UNIVERSITY OF LJUBLJANA
FACULTY OF ECONOMICS

MASTER'S THESIS

ENERGY PERFORMANCE CERTIFICATES IN RESIDENTIAL BUILDINGS AND THEIR IMPACT ON MARKET PRICES AND RENTS IN SLOVENIA

Ljubljana, July 2018

ŽIGA DROFENIK

AUTHORSHIP STATEMENT

The undersigned Žiga Drofenik, a student at the University of Ljubljana, Faculty of Economics, (hereafter: FELU), author of this written final work of studies with the title Energy Performance Certificates in Residential Buildings and their Impact on Market Prices and Rents in Slovenia, prepared under supervision of Associate Professor Andreja Cirman, PhD,

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LIST OF ABBREVATIONS

BREEAM	Building Research Establishment Environmental Assessment Method
EC	European Commission
EE	Energy Efficiency
EEC	European Economic Community
EPBD	Energy Performance of Buildings Directive
EPBD	the Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
ETN	“Evidenca trga nepremičnin” Real estate market register
EU	European Union
EZ-1	“Energetski zakon” Energy Act
GURS	“Geodetska uprava RS” The surveying and mapping authority of the Republic of Slovenia
HQE	High Environmental Quality
HVAC	Heating, ventilating, and air conditioning
ID	Identification number
LEED	Leadership in Energy and Environmental Design
OECD	Organization for Economic Cooperation and Development
OG	Official Gazette
PURES	“Pravilnik o učinkoviti rabi energije v stavbah” Rules on efficient use of energy in buildings with a technical guideline
RICS	Royal Institute of Chartered Surveyors
RS	Republic of Slovenia
SURS	“Statisticni urad RS” Republic of Slovenia statistical office
U.S.	United States
VIF	Variance Inflation Factors
ZVN	“Zbirka vrednosti nepremičnin” Real estate value collection
ZVO-1	“Zakon o varstvu okolja” Environmental protection Act

INTRODUCTION

Environmental sustainability has become a topical issue, particularly in the real estate and buildings sector. As per reports, 40% of total energy consumed and 40% of raw materials consumed are associated with the building sector (Royal Institute of Chartered Surveyors, 2005). On the whole, approximately 30% of the global emission of greenhouse gases comes from buildings and related activities of construction. Therefore, real estate operation and design play a significant role in conservation of energy, specifically in advanced societies. Consciousness towards this fact is increasing. Emphasis is now being laid on various systems of 'green rating' for buildings (Eichholtz, Kok, & Quigley, 2009). Such systems are initiated by the industry as well as governments, which is an evidence of this development. Ratings are given for assessing energy consumption of buildings. These rating systems provide the tenants, buyers and building owners with a strong yardstick that measures the sustainability of buildings and also their energy consumption. However, these rating systems, so far, have been used in a limited manner and diffusion of rating systems on the global level is comparatively slow. Furthermore, institutional investors as well as real estate developers are uncertain about implementing investments in environment. The reason behind this can be attributed to the fact that there is still limited amount of evidence about the economic rationale for sustainable development of buildings and property.

European Union is imposing member states to ensure that all new buildings shall be nearly zero energy buildings by the end of 2020. Nearly zero energy buildings are buildings with very high-energy performance, and the majority of energy requirements should be covered by renewable energy sources. Apart from new buildings, it is encouraged for existing buildings to undertake energy efficient renovations and meet the minimum energy performance requirements set by the member states in Council Directive 2010/31/EU. Nonetheless, it is difficult to measure the progress of energy efficiency. To address the issue Council Directive 2012/27/EU suggests policy measures recommendations for the member states to achieve higher energy efficiency through taxation, financial incentives, regulations, standardization, education, and labelling.

Labelling scheme is considered as an enabler. It can be referred as an intervention of policy that leads to a certain outcome although it gives no guarantee about such an outcome. Implementation of the policy so framed must be effective to ensure that the role for which it is being implemented is fulfilled. For example, labels which are put on various products must be clearly visible to the general public. In addition to this, it must be ensured that the energy performance level of the product as depicted in the label must be precise. Various opportunities are available in which the effectiveness of labelling scheme can be enhanced so that energy efficiency can easily be achieved (Rosen, 2015).

Labelling in energy performance of buildings directive was introduced as an energy performance certificate of buildings as in Council Directive 2010/31/EU. The energy performance certificates (from here on EPC) include energy performance of a building and some reference values, for example, minimum energy performance requirements. Consumers are facilitated to compare and evaluate the energy performance using the EPC's. For making investments in energy efficiency more attractive, it is essential to provide the customers (building owners, buyers and tenants), with relevant and reliable information. Such information must be made available to them at affordable costs and an appropriate time to increase the investments in energy efficiency by them.

Thus, my thesis aims to provide a systematic evaluation of the influence of energy efficient residential building practices (in Slovenia) on market prices and rents. My master thesis focuses upon residential property - apartments. Efficiency is observed from the viewpoint of energy saved in design and construction of a residential building. Incentives introduced by the European Union are thriving to achieve a better energy performance of buildings and are directly correlated with lower primary energy consumption. Financial benefits derived from energy saving incentives are measurable but most of the studies concentrate upon environmental outcomes rather than financial outcomes. Furthermore, relation between energy performance of buildings which are conveyed by EPC's and the values proposed by such certificates is explored. In other words, this study explores whether the EPC’s labels of residential buildings energy performance has an impact on the rent or purchase price of residential buildings (ceteris paribus) at the time when the transaction occurs.

The major concern that is being addressed through this study is the impact of energy efficiency improvement on the apartments’ rent and purchase price. Residential buildings and properties that are built with better energy efficient equipment and materials are more expensive to construct than traditional residential buildings. However, whether such additional investment leads to better returns to the investors or not is an interesting topic to research upon. Similar is the case with renovation of already existing properties and buildings. From view point of an investor, it is essential to identify whether the buyer or tenant is prepared to pay a premium amount for those residential buildings and properties that are performing better on the basis of energy efficiency or not, ignoring the costs of constructing an energy efficient residential building. In other words, this type of information encourages people to invest in those residential properties, which are energy efficient.

The aim of this study is to find a relationship between the rental and market value of a residential property and its energy performance as identified by energy performance certificates. Energy performance certificate serves as an indicator for building owners, occupiers and real estate actors to assess the energy performance of a building. Study shows the extent to which the energy performance certificates affect the real estate market prices and rents and awareness among the people of Slovenia with respect to the energy efficient buildings and their benefits. Issues related to energy efficiency in the real estate sector are usually confounded with capital budgeting decisions, wherein different choices of increasing the returns of investors are enumerated. In relation to this, study is focusing on the real estate markets premiums received from investments in more energy efficient residential buildings. The goal of this study is to develop two linear regression models (one for transaction prices and the other for rents) that will help the potential investor to predict financial outcomes of capital investments in residential green buildings. Models are predicting financial outcomes for renting out or selling the property on the Slovenian real estate market based on historic transaction data.

In order to reach the set goal, the first step is to construct a review of domestic and foreign literature. Its purpose is to search for existing evidence on finding a relationship between the price or rent of a property and energy performance certificates.

Secondly, an empirical analysis is conducted. In the analysis, the assumptions are tested on the following hypothesis, one for the market of sold residential properties (H1) and the other for the market of rented residential properties (H2).

Hypothesis 1 - H_1: Energy efficient properties will achieve a higher market value compared to less efficient residential properties.

Hypothesis 2 - H_2: Rental value of energy efficient properties is higher, compared to less efficient residential properties.

The analysis is done using a quantitative research approach. For the research, two different data sets are created. The first data set contains information about the transactions of sold residential properties, and the second one contains information of rented residential properties in a given period of time after the energy performance certification was made mandatory in Slovenia. Data sets contain information collected from publicly accessible databases such as Trgoskop 2 ™, spatial cadastre database, energy performance certificates, and value zones established by the Slovenian real estate value collection. Every transaction includes data about the properties size, age, price, location, energy performance label, and date of transaction.

Further on a statistical analysis is conducted for the individual data sets containing multiple variables for every transaction. Descriptive statistics, correlations between variables, and hedonic regressions are performed on the datasets. The hedonic regression will confirm or reject the hypothesis H_1 and H_2. Possible constraints are with data collection, it is expected that some labels of EPC will be less represented than others, and not every value zone will have all the types of energy efficient properties. The EPC method is questionable if it is a real representation of a buildings energy performance, and if the methods used to assess a buildings performance are reliable. There is a risk of distorted contractual prices of properties that are reported in order to achieve a lower tax base.

1 ENERGY EFFICIENCY

1.1 Definition

There are several definitions of energy efficiency that can be found in the literature. The most scientific and strict definition is provided by the European Parliament and Council, they define energy efficiency as the ratio of output of performance, service, goods or energy, to input of energy as in Council Directive 2012/27/EU.

Their definition is predominantly characterized by engineering science. Energy efficiency can be defined by efficient factors or so called utilization ratios (input/output), the ratio between generated end-use of energy in proportion to primary energy. These ratios can be found while describing efficiency of power plants, solar systems, heating systems, refineries, etc. (Irrek, Thomas, Bohler, & Spitzner, 2008).

The United States department of energy explains energy efficiency in a less complex way. The explain it as an example of using technology that requires less energy to perform the same function. They backed up their definition by using the example of two light bulbs, one being the fluorescent and the other incandescent. The fluorescent bulb will use less energy as the fluorescent bulb, while providing the same amount of light (Energy Information Administration, 2017).

In terms of housing, the apartment that uses less energy to achieve the same level of comfort (air temperature, lighting, etc.) is considered more efficient compared to the other. Irrek et al. (2008) refers to this energy as end-use energy efficiency, energy is used for the satisfaction of personal needs such as physical benefit of room temperature.

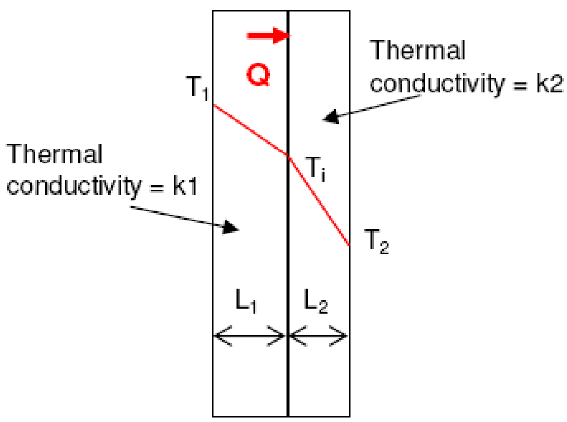
1.2 Improving buildings energy efficiency

When it comes to improving a buildings energy efficiency that can be achieved with three primary ways:

- By improving design and construction techniques that reduce lighting, cooling, ventilating, and heating.
- By upgrading the existing buildings and replacing the obsolete energy-using equipment.
- Through active managing of energy usage of a building

Design improvement and construction techniques that improve energy efficiency can be done while planning and constructing new developments. The best opportunity for reduced heating, lightning, and cooling loads is with well-planned and well-constructed new buildings. Planning in accordance with the Building Energy Efficiency Codes will provide the most effective way to develop an energy efficient building. Energy efficiency code provides a minimum energy efficiency requirement of a building. It includes the thermal performance of a building's "envelope" and standards of its internal equipment (Liu, 2014). Building's envelope presents the outer shell of the building, the roof, the outer walls, and the foundation. Its purpose is to protect the building from the exterior elements, to preserve energy, and to provide structural stability. In form of energy preservation, different material combinations of wall cross-sections will perform differently. The measure of energy preservation in a wall cross-section is heat transmission coefficient; heat transfer through a two-layered wall can be seen bellow in figure 1.

Figure 1: Heat transmission in a wall section.



Source: Heat transfer (N.D.) Enggcyclopedia.

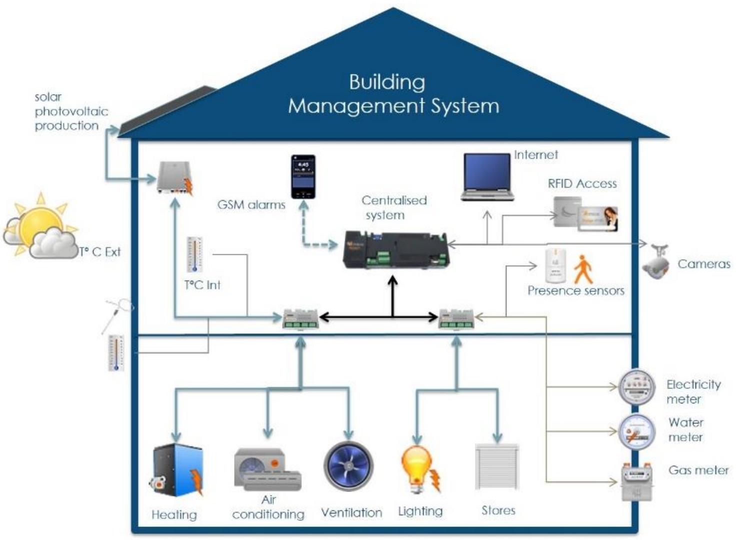
The second way is to retrofit existing buildings. Existing buildings need refurbishments and replacement of existing energy consuming equipment. The challenge is how to motivate building owners to improve the energy efficiency of their building. Solutions to address this issue is using the incentives that result in investments in energy efficient upgrades of buildings and/or requiring energy efficiency upgrades. In order to make this a reality, an enabling environment, effective financing, and delivery mechanisms must take place (Liu, 2014).

There are multiple approaches to retrofit an existing building. Formerly the focus was on technical improvements such as the installation of renewable energy systems, e.g. solar systems (Chan, Riffat, & Zhu, 2010). Another key element of retrofitting is the buildings envelope (Asadi, da Silva, Antunes, & Dias, 2012). Improving efficiency of a buildings heating, ventilating, and air conditioning system (from now on HVAC system) is significant to improve a buildings energy efficiency (Jaffal, Ouldboukhitine, & Belarbi 2012).

Despite the approach used to retrofit a building, the most important factor in consideration is economic viability of a used approach. The initial step in the process of choosing the right retrofitting approach is conducting an economic analysis with the emphasis on the payback period (Amstalden, Kost,Nathani, & Imboden, 2007).

The low-cost option to tackle the improvement of EE in buildings is establishing and maintaining energy management systems. This option is more suitable for public or commercial buildings, but could as well be used in residential buildings. Effective energy management systems monitor and control energy use of a building, and eliminates all the wastage of energy where it is possible (Liu, 2014). Example of an energy management system scheme in a building can be seen in figure 2. The modern building management system, seen in figure 2 initially uses a smart system central that acts as a home's brain and is managing homes features such as heating, cooling, access control, metering, shades, lighting, etc. To control the features, the central uses feedback that comes from sensors that measure the environments temperature, humidity, light, pressure, etc., and based on the feedback it will make smart management choices that will optimize the energy consumption of a home.

Figure 2: Energy management system



Source: Fermaud M.,(2013) Building Energy Management

1.3 Energy efficiency gap

Although we already know several economical ways to improve the energy efficiency of a home, there still exists an issue of encouraging end users to invest in a more energy efficient home or equipment. The difference between existing investment and potential investment in energy efficiency that is still economical is defined as the energy efficiency gap (Brown, 2001). While Jaffe and Stavins (1994), describe the energy efficiency gap as the difference between current or expected future energy use, and the optimal current or future energy use. In the European Union (from here on EU), it is estimated that the gap presents 30% of potential energy savings of the Organizations for Economic Cooperation and Development (from here on OECD) countries (Weber, 1997). In other words OECD countries waste 30% of energy that could be saved with existing technology. Most of the potential energy savings lie within the building sector (Royal Institute of Chartered Surveyors, 2005). In this study, we focus on the economical side of the energy efficiency gap and search for barriers that halt the investments, and what might drive the investments in energy efficiency.

The energy efficiency gap is a widely researched issue, researchers are trying to pin point the barriers and drivers in order to close the existing gap. Researchers have identified two main types of barriers that halt the investments in energy efficiency. The first type of barriers are the structural barriers, and the second type are the so-called behavioral barriers (Brown, 2001; Hirst and Brown, 1990; Shrogen and Taylor, 2008; Weber, 1997).

Structural barriers arise from behaviors of institutions and organizations, and are not influenced by the end-user. Barriers arise when in theory perfect markets fail to operate in an intended way. In theory, failures divide into market failures and non-market failures. Failures associated to the market are often linked to imperfect information, external factors, failures in innovation markets, and imperfect capital markets. Non-market failures are linked to risk aversion and barriers that arise from within organizations and institutions. Most of market and non-market failures link to the actions of individuals that act in their own interest, no matter if it is an end-user or an individual acting as private entity.

Decision-making individuals are inclined to the behavioral barriers (Häckel, Pfosser, Tränkler, 2017). Barriers on substantial increase of market value by rental apartments, which were energy efficient, were foreseen by Sanstad & Howarth (1994). They explain that unlike privately owned residential housing the rate of increase of market value for rented properties would be hindered by presence of market imperfections. There should be a great concern to the policy makers not only on ways in which energy efficiency would be achieved in these residential buildings but should also consider “imperfect information and bounded rationality” of consumers of these a residential buildings. They attack the procedure to ensure energy efficiency of buildings by stating that they mainly focused on the engineering part of ensuring efficiency and forgot on the economic value of the aspect which is the main driver of growth of this real estate sector.

The behavioral barriers derive from individuals and their different values and attitudes towards energy preservation. Barriers can occur based on the individual's lack of interest towards energy consumption, inability to act on the issues, or individual's lack of knowledge on the possible actions that result in reduced energy consumption. Energy consumption differs on individual's lifestyle and social norms (Weber, 1997).

If the population of possible tenants is not risk aversive most will not relate any necessity for valuing the energy efficient highly that those which are not energy efficient (Farsi, 2010). European Commission blames the insignificant increase in market value of energy efficient residential housing to lack of information on tenants. The organization insists that most of the tenants make the decision on which apartments to rent without knowledge of energy efficiencies of these rentals. Most of them find out when it is too late to stir any significant change in the market values on rentals which are energy efficient. They advocate for the provision of this information so that market value on energy efficient rentals can be achieved prior to renting the apartments (European Commission, 2012).

Ideally, attitudes of individuals that take energy preservation in to consideration divide in to efficiency and curtailment behaviors (Barr, Gilg, & Ford, 2005). Curtailment type of behavior focuses on everyday actions that reduce the energy consumption. This type of behavior includes actions like tinkering with thermostat settings, using the washer only when it is full, reduce heating on unused rooms, turn the lights off in unused rooms, close the windows while heating or cooling a room, use the clothes rack to dry laundry instead of using dryers. These everyday actions are usually the result of habits and are a part of an individual's lifestyle (Black, Sterm, Elworth, 1985). Another element of curtailment type of behavior is the frequency of maintenance on existing integrated systems, such as boilers, heaters, washing machines. These kind of actions prolong the use of such fitments and keep their energy consumption at an optimal level (Van Raaij & Verhallen, 1983). This kind of behavior is encouraged since it benefits the entire population, and it is encouraged at an early stage of education in order to achieve the repetitive behavior that develops into a habit and becomes a part of an individual's lifestyle.

Efficiency or "purchase-related behavior" as Van Raajj & Varhallen (1983) named the type of a behavior that focuses on long term benefits of investing in a more energy efficient products. This kind of behavior requires a capital investment and is not solely on the effort of the individual. This type is more diverse compared to the curtailment type, here individuals differ on the size of financial investment or other resources. Efficiency behavior type invests in double or triple glazed windows, sufficient thermal insulation, energy efficient HVAC systems, energy efficient appliances, low energy consuming lighting.

Although it is hard to assign the investment in energy efficient product to the energy saving behavior, the purchasing decision could be based on other features such as appearance.

The behavioral barriers arise when an individual fails to act in a rational way even if in theory they are perfectly informed (Kahneman & Tversky, 1979). Masini & Menichetti (2012) have provided evidence that individuals fail to invest in energy efficient products due to their limited experience and due to risk averting personalities, they will more likely invest in a more conventional and tested solutions, than in a technology that is superior in terms of energy efficiency. This kind of barriers halt the potential energy savings. Untested technologies or methods compared to older that have been proven can be seen as risks by the decision makers. They are most likely to go for a proven technology or method even though there are available cost-effective alternatives (Pinkse & Dommisse, 2009).

In reality, the information on energy efficiency technology is not present enough, and is causing end-users not to change their behaviors (Rogers, 2003). In study performed in the UK they were searching for barriers that explain absence of market demand for sustainable properties. They have identified that one of the major barriers of zero-energy buildings adaptation is the lack of information on costs of zero-energy homes. (Osmani & O'Reilly, 2009). Consequently, supply of zero-energy housing is affected. Reason behind it is that the manufacturers and builders do not benefit from an energy efficient housing directly, unless there is an increased market demand for it (Persson & Grönkvist, 2015). In order to drive the investments in energy efficiency and close the energy efficiency gap it is required for governments to have an active role in the decision making process. They have to establish an enabling environment for energy efficient investments (Persson & Grönkvist, 2015).

In line with Sanstad and Howarth argument Popescu, Bienert, Schützenhofer, and Boazu (2012) argue that society, government and citizens are interested in energy efficiency residential housing. However, there is a need for the government and policy makers to match the cost of achieving energy efficiency and the cost of potential savings so that the financial benefit can drive the change to achieving more energy efficient buildings.

1.4 Legislation

As discussed before, to increase the energy efficiency of buildings, an enabling environment, effective financing and delivery mechanisms must take place. In this subchapter, the environment of European Union is presented; the emphasis is on the energy efficiency of buildings.

In 2007, the European Union set a goal to reduce the EU's predicted energy consumption by 20% by the year of 2020. The goals were set in 2007 and in 2009 enacted in legislation. They state that lowering the projected consumption by 20% is equivalent to closing approximately

400 power plants. Committed to this goal, they have decided that the most cost-effective way of reducing energy consumption, while the economic activity remains maintained, is through energy efficiency. As set in the objectives of “Energy Policy for Europe”, this is also the most immediate way to achieve security of supply, competitiveness, and sustainability. The EU leaders set a so called “20-20-20” goal, that not only aims at reduced energy consumption but also aims at 20% lower greenhouse gas emissions and 20% increase in renewable energy. The legislation on energy efficiency has been designed to improve the energy efficiency in sectors that are the most energy consuming. These sectors are:

- industry;
- transport;
- households and services.

In 2006 the Households and services were consuming 41% of EU’s final energy consumption, while the industry was at 28%, and transport was at 31%. The saving potential of residential and commercial buildings is significant: 30% less energy used within the sector by 2020 is possible (European Commission, 2008).

In order to achieve the goal, the European Union has presented the 2020 climate & energy package. To meet the targets EU is taking action in different areas, such as (European Commission, 2017):

- renewable energy;
- emissions trading system;
- national emission reduction targets;
- innovation and financing;
- energy efficiency.

The EU passed several legal acts that tackle the energy efficiency in buildings issue. The most important acts among these acts and should be given more focus in this study are:

- Directive 2009/125/EC Eco-design directive;
- Directive 2010/31/EU on the energy performance of buildings;
- Directive 2012/27/EU on energy efficiency.

Slovenia answered the directives listed above with the adaptation of the Energy Act (EZ-1) OG. I. RS., no. 17/14.

Directive 2009/125/EC on eco-design of products sets the framework of minimum requirements for energy related products, that the products have to meet before they can be used or sold in the EU. All the energy-consuming products that are within the directives framework, bear the CE label, and can be sold in the EU. While the eco-design directive is focusing on energy related products, which are usually integrated in the form of cooling or heating systems, or any other installed energy consuming products of buildings. The directive 2010/31/EU on energy performance of buildings is concentrating on a building as a whole.

Directive 2010/31/EU on the energy performance of buildings (from now on EPBD) amended the 2009/125/EC directive in order to extend the promotion of energy efficiency. In consideration with cost-effectiveness, climate zone characteristics, and indoor climate requirements, it encourages improvement of energy performance of buildings in the European Union (The European parliament and the council of the European Union, 2010).
The directive sets minimum requirements as regards to:

- the application of minimum requirements to the energy performance of new buildings and new building units;
- the common general framework for a methodology for calculating, the integrated energy performance of buildings and building units;
- the application of minimum requirements to the energy performance of:
  - existing buildings, building units, and building elements that are subject to major retrofitting's;
  - technical building systems at the point of installation, replacement or upgrading; and
  - elements that from part of the building envelope have a significant impact on the energy performance of the buildings envelope when they are renovated or replaced.
- strategies that will increase the number of so called zero-energy buildings;
- energy certification of buildings or building units;
- supervision of heating and cooling systems in buildings; and
- independent supervision systems for energy performance certificates and inspection reports (the European parliament and the council of the European Union, 2010).

Directive 2012/27/EU on energy efficiency introduced a common framework of energy efficiency measures for the member states in order to ensure that the 2020 goal is met, and to enable energy efficiency improvements beyond that date. Regulations were designed to take on the barriers in the energy market and to overcome shortcomings that are disrupting efficiency in the supply and use of energy. The rules are set in order to establish minimum energy efficiency targets for 2020, which all the member states have to achieve as in European Commission Directive 2012/27/EU.

With this directive, the EU parliament and the council imposed the member states to establish a long-term strategy for investments in the renovation of the overall stock of residential and commercial buildings, including both private and public sector. The strategy had to include the following elements:

- an overview of the national building stock;
- identification of economically feasible approaches to renovations relevant to building type and climate zone;
- measures and policies to encourage cost-effective deep retrofitting of buildings;
- credible energy saving estimate that is expected, included with wider benefits of savings;
- future oriented perspective to steer investment decisions of individuals, financial institutions, and the construction industry.

However, most importantly the directive on energy efficiency suggests the member states with the following policy measures suggestions as in European Commission Directive 2012/27/EU:

- taxes that result in lower energy consumption by the end user, taxes should be based on energy or carbon dioxide measures;
- financing programs and mechanisms or fiscal incentives that result in implementing of energy efficient technology or methods, and consequently reduce end-use energy consumption;
- regulations or voluntary agreements that result in implementing energy efficient technology or methods, and consequently reduce end-use energy consumption;
- norms and standards that result in improved energy efficiency of services and products;
- labelling schemes;
- education and training, along with energy advisory programs, that result in implementing energy efficient technology or methods, and consequently reduce end-use energy consumption.

Energy Act (EZ-1) states its sole purpose to ensure competitive, safe, reliable, and affordable supply of energy and energy services in regard with sustainable development. The act was passed based on directives issued by the European Union, Directives 2012/27/EU and EPBD included. The goals set for this Act are as follows (EZ-1):

- reliable energy supply;
- ensuring effective competition on the energy market;
- effective energy transformation;
- reduced energy use;
- efficient use of energy;
- energy efficiency;
- increased production and use of renewable energy sources;
- converting to low carbon society using low carbon energy technologies;
- ensuring energy services;
- ensuring social cohesiveness;

- end-use energy consumer protection;
- ensuring effective supervision of the acts implementation.

1.5 Policy measures

As stated before, the 2012/27/EU directive on energy efficiency introduced a common framework of energy efficiency measures for the member states in order to achieve the 2020 goal. In this paragraph policy measures are presented more in to detail.
The sole purpose and potential of green policy measures is reducing the CO_2 emissions. Lowering the CO_2 emissions will result in reduced damage to the environment and with the right measures and instruments it should be achieved with a minimum economic cost.
The EU recommends member states to use the following policy measures: taxation, financial incentives, regulations, standardization, labelling, and education.

1.5.1 Taxation

The first recommended policy to tackle the sustainable environment issue is the taxation of entities with environmentally harmful activities. The environmental tax reform was carried out and was intended to transfer the burden of taxation on the shoulders of environmentally harmful activities, e.g. the activities that use unsustainable resources or are polluting the environment (European Environment Agency, 2005). The EU have focused their environmental taxation and charges on transport, emissions, energy, and mineral oil. On the other hand, the motivation for a green future comes with the help of subsidies and tax credits. Tax credits are motivating the end users to upgrade or invest in a more energy efficient technology in various areas. The tax credits and subsidies are focusing on buildings, transport, and households (International Labour Organization, 2011).

EU member states are widely using special tax provisions that increase the energy efficiency and motivate the end-users to invest in environmentally friendly house equipment, buildings, vehicles and technical equipment, e.g. heating and cooling systems. The measures used in this toolset are tax deductions, grants, tax credits, tax exemptions (International Labour Organization, 2011).

In Slovenia based on the Environmental Protection Act (ZVO-1), OG. I. SI. no. 41/04 environmental taxes were implemented. The burden of taxation was shifted on the shoulders of entities that are causing the pollution of the environment. The tax is based on the type, quantity and characteristics of the pollutant, waste or harmful substances. The following duties are currently being charged in Slovenia on the pollution of (ZVO-1):

- air with carbon dioxide;
- environment with usage of mineral oils and other fluids;

- environment with increasing number of obsolete vehicles;
- environment with packaging waste;
- environment with electronic waste;
- environment with used rubber tires;
- environment with waste water;
- environment with waste disposal.

The taxpayer's burden can be lowered, exempted or even returned if the polluter signs an agreement with the Republic of Slovenia, that result in lower negative impact on the environment or if the polluter is respecting the international environmental protection agreement that the state has adapted (ZVO-1).

1.5.2 Financial incentives

The other side of the coin that is more pleasing to the end user, and probably more efficient in the "long-run", are the financial incentives. The financial incentives are intended to persuade the consumer to consider choosing a greener product or service. This is especially important and has the most potential in lowering the emission if it is used in the building sector. The average European household do not fully understand or take in consideration the future discounted cost of fuels when buying durable goods. That is the reasoning behind the financial incentives and other instruments that steer the decision making in the time of the investment (Grigolon, Reynaert, & Verboven, 2015).

Financial incentives are key drivers of investment in the housing market. The EU's Directive on Energy Performance of Buildings imposed the member states to implement financial and other instruments to tackle the energy performance of buildings and to achieve the transition to nearly zero-energy buildings. The EU is strictly monitoring the effects of the member states financial incentives and other instruments, and is making sure that the "20-20-20" goal is met as in European Commission Directive 2010/31/EU.

The Republic of Slovenia in its Energy Act (EZ-1) developed a financial incentive program delivered by Eko Sklad institution. Eko Sklad prepares and implements programs that improve the energy efficiency on a national level. It is funded through a financial scheme that imposes a contribution on energy sources used for heating such as district heating, electrical energy, and fossil fuels. The contribution is called "energy efficiency contribution" and is paid by the end-user (EZ-1).

1.5.3 Regulations

Slovenia's Energy Act was passed by the Parliament in 2014 and enabled the structuring and enforcement of minimum energy performance levels regulations for energy-using products, included the labelling of energy-using products (EZ-1).
The Slovenia’s Energy Act transpositioned and implemented EU’s regulations. To set an example, the directive imposed the member states to annually renovate 3% of total floor area that is heated or cooled and is owned by its central government. The renovations have to meet at least the minimum energy performance requirements that they have set in their strategy as in European Commission Directive 2012/27/EU.

One of the most relevant regulations for this research are the so-called “Rules on efficient use of energy in buildings with a technical guideline” (Pravilnik o učinkoviti rabi energije v stavbah – Uradni list, from here on – PURES). PURES sets technical requirements that have to be met in order to achieve efficient use of energy in buildings, and is used for new developments, retrofitting’s of existing buildings or parts of existing buildings.. The requirements are set for the following areas (PURES, 2010):

- thermal insulation of the buildings envelope;
- heating;
- cooling;
- ventilation;
- combinations of heating, cooling and ventilation;
- hot water preparation;
- lighting;
- own renewable energy systems that drive energy-using products of the building;
- methodology used to calculate energy performance of buildings.

1.5.4 Standardization

The main mechanism for displaying and measuring improvements in energy efficiency is standardization. The buildings energy performance is calculated based on a methodology, which differentiates from country to country, on a regional or national level. The methodology takes in consideration the annual energy performance of a building, and it takes into consideration existing European or international standards. The use of European and international standards enables for a general common framework for a methodology that result in improved energy performance. Another aspect of standardization is to develop a common labeling scheme that also results in improved energy performance and to improve the awareness of the consumers as in European Commission Directive 2012/27/EU.

1.5.5 Labeling

For over 40 years, energy performance standards and labeling programs are used for appliances. They are an important policy tool that regulates energy efficiency of energy using products. They have been proven as one of the most successful drivers that improve energy efficiency of products. The EU's labeling program originates from the 1990's, when the directive 1992/75/EEC was passed. The 1992/75/EEC directive made comparative energy performance labeling mandatory for refrigerators, dryers, water heaters, ovens, lighting, air-conditioning, and washing machines (Schmitz, Chad, 2013).

This directive provides indication by putting labels on consumption of energy by the household appliances and equipment's. This approach, at present, covers not just professional, domestic and lightening appliances and equipment's but also covers buildings and cars, although through different directives. In the similar manner, various debates are undertaken in order to find out the whether these schemes must be implemented or not. If these schemes are agreed to be implemented, then debates on the manner of implementation are also undertaken. However, some variations are identified which usually depend upon the product groups and the policy of the community which is involved (Mudgal, Lyons, & Cohen, 2013).

Labelling scheme is considered as an enabler. It can be referred as an intervention of policy that leads to a certain outcome although it gives no guarantee about such an outcome. Implementation of the policy so framed must be effective to ensure that the role for which it is being implemented is fulfilled. For example, labels which are put on various products must be clearly visible to the general public. In addition to this, it must be ensured that the energy performance level of the product as depicted in the label must be precise. Various opportunities are available in which the effectiveness of labelling scheme can be enhanced so that energy efficiency can easily be achieved (Rosen, 2015).

Schemes related to environmental and energy labelling helps in enhancing the visibility of energy performance. Since, energy performance is a market dimension which is not clearly visible to the general public, labelling them on the products helps making people aware about this particular dimension. However, absence of information with respect to the energy performance of buildings and real estate properties from the sellers to the purchasers and tenants, value added of a building which is well-insulated might not be included in the rental value or the transaction value (as the case may be). This result in discouragement of the owners of properties and buildings to make such investments which enhances the energy efficiency of their properties, specifically during the time in which they are planning to sell their property or give it on rent in the short term (Mudgal, Lyons, & Cohen, 2013).

As per Lancaster (1971), all the products such as appliances and buildings have a huge bundle of different features. Some features might be more clearly and completely visible than the others. Labelling schemes for energy efficiency are required to provide the buyers basic conditions that must be considered while evaluating the product on energy dimension. If such labelling schemes are absent, then it becomes difficult for the buyers of the products to compare them on the basis of energy performance and select the most energy efficient product. In absence of such labels, consumer is required to have greater determination along with appropriate technical knowledge. Only when the buyers or tenants regard energy efficiency as a salient attribute while making decisions the information with respect to this can produce an impact. Another time when the energy performance can be considered to be producing requisite effect is when sellers or landlords expect that energy efficiency has a capability to become a salient attribute in near future and the selection of buyers is about to become structures in this particular direction.

For attaining effectiveness in implementation of labelling scheme, mobilization of various social practices and even the practitioners are essential. Example of product labelling issued via Directive 2010/30/EU can be provided in which it explicitly places responsibility on product manufacturers and retailers to label energy performance of their products. However, all the parties involved are required to take decisions based on this new information. Buyers are expected to integrate information on energy while taking purchasing decisions. Intermediaries are expected to integrate this information while advising the customers and sellers are expected to anticipate a change in purchasing behaviour of buyers. As per the views of Fawcett and Boardman 2012, labelling schemes help in achieving a broader transformation in the approach of market. The authors also stated that labelling schemes "grew out of product policy and has more recently been applied to the complex area of transforming property markets". In other words, it can be said that transformation of markets has led to converting the policies into strategies which ensure that product selling moves towards attaining greater efficiency in energy performance (Boardman, 2012).

Thus, it can be said that labelling plays a significant part in driving innovation for improving energy performance of products and thus cannot be understood in isolation. Labelling is essential in all forms of products be it appliances, buildings, vehicles and electrical equipment (Hinnells & Boardman, 2008).

For promoting energy efficiency of buildings and properties in the European Union, one of the main instruments is the EPC’s. It takes into consideration local requirements and cost effectiveness of establishing energy efficiency systems. Since, energy performance of buildings is greatly affected by local culture and climatic conditions of the place and therefore, promotion of energy efficiency is essential. Energy performance certification introduced in the year 2006 is being adopted by the member states on gradual basis (Mudgal, Lyons, & Cohen, 2013).

Energy performance labelling programs for buildings originate from the first building assessment method called BREEAM founded in 1990 (BREEAM, 2017). Over the years, several other labelling programs have emerged, i.e. programs like Minergie, HQE, LEED, Energy star, and EPC. Labels can in general be distinguished based on whether they are voluntary such as BREEAM or mandatory like the EPBD's label. Another differentiation is the labels characteristic itself, it can be divided into two pillars; one that uses endorsement labels, it will only certify buildings that meet their criteria, another pillar consist out of comparison labels, that will provide label to all the buildings using multi-category scales. Comparison labels have to take in consideration all the buildings on the market; it later on compares them and shows buildings that are better or worse in the aspect of energy performance. Endorsement labels can as well use multi-category scales, but it will only include buildings that meet their minimum requirements, and will later on distinguish on how well they meet their criteria (e.g. BREEAM uses a scale from Pass to Outstanding) (Winward, Schiellerup, & Boardman, 1998).

For better understanding, short descriptions of previously mentioned certification programs are presented below.

BREEAM is an endorsement sustainability assessment method used in buildings, masterplan designing, and infrastructure. It takes in consideration all the lifecycle stages such as new development, in-use, and retro-fitment. The process using scientifically backed standards, evaluates buildings design, construction and operation. BREEAM evaluates developments against targets that are set by energy performance benchmarks, developments are rated and certified on a multi-level scale. It is applied in over 70 countries worldwide; it holds 80% of European market share. Every year BREEAM will host an international event where the most sustainable places and project teams receive a BREEAM award (BREEAM, 2017).

Minergie is a Swiss building standard for new and modernized buildings. The trade mark is co-sponsored by industry, the cantons and the Confederation and is protected against misuse. At the center is the comfort - the living and working comfort of building users. This comfort is made possible by a high-quality building envelope and a systematic air renewal. Minergie buildings are also characterized by a very low energy requirement and the highest possible share of renewable energies. A building is certified if it passes the before chosen Minergie standard (Minergie, 2015).

HQE is an endorsement certification method used in France. It awards building management, construction, and master planning. HQE is promoting best practices, sustainability in building development, and providing technical expertise through the entire projects lifecycle. HQE evaluates the project with multi-level scale in four different categories. The project is given a four star rating on Energy, Environment, Health, and Comfort (HQE, 2017).

LEED stands for Leadership in Energy and Environmental Design and is an independent endorsed building certification based in the US, but is operating on a massive global scale. LEED is the most widely used green building evaluation scheme in the world (LEED, 2017). It evaluates the so-called "green" properties of buildings or entire neighborhoods. It is focusing on design, construction, and management of buildings that are economical, efficient, healthy and high performing. LEED certified buildings contribute to people, planet, and profit. Certified buildings are recognized as healthier, more productive places, with lower impact on the environment. The buildings with lead label are achieving higher market values, and higher rents while having lower utility costs. LEED is a multi-level certification; a building will earn one of four rating levels. Levels are based on points that a project earns in nine categories; Integrative process, location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, and regional priority. Rating levels are certified, silver, gold, and platinum.

Energy star endorsement certificate is issued by the US government. Homes that are Energy star certified are 15% - 30% more energy efficient than an average newly built home (Energy Star Overview, 2017). Energy star is helping to improve EE of homes through their Energy star program, they are also providing practical information to homeowners on how to save energy and consequently reduce their energy bills. Energy star labeled products are recognized as products that save consumers money and protect the environment. It makes purchases for consumers and businesses easier.

EPC or longer Energy performance certificate issued by the EU is a comparison type of label that, takes into comparison the entire pool of existing or planned properties. It categorizes them based on the measured or calculated energy performance of buildings.
The main role of an EPC is to raise awareness of better energy performance of buildings. It is providing energy performance indicator as commonly seen on the appliances. It was made mandatory to include the energy performance indicator for the building while being advertised for sale or rental (EC, 2013).

The performance is graded based on the energy consumption needed to heat a building, and the energy needed for the building to function. Beside these two, emissions are taken in equation as well. EPCs includes the information on the energy needs or consumption of a reference building. All the properties will receive a grade on a nine grade scale ranging from A1 to G (A1 being the best performing and G the least performing grade). The certificate will also include the minimal performance requirements for the year, and suggest improvements that can be done to better the energy efficiency of the rated building.

It is difficult to compare the labels since the goal of every single one of them is to improve the energy efficiency of a building; their methods differentiate in the sense of ratings, scale, measure, obligation and the incremental type of the label. It is difficult to say that one of the labels is superior to the other. Recent studies have proven that building EE certification requires location-specific assessment methods that take into consideration local specifics, that being environmental and social-political specifics. That being said the superior certification system is the one that can better fit the local specifics (Ebert et al, 2011).

Ruderman, Levine, and McMahon (1987) in their study state that most energy saving calculation costs have been poorly done. This has led to most of energy efficient buildings identifying dishonestly on energy efficiency policies since the estimated saving on energy cost do not match those they actually register after energy efficiency application on their buildings. In line with that being said, the certifications with greater transparency, reliable methods are considered to be more credible. Overview of discussed labeling schemes is presented in table 1.

Table 1: Labeling schemes overview

Labeling scheme	**BREEAM**	**MINERGIE**	**HQE**	**LEED**	**ENERGY STAR**	**EPC**
Type	Endorsement	Endorsement	Endorsement	Endorsement	Endorsement	Comparison
Obligation	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Mandatory
Scale	Multi-level	Single	Multi-level	Multi-level	Single	Multi-level
Measure	Percentage	Pass	Stars	Custom	Index	Grade scale
Rating Low to High	Pass Good Very Good Excellent Outstanding	/	1 star 2 star 3 star 4 star	Certified Silver Gold Platinum	Less Equal More	G F E D C B2 B1 A2 A1
Origin	UK-Global	Swiss	France-Global	USA-Global	USA	EU

1.5.6 Education

Education and training can be divided into two main branches. On one branch, there is expert training that results in independent licensed assessors that deal with certification of buildings energy performance, and the integrated energy consuming systems (heating, cooling, etc.). Experts take on education programs that are performed by licensed education organizations licensed by the ministry responsible for energy to perform mandatory energy performance certification, or private voluntary certification organizations that provide licensing programs for their voluntary building certifications such as LEED, BREAM, etc. More importantly on the other branch, there is an agenda to provide general information, increase awareness, and provide training for the general public when it comes to energy efficiency. These energy advisory programs are set out by the so called support center that is in the form of an organization called “Borzen d.o.o.”. For programs intended to increase the awareness, inform or train the local community, support center collaborates with local governments. On the supports centers website, the general public can access information such as (EZ-1):

- information about the performance, benefits, and expenses of energy efficient systems for heating, cooling or producing green energy;
- information about support programs for energy efficiency measures;
- certification information;
- list of licensed experts;
- information about renewable energy;
- information about available mechanisms that improve energy efficiency;
- information about financing and legislative frame of measures that improve energy efficiency.

Energy advisory programs for citizens organize a network of energy advisory offices, which are financed, organized, and led by the Eko sklad with the help of local communities. Information can also be shared in other forms of promotional material (EZ-1).

Eko sklad or Slovenian Environmental Public Fund is an independent organization with the Ministry of the Environment and Urban Planning officials representing the majority in the supervisory board. Eko sklad grants soft loans and guaranties that support investments into green technology. As the Eko sklad claims “Eko sklad’s main purpose is to promote development in the field of environmental protection.”, it does so through providing information and most importantly helps private and commercial entities with subsidies that propel decisions into a direction of “greener” product or energy consuming system (Eko sklad, 2017).

2 ENERGY EFFICIENCY CERTIFICATES AND THEIR EFFECT ON RENTS OR PRICES OF RESIDENTIAL BUILDINGS

This section includes a literature review for identification of existing evidence on finding a relationship between the value of a property and energy performance certificates. The study is done for Slovenia, which is situated in Central Europe. The impact of EPC on the value and rents of residential properties in Ljubljana - Slovenia is studied. Ljubljana is the only region in which real estate market is functioning in a way that there are enough transactions annually to have a proper insight of the real estate market. Study revolves around the impact of EPC’s on the value and rents of properties and buildings in Ljubljana. EPC’s in Slovenia were made mandatory with the 1st of January 2015. Manner and extent to which the EPC's affect the market depends upon design of certification schemes proposed, forcefulness with which the scheme has been implemented and awareness among the people of Slovenia with respect to the same (Gilmer, 1989).

In the section below we investigate what has already been done in this field of study, and it helps our understanding with gathering an in depth knowledge about the importance of the energy performance certificates and the extent to which they are being used for making a place energy efficient. Literature review is conducted for understanding the importance of establishing the relationship between value of properties and energy performance certification. Review of literature also helps with understanding the reason behind of which values of property get influenced by energy performance certificates. Research study also investigates the impact of energy performance certification on the values of property which is reflected in the transaction data available with respect to sales and rentals. In the end, conclusion is provided which suggests the relation between the property values and energy performance certificates, at present as well as in future.

2.1 Literature review

One of the studies conducted by Killip (2011) throws light upon various challenges gained in shifting from the product market transformation to property market transformation, which is all the more complex. The focus of his study is on already existing residential buildings. The arguments presented in his study can be applied to all the properties whether residential or non-residential. It has been argued that for the first time EPC leads to creation of a connection between two different markets, namely, property transaction market and refurbishment market. Property transaction market includes both sales as well as rentals. Refurbishment market includes installation of various measures of energy efficiency, micro-generation technology installation and general services such as repair, improvement and maintenance.

Within the refurbishment market, the most dominant segment is improvement, maintenance and repairs and the authors state that "significant savings can be made in cost and disruption by seeking to integrate energy-saving refurbishments with the “normal” operation of this market" (Mudgal, Lyons, & Cohen, 2013). This link is called as “dual rating” provided by the EPC, which in the EU integrates both current as well as potential rating. The EPC includes recommendations for economically feasible improvements in energy performance of a building.

However, it must be noted that the directive in respect to EPC only requires that along with the certificate some recommendations are to be provided for making the energy efficiency cost effective. This method of energy improvement through recommendations is considered as an improvement over appliance labelling, but in case of properties, energy performance can be improved not through replacement but through refurbishment. Thus, it can be said that refurbishment cycle plays a crucial role in property market transformation (Andaloro, Salomone, & Ioppolo 2010).

With the help of refurbishment of existing property, there is a huge possibility of reducing emissions in the real estate properties and buildings. For increasing the energy efficiency in the real estate sector, all the participants of the sector such as buyers, sellers, policy makers and estate agents need to work for increasing the use of EPC and enhance energy efficiency (Schiellerup & Gwilliam, 2009).

Issues related to energy efficiency in the real estate sector are usually confounded with capital budgeting decisions, wherein different choices of increasing the returns of investors are enumerated. In relation to this, investing in green buildings can lead to various benefits to the investors.

Firstly, at the time of renovation or new construction of buildings, investment in energy efficiency may help in saving expenditures on current resources required for energy, waste disposal and water. Such investments also lead to decrease in operating costs and decrease emissions of greenhouse gases. Financial benefits derived from energy saving investments are measurable but most of the studies concentrate upon environmental outcomes rather than financial outcomes. However, as per Eichholtz, Kok and Quigley (2009), capital investments on energy savings in buildings and properties are cost effective.

Secondly, green buildings have a great environmental quality. People residing in such buildings possess increased productivity and efficiency (Winward, Schiellerup, & Boardman, 1998). Beside productivity and efficiency, with improved indoor environmental quality residents tend to be healthier (Issa, Rankin, Christian, 2010). A study published in Harvard Gazette (2017) provided evidence on increased cognitive function, increased sleep quality and they have noticed a decrease in symptoms of a medical condition where people residing in a building suffer from illnesses for no apparent reason, this condition is referred to as sick building syndrome. If a whole life cycle of a commercial building is assessed, improvement in productivity and health of employees can account for about 70% of total cost savings (Kats, 2003). That is why entities that are working in a service sector are encouraged to rent office spaces in green buildings (Eichholtz, Kok, Quigley, 2016).

Thirdly, investments in green buildings signal that the investors are socially aware about their responsibility towards the environment and society at large (Wiley, Benefield, & Johnson, 2010).

Fourthly, most of tenants and buyers of properties prefer sustainable properties because such properties are bound to have a longer economic life as compared to conventional buildings. Lower volatility in the market can be achieved because of less risk to environment and better marketability. This results in high valuation of buildings and reduced risk premium. As per Orlitzky and Benjamin (2001), relationship between risk and corporate social performance is that if an organization has a good social reputation then the market risk of such organization is lower. If this relationship is applied to real estate sector, it would mean promoting green buildings might lead to high property valuation at lower cost of capital. Therefore, even if the rental value of a green building is lower, it would still be valued higher than the others.

Thus, it can be said that if appropriate investments are made in energy efficiency then it would lead to decline in life cycle costs and increase in developer returns (Quigley, 1991).
Another research conducted to investigate the relationship energy efficiency and its contribution to residential property value in Belfast housing market indicated that their findings identified a small positive relationship between residential property values in relation to energy efficiency (Davis, McCord, J. A., McCord, M., & Haran 2015). This research added that positive relationship between this variable would stimulate demand for energy performance labelled housing hence stimulating construction of these kind of properties by investors.

Value of property, with respect to this particular study, includes the transaction value (which includes both the sales value as well as the rental value). Interest in understanding the link between energy performance of properties and their values (prices or rents) is not recent and new. Various studies in relation to this have already been conducted which include Brounen and Kok (2010), Laquatra (1986), Gilmer (1989), Dinan and Miranowski (1989) and others. Concept associated with the energy efficiency premiums in the real estate market is called "green value". As per Rosen (2015), "the "green value" of a building can be defined by the impact on property value of energy efficiency and other environmentally friendly features, access to public transportation and others". High green value of buildings is indicative of higher transaction value of such buildings.

The major concern that is being addressed through this study is the impact of energy efficiency improvement on the value of properties. Properties that are built with better energy efficient equipment and materials are more expensive to construct than conventional properties. However, whether such additional investment leads to better returns to the investors or not is an interesting topic to research upon. Similar is the case with renovation of already existing properties and buildings. From view point of an entrepreneur, it is essential to identify whether the purchaser is agreeing to pay a premium amount for those properties which are performing better on the basis of energy efficiency or not, irrespective of the costs of constructing involved (Lützkendorf & Lorenz, 2011). Plesnik and Vuk (2015) explained that the results for increased market value for energy efficient residential properties was contributed by improvement on the quality of buildings through the use of thermal insulators on walls, ceilings, and roof as well as the use of energy efficient systems such as air conditioning and heating and cooling the houses. Even though these factors made construction more expensive and expertise used in the construction also was sought at a higher wage and in turn increased the cost of the properties being sold, tenants were willing to pay a higher value for the residential properties for its quality.

According to study made by Eichholtz, Kok and Quigley (2009) in the United States on commercial buildings having a green rating, it was found that those buildings which were having a green rating, had a rental value approximately 3% higher than the others. Selling prices of such buildings have had premiums of 16%. The study also found that in locations where the economic premium was lower, the comparative premium of green buildings was higher. As per the authors of the study, "the increment to market value attributable to its certification as "green" reflects more than an intangible labelling effect".

A study performed by the European Commission in 2013 through an international survey has provided similar findings. In the survey, they were including newly sold or rented apartment units and looking at markets in Austria, Belgium, France and Ireland. The biggest premiums for sold apartments were identified in Vienna – Austria with 10 to 11 % premiums. The lowest premiums for sold apartments were noticed in Ireland with 2.8 %. When they looked at rented properties they have found significant evidence that EPC's have had a moderate premiums at 2.6% for every label grade improvement or they were non-existent. Rental premiums were significantly lower compared to the ones they were achieved on sales market (Bio Intelligence Service, Ronan Lyons and IEEP, 2013).

Brounen and Kok (2010) have also confirmed the existence of premiums in their research conducted in the EU in which they looked at the effects of EPC's. They state that buyers of the properties with more energy efficient labels or "green" properties were willing to pay a premium on the price. The results showed that the premium varied between different label categories and is correlated to the housing quality. The variation of the premiums is explained with buyer's ability to recognise the present value of future savings on behalf of better energy efficiency. Moreover, they identified that the adaptation of EPC's was strongly influenced by the neighbourhood's characteristics. They are mostly adopted in densely populated neighbourhoods and in neighbourhoods with lower household income.

3 EMPIRICAL RESEARCH

In the following part, an empirical research is conducted. This research is trying to find direct evidence of the residential properties' EE's measured impact on transactional prices or rents.

The research is trying to identify premiums that were paid for comparable, more energy efficient residential properties, and if they exist, what is their direct impact on prices or rents. In order to do so two hypothesis are being tested, one for rented properties and one for the sold properties.

3.1 Hypothesis

H_1: Energy efficient properties will achieve a higher market value compared to less efficient properties.

H_2: Rental value of energy efficient properties is higher, compared to less efficient properties.

3.2 Methodology

3.2.1 Sample

The study sample is divided into two different data sets. The first data set consists out of 214 transactions of residential properties, 73 out of initial 287 transactions were deleted due to missing data on EE. The second data set consists out of 200 rented residential properties, 63 out of initial 263 were deleted due to missing data on EE. The data was collected for transactions and rents made in the Municipality of Ljubljana. The Municipality of Ljubljana was selected since the Ljubljana's real estate market has enough yearly transactions, and allows for conducting a viable research, which cannot be said for other smaller municipalities in Slovenia.

The transactions were collected from 1.1.2016 until 31.3.2016. The selected time frame was chosen because in that time period the real estate market was stable in Ljubljana and in this way time as a variable could be excluded from the research. The data was collected from publicly available databases. The transactional data was collected from Trgoskop 2 database, additional data on observed properties was collected from the database of "Geodetska uprava Republike Slovenije" (Geodetic institute of Slovenia, further on GURS), location data was collected using data from "zbirka vrednosti nepremičnin" (real estate value collection, further on ZVN). Further available data, data collection, and data transformation will be explained more in detail.

3.2.2 Data collection and data transformation

Primary data was collected using a real estate transaction data base called Trgoskop 2 ™ v1.0.14. published by GURS, and is available online as an application.

Firstly, the advanced search tab was selected to access advanced search options facilitates the selection process of property transactions. Sales or rent transactions on the market were selected in the period from 1.1.2016 until 31.3.2016 in the Municipality of Ljubljana.
The search provides the following basic information about every transaction:

- Identification number of the transaction;
- Type of transaction (on the market transaction);
- Date of transaction;
- Contract price (with or without tax);
- Calculated price per m^2 of floor area;
- Type of property (Transactions can include multiple types of properties such as apartment, storage, garage, parking, lot, etc.);
- Cadastral area;
- Building year;
- Contracted floor area;
- Floor area from a GURS register;
- Spatial cadastre data (lot no., building no., part of building no.).

After a transaction is selected, some additional information is provided:

- Value added tax information (if it is included in price);
- Seller and buyer information (if they are private or public entities);
- Property address;
- Floor number;
- Use class of property (for each part separately);
- Coordinates;
- Google maps™ direct link.

The next step was to check every transaction if it has EPC. That was done using GURS spatial portal called "Prostor". Spatial cadastre data (Cadastre area code/name, building number, no. of the part of the building), from the transaction was used to search the GURS database. The data available on the GURS portal is:

- Properties address;
- Information on properties registration status in cadastral registration (some older properties are not listed in this relatively new database);
- Properties useful floor area;
- Properties net floor area;
- Properties position in a building - floor number;
- Information on building management;

- Information on building renovations (year of renovation, what has been renovated);
- Room type check-list (i.e. does it have a kitchen or a bathroom);
- Properties technical equipment;
- Number of rooms;
- A list of additional spaces with surface area (balcony, storage, parking, etc.);
- EPC (EPC number, issue date, valid till, EPC scan);
- Data on property ownership or management.

If the transaction had the EPC it was included in the sample and the EPC was downloaded in order to receive the energy performance label of the property. Firstly, consumption data in kWh/m^{2}a was collected. It tells us how much energy does a specific property need for heating per year. While testing the models it showed that it is better to transform the data in to labels, similarly was made in research conducted by the European Commission (Bio Intelligence Service, Ronan Lyons and IEEP, 2013).

EPC's consumption data expressed in kWh/m^{2}a was used in the analysis. The values are grouped in the following labels: A1, A2, B1, B2, C, D, E, F, and G (A1 is very efficient and G is very inefficient). The Slovenia's EPC labels values are presented in Table 2 bellow.

Table 2: EPC label grades

Label	Consumption				
A1	from	0	to	9	kWh/m^{2}a
A2	from	10	to	14	kWh/m^{2}a
B1	from	15	to	24	kWh/m^{2}a
B2	from	25	to	34	kWh/m^{2}a
C	from	35	to	59	kWh/m^{2}a
D	from	60	to	104	kWh/m^{2}a
E	from	105	to	149	kWh/m^{2}a
F	from	150	to	209	kWh/m^{2}a
G	from	210	to	-	kWh/m^{2}a

Frequencies of rented and sold properties can be seen in table 3 below.

Table 3: Frequencies of sold and rented apartments per EPC label

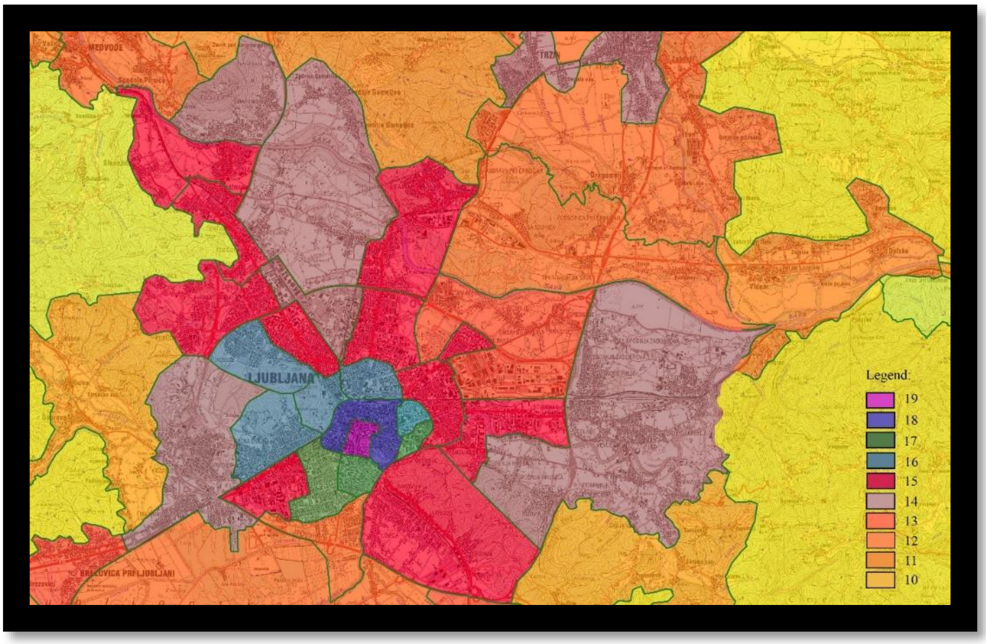
EPC Label	Mean [€/m^2]	N	Std. Deviation
A1	3,101	6	465.18
B1	2,291	6	560.27

Table 3: Frequencies of sold and rented apartments per EPC label (cont.)

EPC Label	**Mean [€/m²]**	**N**	**Std. Deviation**
B2	2,230	10	537.01
C	2,318	75	490.20
D	2,143	72	575.72
E	1,955	28	386.42
F	1,888	13	599.67
G	996	2	72.01
Total	2,189	212	563.27

Next step was to evaluate the properties location. Evaluation was based on the basis of ZVN. ZVN is providing a collection of values from various types of real estate. Based on the properties values and locations of properties, they have developed value zones. In value zones there are properties of the same type and similar value. Higher the price in a neighborhood, higher the zone number (from 1 to 19). The zone number was assigned using properties address acquired from Trgoskop2™'s database and pinpointing it on the ZVNs map with the help of google maps™. ZVN zones are presented in figure 3 bellow.

Figure 3: Value zones



Source: Modified on data obtained from ZVN, 2018.

Lastly properties price per square meter was calculated, but before that could be done, sellable area had to be calculated for each property. The reason behind this is that in order to make properties comparable, they had to be put on the same denominator, and the same method of calculating their floor area had to be used. The following formula (1) was used to calculate the sellable area:

$$S_{selable} = S_{usable} + f_{balcony} * S_{balcony} + \cdots + f_n * S_n \quad (1)$$

$S_n \ldots floor\ area$
$f_n \ldots factor$
$n \ldots type/premisis$

Factors used to calculate sellable floor area are done according to standard SIST ISO 9836 that is providing the following factors for adding additional premises' floor area to the sellable area:

Table 4: Floor area factors according to SIST ISO 9836

Additional premises	**Factor**
Balcony, open terrace	0.25
Loggia	0.75
Covered terrace or balcony	0.50
Storage	0.75
Shed in a building	0.50
Wooden independent shed	0.25
Garage	0.50

Source: Slovenian Institute for Standardization, 2011.

3.2.3 Data used

Of all the available data, the following data was chosen in this study to help us with understanding the impact of energy performance on properties value:

- Price per square meter of sold residential property;

- Properties location;
- EPC label;
- Age of property;
- Size of property
- Parking.

Similarly, the following data was used for rented properties:

- Monthly rent;
- Property's location;
- Age of property;
- Size of property;
- Lease duration (long term or short term);
- EPC label;
- Parking.

3.2.4 Statistical analysis

The statistical analysis was conducted using IBM SPSS Statistic (version 23) software. Descriptive statistics were calculated for both datasets, each variable was described using statistics of sample size, range, minimum, maximum, sum, mean, standard deviation, and variance. Later on the association between variables was analysed using Pearson's correlation test where the Pearson correlation coefficient value from 0.1 to 0.3 indicated small correlation, value of 0.3 to 0.5 indicated medium correlation, and value of 0.5 to 1 indicated strong correlation between variables. To study the impact of EPC's on properties value, hedonic regression analyses were conducted. The confidence interval chosen for all tests was at 95%, and P values under 0.05 were considered significant.

3.3 Hedonic regression

Hedonic modeling firstly appeared as a method to value the farm lands demand and pricing (Haas, 1922). The first attempt to develop a theoretical foundation for hedonic modeling was taken by Lancaster in 1966. He developed his framework based on an observation that goods do not create utility on their own, but their utility is a result of combined characteristics individual utility (Lancaster, 1966). Lancaster was the first to mention hedonic utility, but he did not discuss anything on hedonic modelling. Rosen presented hedonic modelling in 1974. He discussed that a good can be valued as aggregated utilities of its characteristics. He is implying that a price of a good can be regressed upon the characteristics to determine a characteristics individual contribution to the price (Rosen, 1974).

The hedonic modelling knows several types of models. The linear model, semilog model, log-log model, and box-cox model. The linear model equation is linear on both sides of the equation. In the linear model, the marginal prices are constant for every characteristic. To avoid linearity we can use semilog models. In semilog model, the log of dependent variable is the sum of its characteristics (Sopranzetti, 2015). The marginal price in nonlinear model, of an additional unit increase for an individual characteristic depends on the quantity of other characteristics. For example the price increase of an additional bathroom in a 1 bedroom home will vary to a 5 bedroom home (Freeman III, 2011). Another advantage over linear model is the simpler interpretation of models coefficients; they are expressed as percentage change of the value. The box-cox model in general is just a transformation function that lets the data choose the appropriate model (linear, semilog or log-log), but will compromise its characteristics accuracy (Sopranzetti, 2015).

Based on theory and literature review I have decided to choose the semi-log model for my study. Using the log transformation is a good step in lowering variance and normalizing the data. Data on prices may have large variation especially for residences and may have extreme cases that deviate from normality. Using the log transformations allows us to express changes in percentages and lowers total variance. This has both practical and statistical advantages.

The semi-log regression equation is presented by the following formula (4):

$$\ln(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n \tag{4}$$

ln - natural logarithm
y - dependent variable
β_n – coefficients
x_n – independent variables

Interpretation of coefficients is presented as percentage change of the price/rent, and it can be easily interpreted.

For the interpretation of dummy variables, small transformation is required as seen in the equation 5 bellow (Halvorsen & Palmquist, 1980)

$$c_n = \left(e^{\beta_n} - 1\right) \times 100 \tag{5}$$

β – Regression coefficients
c_n – Percentage change

3.3.1 Variables of sold apartments

Bellow in Table 5 is a list of used variables that were included in the hedonic regression of sold apartments. The first subcategory of sold properties has a final sample size of 212 samples. The data set was cleaned by eliminating the outliers, and corrected for human errors, that might have occurred during data collection. Descriptive statistics of the sold properties dataset is presented in Table 6.

Table 5: Variables of sold apartments

Variable name	Variable description
PRICE	Price per square meter [€/m^2]
LOC	Location presented in zone values
EPC	Energy performance [kWh/m^2a]
AGE	Age of properties in years
SIZE	Sellable floor area of apartment [m^2]
GAR	Apartment including/excluding garage
PAR	Apartment including/excluding parking

Table 6: Descriptive statistics of sold properties' variables

	N	Mean	Median	Mode	Range	Min	Max
PRICE	212	2189.7	2161.2	2333.3	3237.4	772.3	4009.7
LOC	212	15.3	15.0	15.0	6.0	13.0	19.0
EPC	212	76.0	64.0	37.0	387.0	8.0	395.0
AGE	212	39.9	40.0	2.0	144.0	2.0	146.0
SIZE	212	51.1	50.8	23.0	116.2	17.0	133.2
GAR	212	0.2	0.0	0.0	1.0	0.0	1.0
PAR	212	0.1	0.0	0.0	1.0	0.0	1.0

PRICE variable is measured as price expressed in € per square meter of an apartment. The contractual price was divided by the sellable area of an apartment. The average price of the sold apartment sample was 2,189.7 €/m^2, and it ranged from the low 772.3 €/m^2 to as high as 4,009.7 €/m^2.

LOC is an ordinal variable that is measuring the value of a location, the scale goes from 1 to 19, with 1 being the lowest valued location and the 19 the most expensive location. In the sold apartments sample the mode of LOC was 15 and it ranged from 13 to 19.

EPC variable is used to measure the energy performance of a sold apartment, the data was collected from individual apartments EPC. It is measured as the average annual energy consumption per square meter of an apartment [kWh/m^{2}a]. The average annual consumption per square meter of apartment was 76.0 kWh/m^{2}a, and it ranged from 8.0 kWh/m^{2}a to 395.0 kWh/m^{2}a. In table 7, we can see how the average price differentiates between categories. Apartments with better grades achieve a substantially higher price compared to lower graded apartments.

Table 7: Label - Average price per square meter

EPC Label	**Mean [€/m^2]**	**N**	**Std. Deviation**
A1	3,101	6	465.18
B1	2,291	6	560.27
B2	2,230	10	537.01
C	2,318	75	490.20
D	2,143	72	575.72
E	1,955	28	386.42
F	1,888	13	599.67
G	996	2	72.01
Total	2,189	212	563.27

AGE is a variable that measures the age of a building in years, from the year it was build until the year 2016. On average the apartments were 40 years old, and they ranged from two to as old as 146 years.

SIZE variable is expressed in square meters of sellable floor area. The average size of an apartment was 51.1 m^2, and it ranged from 17.0 m^2 to 133.2 m^2.

GAR variable is a dummy variable that is showing the presence of a garage. The value 0 means that there is no garage while the value 1 is showing the apartment was sold with a garage.

PAR variable is in line with the variable GAR, the difference is that PAR is looking at outdoor parking spaces that are sold with the apartment. Value 0 is showing the apartment was sold without a parking space, and the value 1 us showing the apartment was sold with a parking space.

3.3.2 Variables of rented apartments

Bellow in Table 8 is a list of used variables that were included in the hedonic regression of rented apartments. The second subcategory of rented properties has a final sample size of 185 samples. The data set was cleaned with eliminating the outliers, and was corrected for human errors, that might have occurred during data collection. The descriptive statistics of rented properties' variables is presented in Table 9.

Table 8: Variables of rented apartments

Variable name	Variable description
RENT	Monthly rent [€/month]
LOC	Location presented in zone values
AGE	Age of properties in years
SIZE	Sellable floor area of apartment [m^2]
DUR	Rent duration short/long term
EPC	Energy performance [kWh/m^2a]
GAR	Apartment including/excluding garage

Table 9: Descriptive statistics of rented properties' variables

	N	Mean	Median	Mode	Range	Minimum	Maximum
RENT	185	380.4	346.0	169.8	1300.2	100.1	1400.3
LOC	185	15.4	15.0	15.0	6.0	13.0	19.0
AGE	185	39.0	41.0	44.0	142.0	4.0	146.0
SIZE	185	47.3	43.2	19.2	135.5	17.0	152.5
DUR	185	0.1	0.0	0.0	1.0	0.0	1.0
EPC	185	76.7	62.0	52.0	407.0	18.0	425.0
GAR	185	0.1	0.0	0.0	1.0	0.0	1.0

RENT variable is measured as contractual monthly rental price expressed in €. The average rent of the rented apartment sample was 380.4 €/month, and it ranged from the low 100.1 €/month to as high as 1,400.3 €/month.

LOC is an ordinal variable that is measuring the value of a location; the scale goes from 1 to 19, with 1 being the lowest valued location and the 19 the most expensive location. In the rented apartments sample the mode of LOC was 15 and it ranged from 13 to 19.

AGE is a variable that measures the age of a building in years, from the year it was built until the year 2016. On average the rented apartments were 41 years old, and they ranged from four to as old as 146 years.

SIZE variable is expressed in square meters of sellable floor area. The average size of an rented apartment was 47.3 m^2, and it ranged from 17.0 m^2 to 152.5 m^2.
DUR variable is a dummy variable that is looking at the duration of a lease agreement. For values of 0 the lease agreement was short termed and for values of 1 the rented apartment have long term lease agreements.

EPC variable is used to measure the energy performance of a sold apartment; the data was collected from individual apartments EPC. It is measured as the average annual energy consumption per square meter of an apartment [kWh/m^2a]. The average annual consumption per square meter of rented apartment was 76.7 kWh/m^2a, and it ranged from 18.0 kWh/m^2a to 425.0 kWh/m^2a.

GAR variable is a dummy variable that is showing the presence of a garage. The value 0 means that there is no garage while the value 1 is showing the apartment was rented with a garage.

3.4 Results

In this section various results of the hedonic regression are presented, and are further on discussed in the discussion section of this study. They are divided in to two different subcategories of sold and rented properties.

3.4.1 Sold properties

We are going to use logarithmic transformation of variable PRICE as the dependent variable, transformed into variable labelled LN_PRICE. We are going to conduct a hedonic regression to look at impact of individual variables on the price of sold properties.

Table 10: Correlations Sold Properties

		LN_PRICE	EPC	AGE	SIZE
LN_PRICE	**Pearson Correlation**	1.000			
	Sig. (2-tailed)				
EPC	**Pearson Correlation**	-0.396	1.000		
	Sig. (2-tailed)	0.000			
AGE	**Pearson Correlation**	-0.558	0.537	1.000	
	Sig. (2-tailed)	0.000	0.000		
SIZE	**Pearson Correlation**	-0.136	-0.147	-0.045	1.000
	Sig. (2-tailed)	0.048	0.033	0.519	

Next, we use correlation analysis to see if there is any significant association between LN_PRICE on one end and EPC, AGE or SIZE on the other. We find a very significant correlation in each case ($p < 0,05$) but the correlation strength varies. Regarding on the directions, all factors are negative, meaning that all variables affect a property negatively. The largest correlation is between LN_PRICE and AGE, which is moderately negative. EPC has had mild effect on LN_PRICE, while SIZE has a small negative effect. The correlation between variables is presented in Table 10 above.

Scatterplots display each relation alongside the linear fit. We use the scatterplot to detect any non-linear effects. AGE has the best fit with the data, although we do not notice any particular pattern beside the linear approximation. Scatterplots of EPC, AGE and SIZE can be seen in figure 4 and figure 5.

Figure 4: AGE, EPC, and LN_PRICE Scatterplots

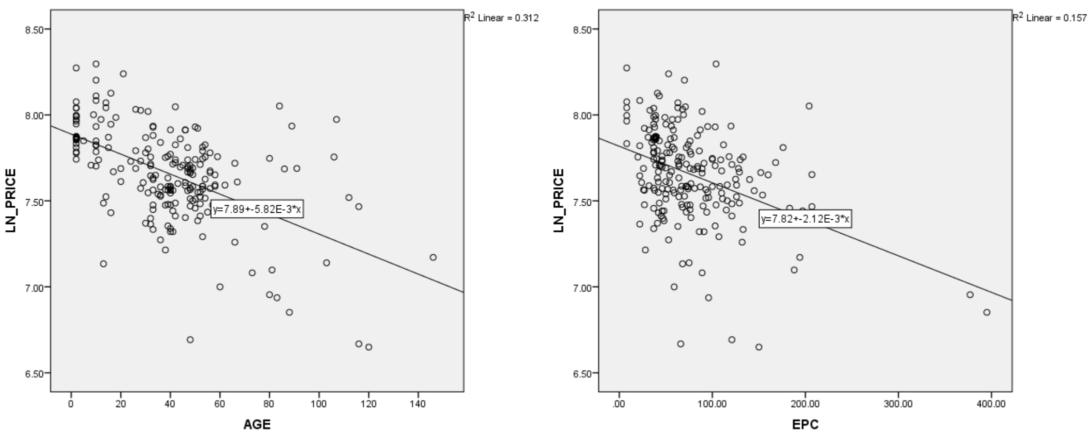
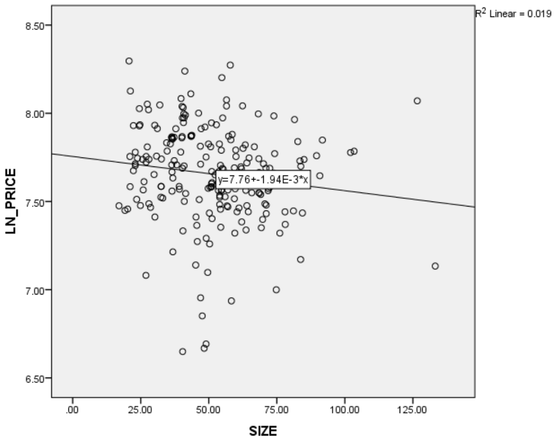


Figure 5: SIZE and LN_PRICE Scatterplot



Lastly, we conduct a semi-log hedonic regression for sold properties, dependent variable is LN_PRICE, and independent variables are LOC, PAR, GAR, SIZE, EPC, and AGE

Table 11: Model summary for Sold properties

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Durbin-Watson
1	0.705	0.497	0.482	0.198	1.897

Table 12: ANOVA of sold properties

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	7.947	6	1.324	33.762	0.000
	Residual	8.042	205	0.039		
	Total	15.989	211			

Table 13: Regression results for sold properties

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 Constant	6.887	0.200		34.363	0.000		
EPC	-0.001	0.000	-0.179	-3.013	0.003	0.695	1.438
AGE	-0.004	0.001	-0.424	-5.818	0.000	0.462	2.163
SIZE	-0.004	0.001	-0.279	-5.378	0.000	0.914	1.094
GAR	0.164	0.043	0.234	3.816	0.000	0.655	1.528
PAR	0.143	0.057	0.134	2.503	0.013	0.860	1.163
LOC	0.077	0.014	0.302	5.562	0.000	0.833	1.201

**Dependent Variable: LN_PRICE*

As it can be seen in Tables 11 and 12, the model is very significant in explaining variation in the dependent variable LN_PRICE, $p < 0.01$. With an $R^2 = 0.497$ the model explains roughly 49.7% of variation observed in the dependent variable.
Results show that variables EPC, AGE, SZE, GAR, PAR and LOC, are all statistically significant, $p < 0,05$. The regression results for sold properties are presented in Table 13.
Results for EPC show that on average for every kWh/m2a increase in consumption the price of a property will fall for 0.1%, ceteris paribus. If we transform the effect of EPC to the effect of label grade change, we can see a clearer meaning of the effect. The transformation is made by looking at EPC's grades range mean (Me), and multiplying the difference (Diff) between the highest value of improved grades range (Max) and the mean of referential grade (Me) with the effect of 0.1% per kWh/m^2a change, ceteris paribus. The transformation can be seen in Table 14. The average premium is at 1,9 %.

Table 14: Label Grade Premium for Sold apartments

Grade	Min [kWh/m^2a]	Max [kWh/m^2a]	Me [kWh/m^2a]	Diff. [kWh/m^2a]	Premium
A1	0	9			
A2	10	14	12.0	-3.0	0.3%
B1	15	24	19.5	-5.5	0.6%

To be continued

Table 14: Label Grade Premium for Sold apartments (cont.)

Grade	Min [kWh/m²a]	Max [kWh/m²a]	Me [kWh/m²a]	Diff. [kWh/m²a]	Premium
B2	25	34	29.5	-5.5	0.6%
C	35	59	47.0	-13.0	1.3%
D	60	104	82.0	-23.0	2.3%
E	105	149	127.0	-23.0	2.3%
F	150	209	179.5	-30.5	3.1%
G	210	300	255.0	-46.0	4.6%
			Average Premium		1.9%

For AGE on average, every year increase will cause the price of the property to drop by 0.4%, ceteris paribus.

SIZE not surprisingly has a negative effect on the price. On average for each square meter increase of the apartment, the price per square meter will decrease by 0.4%, ceteris paribus. Presence of a Garage (GAR) or parking lot (PAR) has a clear positive and relatively large effect on a selling price. After transformation on average if, the apartment does have a garage its value will increase by 17.8%, and if it has a parking lot, its value will increase by 15.4%, compared to apartments without garage or parking lot respectively, ceteris paribus.

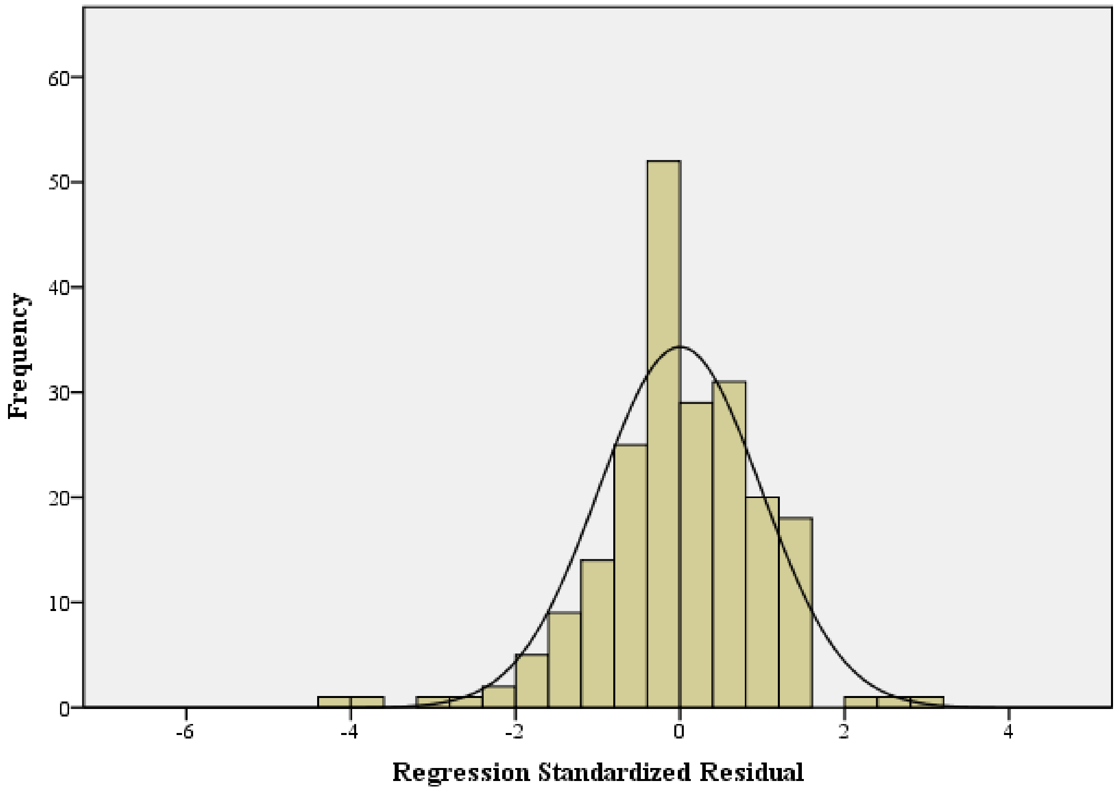
Location (LOC) has a relatively large effect on selling price of an apartment, the results show that for every value zone increase the price will increase by 7.7%, ceteris paribus.

Lastly we use the variance inflation factors (from here on VIF) coefficient to see if the model does not suffer from multicollinearity. The rule of thumb suggests that if VIF scores are under the value of 2.5 and the tolerance is above 0.4 there is no concern that the model would suffer from multicollinearity. The results seen in Table 14 show no concern of multicollinearity.

The Durbin-Watson $d = 1.897$, which is between the two critical values of $1.5 < d < 2.5$. Therefore, we can assume that there is no first order linear auto-correlation in the multiple linear regression data.

Histogram (Figure 6) of standardized residuals shows that the errors are approximately normally distributed with an average of zero, as it is expected for the optimal case.

Figure 6: Histogram standard residuals



Scatterplot of residuals of predicted values show no patterns whatsoever, meaning that there is no omitted variable problem in the model. Furthermore, there is no funneling effect present in the data so we are also able to reject the presence of heteroscedasticity in the model. Scatterplots are presented in Figures 7 and 8.

Figure 7: Regression Scatterplots for Sold Properties

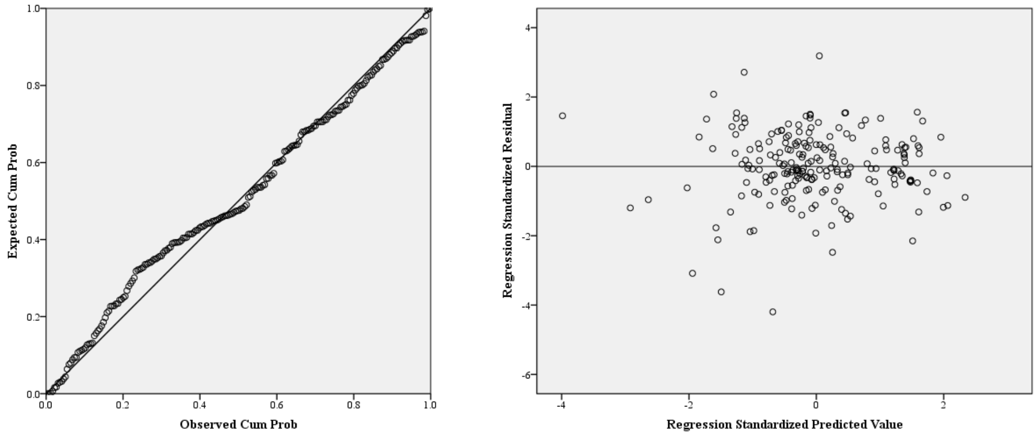
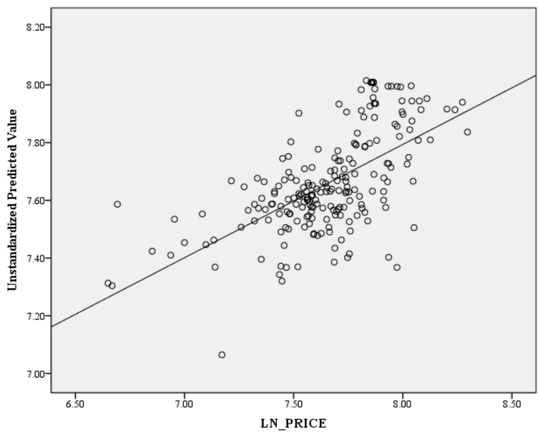


Figure 8: Scatterplot LN_PRICE and unstandardized predicted value



**LN_PRICE dependent variable*

3.4.2 Rented properties

Rented apartments do follow the same model structure, as sold apartments, according to the hedonic-pricing model; both should be specified by the properties' individual elements. On the other hand, one might expect some changes at least in the effect strength.

Again, we are going to use logarithmic transformation of variable RENT as the dependent variable, transformed into variable labelled LN_RENT, and later on conducting a hedonic regression model.

Table 15: Correlations Rented Properties

		LN_RENT	EPC	AGE	SIZE
LN_RENT	**Pearson Correlation**	1.000			
	Sig. (2-tailed)				
EPC	**Pearson Correlation**	-0.220	1.000		
	Sig. (2-tailed)	0.003			
AGE	**Pearson Correlation**	-0.260	0.348	1.000	
	Sig. (2-tailed)	0.000	0.000		
SIZE	**Pearson Correlation**	0.484	0.027	-0.045	1.000
	Sig. (2-tailed)	0.000	0.717	0.545	

Correlation analysis (Table 15) reveals us an interesting fact. Although AGE and EPC positions continue to have a negative impact on LN_RENT, which is also of a mild effect size, we see a large positive effect of SIZE on LN_RENT. We saw earlier that the effect of SIZE on selling price (LN_PRICE) had a limited negative effect, but the effect seems to increase in size and revert in the case of rents.

The above-mentioned correlations can be seen in the scatterplots below (Figure 9 & 10) where clearly we can notice that the relationship between SIZE and LN_RENT is the strongest.

Figure 9: AGE, SIZE and LN_RENT Scatterplots

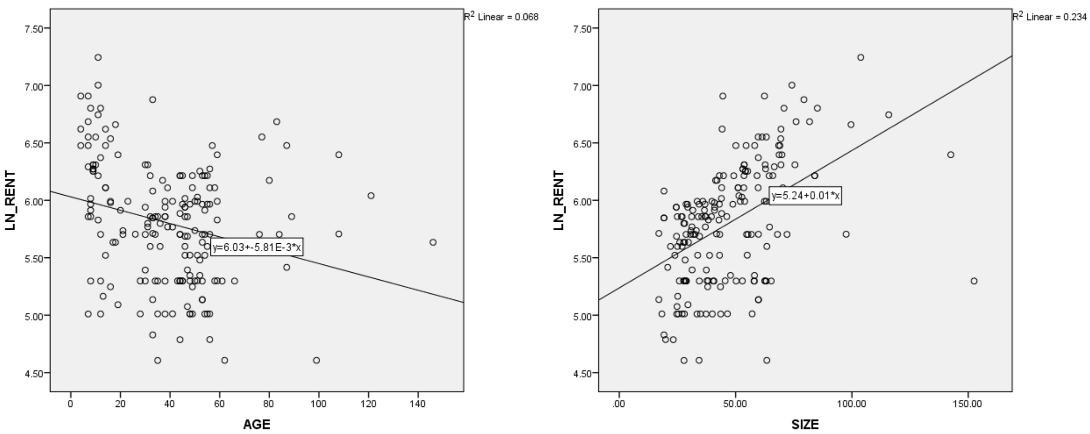
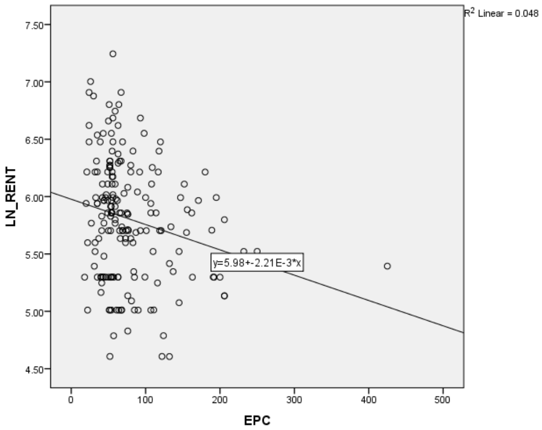


Figure 10: EPC and LN_RENT Scatterplot



Lastly, we conduct a hedonic regression for rented properties, dependent variable is LN_RENT, and independent variables are EPC, LOC, AGE, SIZE, and GAR.

Table 16: Model summary of rented properties

Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error of the Estimate**	**Durbin-Watson**
1	0.616	0.379	0.362	0.420	1.884

Table 17: ANOVA of rented properties

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	19.334	5	3.867	21.882	0.000
	Residual	31.631	179	0.177		
	Total	50.966	184			

Table 18: Regression results for rented properties

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 Constant	4.119	0.434		9.429	0.000		
AGE	-0.004	0.002	-0.176	-2.502	0.013	0.698	1.433
LOC	0.094	0.029	0.201	3.210	0.002	0.887	1.127
EPC	-0.002	0.001	-0.152	-2.386	0.018	0.860	1.163
SIZE	0.010	0.002	0.412	6.659	0.000	0.906	1.104
GAR	0.246	0.112	0.152	2.200	0.029	0.726	1.377

**Dependent variable: LN_RENT*

As expected the overall model is very significant, $p < 0.01$. This means that the model provided does offer a significant explanation for the variation seen in rents. The model has a $R^2 = 0.379$, meaning that roughly 37.9% of variation in rents is explained by our model. Model description can be seen in Tables 16 and 17 above.
Regression (Table 18) provided the following results:

AGE has the same effect on rented properties as it has on sold properties. On average, every year increase will cause the price of the property to drop by 0.4%, ceteris paribus.
We find that for each kWh/m2a increase in the EPC score or positioning on average the rent price falls by 0.2%, ceteris paribus. Once again if we make a transformation to look at label grade difference effects, we see that on average there is 3.7% difference between labels, ceteris paribus. The transformation can be seen in Table 19 and 20.

Table 19: Label Grade Premium for Rented apartments

Grade	Min [kWh/m^{2}a]	Max [kWh/m^{2}a]	Med [kWh/m^{2}a]	Diff. [kWh/m^{2}a]	Premium
A1	0	9			
A2	10	14	12.0	-3.0	0.6%
B1	15	24	19.5	-5.5	1.1%
B2	25	34	29.5	-5.5	1.1%
C	35	59	47.0	-13.0	2.6%

to be continued

Table 19: Label Grade Premium for Rented apartments (cont.)

Grade	Min [kWh/m²a]	Max [kWh/m²a]	Med [kWh/m²a]	Diff. [kWh/m²a]	Premium
D	60	104	82.0	-23.0	4.6%
E	105	149	127.0	-23.0	4.6%
F	150	209	179.5	-30.5	6.1%
G	210	300	255.0	-46.0	9.2%
			Average Premium		3.7%

SIZE, in contrast with the sales model, has a positive effect which is also somewhat larger is size. For instance, for each square meter increase in the size of the apartment, on average we are expected the rent to go up by 1.0%, ceteris paribus.

Variable GAR shows that convenience of a garage seems to be more important when it comes to leasing a property. Results show that on average (after transformation) an apartment with a garage, will on average achieve a 27.9% higher rent price compared to apartments without a garage, ceteris paribus.

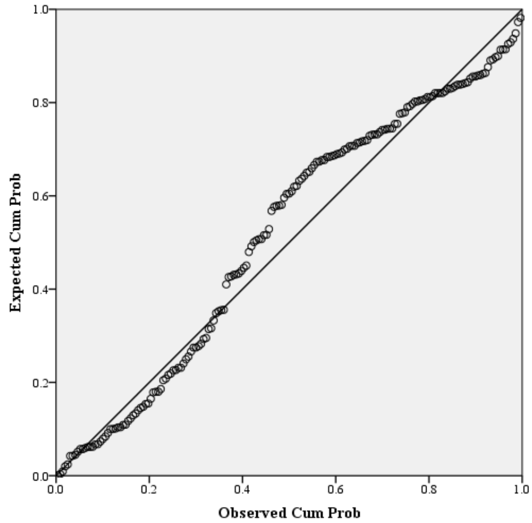
One of the biggest impacts on rents has the variable LOC, location of a rented apartment is of a great importance to the consumer. The rent will increase by 9.4% for every value zone higher. For instance an apartment in old city center (value zone 19) compared to Šiška district (value zone 15) will on average achieve a 37.6% higher rent, ceteris paribus.

Once again, we look at VIF coefficient to see if our model does not suffer from multicollinearity. As the values do not exceed the value of 2.5 and tolerance is not above 0.4, we can be confident that there is no multicollinearity effect.

The Durbin-Watson d = 1.884, the value is between the two critical values of $1.5 < d < 2.5$. Therefore, we can assume that there is no first order linear auto-correlation in our multiple linear regression data.

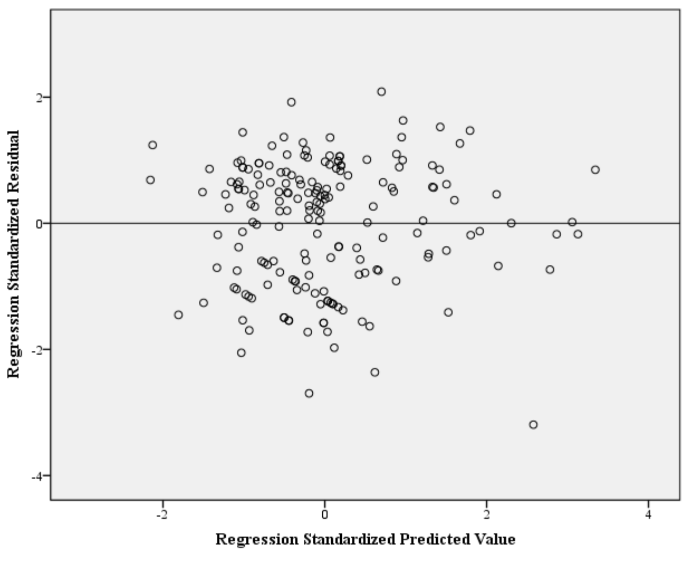
The P – P plot of the residuals shows a generally normal distribution. As we can see, although with some deviation, the residual points are in the diagonal line with no apparent outliers present (Figure 11).

Figure 11: P-P plot of residuals



Scatterplot of residuals of predicted values shows no pattern whatsoever meaning that there is no omitted variable problem in the model. Furthermore, there is no funneling effect present in the data so we are also to reject the presence of heteroscedasticity in the model (Figure 12).

Figure 12: Scatterplot of residuals – Rent



3.5 Discussion

The purpose of this study was to identify evidence on premiums associated with purchased or rented apartments according to energy efficiency attribute of the sold or rented apartments in Ljubljana – Slovenia. We predicted that sold residential properties achieved a higher selling price compared to residential properties that are less energy efficient, the same goes with rented apartments. The measure of energy efficiency was acquired from apartments own energy performance certificate that is expressed with energy consumption in kWh/m2a and categorized into grades scale. Two hypotheses were tested for every category of sold and rented apartments each own.

The hypothesis for sold apartments provides sufficient evidence at the p-value of 0.003 to support the claim that energy efficient properties will achieve a higher market value compared to less efficient properties. The results showed that the increase of value per consumptions point of energy efficiency, was at 0.1% for every point drop in annual consumption per square meter of apartment [kWh/m2a], while other variables were held constant. According to the results, potential buyers are recognizing the long-term benefits of an energy efficient home. If we transform this effect, on average every improved label change will increase the value of an apartment by 1.9%.

The European Commission has conducted a study on EPC’s premiums in 2013, and has provided similar results; in their research, they were looking at markets in Austria, Belgium, France and Ireland. The results for Slovenia (Ljubljana) show that the impact of 1.9% is severely lower compared to the locations studied in their research. The biggest premium can be noticed in Vienna – Austria with 10% to 11%, ceteris paribus. The lowest premium is noticed in Ireland with 2.8 %, ceteris paribus. Results of other regions are summarised in Table 21 below (Bio Intelligence Service, Ronan Lyons and IEEP, 2013).

Table 20: European Commission Study results – Sales

Member state	Region	Premium [%]	Average premium [%]
Austria	Vienna Lower	10-11 5-6	8.0
Belgium	Brussels Wallonia	2.9 5.4	4.2
France	Marseille Lille	4.4 3.2	3.8
Ireland	Ireland	2.8	/

Source: Bio Intelligence Service, Ronan Lyons and IEEP, 2013

The findings of this study are consistent with those of Brounen and Kok (2010) stating that customers of the apartments with better energy performance label took into consideration the label's effects on prices. Additionally, they were willing to pay more for properties with better label grades.

Plesnik and Vuk (2015) explained that the results for increased market value for energy efficient residential properties was contributed by improvement on the quality of buildings through the use of thermal insulators on walls, ceilings, and roof as well as the use of energy efficient systems such as air conditioning and heating and cooling the houses. Even though these factors made construction material more expensive and expertise used in the construction also was sought at a higher wage and in turn increased the cost of the properties being sold, tenants were willing to pay a higher value for the residential properties for its quality.

Davis, McCord, J. A., McCord, M., & Haran (2015) added that looking at residential property value in Belfast housing market provided findings of a small positive relationship between residential property values in relation to energy efficiency. This research added that positive relationship between this variable would stimulate demand for energy performance labelled housing and stimulate refurbishment of existing or construction EE properties by investors.

As for the second hypothesis tested for rented apartments provides sufficient evidence at the p-value of 0.018 to support the claim that energy efficient properties will achieve a higher rental value compared to less energy efficient apartments. The results showed that the increase of value per consumptions point of energy efficiency, was at 0.2% for every point drop in annual consumption per square meter of apartment [kWh/m2a], while other variables were held constant. According to the results, potential renters are recognizing the long-term benefits of an energy efficient home. If we transform this effect, on average every improved label change will increase the value of an apartment by 3.7%. The results of the analysis were not as anticipated. It was expected that the rental market will have smaller premiums compared to sales market, and the results have shown that in Ljubljana the rent premiums are almost two fold higher compared to the sold apartments premiums.

The same study conducted by the European Commission in 2013 that was already mentioned for sold properties has provided similar results. In the research, they were looking at rental markets in Austria, Belgium, France and Ireland. The results of the Ljubljana - Slovenia rental markets behaviour (according to this study) is reflected the most by Brussels – Belgium. For this region they have found significant evidence that EPC's have had a moderate premium on rents at 2.6% for every label grade improvement, while other factors remain constant (table 22). However, studied regions have had premiums that were significantly lower compared to the ones they achieve on sales market. The study tries to explain the low or non-existent premiums with issues of acknowledging financial benefits of EE, unwillingness to pay for better performing properties. They are assuming that owners have already internalised the financial benefits of EE living, while the renters are only enjoying the improved accommodation service (Bio Intelligence Service, Ronan Lyons and IEEP, 2013).

Table 21: European Commission Study results - Rental market

Member state	**Region**	**Premium [%]**	**Average premium [%]**
Austria	Vienna	4.4	4.65
	Lower	4.9	
Belgium	Brussels	2.6	/
	Wallonia	n.s.	
France	Marseille	n.a.	/
	Lille	n.a.	
Ireland	Ireland	1.4	/

Source: Bio Intelligence Service, Ronan Lyons and IEEP, 2013

The mismatch between the studies can be assigned to behaviour specifics of Slovenia. According to Slovenian statistical office, 81.2% of residential properties are owned and used by private individuals, while only 8.2% of occupied residential properties are rented. The 10.6% of properties are user-occupied residences, i.e. holiday homes (SURS, 2015). We can see that the added value is probably due to the regional specifics where renting is considered more of a temporary solution to solving a housing problem. The majority of households in Slovenia are homeowners. Those living in leased apartments are saving up in order to purchase their own property. Scanlon (2015) has shown that even in countries where the percentage of rented apartments is higher compared to owned apartments, families are thriving toward becoming homeowners. Rent regulations, finance availability, and security of tenants are influencing this phenomenon. The research claims that there is important influence of behaviour and attitude specifics of a country that influence the rent/ownership ratio.

In order to save enough to become a homeowner, a tenant is motivated to save as much as possible. Savings can be made in lower utility costs and lower rents. The price ceiling for renting an apartment in Ljubljana is defined by its size, EE, age and location; we can see that from the high correlations with the price. Tenants are recognizing the monthly savings in utilities and are adding them to the rent. They are prepared to pay something extra for an apartment with lower costs, since at the end they are paying the same or even lower total amount with costs included, as they would pay for a cheaper less efficient apartment, and they consequently live in the improved living conditions. Winther and Gurigard (2016) in line with the results obtained identify that tenant is faced with a number of barriers that make him or her consider verification of the value of the apartment not only based on its energy efficiency but on location and the size of the apartment. This can be explained by other correlations identified in the result that indicate that location of the house, age of the house and size of the house to be positively correlated to energy performance compared to price of the housing which is negatively correlated. This means that tenants would be willing to consider to move to residential houses in great locations with their considered space size that pay a higher price for the rental that are energy efficient. The main reason of this kind of behaviour might be that the property owners shift the utility expenses to tenants. Levinson and Niemann (2004) identified that the cost of energy in American rental houses has been incorporated in most of the rent for these houses. This has reduced the incentive for the tenant to recognize the need to use the energy efficiently. As a result, extra cost on use of energy from that which has been projected in the cost of rent is borne by the property owner. This takes away the incentive by the tenant to value a more energy efficient apartment.

Why the premiums for sold apartments is lower compared to premium of rented apartments can probably be assigned to purchasing power of the Slovenia's population and the average price of apartments. According to SURS's report on purchasing power of European countries in 2016, Slovenia is indexed low at 75 while the EU28 average is indexed at 100 (SURS, 2016). We can see that potential homeowners are having difficulties with purchasing the properties. Especially newer, more efficient and consequently more expensive housing.

The purchase price is mostly influenced by its location, age and size. Lower graded apartments are on average older compared to higher graded apartments, so incrementally the price will be higher for more efficient properties. To conclude the premiums of sold apartments compared to rented apartments would probably be higher if the purchasing power in Ljubljana – Slovenia would be stronger. Households with higher incomes would be able to put more emphasis in their decision making on the energy efficiency aspect of an apartment. Constrained with their budgets households are forced to choose apartments that are older, less efficient, on less attractive locations in order to compensate for the size of an apartment. Brounen and Kok (2011) in their study done for Netherland housing market have identified premiums payed for more energy efficient housing. They have identified that local characteristic as the household income has a positive relation to the importance of energy efficiency. As well, they have found that energy efficiency has a higher impact on smaller dwellings as compared to larger dwellings. That confirms that with size the price will increase and the importance of energy efficiency will diminish, unless the household income increases. This interesting topic could present an opportunity for future research.

CONCLUSION

The EU legislators are trying hard to improve the energy efficiency in the near future, with their 20-20-20 goal. They set this goal to provide a sustainable future for future generations and to improve the general living conditions on the EU territory. When it comes to buildings EU is thriving towards converting, existing and developing new nearly zero-energy buildings that are by definition very high-energy performing buildings. Zero-energy buildings should mostly be powered by renewable energy sources and use materials that can be recycled and are being produced in an environmentally preserving fashion. It is very important to tackle this issue since the buildings sector is one of the most energy and raw materials consuming sector.

The EU is trying to direct the member states and maneuver them with all kinds of policies that the member states can implement in order to achieve the collective EU energy efficiency goal. They are suggesting implementation of taxation, financial incentives, regulations, standardisation, education, and labelling policies.

One of the most important suggested and commonly used policy measure through the entire EU is Labelling of energy efficiency of energy consuming products. Labelling is considered an enabler when it comes to energy efficiency. Once again, one of the most energy and raw material consuming sectors is the building sector. The buildings use integrated HVAC energy consuming products and the design of a building is having a huge impact on energy efficiency. It is mandatory for buildings to be labelled with the information about their energy performance in the EU. The EPC's should provide the consumer with simplified and reliable information about the energy performance of a product, it should promote a behavior of a consumer to tilt the scale into a direction of a more energy efficient product, that should provide long term savings in utilities cost and justify potentially more expensive product. To promote the purchase of products that are superior in terms of energy efficiency, the member states are inclined to provide consumers with subsidies or tax exemptions.

So far, the real estate market can sense a bit of an improvement in recognition of energy efficient residential buildings. Member states are experiencing premiums on transaction prices for more efficient apartments, some can even sense it when it comes to rented properties. The gap between sold and rented residential properties can be explained with renters only enjoying the benefits of an efficient short-term rented apartment, while owners are internalizing the long-term financial benefits.

However, when it comes to buildings in Slovenia the measured impact of energy efficiency on the transactional price of a residential apartment is barely present. Other factors are by far more important to an average Slovenian consumer. Nonetheless, Slovenia is comparable to other member states, so this is not a regional characteristic. When it comes to rented properties, the premiums were higher compared to the premiums of sold properties. This regional specific was not noticed in any other research, it could be assigned to local socio-economical specifics. It could be influenced by Slovenia’s low purchasing power, the mindset of a home owning society or any other regional specific. this is a good basis for future research. Slovenia’s general population perceives renting as a temporary solution to their housing problem. In order to become homeowners they have to save as much as they can, and savings are recognized in utilities costs. Owners and renters are becoming more aware of capital benefits of energy efficient homes; the EU is trying hard to increase this awareness with education programs and is providing consultation on how to improve the existing homes. Education and internalization of the benefits, financial or environmental, are of the most importance, it all begins with the seeding an idea in the mindset of residential property buyer or renter. When consumers will internalize the idea of energy efficient housing, and will be prepared to spend more on an energy efficient residential property, the investors will be encouraged to invest into a more energy efficient developments with a higher incremental costs, but will be rewarded with price premiums at the end. As per now investors find too little evidence that would encourage them with investing in more energy efficient systems. As far as they see it, it is not worth the investments if the i.e. renter is unwilling to pay a higher rent for a comparable but more energy efficient apartment on the same location.

It would be wise to explore the options of subsidies that would directly affect the consumers, and make it more approachable for an average consumer. For instance provide buyers with subsidies that would i.e. subsidize a purchase of a higher labelled apartments with 50 €/m2, or subsidize rents. Another subject that would improve this is study is to research the actual understanding of renters, buyers of residential properties, and contractors, about the options and benefits that they have when it comes to energy efficient housing.

When all the pieces will fall into place and all the involved parties in the real estate market will be pulling in the direction of an improved energy efficiency housing, the overall living conditions will improve, and will leave a sustainable environment for the future generations to come.

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APPENDIXES

LIST OF APPENDIXES

APPENDIX 1: Povzetek

V današnjem času se vedno bolj pogosto srečujemo s temami kot so varovanje narave, podnebne spremembe, trajnostni razvoj, »zeleni« produkti, zmanjšanje toplogrednih plinov itd. Vsem temam je skupno, da se osredotočajo predvsem na izboljšavo energetske učinkovitosti. Cilj trajnostnega razvoja je, da družba kljub zadovoljevanju svojih potreb, s svojim početjem ne ogroža obstaja naslednjih generacij. S trajnostnim razvojem v mislih je Evropska Unija v podnebnem in energetskem paketu predstavila svoje cilje za leto 2020. Cilji so zmanjšati porabo energije, povečati delež energije proizvedene iz obnovljivih virov in zmanjšati proizvodnjo toplogrednih plinov. Največji potencial za dosego ciljev so prepoznali v stavbnem sektorju. Da bi te cilje dosegli, so se osredotočili na energetsko učinkovitost stavb. Glavna tema te naloge je ravno energetska učinkovitost stavb. Naloga raziskuje vse vidike energetske učinkovitosti v povezavi s stanovanjskimi stavbami. Nepremičninski sektor velja za enega bolj potratnih sektorjev kar se tiče porabe surovin in energije. Iz naslova tega dejstva Evropska Unija sprejema direktive katerih namen je izboljšava energetske učinkovitosti stavb držav članic. Zakonodajalci predlagajo vse možne predpise in ukrepe, ki naj bi pomagali izboljšati energetsko učinkovitost v stavbah. V tej nalogi so predstavljeni ukrepi zakonodajalcev s poudarkom na energetskih oznakah, ki jih pri stavbah in energetskih produktih poznamo v obliki energetskih izkaznic. Ker papir vse prenese, je glavni namen te naloge poiskati neposredni vpliv energetskih ukrepov na energetsko učinkovitost. Natančneje, naloga se osredotoča na merjeni vpliv oznak energetskih izkaznic na prodajne cene in najemnine stanovanj v Ljubljani - Sloveniji. V študiji je poizkušan prikaz dejanskega vpliva spremembe oznak energetskih izkaznic na prodajno ceno ali najemnino primerljivih stanovanj. Glavno vprašanje na katerega poizkuša naloga dogovoriti je; Ali se cena/najemnina zviša za vsako izboljšano oznako energetske izkaznice? Z odgovorom na to vprašanje lahko ocenimo kako dobro so energetski ukrepi »ponotranjeni« s strani kupcev ali najemnikov stanovanj v Ljubljani. Rezultate se na koncu primerja z obstoječimi študijami na to temo do sedaj in poizkuša se poiskati razloge za vedenje kupcev in najemnikov v tem obdobju.

APPENDIX 2: Abstract

One of the main topics in today's society are planet preservation, sustainability, going "green", etc. All of the topics have one thing in common; they are focusing on improving energy efficiency. Sustainability's goal is to let the society satisfy all the needs, and by doing that, it will not endanger the existence of next generations. The EU with sustainability in mind has presented its 2020 goals in its energy and environmental package. The goals were to lower the total energy consumption, lower the production of greenhouse gases, and produce energy from renewable sources. One of the largest potential to achieve these goals was recognized in the building sector. And to achieve those goals, they had to focus on energy efficiency in buildings. Energy efficiency in buildings is the main topic of this study, it explores all the aspects of energy efficiency in connection with the buildings sector. The building sector is considered to be one of the most raw material and energy-consuming sector. The EU is passing directives that are intended to improve the energy efficiency. The legislators are suggesting all kind of different policies that are considered to improve the energy efficiency, and they are being applied by the member states' legislations. In this study, a broad summary of policies is presented with the emphasis on labelling policy's current situation. While everything looks good on paper, this study is trying to find direct evidence of policies' actual impact on energy efficiency. To be more exact, study focuses on the measured impact of energy efficiency labelling policy passed by the legislators in Slovenia's residential real estate market on the transactional prices and rents. The study is trying to identify the actual premiums that were payed for comparable more energy efficient residential properties, same goes for rental market. The transactional prices/rents were compared to energy performance certificates' ratings of the purchased/rented residential properties, consequently the study is trying to answer one question; will the price/rent increase for every EPC's grade improvement? The answer to this question provides an argument on how well the policies are being adopted and internalized by the average residential property renter or buyer in Slovenia. The results are compared to other studies that have been made on this topic so far, and is looking to find reasoning behind the behavior of todays' residential property buyer or renter.