 2.95 percent (in 2016). The difference in prime yields between average and/or good office locations as well as core segments is stark.

However, the demand in the Viennese office market continues to be strong and active. As a result, delivery overtakes 160.000 sqm whereas take up will climb to 280.000 sqm in the office market. Moreover, forecast for 2017 projects a decrease in the vacancy rate to 5.8 percent. (EHL Real Estate Group, 2017)

Based on the yearly annual reports from some of the leading real estate service providers, there are 8 identified price zones. Beside the office buildings another subdivision indicates the increasing presence of office towers by confirming so the role and importance of this category in the real estate market. As such the Viennese office space development is viewed on the spatial level of following settlement axis.:

North axis: Heiligenstädter Lände- Heligenstadt, Nußdorf –Klosterneuburg, Obere Donaustraße – Brigittenauer Lände

> Office buildings/towers: Skyline, Kay 29, River Gate, BIG BIZ, Millenium Tower, Shuttleworthstraße, Space2Move, Square Plus, Optium, Florido Tower

West axis: Rechte and Linke Wienzeile, Linzerstrasse and Hietzinger Kai

> Office buildings/towers: Forum Schönbrunn, Pfeiffergasse 2, Cumberland Strasse, Bergmillergasse 5, Scheringgasse 2

Wienerberg/ Southern Region: Wiedner Hauptstraße- Triester Straße, Laxenburger Straße-Wienerberg

> Office buildings/towers: Silo Plus, Next office buildings, Arcade Meidling, Twin Towers, Euro Plaza (BH, 5, F), Oberlaaerstraße, Quellenstraße, Triesterstraße, Gudrunstraße 10

Main station quarter/Quartier Belverdere: Wiedner Gürtel- Arsenalstraße-Main Station

Office buildings/towers: The Icon Vienna, HBF1, QBC 4, Favio, Laxenburger Straße 36

Erdberg: Rennweg- Erdberg –Gasometer, St. Marx

Office buildings/towers: MGC Office Park, OCG, Orbi Tower, Smart Campus, Brehmstraße, Marxbox, Doppio Offices, Solaris, Media Quarzer Marx

Prater/Messe: Prater -Lasallestraße

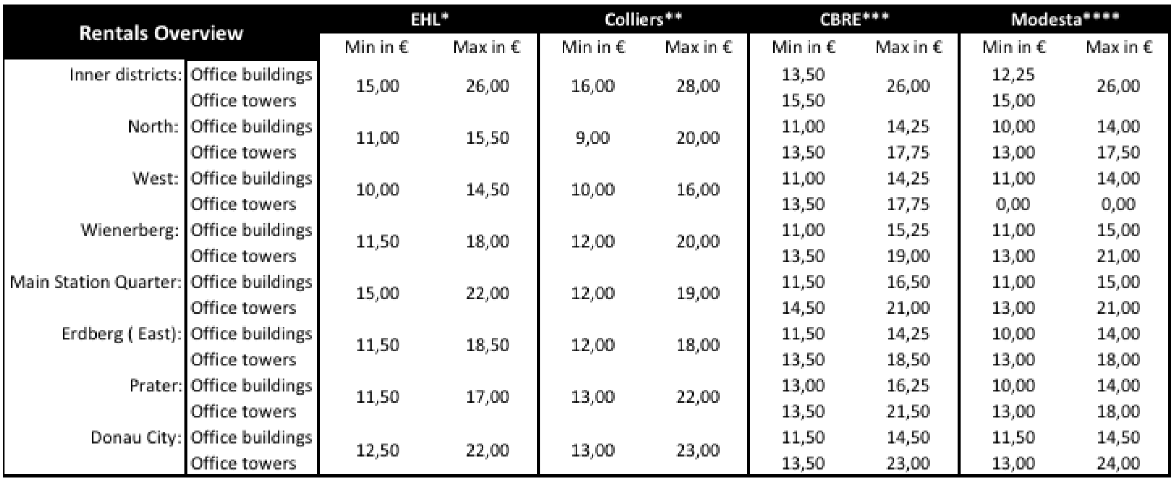
Office buildings/towers: Galaxy Tower, Denk 3, Viertel 2, Messecarre, Fabricks, e-zone, Green Worx, Austria Campus

Donau City/ Surrounding Area:

Office buildings/towers: DC Tower, Ares Tower, Andromeda Tower, Tech Gate Vienna, IZD Tower Seestadt Aspern: HoHo Wien, Aspern IQ, Campus West

Inner districts: Office buildings located between Ringstrasse and the Gürtel

Office buildings: Wiener Börse, Rathausstrasse 1, Palais Herbstein, Kelsenstrasse 2, City point, Operngasse 21, Zieglergasse 6, Rochusmarkt, Goldenes Quatier, Kohlmarkt 8, Schwarzenbergplatz 3, Fleischmarkt 1, Wasagasse 2. In the inner district, the presence of office towers is absent.



Rentals Overview		EHL*		Colliers**		CBRE***		Modesta****	
		Min in €	Max in €	Min in €	Max in €	Min in €	Max in €	Min in €	Max in €
Inner districts:	Office buildings	15,00	26,00	16,00	28,00	13,50	26,00	12,25	26,00
	Office towers					15,50		15,00	
North:	Office buildings	11,00	15,50	9,00	20,00	11,00	14,25	10,00	14,00
	Office towers					13,50	17,75	13,00	17,50
West:	Office buildings	10,00	14,50	10,00	16,00	11,00	14,25	11,00	14,00
	Office towers					13,50	17,75	0,00	0,00
Wienerberg:	Office buildings	11,50	18,00	12,00	20,00	11,00	15,25	11,00	15,00
	Office towers					13,50	19,00	13,00	21,00
Main Station Quarter:	Office buildings	15,00	22,00	12,00	19,00	11,50	16,50	11,00	15,00
	Office towers					14,50	21,00	13,00	21,00
Erdberg (East):	Office buildings	11,50	18,50	12,00	18,00	11,50	14,25	10,00	14,00
	Office towers					13,50	18,50	13,00	18,00
Prater:	Office buildings	11,50	17,00	13,00	22,00	13,00	16,25	10,00	14,00
	Office towers					13,50	21,50	13,00	18,00
Donau City:	Office buildings	12,50	22,00	13,00	23,00	11,50	14,50	11,50	14,50
	Office towers					13,50	23,00	13,00	24,00

* Office Market Report Vienna |Spring 2017 EHL

** Real Estate Market Report Austria | 2016 Colliers

*** Office Market Overview Vienna | Q4 2016 CBRE

**** Office Market Report Vienna | Autum/Winter 2016 Modesta

Table 4: Rentals Overview in Vienna (2016/2017)

The average minimum price for office buildings deducted from the four given real estate agencies is 11,74EUR/sqm whereas, the average maximum price is calculated to be by 35 percent higher. In terms of office towers the prices are slightly higher.

The prices are significantly different from zone to zone. The northern part representing 4 districts charges with the lowest prices for office buildings. As Table 4 shows, office towers spaces are less expensive in the western part of Vienna. However, office buildings and office tower prices peak in the inner districts at around 26 EUR/sqm (Table 4).

Despite of its stable character, (Maier, et al., 2014) the Viennese office real estate market is undergoing a remarkable transformation. Modern office spaces centred in cluster locations of the new city districts (i.e. Donau City) are in high demand. Hedonic characteristics such as very good underground connection, functionality and space, energy efficiency, as well as a wide variety of gastronomy, offer new employment and sufficient parking spaces.

Referring to the data in this research study, the trend of zero energy and passive houses has spread considerably in the last 5 years in Vienna and so have the certifications for green buildings in Austria.

Concerned with the impact of certification in rental prices of environmentally sustainable buildings, this research study concentrates on office buildings and investigates the relationship between investments in energy efficiency for new and refurbished green buildings and effective rent.

The presence of certification makes it easier to gather information and conduct this type of analysis as the certificates present an overview of the building’s characteristics. However, the existence of 5 different certificates relating to different systems and labels does not render this analysis much easier. Other than in the US or UK, where the data is widely available particularly for research purpose, in Austria, this is a new trend and the numerous labelling schemes combined with the inaccessibility of data, explain the absence of other previous analysis or studies related to Austria and uplift the importance of this analysis by making use of it for future reference.

Despite the challenges relating to data collection, I have tried to collect all the data beside of their variety, combine and match them in a single dataset. Because the analysis has in focus the appraised value, rather than the transaction data and in order to define the relationship between the rental prices and energy performance of green certified office buildings the analysis requires three types of data:

- Data on market prices (net and gross rent prices)
- Data on environmental performance (primary energy consumption, CO2 production, heating demand etc.)
- Data on the attributes of green certified office buildings (building characteristics such as size, age, location, transportation facilities etc.)

Again, the presence of five labelling schemes makes it impossible to create a uniformly fulfilled dataset for all three data types.

ii. Sample Size

Through the end of November 2016, there were 118 green office buildings certified under BREEAM/DIFNI, DGNB/ÖGNI, klima:aktiv, TQB/ÖGNB, LEED/GIBG all around Austria (Appendix: Figure 1). Interestingly, there are 12 objects certified as green office spaces from more than one rating system. As such, for research purposes, these objects are present for the analysis related to the rating systems but are excluded from the sample when analysing building characteristics in terms of descriptive statistic.

iii. Location

The dataset used for the descriptive analysis presented in the first part of this chapter, for buildings ‘fit for purpose’, as Fuerst, et al. (2011) refer to, is complete. The number of green certified office buildings that are used in the second part of the thesis will be considerably less. The total number of green rated office buildings compared to the total office building stock remains limited. The presented data are heterogeneous. As such the subsequent tables try to translate the data into a single format (grouped according to their respective label).

Figure 13: The distribution of green office buildings in Austria

The map above gives an overview of all green certified office buildings in Austria. This list excludes special service properties such as hair dresses, laundry, gas stations, fair and congress buildings, educational buildings (primary, secondary, high schools and universities), hotels & restaurants (pubs and cafés included) and garage, and garden buildings. Other subcategories excluded are hospitals and sport facilities.

There is a heavy concentration of green certified buildings in Vienna (48 objects), Lower Austria (30 objects) and Styria (11 objects) (Appendix: Figure 2). The other federal states occupy all together 24,5 percent of the whole.

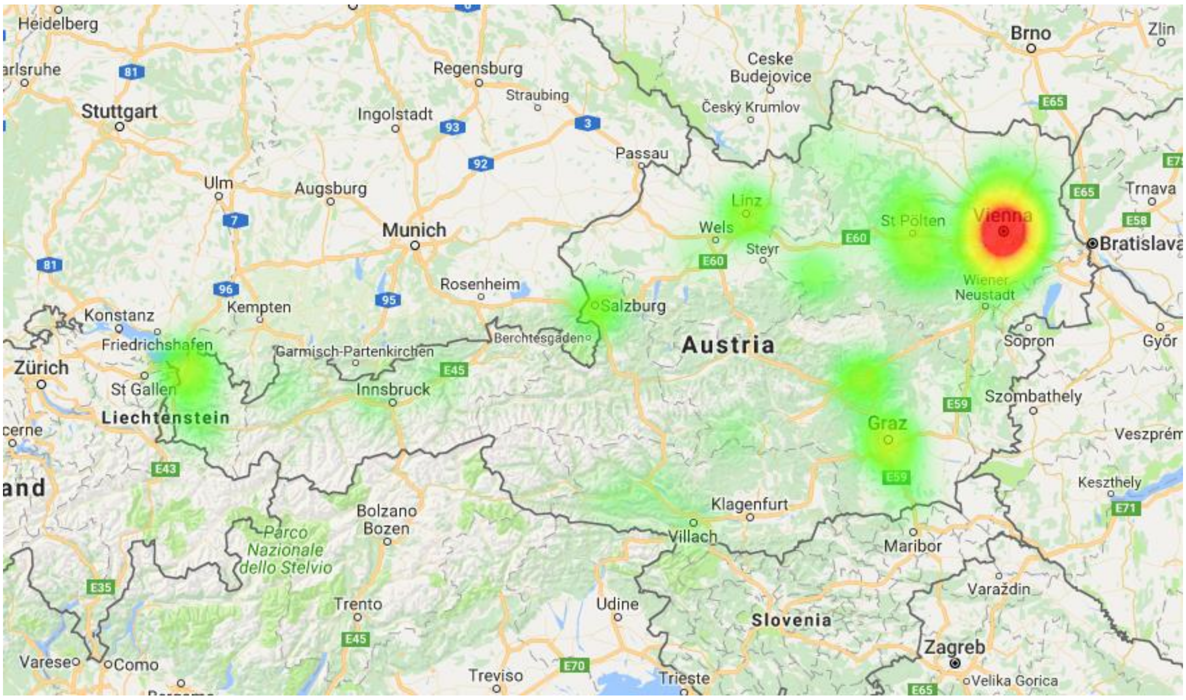


Figure 14: Heat map of green office buildings in Austria

iv. Surface

The overall green certified office space in the sample is 1.370.419,39 sqm. The green certified office space occupies slightly a bit more than the half of the total area of the building in which they are located, namely 54 percent, whereas 64 percent of the green certified office buildings use more than 80% of their surface for office purposes. Considering the melange of office space concepts developed and offered in the recent years from the traditional office spaces, to tech /creative spaces, executive suite or co-working space, the amount of variation of the green dataset values is wide. Their size extends from small ones with 146,65 sqm to tower certification with a surface of above/over 78,000 sqm.

As mentioned in the second chapter of this research, klima:aktiv leads with the highest number of certified buildings (53 objects). Klima:aktiv offers several programs on climate protection and building assessment. It focuses on energy efficiency and allows certification when at least one low energy standard is achieved and is an Austrian agency which provides a self-declaration platform without access restriction and a free plausibility check. All these make klima:aktiv very useful and as such it has the highest degree of recognition among the rating systems present in Austria.

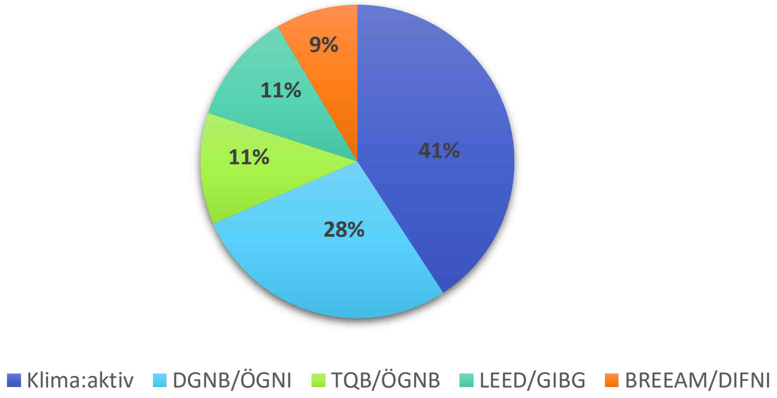


Figure 15: Share of rating tools in Austria

v. Period

The period covered from this research is from 2003 until 2016. Included are also green certified objects planned for 2016 but postponed to 2017 because of construction reasons. The pioneer of green office certification is TQB/ÖGNB followed by klima:aktiv 5 years later. Year 2015 signed the highest certification number and klima:aktiv is the rating agency with the highest rate of certifications.

Interestingly, in 2004 and 2007 there were no green certifications for office buildings.

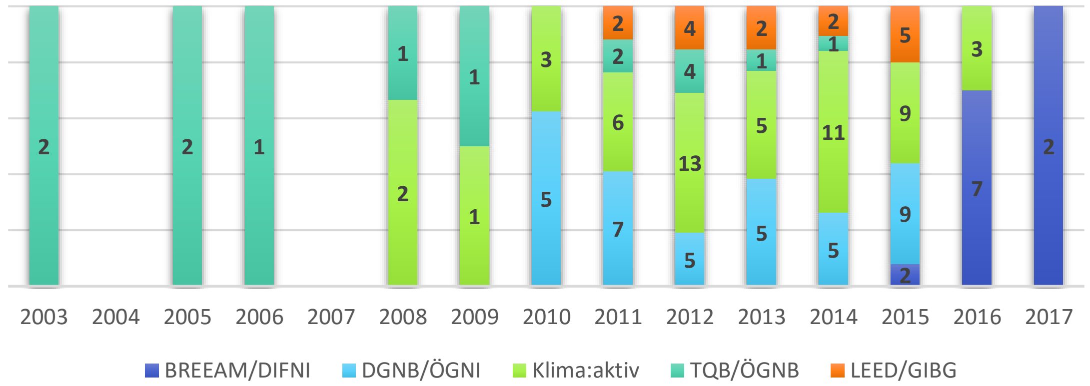


Figure 16: Number of green certified buildings over the years

vi. Purpose of Buildings

The major part of green certified objects is only for office purpose. The rest (43,2 percent) of the green certified objects are mixed such as for retail purposes (i.e. shopping centres), or office towers including warehouses and/or garage spaces (Appendix: Figure 3). Other specific characteristics of the certified buildings relate to their state and age. More than 80 percent of the green properties are new buildings whereas, the rest are refurbished (Appendix: Figure 4). Renovating old office spaces and labelling the m green implicates additional costs. Also, green renovated spaces are accompanied with complementary info including further greening recommendations and suggestions when possible. Usually, the rating systems accord to the renovated spaces Bronze Certification/Certificate.

vii. Age Bands and Buildings Height

Referring to the representative age bands[5], green properties built after 2010 add up to 'Recent' age bands. Considering a time frame of 29 years for each band, the time lag starting from 1991 extends until 2020 thereby incorporating green certified properties. From this data, we can observe that 87 percent of green certified buildings were built in the last 15 years and only 10 percent of them are refurbished.

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[5] Refer to pg. 11

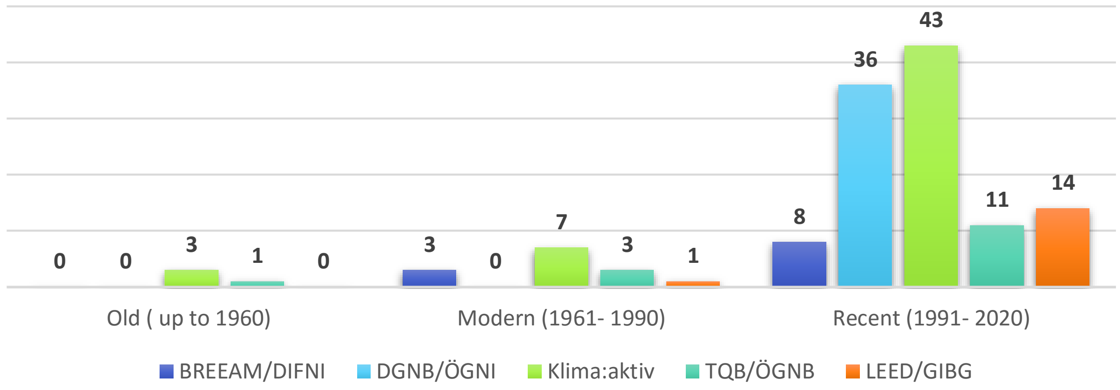


Figure 17: Age bands of certified buildings

Among the essential characteristics of the sample data, classifying buildings based on their height becomes difficult because the exact definition differs from source to source. Referring to the **NFPA (National Fire Protection Association)** yearly reports, Toronto City Council and **Jessona et al., (2015)** recognize 4 classifications based on our samples' building heights:

- Low – Rise Buildings: 1-4 stories/storeys (up to 30m)
- Mid – Rise Buildings: 5-12 storeys (up to 60 m height)
- High – Rise Buildings: 13- 46 storeys (up to 200 m height)
- Skyscrapers: 47-70 storeys (up to 300 m height)

Most green certified office buildings are mid-rise buildings (46,6 percent), yet low-rise buildings follow them by only 2,3 percent less (Appendix: Figure 5).

Despite of the considerable number of high buildings in Austria, the number of skyscrapers is not so prominent. Their number is limited in two, one certified from DNGB/ÖGNI and the other one certified from LEED/GIBG. DNGB/ÖGNI has the highest number of mid– rise green buildings among 118 certified buildings of the sample whereas, klima:aktiv leads with the certification of low-rise buildings.

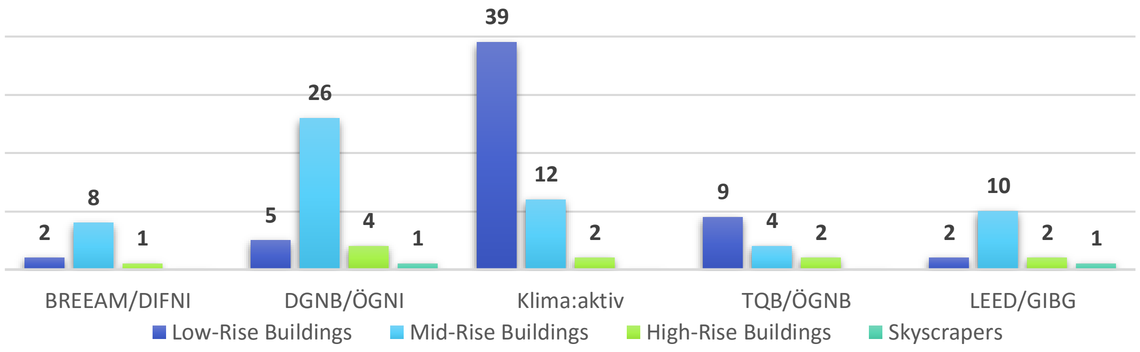


Figure 18: Low-, Mid-, and High Rise Green Office Buildings

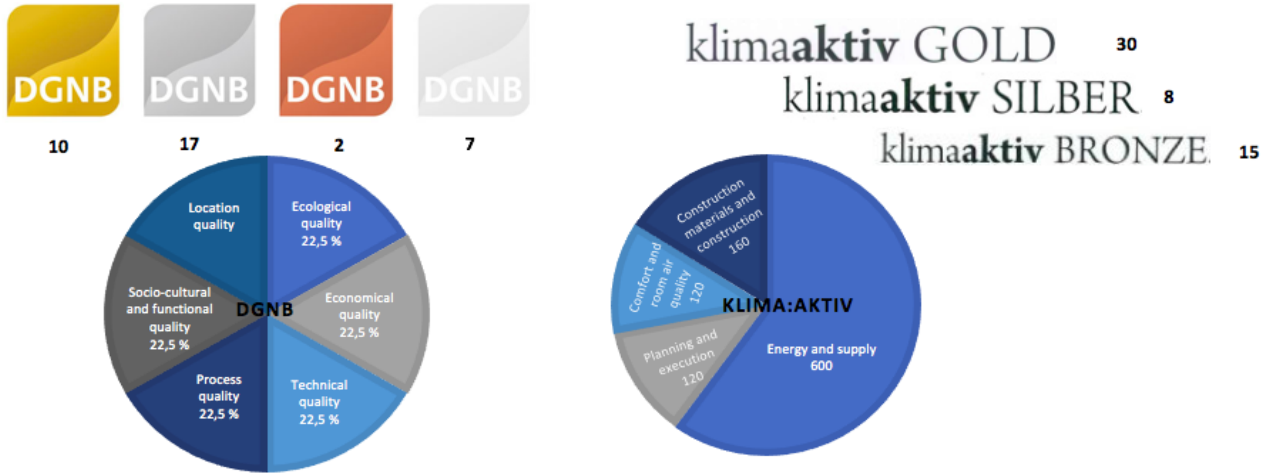
viii. Rating Agencies

The five rating agencies active in Austria presented in Figure 18, have certified all together 118 objects. 9 buildings from our sample have been certified from both labels TQB and klima:aktiv, 2 others from LEED and DGNB/ÖGNI and one from klima:aktiv and BREEAM. As such, the sample retains information from both rating agencies. Unlike the other rating tools, TQB is based on a point system and is partially founded from klima:aktiv. The high compatibility level of TQB with klima:aktiv building standards enables parallel certification.

Beside TQB and klima:aktiv, the presence of multi-criteria schemes provides more than one certificate for the same building, not necessarily awarding them with a common level certificate. Referring to our sample, the observed data reveal that for TQB it is not possible to provide a similar categorization which is also influenced from the shortcoming of data. Klima:aktiv, with the highest number of certifications also leads with the highest number of Gold certificates. Almost 50 percent of DGNB/ÖGNI green certified office buildings are awarded with Silver. A minority of green certified office buildings are Platinum certified (13 objects) (Appendix: Figure 6). This can be as a result of the requirements and their fulfilment, or rather costs implication, but also because only 2 out of five rating tools provide such a certification. BREEAM green certified office buildings are mainly existing objects. Because of their age, construction materials, green enhancement, and other factors an outstanding certification level would be difficult to achieve. Our sample consists mainly of Very Good, Excellent and Good certifications.

Taken together, these results provide important insights into the choice of rating tools. A very large number of buildings from the sample, are evaluated and certified from klima:aktiv. Access to this information is not restricted and it retains very distinctive characteristics from a comparative perspective. Being an Austrian service, as well as the low cost implication **(Figure 19)** makes klima:aktiv the most widely used alternative.

Figure 19: Cost Overview based on data in Table 2

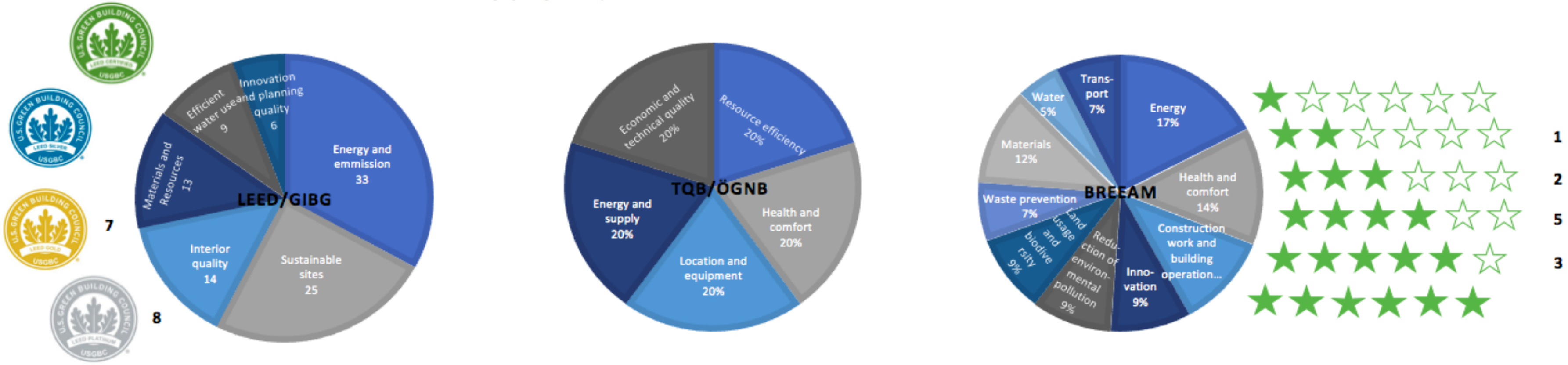


Valuation: Gold > 80 %, Silver > 65 %, Bronze > 50 %

Platinum: Projects with the same conditions of projects previously awarded with Gold

Valuation klima:aktiv gold: > 900 Points, klima:aktiv silver: > 800 Points

klima:aktiv bronze: all basic criteria are fulfilled



Valuation: 40–49 Points = Certified, 50–59 Points = Silver,

60–79 Points = Gold, 80–110 Points = Platinum

Valuation: < 30% = Unclassified, ≥ 30% = Pass, ≥ 45% = Good,

≥ 55% = Very Good, ≥ 70% = Excellent, ≥ 85% = Outstanding

Figure 20: Comparative assessment of rating systems

ix. Heating Demand

The multi-criteria of rating systems and the privacy policies of the corresponding companies affect the complexity of the data and their uniformity. For instance, there is a group of objects in the sample missing some of the data and a second group where the data is in different units. The missing at random (MAR) data are ignored whereas for the second group of data I have tried to unify them.

The heating demand is expressed in kwh/cbm and kWh/sqm. The mean score for heating demand of green certified buildings is 7,29 kWh/cbm (24 objects in the sample express heating demand in kWh/cbm) and 23,08 kWh/sqm (86 objects in the sample express heating demand in kWh/sqm) (Appendix: Figure 7). These results are significant because both values reveal that the average of the certified objects belongs to the nearly zero-energy buildings (Class: A+/A). Besides these results, the range of the certifications is very broad.

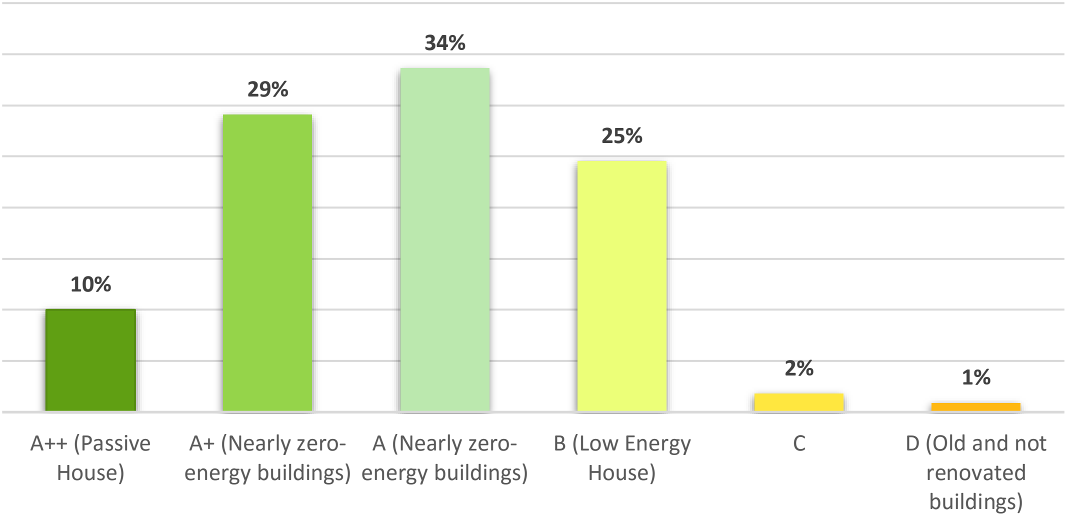


Figure 21: Share of green certified office buildings based on data in Table 1

Part of the sample are also objects belonging to old buildings which have fulfilled the standards because of possible renovations. Based on Table 1, the sample objects can be classified among the first 6 classes (Figure 21). Nearly zero energy buildings falling under A+ and A classes (15-25 kWh/sqm) represent the majority of the objects (69 objects). 1/10 of certified buildings are passive houses and only 1 percent of them fall under old and not renovated buildings. The latter result might reveal the low interest from the both parties in involving, on the one hand the investors/ owners to refurbish old buildings and on the other hand the ratings agencies focusing on these building category. The only rating system providing exclusively such a certification is BREEAM with its fit-out program.

x. Cooling Demand, Primary Energy Demand and CO2 Emission

Cooling demand data were extracted partially from 3 rating systems BREEAM, klima:aktiv and TQB and other external sources. The sample concludes 68 objects and for 9 of them the data is not accessible. All klima:aktiv (47 objects) and TQB (10 objects) green certified office buildings have a cooling demand of A++ class. BREEAM reports mixed results (Appendix: Figure 8).

Regarding primary energy demand and CO2 emissions BREEAM provides no information and the relevant rating systems are klima:aktiv and TQB. Referring to Table 1 and based on primary energy demand data, the main part of the green certified office buildings are low energy houses and belong to class B.

The high CO2 emission values classify green certified office buildings under D and F class (here again, the low interest on green certification regarding these building categories.)

At a national level the numbers in Table 5 reveal the same tendency. The presence of 6 classes in the sample justifies from the wide range of all three indicators. Differently from the results pertained when analysing heating demand and cooling indicators, the class of buildings for CO2 Emissions and primary energy demand moves one level below (Table 6).

Crosstabulation			
	CO2 Emission (kg/m2) BGFa	Primary energy demand (kWh/m2)	Cooling demand (kWh/m2a)
A++ (Passive House)	2	3	51
A+ (Nearly zero-energy buildings)	2	1	2
A (Nearly zero-energy buildings)	2	2	5
B (Low Energy House)	32	34	1
C	5	9	-
D (Old and not renovated buildings)	1	5	-
F (Old and not renovated buildings)	1	-	-
Subtotal	45	54	59
Missing	14	5	9
Total	59	59	68

Table 5:Classification of green certified office buildings in the sample

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Cooling demand (kWh/m2a)	59	0,04	52,60	6,2358	12,37
Primary energy demand (kWh/m2)	54	13,00	278,30	13,15806	55,23
CO2 Emission (kg/m2) BGFa	45	2,00	62,00	2,37122	9,70
Valid N (listwise)	42				

Table 6:Descriptive statistics of green certified buildings in the sample

xi. Other Indicators

Further information extracted from the rating agencies, building investors/owners and architectural offices relate to the energy efficiency of the green certified office buildings. More specifically, it relates to the presence of hybrid renewable energy systems, cooling and heating systems, and ventilation systems.

Regarding hybrid renewable energy systems, the use of photovoltaics and biomass is very common. Figure 22 shows that at a national level half of the green certified offices use photovoltaics (PV), whereas, only 14 percent of them use biomass to provide electricity for remote areas (Figure 23).

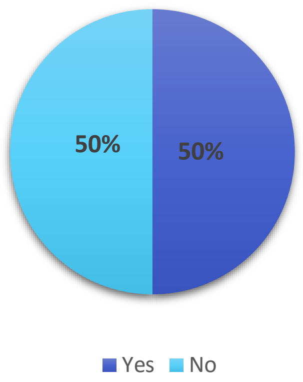


Figure 23: Share of green certified office buildings using PV

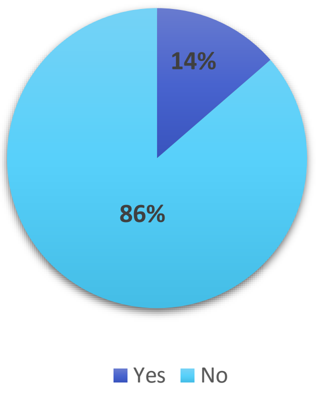


Figure 22: Share of green certified office buildings using Biomass

Usually, hybrid power consists of two or more renewable energy sources together. However, less than half of the green certified offices in a sample of 118 objects combine the renewables or the energy systems.

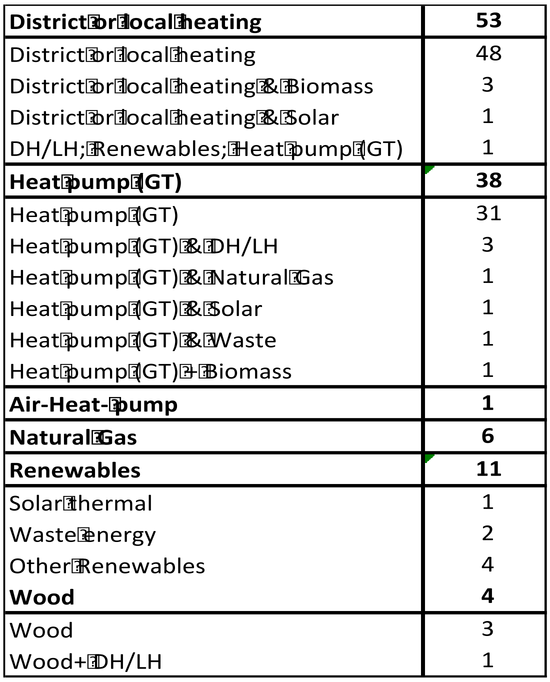
Crosstabulation

PV	**BREEAM/DIFNI**	**DGNB/ÖGNI**	**Klima:aktiv**	**TQB/ÖGNB**	**LEED/GIBG**	**Total**
Yes	**2**	**9**	**38**	**11**	**7**	**67**
No	**7**	**26**	**15**	**4**	**7**	**59**
Total	**9**	**35**	**53**	**15**	**14**	**126**
Biomass						
Yes	**0**	**1**	**15**	**4**	**0**	**20**
No	**9**	**31**	**37**	**11**	**14**	**102**
Total	**9**	**32**	**52**	**15**	**14**	**122**

Table 7: Number of green office buildings using PV and Biomass per rating system

Table 7 presents an overview of PV and biomass systems grouped based on the rating agencies. Despite the diversity of the materials used for biomass fuel, wood chips, corn, animal waste and some types of garbage the number of buildings using biomass in research make up a very small portion.

The overall response rate to the section regarding heating and cooling system was positive (109 objects nationally) but because of the system's complexity (scalability, attributes) and limited information, creating adequate clusters becomes a challenge. As such an appropriate subdivision is visualized in Table 8 where the main part of the green certified office buildings use district heating (Fernwärme), and in Vienna around 6800 key account customers (Wiener Stadtwerke, 2015) are supplied by district heating. Geothermal energy occupies approx. 35 percent of the pie (Figure 24) and the rest is renewables (10 percent) and natural gas (5,5 percent).



District or local heating	**53**
District or local heating	48
District or local heating & Biomass	3
District or local heating & Solar	1
DH/LH; Renewables; Heat pump (GT)	1
Heat pump (GT)	**38**
Heat pump (GT)	31
Heat pump (GT) & DH/LH	3
Heat pump (GT) & Natural Gas	1
Heat pump (GT) & Solar	1
Heat pump (GT) & Waste	1
Heat pump (GT) + Biomass	1
Air-Heat- pump	**1**
Natural Gas	**6**
Renewables	**11**
Solar thermal	1
Waste energy	2
Other Renewables	4
Wood	**4**
Wood	3
Wood+ DH/LH	1

Table 8: Energy systems for green certified office buildings

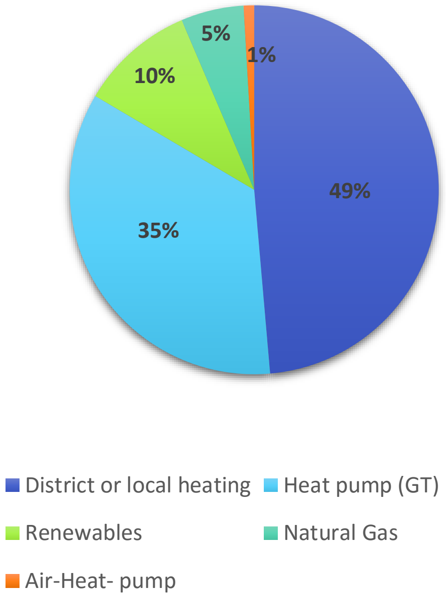


Figure 24: Share of energy systems for green certified office building in the sample

Because some of the green certified office spaces do not specify what they use for renewable sources, or which providers they have contracted, they are grouped under the general heating system or hybrid system present in the sample. By including them, it is understandable that this will affect the accuracy of the information regarding heating systems. However, if the building was once classified under one heating system it is not counted again in the case of hybrid energy use.

Table 9 presents heating systems grouped accordingly to the rating tools. A considerable number of green offices certified from BREEAM, DGNI / ÖGNI and LEED use district heating. Klima:aktiv green certified office spaces use geothermal energy from the heat pumps and natural gas. Some of the green office spaces use more than one energy sources such as renewables, geothermal and district heating.

	BREEAM/DIFNI	DGNB/ÖGNI	Klima:aktiv	TQB/ÖGNB	LEED/GIBG	Total
Air-Heat-pump	-	-	1	-	-	1
District or local heating	8	23	7	5	9	52
District or local heating & Biomass	-	-	3	-	-	3
District or local heating & Solar	-	-	1	-	-	1
DH/LH; Renewables; Heat pump (GT)	-	-	1	-	-	1
Heat pump (GT)	1	6	20	4	3	34
Heat pump (GT) & Biomass	-	-	1	-	-	1
Heat pump (GT) & DH/LH	-	1	1	-	1	3
Heat pump (GT) & Natural Gas	-	-	1	-	-	1
Heat pump (GT) & Solar	-	-	1	-	-	1
Heat pump (GT) & Waste	-	-	1	1	-	2
Natural Gas	-	-	6	1	-	7
Renewables	-	-	4	-	-	4
Solar thermal	-	-	-	1	-	1
Waste energy	-	-	2	1	-	3
Wood	-	-	2	2	-	4
Wood+ DH/LH	-	1	-	-	1	2
Total	9	31	52	15	14	121

Table 9: Number of green certified office buildings for each energy system per rating system

Ventilation and cooling system is very common for green certified office spaces. More than 90 percent of the green certified office spaces from each rating agency are equipped with both ventilation and cooling system, representing respectively 91 and 94 percent (Appendix: Figure 9).

BREEAM and klima:aktiv go further and provide distinct information about ventilation system through **heat recovery (HRV)**. HRV, as a mechanical ventilation enables the circulation of fresh air into the building and improves the indoor air quality whilst assuring energy efficiency. More than 80 percent of klima:aktiv certified office spaces have a HRV system and another half from green office spaces certified from BREEAM add up to this group (Appendix: Figure 10) Besides the mechanical ventilation systems, natural ventilation or passive ventilation systems are also present in the sample.

Crosstabulation						
Ventilation System	BREEAM/DIFNI	DGNB/ÖGNI	klima:aktiv	TQB/ÖGNB	LEED/GIBG	Total
Yes	7	31	47	14	13	112
No	2	3	2	0	0	7
Partly	0	0	1	1	1	3
Total	9	34	50	15	14	122
Cooling System						
Yes	8	33	46	15	14	116
No	0	0	5	0	0	5
Partly	1	1	0	0	0	2
Total	9	34	51	15	14	123

Table 10: Number of green office buildings using ventilation and cooling systems per rating system

Building orientation, operable windows, night purge ventilation and other architectural features make possible mixed mode ventilation. Mixed mode ventilation is presented in Table 10 and Figure 25 under the category 'Partly'.

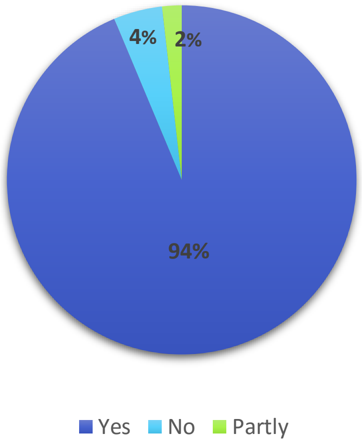


Figure 25: Share of green certified buildings using ventilation system

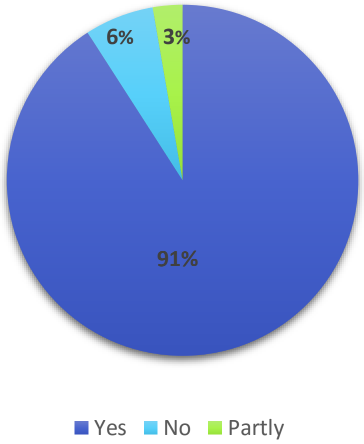


Figure 26: Share of green certified buildings using cooling system

The certificates for green office spaces in our sample rarely specify whether the buildings use active or passive ventilation, or whether the cooling system provided is active or passive. Regarding cooling systems, the central or decentral control aspect was partly provided as an information from klima:aktiv but because of the weak evidence from all rating tools, it is not possible to provide or confirm further implications.

2. Empirical Analysis

i. Hedonic Rent Model

This section of the paper will present the hedonic regression modelling used to measure the price effect of BREEAM, LEED/GIBG, DGNB/ÖGNI and klima:aktiv certification. Because of the heterogeneous nature of an office, hedonic modelling identifies and quantifies the range of size, age, location and lease characteristics used as independent variables to determine price. Despite the econometric problems, the hedonic model sketched by Rosen (1974) shows that the hedonic price function covers any goods or services consisting of a variety of utility-bearing characteristics. In addition, it has become the workhorse model for examining price determination in real estate research. To investigate the effect of energy efficiency on the rent of commercial buildings, a similar hedonic methodology to Eichholtz, et al., (2010) is applied. Although using the same modelling, in order to avoid endogeneity problems with the correlation of rent and vacancy rates in a building (in Eichholtz, et al., (2010) model asking rent is multiplied by the occupancy rate), and because no rating tool offers the available information, researched rental prices are used. In the following empirical model rent prices are explained.

Equation 1:Hedonic Rent Model

$$\ln R_i = \beta_0 + \beta_1 \ln A_i + \beta_2 \ln S_i + \beta_3 \ln OS_i + \beta_4 \ln BS_i + \beta_5 \ln P_i + \beta_6 \ln M_i + \beta_7 \ln HD_i + \beta_8 BC_i + \beta_9 G_i + \beta_{10} BF_i + \beta_{11} TM_i + \beta_{12} SW_i + \beta_{13} AB_i + \beta_{14} TN_i + \varepsilon_i$$

In this formulation, the dependent variable is the logarithm of the rent per square meter R_i in office buildings. A_i is the variable representing either the year of construction or the year of a major refurbishment and S_i is for the building storeys. OS_i and BS_i control the effect of office and building size in the rental prices. To control for locational effects, P_i and M_i capture the spatial distribution at a geographical level by its coordinates (parallel and meridians). Only three buildings in the sample are located outside Vienna, respectively Lower Austria, Linz and Salzburg. Figure 27 pins green (in green) and control buildings (in yellow) in Vienna (30 objects) and Lower Austria (1 object).

HDi represents the heating demand per square meter used in green office buildings, whereas BC_i refers to the building class variable.[6] Gi is a dichotomous independent variable representing green certification. In Model 2 instead of a dummy variable, the regression is lead according to the respective rating agencies. Besides the variables related to building characteristics, the model includes a set of hedonic characteristics such as accessibility (BF: barrier-free) and transportation (tram (TM), subway (SW), by bus (AB), by train (TN)). β_i are estimated coefficients and ε_I is the error term.

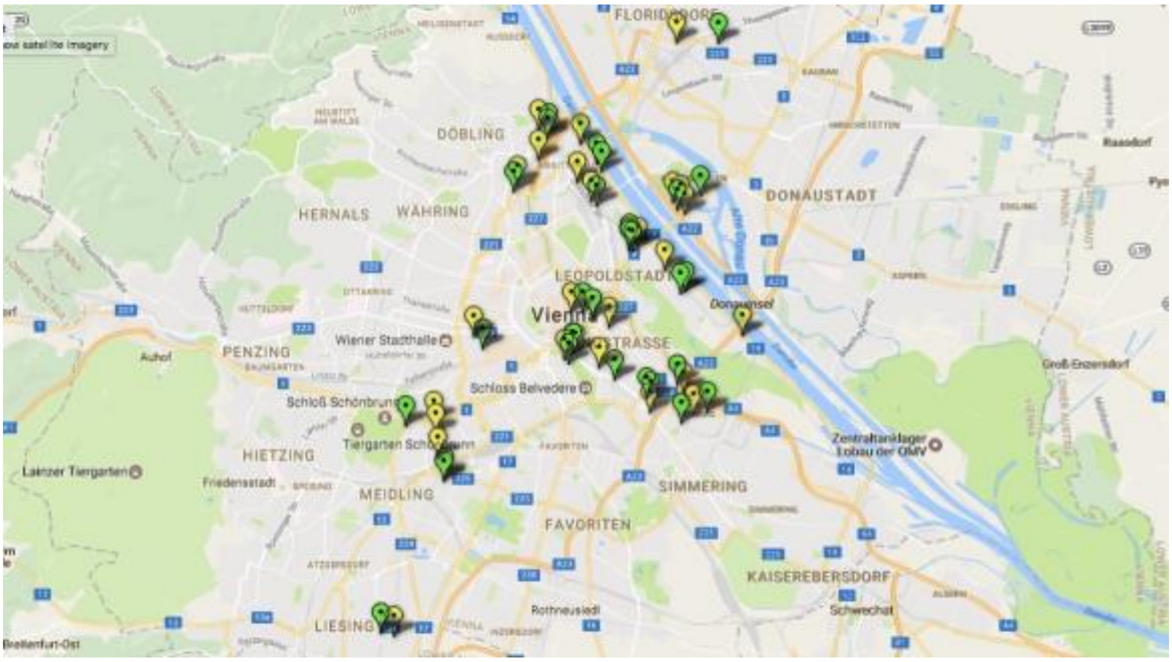


Figure 26:Distribution of green and control buildings in Vienna

3. Empirical Results

Of the 118 certified buildings identified in Austria, information about building characteristics and monthly rent were available for 31 buildings. The other part of the buildings belongs to the public sector, institutional offices (state-owned) and/or built for self-use purpose. Using the GIS technique and based upon the address of each rated building in the sample, green certified office buildings were matched to a randomly selected non-certified building in the same market within 2 km. Because of the market size, country size and the high concentration of green

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[6] Table 1 classifies the buildings accordingly to their heating demand, primary energy demand, cooling demand and CO2 emission.

buildings in Vienna, distance based clusters are absent. The regression includes 62 observations (Figure 27).

i. Descriptive Statistic

In order to assess the sample, a descriptive analysis based on rating agencies was performed. Klima:aktiv green certified office buildings result to be the oldest certified buildings confirming the interest in refurbishment and their certification not only from BREEAM. Despite the moderate number of relevant green certified office buildings in the sample, LEED leads with the largest certified surface, and the average of green certified office buildings is 17 stories tall, which classifies it under nearly -zero energy buildings. Low- rise buildings, with a minimum of 10.83 kWh/sqm and very low operating costs are the main characteristics for klima:aktiv green certified buildings. Average net rent contracts for BREEAM and klima:aktiv are below the average net rent contract of the whole sample whereas, LEED and DGNI/ÖGNI green certified buildings charge approximately 11 percent higher rent prices. The Pearson product moment correlation coefficient was used to determine the relationship between the heating demand and Gross Rent contracts. The coefficient r = -0.408 with P-value= 0.001 reveals the negative correlation between the dependant variable and heating demand (Figure 28).

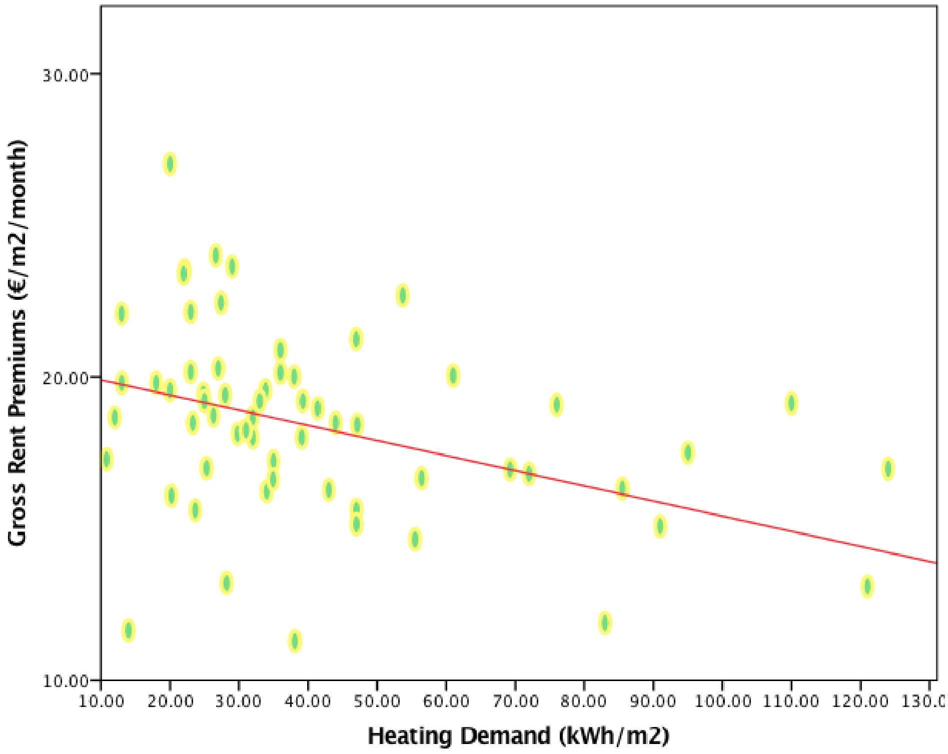
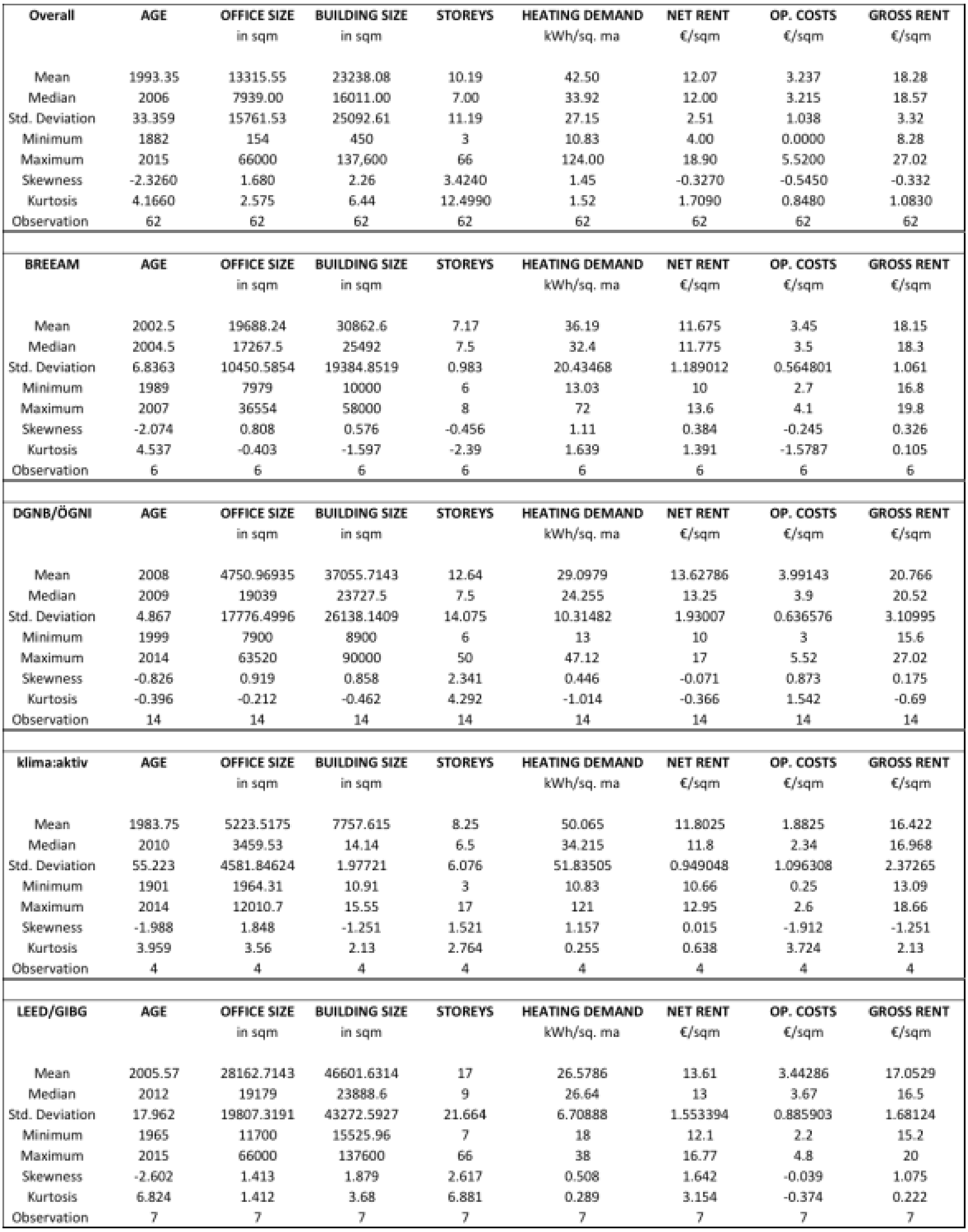


Figure 27: Heating Demand vs Gross Rental Prices (whole sample)



Overall	AGE	OFFICE SIZE in sqm	BUILDING SIZE in sqm	STOREYS	HEATING DEMAND kWh/sq. ma	NET RENT €/sqm	OP. COSTS €/sqm	GROSS RENT €/sqm
Mean	1993.35	13315.55	23238.08	10.19	42.50	12.07	3.237	18.28
Median	2006	7939.00	16011.00	7.00	33.92	12.00	3.215	18.57
Std. Deviation	33.359	15761.53	25092.61	11.19	27.15	2.51	1.038	3.32
Minimum	1882	154	450	3	10.83	4.00	0.0000	8.28
Maximum	2015	66000	137,600	66	124.00	18.90	5.5200	27.02
Skewness	-2.3260	1.680	2.26	3.4240	1.45	-0.3270	-0.5450	-0.332
Kurtosis	4.1660	2.575	6.44	12.4990	1.52	1.7090	0.8480	1.0830
Observation	62	62	62	62	62	62	62	62

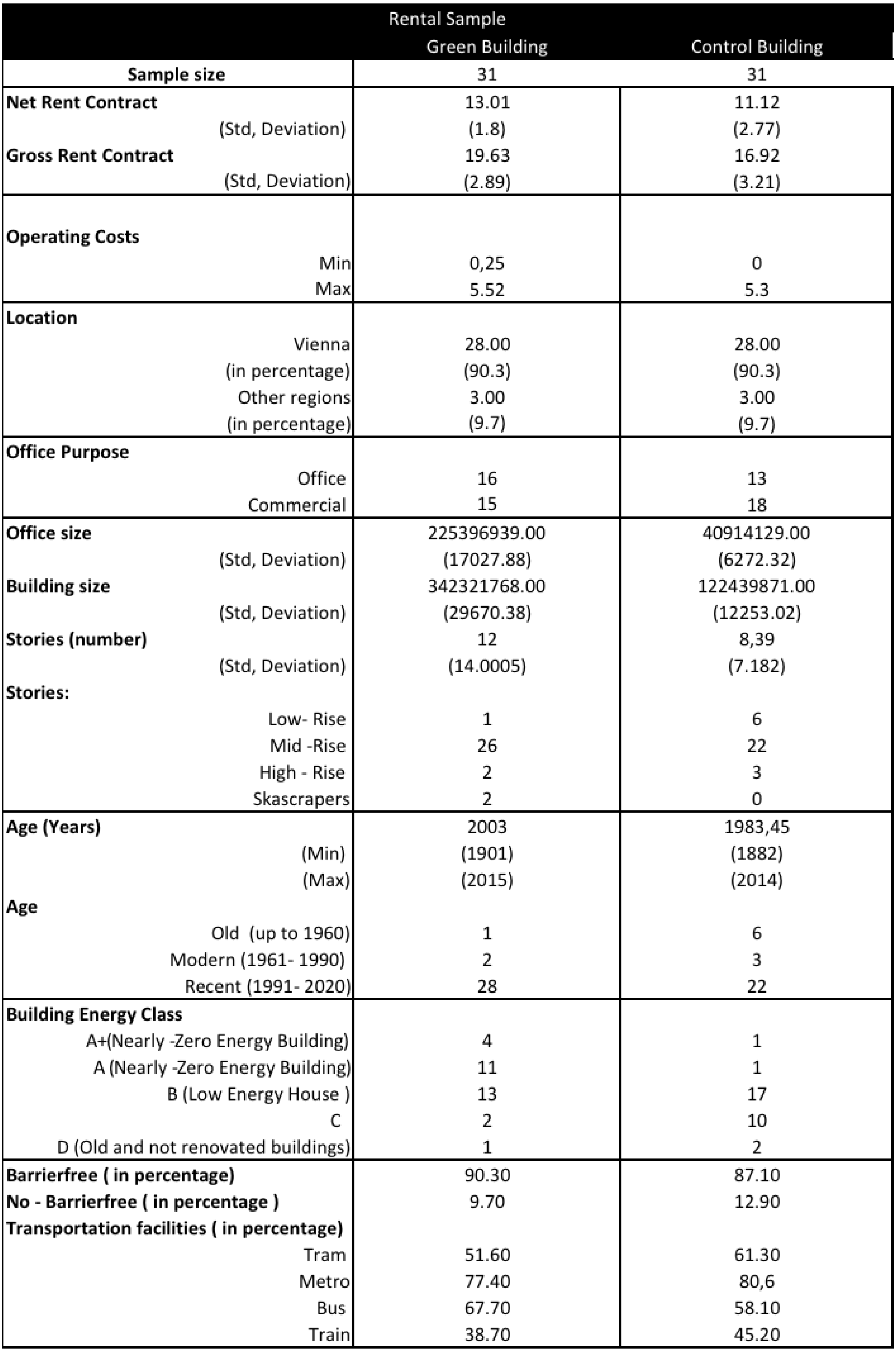
BREEAM	AGE	OFFICE SIZE in sqm	BUILDING SIZE in sqm	STOREYS	HEATING DEMAND kWh/sq. ma	NET RENT €/sqm	OP. COSTS €/sqm	GROSS RENT €/sqm
Mean	2002.5	19688.24	30862.6	7.17	36.19	11.675	3.45	18.15
Median	2004.5	17267.5	25492	7.5	32.4	11.775	3.5	18.3
Std. Deviation	6.8363	10450.5854	19384.8519	0.983	20.43468	1.189012	0.564801	1.061
Minimum	1989	7979	10000	6	13.03	10	2.7	16.8
Maximum	2007	36554	58000	8	72	13.6	4.1	19.8
Skewness	-2.074	0.808	0.576	-0.456	1.11	0.384	-0.245	0.326
Kurtosis	4.537	-0.403	-1.597	-2.39	1.639	1.391	-1.5787	0.105
Observation	6	6	6	6	6	6	6	6

DGNB/ÖGNI	AGE	OFFICE SIZE in sqm	BUILDING SIZE in sqm	STOREYS	HEATING DEMAND kWh/sq. ma	NET RENT €/sqm	OP. COSTS €/sqm	GROSS RENT €/sqm
Mean	2008	4750.96935	37055.7143	12.64	29.0979	13.62786	3.99143	20.766
Median	2009	19039	23727.5	7.5	24.255	13.25	3.9	20.52
Std. Deviation	4.867	17776.4996	26138.1409	14.075	10.31482	1.93007	0.636576	3.10995
Minimum	1999	7900	8900	6	13	10	3	15.6
Maximum	2014	63520	90000	50	47.12	17	5.52	27.02
Skewness	-0.826	0.919	0.858	2.341	0.446	-0.071	0.873	0.175
Kurtosis	-0.396	-0.212	-0.462	4.292	-1.014	-0.366	1.542	-0.69
Observation	14	14	14	14	14	14	14	14

klima:aktiv	AGE	OFFICE SIZE in sqm	BUILDING SIZE in sqm	STOREYS	HEATING DEMAND kWh/sq. ma	NET RENT €/sqm	OP. COSTS €/sqm	GROSS RENT €/sqm
Mean	1983.75	5223.5175	7757.615	8.25	50.065	11.8025	1.8825	16.422
Median	2010	3459.53	14.14	6.5	34.215	11.8	2.34	16.968
Std. Deviation	55.223	4581.84624	1.97721	6.076	51.83505	0.949048	1.096308	2.37265
Minimum	1901	1964.31	10.91	3	10.83	10.66	0.25	13.09
Maximum	2014	12010.7	15.55	17	121	12.95	2.6	18.66
Skewness	-1.988	1.848	-1.251	1.521	1.157	0.015	-1.912	-1.251
Kurtosis	3.959	3.56	2.13	2.764	0.255	0.638	3.724	2.13
Observation	4	4	4	4	4	4	4	4

LEED/GIBG	AGE	OFFICE SIZE in sqm	BUILDING SIZE in sqm	STOREYS	HEATING DEMAND kWh/sq. ma	NET RENT €/sqm	OP. COSTS €/sqm	GROSS RENT €/sqm
Mean	2005.57	28162.7143	46601.6314	17	26.5786	13.61	3.44286	17.0529
Median	2012	19179	23888.6	9	26.64	13	3.67	16.5
Std. Deviation	17.962	19807.3191	43272.5927	21.664	6.70888	1.553394	0.885903	1.68124
Minimum	1965	11700	15525.96	7	18	12.1	2.2	15.2
Maximum	2015	66000	137600	66	38	16.77	4.8	20
Skewness	-2.602	1.413	1.879	2.617	0.508	1.642	-0.039	1.075
Kurtosis	6.824	1.412	3.68	6.881	0.289	3.154	-0.374	0.222
Observation	7	7	7	7	7	7	7	7

Table 11: Descriptive statistics of overall sample with BREEAM, DGNB/ÖGNI, klima:aktiv, LEED/GIBG



	Rental Sample	
	Green Building	Control Building
Sample size	31	31
Net Rent Contract	13.01	11.12
(Std, Deviation)	(1.8)	(2.77)
Gross Rent Contract	19.63	16.92
(Std, Deviation)	(2.89)	(3.21)
Operating Costs		
Min	0,25	0
Max	5.52	5.3
Location		
Vienna	28.00	28.00
(in percentage)	(90.3)	(90.3)
Other regions	3.00	3.00
(in percentage)	(9.7)	(9.7)
Office Purpose		
Office	16	13
Commercial	15	18
Office size	225396939.00	40914129.00
(Std, Deviation)	(17027.88)	(6272.32)
Building size	342321768.00	122439871.00
(Std, Deviation)	(29670.38)	(12253.02)
Stories (number)	12	8,39
(Std, Deviation)	(14.0005)	(7.182)
Stories:		
Low- Rise	1	6
Mid -Rise	26	22
High - Rise	2	3
Skascrapers	2	0
Age (Years)	2003	1983,45
(Min)	(1901)	(1882)
(Max)	(2015)	(2014)
Age		
Old (up to 1960)	1	6
Modern (1961- 1990)	2	3
Recent (1991- 2020)	28	22
Building Energy Class		
A+(Nearly -Zero Energy Building)	4	1
A (Nearly -Zero Energy Building)	11	1
B (Low Energy House)	13	17
C	2	10
D (Old and not renovated buildings)	1	2
Barrierfree (in percentage)	90.30	87.10
No - Barrierfree (in percentage)	9.70	12.90
Transportation facilities (in percentage)		
Tram	51.60	61.30
Metro	77.40	80,6
Bus	67.70	58.10
Train	38.70	45.20

Table 12: Comparison of Green-Certified Buildings and Control Buildings

There are a number of important differences between green certified buildings and non -certified buildings. Green certified buildings tend to be newer in terms of age, taller by about 4 stories and serve office purposes rather than mixed commercial purposes. Other differences are reflected in rental prices and operational costs. Green certified office buildings charge on average higher rent (Table 12: 19.63 EUR/sqm/month). They might charge up to 27 EUR/sqm/month (Table 11) whereas, the maximum price for non-green certified buildings reaches 16.91EUR/sqm/month (Table 12). Furthermore, the introduction of co-working spaces has redefined the net rent contract by including operating costs in rentals and notably charging lower rent for non–green certified buildings. The average operating costs for green buildings are approximately 8 percent higher than for non-green certified buildings. (Table 12) However, green certified buildings belong mainly to Energy Class A+, A and B assuring lower heating demand and energy consumption.

Green certified buildings are in more than 90 percent of the cases barrier free. (Table 12) However, a larger fraction of the non- green buildings has a better access to public transportation such as tram, subway, bus and train.

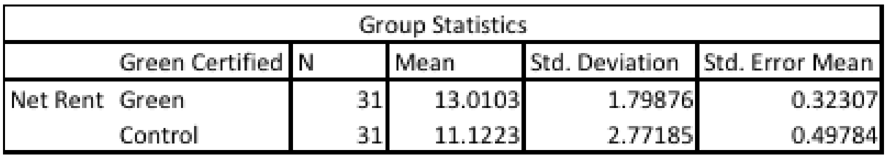
ii. Independent T-test

Starting the investigation on the effect of the hedonic characteristics (green certification and heating demand) an independent T-test is performed. The research question presented is as follows: ‘Is there a difference in the mean net rental prices for green certified buildings and control buildings in the sample?’. Based on this research question the null hypothesis which will be tested is:

There is no statistically significant difference between the mean net rent of green and control buildings (non- green buildings) in the sample.

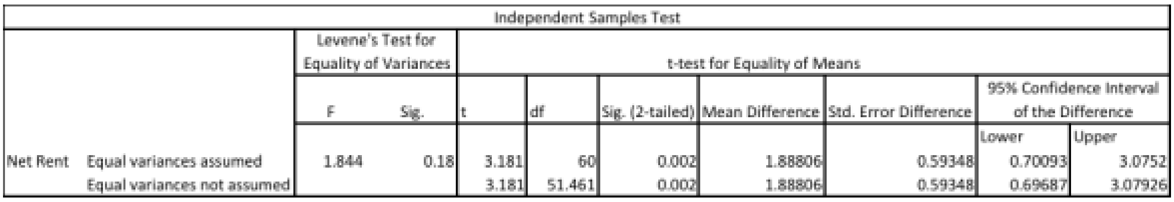
From both, the net rental is defined as the dependent variable and green certification as the independent variable.

Furthermore, the Levene’s Test result shows that the significance level is above 0.05. Therefore, the assumption of equal variance has not been violated and is tenable.



Group Statistics

	Green Certified	N	Mean	Std. Deviation	Std. Error Mean
Net Rent	Green	31	13.0103	1.79876	0.32307
	Control	31	11.1223	2.77185	0.49784



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Net Rent	Equal variances assumed	1.844	0.18	3.181	60	0.002	1.88806	0.59348	0.70093	3.0752
	Equal variances not assumed			3.181	51.461	0.002	1.88806	0.59348	0.69687	3.07926

Table 13:Independent Sample T-test (Green buildings vs. Control Buildings)

In Table 13, a p- value of 0.002 reports the statistically significance difference at the conventional levels of our Hypotheses. As such we can reject the null hypotheses and confirm the difference between the mean net rent of green buildings and control buildings. To set the magnitude of differences, effect size was calculated based on the following formula:

Cohen's $d = M_1 - M_2 / \sigma_{\text{pooled}}$[7]

where: $\sigma_{\text{pooled}} = \sqrt{[(\sigma_1^2 + \sigma_2^2) / 2]}$

$r_{Y\lambda} = d / \wp(d^2 + 4)$

This estimation specifies a large effect size where Cohen’s d equals 0.80803 and r= 0.3746 (the correlation coefficient) represents a medium effect size.

iii. Hedonic Regression Results

To further examine the effect of green certification in rent of office buildings, a standard evaluation framework - hedonic regressions based on the outlined model was estimated. In order to reduce heteroscedasticity and non-normality, as well as, for interpretation purposes the log values of the hedonic characteristics for all continuous numeric variables were estimated.

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[7] In order to quantify the difference between the groups, it is appropriate to compute the effect size. Because of similar size of the two groups and standard deviation, I use Cohen’s d. From the results a positive effect size indicates that the effect increases the mean.

In equation (1) the dependent variable is the logarithm of the rent per square meter Ri. In the hedonic regression, age, stories, heating demand, green certification and building class are among the most influential rent determinants.

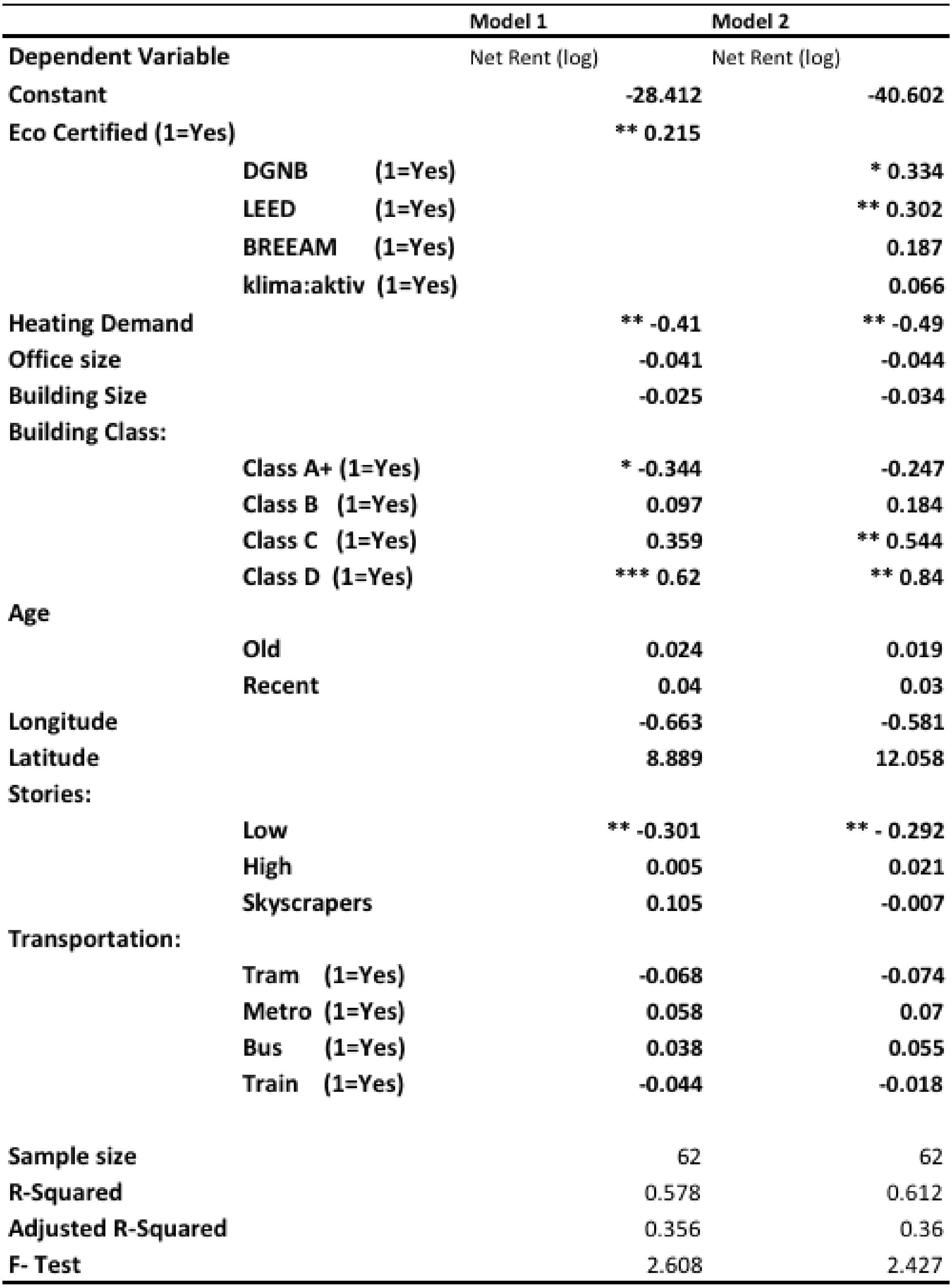
Model 1 shows the regression results of the basic model relating rent to building characteristics measured by age, stories, size and most importantly heating demand (Table 14). The regression performed for 62 observations explains approximately 58 percent of the cross-sectional variation in rent and a statistically significant net rent of approximately 22 percent in green certified buildings compared to non–certified buildings (Table 14: Model 1).

Model 1 shows the inverse effect that heating demand has on rent. Buildings with a lower heating demand trigger a higher rent price by approximately 41 percent. Because building class is defined from energy class, the same concept applies for building class. Rent charged for buildings quoted under Class A+ are 34 percent higher whereas class D buildings are lower by 62 percent. The difference between net rent and gross rent quotation is presented in Model 3. Age is a slightly significant determinant for gross rent. Buildings builds in the last 20 years have the tendency to charge higher prices by 7.8 percent. Regarding buildings falling under Age category Old, rent prices can also exert a higher price, however, this might be related to their architectonical value. Despite gross of net rent being a dependent variable low rise buildings cost between 26- 30 percent less (Table 15).

To investigate further on the impact of the rating tools in rental prices for certified buildings, Model 2 reports the results of the regression for all the rating agencies individually (Table 14). A closure inspection with dichotomous variables indicates that all rating agencies, despite their certification level are considerably significant to rental price. Relating to the number of green certified buildings from each rating agency DGNB/ÖGNI and LEED have a positive impact by affecting the rental prices by respectively 33 and 30 percent for Net Rent (Table 14: Model 2) and approximately 28 and 20 for Gross Rent. These results are highly significant. Whereas, klima:aktiv and BREEAM green certification result to be insignificant.

The other coefficients reveal the same rental trends. In Model 4 the results indicate that older building can be associated with higher rental prices but prices for office buildings with less than 4 stories are 24 percent lower (Table 15).

The dummy variables adjusted for intangible amenities such as transportation means are statistically insignificant.



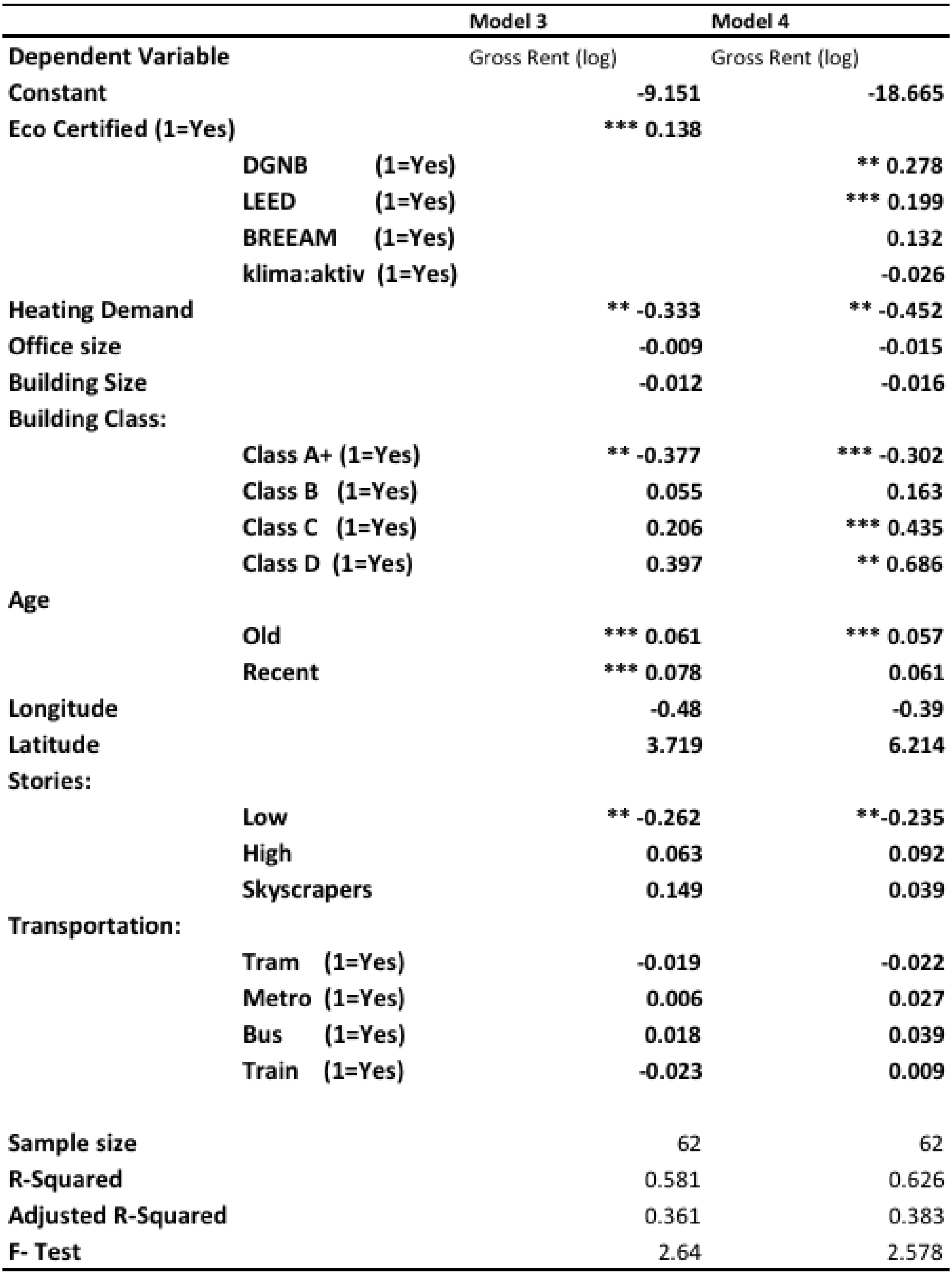
		Model 1	Model 2
Dependent Variable		Net Rent (log)	Net Rent (log)
Constant		-28.412	-40.602
Eco Certified (1=Yes)		** 0.215	
	DGNB (1=Yes)		* 0.334
	LEED (1=Yes)		** 0.302
	BREEAM (1=Yes)		0.187
	klima:aktiv (1=Yes)		0.066
Heating Demand		** -0.41	** -0.49
Office size		-0.041	-0.044
Building Size		-0.025	-0.034
Building Class:			
	Class A+ (1=Yes)	* -0.344	-0.247
	Class B (1=Yes)	0.097	0.184
	Class C (1=Yes)	0.359	** 0.544
	Class D (1=Yes)	*** 0.62	** 0.84
Age			
	Old	0.024	0.019
	Recent	0.04	0.03
Longitude		-0.663	-0.581
Latitude		8.889	12.058
Stories:			
	Low	** -0.301	** - 0.292
	High	0.005	0.021
	Skyscrapers	0.105	-0.007
Transportation:			
	Tram (1=Yes)	-0.068	-0.074
	Metro (1=Yes)	0.058	0.07
	Bus (1=Yes)	0.038	0.055
	Train (1=Yes)	-0.044	-0.018
Sample size		62	62
R-Squared		0.578	0.612
Adjusted R-Squared		0.356	0.36
F- Test		2.608	2.427

Significance at the 0.1, 0.05, and 0.01 levels are indicated by ***, **, and *.

Table 14: Regression Results

Office Rent and Green Certification

(dependent variable: Logarithm of net rent per square meter)



		Model 3	Model 4
Dependent Variable		Gross Rent (log)	Gross Rent (log)
Constant		-9.151	-18.665
Eco Certified (1=Yes)		*** 0.138	
	DGNB (1=Yes)		** 0.278
	LEED (1=Yes)		*** 0.199
	BREEAM (1=Yes)		0.132
	klima:aktiv (1=Yes)		-0.026
Heating Demand		** -0.333	** -0.452
Office size		-0.009	-0.015
Building Size		-0.012	-0.016
Building Class:			
	Class A+ (1=Yes)	** -0.377	*** -0.302
	Class B (1=Yes)	0.055	0.163
	Class C (1=Yes)	0.206	*** 0.435
	Class D (1=Yes)	0.397	** 0.686
Age			
	Old	*** 0.061	*** 0.057
	Recent	*** 0.078	0.061
Longitude		-0.48	-0.39
Latitude		3.719	6.214
Stories:			
	Low	** -0.262	**-0.235
	High	0.063	0.092
	Skyscrapers	0.149	0.039
Transportation:			
	Tram (1=Yes)	-0.019	-0.022
	Metro (1=Yes)	0.006	0.027
	Bus (1=Yes)	0.018	0.039
	Train (1=Yes)	-0.023	0.009
Sample size		62	62
R-Squared		0.581	0.626
Adjusted R-Squared		0.361	0.383
F- Test		2.64	2.578

Significance at the 0.1, 0.05, and 0.01 levels are indicated by ***, **, and *.

Table 15: Regression Results

Office Rent and Green Certification

(dependent variable: Logarithm of gross rent per square meter)

4. Conclusion

The current study is the first of its kind to analyse the economic aspect of energy efficient buildings in Austria. Overall, the research presented in this thesis reports the current situation of real estate markets regarding green buildings as well as the economic value of green certification. Despite the data limitation, the identification of green buildings in Austria and the impersonal market comparison of all rating agencies provide important insights.

The five rating agencies that are active in Austria BREEAM, LEED, DGNB, klima:aktiv and TQB are responsible for 118 certified office spaces. Based on the characteristics and information provided for each relevant office building, a control group located within approx. 2 km was identified. As such, a total subsample of 31 buildings received a non-labelled or non-certified nearby building. Because of the complexity of the rating system, limited information, market size and geographic position of the properties, the link between rental prices of all properties to the hedonic characteristics was defined without clustering the data.

The findings point out that the green label is more than an intangible effect and impacts rental prices for office spaces. The results detect a considerable average net rent difference when compared to identical office buildings with a green certificate from one of the above-mentioned rating agencies. Tenants of green office buildings should be willing to pay approximately 14.5 percent, or up to 3 EUR more on average per sqm. Considering the operational costs, gross rent contracts for green certified buildings might come to a lower average, however, their rent will decrease by no more than 1 percent.

Net rent prices vary, thus the office buildings in the sample associate considerably with green certification, building class and heating demand, and moderately to their stories. The net rent is negatively related to heating demand. A green certification affects the rent positively and the added value exceeds the 20 percent (Model 1: Table 15), whereas the effect is larger for DGNB certified buildings by approximately 33 percent (Table 15: Model 2). A lower heating demand would favour the net rent high price and the same relationship consists for the building class of buildings. A reduction by 1 unit (log (kWh/sqm)) in heating demand would increase gross rent by more than 85 percent. The results show that for office buildings with less than 4 stories, gross rent might decrease by approximately 24 percent. However, the strong effect is absent for the rest of the hedonic characteristics. It is important to emphasize that age, building and office size, location, modes of transportation have little to no effect on net or gross rent of office buildings.

Finally, the results provide strong evidence for price differentials between green certified and non -green certified buildings. The logistic framework confirms also a price differential among rating agencies and building classes. In spite of the theoretical and feasible evidence of price differences between certified and non-certified buildings, that does not apply a priori to all the markets.

Considering the dynamic nature of real estate markets and in particular office real estate markets and its development, there is a clear scope for future research perspectives. In conclusion, additional research based on economic rentals and sale premiums of green buildings and/or investigating the price dynamics of energy efficient and sustainable office buildings in two different points in time, could amplify the findings of these research thesis and interrelate it to other sectors of the economy.

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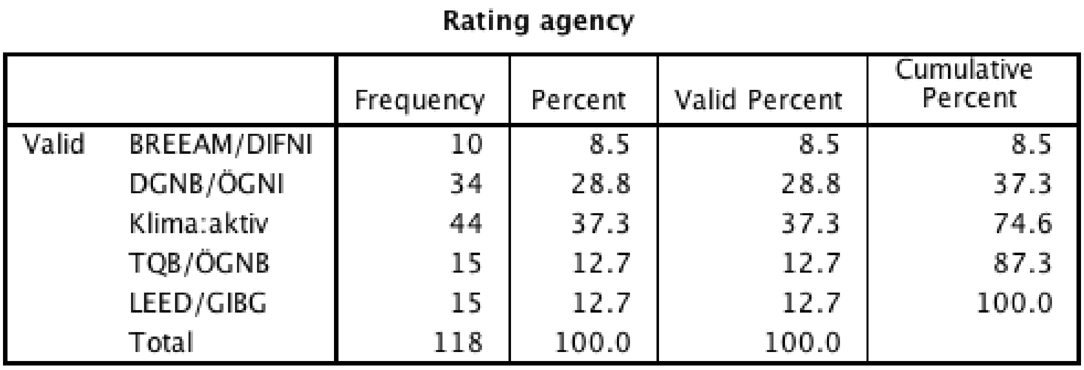
Appendix

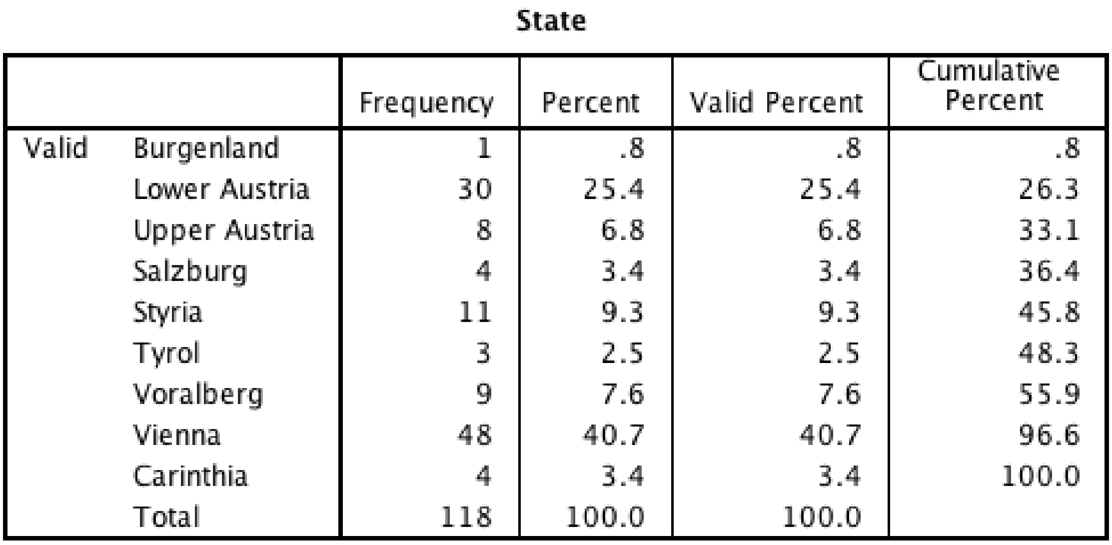
Figure 1



Rating agency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BREEAM/DIFNI	10	8.5	8.5	8.5
	DGNB/ÖGNI	34	28.8	28.8	37.3
	Klima:aktiv	44	37.3	37.3	74.6
	TQB/ÖGNB	15	12.7	12.7	87.3
	LEED/GIBG	15	12.7	12.7	100.0
	Total	118	100.0	100.0	

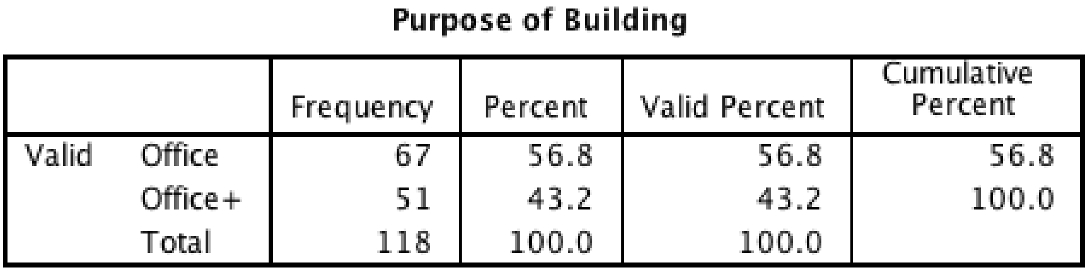
Figure 2



State

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Burgenland	1	.8	.8	.8
	Lower Austria	30	25.4	25.4	26.3
	Upper Austria	8	6.8	6.8	33.1
	Salzburg	4	3.4	3.4	36.4
	Styria	11	9.3	9.3	45.8
	Tyrol	3	2.5	2.5	48.3
	Voralberg	9	7.6	7.6	55.9
	Vienna	48	40.7	40.7	96.6
	Carinthia	4	3.4	3.4	100.0
	Total	118	100.0	100.0	

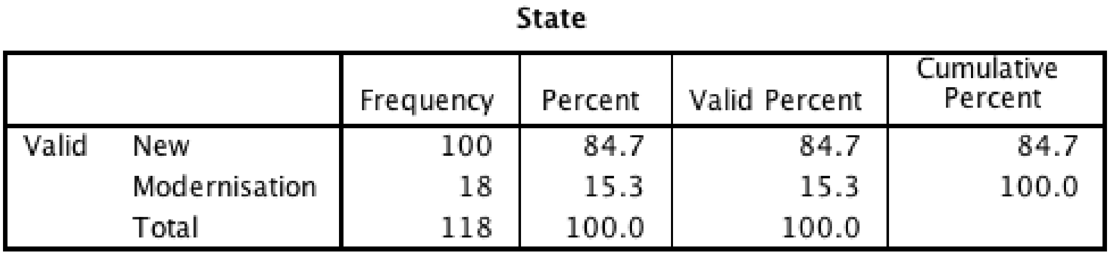
Figure 3



Purpose of Building

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Office	67	56.8	56.8	56.8
	Office+	51	43.2	43.2	100.0
	Total	118	100.0	100.0	

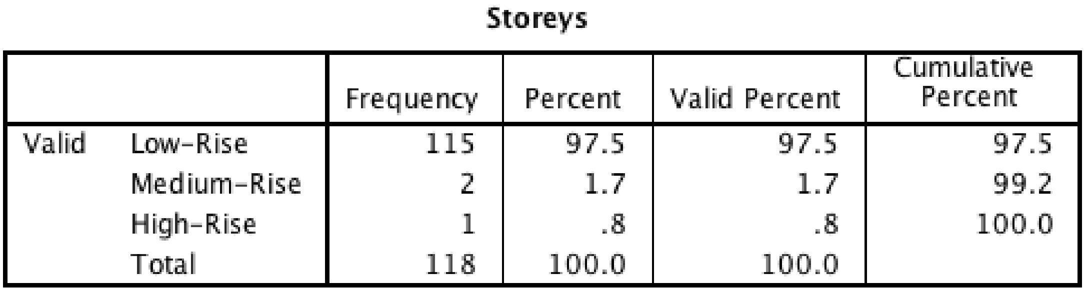
Figure 4



State

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	New	100	84.7	84.7	84.7
	Modernisation	18	15.3	15.3	100.0
	Total	118	100.0	100.0	

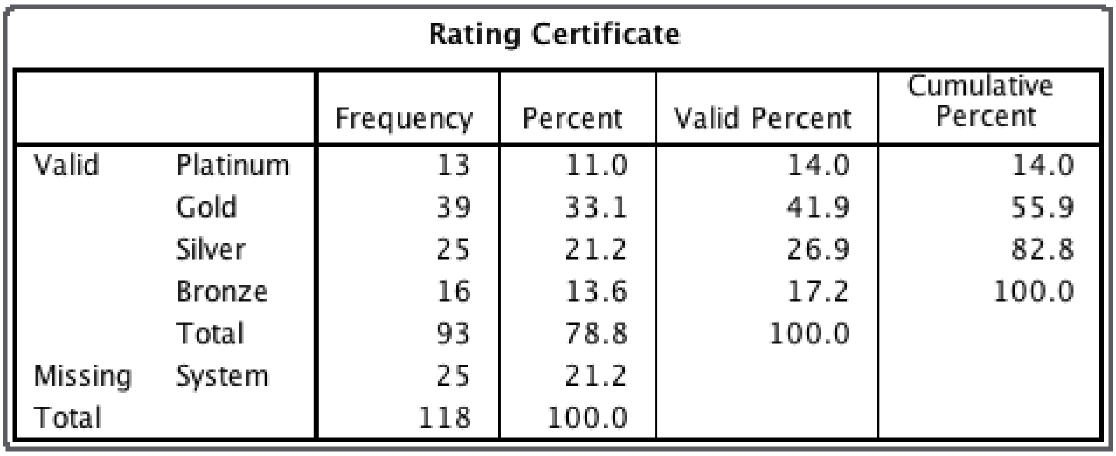
Figure 5



Storeys

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low-Rise	115	97.5	97.5	97.5
	Medium-Rise	2	1.7	1.7	99.2
	High-Rise	1	.8	.8	100.0
	Total	118	100.0	100.0	

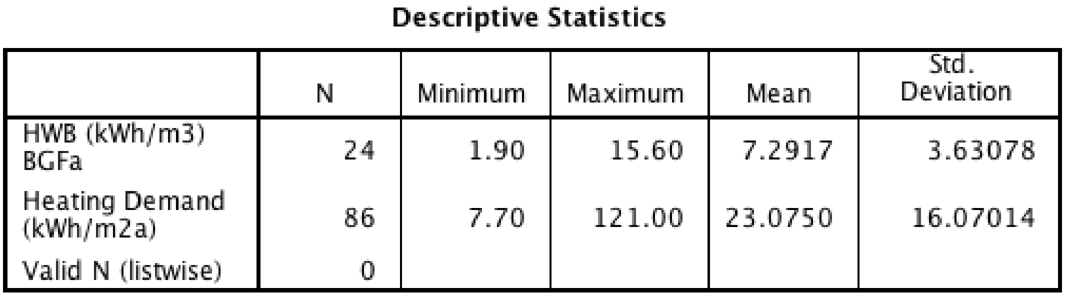
Figure 6



Rating Certificate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Platinum	13	11.0	14.0	14.0
	Gold	39	33.1	41.9	55.9
	Silver	25	21.2	26.9	82.8
	Bronze	16	13.6	17.2	100.0
	Total	93	78.8	100.0	
Missing	System	25	21.2		
Total		118	100.0		

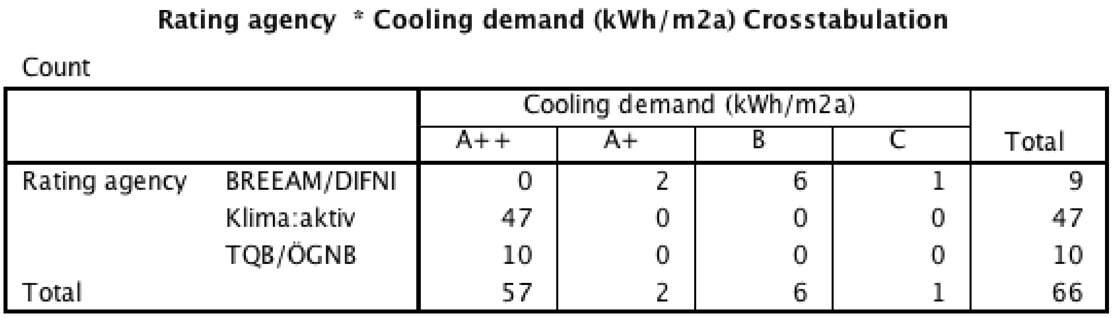
Figure 7



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
HWB (kWh/m3) BGFa	24	1.90	15.60	7.2917	3.63078
Heating Demand (kWh/m2a)	86	7.70	121.00	23.0750	16.07014
Valid N (listwise)	0				

Figure 8

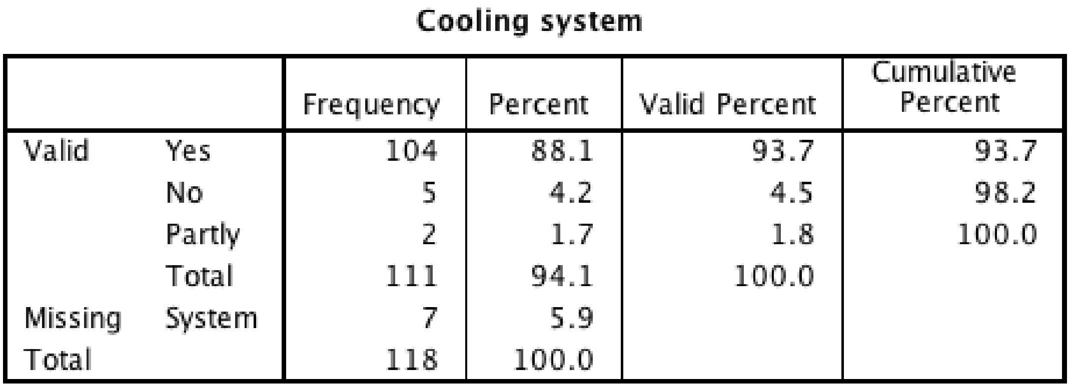


Rating agency * Cooling demand (kWh/m2a) Crosstabulation

Count

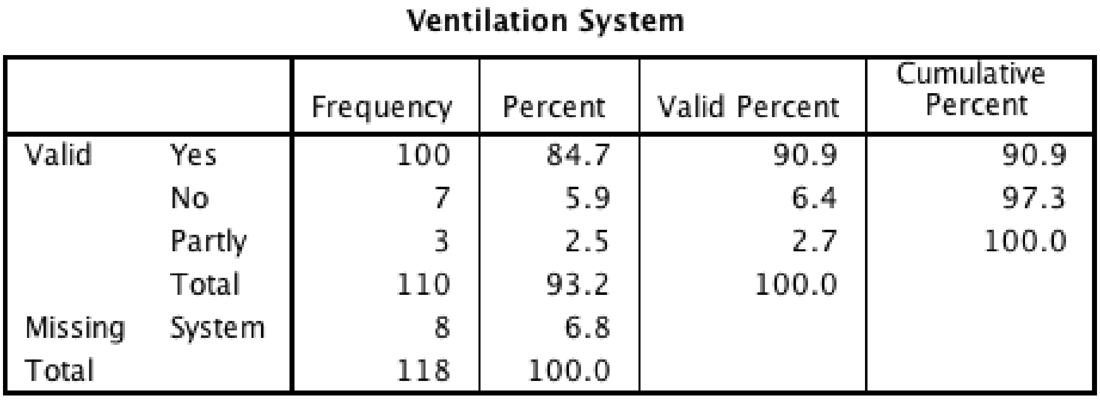
		Cooling demand (kWh/m2a)				Total
		A++	A+	B	C	
Rating agency	BREEAM/DIFNI	0	2	6	1	9
	Klima:aktiv	47	0	0	0	47
	TQB/ÖGNB	10	0	0	0	10
Total		57	2	6	1	66

Figure 9



Cooling system

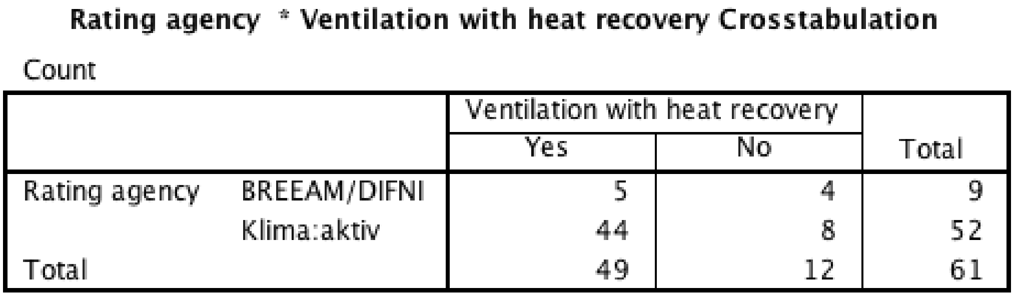
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	104	88.1	93.7	93.7
	No	5	4.2	4.5	98.2
	Partly	2	1.7	1.8	100.0
	Total	111	94.1	100.0	
Missing	System	7	5.9		
Total		118	100.0		



Ventilation System

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	100	84.7	90.9	90.9
	No	7	5.9	6.4	97.3
	Partly	3	2.5	2.7	100.0
	Total	110	93.2	100.0	
Missing	System	8	6.8		
Total		118	100.0		

Figure 10: Descriptive statistic



Rating agency * Ventilation with heat recovery Crosstabulation

Count

		Ventilation with heat recovery		Total
		Yes	No	
Rating agency	BREEAM/DIFNI	5	4	9
	Klima:aktiv	44	8	52
Total		49	12	61