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The socioeconomic impact of energy saving renovation measures in urban buildings

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ABSTRACT
The purpose of the paper is to investigate the role of measures oriented to energy savings in residential buildings in the economic development at the regional level. The aim of the paper is to estimate overall socio-economic impact of energy saving renovation measures in the Croatian urban areas. Impact assessment is based on input–output methodology which is able to quantify direct and indirect effects of investment in the energy saving projects on the economic activity and employment. Gross output, gross value added and employment multipliers for building renovation projects are estimated to be in the range 2.5–2.9.

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Energy efficiency; input–output model; multipliers; process of renovation; urban areas

JEL CLASSIFICATIONS
Q41; C67; D12

1. Introduction

The objectives of the Europe 2020 strategy very clearly emphasise the general concern for sustainable use of energy and the implications of energy use on climate change. The Europe 2020 sets the objective to reduce the consumption of energy and resources by EU member states, as well as to increase the energy efficiency by 20% until 2020. EU countries agreed on a new framework for climate and energy policy which defines objectives for the period 2020 and 2030. Targets for 2030 are: a 40% cut in greenhouse gas emissions compared to 1990 levels, at least a 27% share of renewable energy consumption and at least 27% energy savings compared with the business-as-usual scenario (European Commission, 2014). Investments in energy renovation of buildings and houses can substantially contribute to the priorities of the Europe 2020 strategy. As European Commission (2015) state 'buildings are responsible for 40 percent of energy consumption and 36 percent of carbon dioxide (CO2) emission in the EU'. In Croatia, 42.3% of total energy consumption is consumed in buildings (Ministry of Construction and Physical Planning, 2014). Such data evidently shows the importance of investigating the effects of energy renovation of buildings. Research from the Buildings Performance Institute Europe (2011) states that the investment in energy efficiency is the

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most convenient way to achieve reductions in carbon dioxide emissions and that 30% of energy savings could be achieved from investments in energy renovation of buildings in the EU by 2020. Thus, Member States were called upon to promote investments in energy efficiency in public buildings and also to promote the conversion of old buildings to high energy performance and renewable energy sources. If significant energy and environmental effects of energy renovation of buildings actually exist, it is important to analyse the costs and socioeconomic impacts of such an investment as well.

The analysis of the impact of energy efficiency improvements has recently gained a lot of attention in the literature, but from different perspectives than those used in this article. The goal of this article is to analyse the socioeconomic impact of energy efficient renovation in the urban areas, the topic which is rarely analysed in the literature. To measure the impact we use the input–output method which enables the evaluation of impact of energy efficient renovations on employment, gross domestic product (GDP) and economic structure.

The structure of the article is as follows. The next section contains a literature overview focusing on the direct and indirect impact of energy efficient renovation on the economy. The third section deals with stylised facts about economic situation in Croatia, with a specific focus on the city of Zagreb as the capital city and typical urban area. Methodology is discussed in section 4 while section 5 presents the results of the empirical model and discusses some implications. Conclusions are drawn in the last section.

2. Literature review

The growing literature recognises the potentials of energy efficiency investments in the building sector. The effects of such investments have usually been observed from several different perspectives. The first group of papers analyse the correlation between energy prices and/or energy efficiency investment and energy consumption (e.g., Burman, Mumovic, & Kimpian, 2014; Hamilton, Steadman, Bruhns, Summerfield, & Lowe, 2013). The second group observe effects of energy efficiency investments from an environmental perspective (e.g., Germani, Landi, & Rossi, 2015; Konstantinou & Knaack, 2011; Nemry et al., 2010; Power, 2008). The third group of papers recognise the economic potential of energy efficiency investments and observes it from private and/or public perspective which is also the main goal of this article. Thus our literature overview mostly focuses on this part of the literature.

In recent years there have been numerous studies estimating the cost and impact of investing in energy efficient renovation of buildings which show that such investments have a significant impact on a variety of socio-economic processes. Ryan and Campbell (2014) identify multiple benefits of investment in energy renewal, which they systematise depending on which sector they have an impact on. They state that benefits for individuals, households and enterprises arise from improved quality of life and health, increased disposable income as well as improved supply-side efficiency (energy affordability and access). Investments in energy efficiency influence performance of various other sectors as well (industry, transport, services sector, etc.). The authors stress a positive impact of investments in energy efficiency on the level of industrial productivity and competitiveness, the quality of services by energy providers and the value of assets, particularly real estate. Besides indirect effects through the previously mentioned sectors, the national economy benefits from an increase in employment, energy-related public expenditures decrease and there is increased energy security. Increasing energy efficiency should also have a positive

Table 1. Estimation of the impact of energy efficiency investments on job creation.

Coverage of research	Impact of energy efficiency in buildings and houses on employment**	Source
Evaluation of effects of investments in energy renovation of buildings on employment	On average, 17 jobs per €1 million ***. Evaluations in various studies range from four to 83 jobs per million euro investment	Ürge-Vorsatz, Arena, Herrero, and Burcher (2010)
A review of research in energy renovation of buildings on employment	11–19 jobs per €1 million invested	Meijer, Visscher, Nieboer, and Kroese (2012)
Evaluation of the energy efficiency programme 'Energie Schweiz' in Switzerland	The total investment of €256 million * (of which €26 million in subsidies from the budget) influenced the creation of 2,600 jobs. Of the total, 73% were employed in the construction sector	Sauter and Volkery (2013) on the basis of the INFRAS (2007) research
Evaluation of impact of investments in energy renovation of buildings in the European Union	Annual investments in energy renovation of buildings of €40 billion would result in creation of about 760,000 jobs per year	Copenhagen Economics (2012)
The study of impact of investments in the energy efficiency of buildings on employment	An average of 19 jobs per €1 million*** of investments. The average is calculated based on the analysis of several researches in which the estimated impact is 6–58 jobs per million euro investments	Janssen and Staniaszek (2012)
The study of the impact of energy efficiency investments in the buildings on employment in the United States and European countries	It is estimated that €1 million of investments lead to the opening of 4 to more than 20 new jobs	Ministry of Construction and Physical Planning (2014B)

*The exchange rate of the Swiss franc to the euro is converted according to the annual rate of the Croatian National Bank for 2013.

**Results from different studies are not mutually comparable due to different coverage, applied methodology, used data and other reasons.

***Estimated based on the results of various studies.

Source: Authors.

macroeconomic impact due to the GDP growth, improving external trade in countries that depend on energy imports, increasing national competitiveness and increase the level of employment in the country. Looking at the international level, the benefits arise from the reduction of greenhouse gas emissions, changes in natural resources management and energy prices and contribution to achieving development goals.

Analysis of the employment impact has received special attention in the period since the 2008 financial crises when job creation became an important argument for supporting such programmes in EU countries. Estimations of the energy efficiency investments on employment are shown in Table 1.

The high costs of energy efficiency programmes raised the question of the return of such an investment and need for the (co-)funding of such programmes. Amstalden, Kost, Nathani, and Imboden (2007) used the discounted cash flow method to analyse profitability of energy-efficient retrofit investment in the Switzerland building sector. The result confirmed that such investments are profitable, from the house owner's perspective, if policy instruments (subsidies, income tax deduction, carbon tax) are used to support such investment. Rosenow, Platt, and Demurtas' (2014) and Copenhagen Economics' (2012) estimation of the fiscal impact of energy efficiency investments showed that such an investment influence revenue and expenditure side of the budget, and that the significant part of the support, could be offset by increased budgetary revenues and savings. Copenhagen Economics (2012) stressed that governments investing in energy efficient renovation of buildings could achieve net revenue gains as the result of decreased public spending on energy and health, reduced subsidies to energy consumption and expenses for unemployment, and improved economic activity.

The estimated effects of investments in energy renovation of buildings in the EU on public finances includes two scenarios, depending on how investments contribute to energy efficiency. Both indicate a large potential for energy savings due to the renovation of existing buildings (Copenhagen Economics, 2012). Experts from Copenhagen Economics (2012) estimate that for achieving energy savings from a scenario of low energy efficiency, a total gross annual investment of about 41 billion euros is needed in the period 2012–2020, according to the scenario of high energy efficiency an annual investment of 78 billion euros is needed. Investment in energy renovation of buildings in the EU may contribute to between 66 and 94 billion euros of the annual energy savings in the period 2012–2020, and twice as much if they reach the energy potentials for the coming 10-year period. In addition, experts from Copenhagen Economics (2012) estimate savings in public and private sectors. Starting from the data that the public sector is the owner of 7 % of residential buildings and 29% of other buildings in EU, they estimate that the energy efficient renovation of buildings could contribute to achieving energy savings in the public sector from 11 billion a year in a scenario of low energy efficiency and 15 billion a year in a scenario of high energy efficiency. During the period 2020–2030, savings would increase to between 21 and 29 billion euros a year. Reducing energy consumption causes a drop in budgetary tax revenues. According to estimates, revenues from taxes on energy would be reduced by between 5.2 and 7.2 billion euros a year by 2020. At the same time, the subsidies would decrease by 8 billion a year (regardless of which scenario works).

The main indirect benefits of energy renovation of buildings are the benefits to health, due to the reduction of air pollution. It is estimated that such a benefit, expressed in cash, could reach between 5 and 8 billion a year by 2020, with further growth in the coming years (Copenhagen Economics, 2012). Kuckshinrichs, Kronenberg, and Hansen (2010) use input–output methodology to estimate social and macroeconomic effects of energy efficiency investments in Germany and showed that conduction of such refurbishment programme cause significant social and environmental benefits. However, in contrast to the positive effects, the literature recognise the problem of rebound effects (Ryan & Campbell, 2014 and others) which reduces the benefits and needs to be taken into account when estimating economic impacts. The direct rebound effect occurs when improving energy efficiency leads to a reduction in prices of certain products and services and then lower prices caused by increased consumption of these products and services. The indirect rebound effect is due to an increase in demand for other goods and services due to the reduction in the price of energy and energy services. The macroeconomic rebound effect occurs when the improvement of energy efficiency leads to effects (for example, economic growth) for which there is an increase in energy consumption. Burman et al. (2014) stress that the rebound effect causes significant discrepancy between theoretical estimations and actual results and that energy savings are less than expected for renewal projects, while the energy use is larger than estimated for new buildings and houses in Europe.

3. Energy consumption, GDP and employment in Croatia and the city of Zagreb

Economic benefits from owners' perspectives and broader socioeconomic impacts of energy efficient investments are primarily related to current energy consumption and potential for future energy savings. Additionally, availability of unemployed resources is a crucial

Table 2. Gross domestic product per capita, Croatia and the city of Zagreb, 2001–2012.

	GDP p.c.				
	Croatia	The City of Zagreb	The City of Zagreb HR=100	Croatia EU27=100	The City of EU27=100
2001	43,748	75,429	172.4	51.0	87.0
2002	47,614	80,985	170.1	53.0	89.0
2003	52,312	90,927	173.8	55.0	95.0
2004	56,467	99,093	175.5	56.0	99.0
2005	60,807	109,798	180.6	57.0	103.0
2006	66,284	119,995	181.0	58.0	104.0
2007	72,612	129,742	178.7	61.0	108.0
2008	78,383	140,875	179.7	63.0	113.0
2009	74,703	134,018	179.4	62.0	109.0
2010	74,235	139,231	187.6	59.0	109.0
2011	77,654	140,560	181.0	61.0	109.0
2012	77,407	139,119	179.7	-	-
2012 (2001=100)	176.9	184.4	104.2	*119.6*	*125.3*
2012 (2008=100)	98.8	98.8	100.0	*96.8*	*96.5*
Average annual rate 2001–2008, %	8.7	9.3	0.6	*3.1*	*3.8*
Average annual rate 2008–2012, %	-0.3	-0.3	0.0	*-1.1*	*-1.2*

Source: CBS, Eurostat.

Table 3. Building stock in Zagreb by gross floor area (as % of Croatia and Continental Croatia).

	Total area (m^2)
Zagreb	25,789,993
% of Continental Croatia	26.9%
% of Croatia	17.3%

Source: Population Census 2011.

assumption of input–output analysis. An increase in demand will induce multiplicative effects only if producers are able to increase supply by engagement more labour and other production inputs. Because of that, this section presents an overview of energy consumption in dwellings and the latest development in GDP and employment in Croatia and the city of Zagreb as region with dominant share in the total gross flour area (Table 3). The main positive impacts from the investment in energy efficiency are expected in the construction industry which is the most seriously affected by the economic crisis in Croatia.

The impact of the financial crisis and economic downturn on the development of GDP per capita is shown in Table 2, which indicates average annual growth rates (nominal) of GDP per capita in Croatia and the city of Zagreb for both the pre-crisis period (2001–2008) and crisis period (2008–2012). Both Croatia as a whole and the city of Zagreb recorded steady growth of their GDP per capita until 2008, when the values peaked. High and sustained rates of economic growth resulted in consistent growth in per capita GDP over the 2001–2008 period. As a result, Croatia and Zagreb's per capita GDP converged towards the EU levels. However, since the onset of the economic crisis in 2008 both Croatia and Zagreb recorded a fall of their GDP per capita. The 2008–2012 period is characterised by clear divergence trends, in 2012 national GDP per capita was around 40 percentage below the EU-28 average, while GDP per capita of Zagreb was 9 percentage above the EU-28 average (in comparison to 2008 – 12 percentage above the EU-27 level).

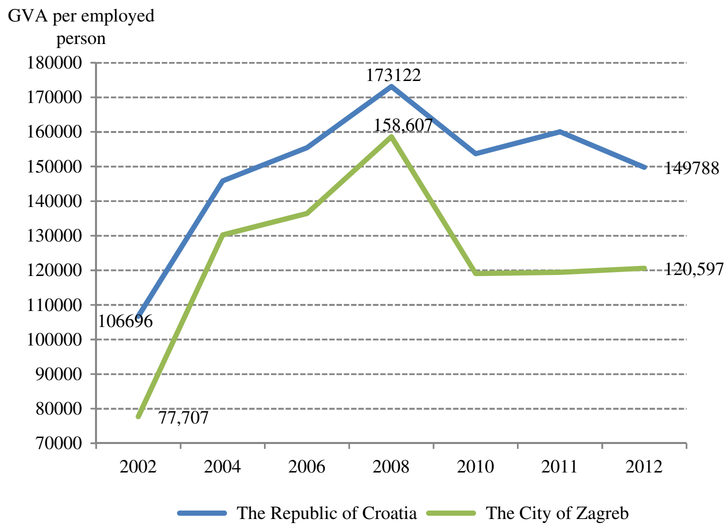

Figure 1. Labour productivity: construction industry, Zagreb and the Republic of Croatia (2002–2012). Source: Authors' calculations based on CBS data.

During the financial and economic crisis, GDP per capita in Zagreb dropped from a high of 140,875 Croatian Kuna (HRK) in 2008 to HRK 134,018 in 2009 before partially recovering to HRK139,231 in 2010 and then moving on to a level that was slightly below its pre-crisis peak, with an average of HRK 140,560 in 2011 and HRK 139,119 in 2012. The overall development of GDP per capita during the period from 2008 to 2012 in Zagreb and Croatia was negative. The average annual growth rate of the GDP per capita for both Zagreb and Croatia between 2008 and 2012 was -0.3%.

Employment rose in the pre-crisis years until 2008 when it reached its peak, and started falling again in the subsequent years. While from 2002 to 2008 there was a continuous growth in employment both in the capital town of Zagreb and at national level, employment contracted sharply in 2009. The number of employed people in Zagreb decreased by 7.4% between 2008 and 2013 (31,116 employees), while the state-level employment in the same period decreased by as much as 12.3% (188,530 employees).

The emergence of the economic crisis stopped the previous longer lasting trend of strong growth in construction. Until 2008, the construction industry in Croatia showed constant growth. However, since the onset of the economic crisis the Croatian construction industry has been faced with the significant decline. During the 2002–2008 period the gross value added (GVA) of the construction industry in Zagreb increased by 20% a year, while between 2008 and 2012 it recorded an average annual decline of 14.2%. Results from these developments have also spread to employment, which shows a decrease of 28.6% during 2008–2012 period. Thereby, a fall in productivity in the construction industry can be considered as a direct consequence of this process (see Figure 1). Energy efficiency projects potentially become a driving force of new economic momentum in the conditions of post-crisis economic recovery in Zagreb.

Residential consumption is the largest consumer of energy in Croatia, about 30% of total final energy consumption, and the largest users of electricity, over 40% of total final electricity consumption (Ministry of Economy, 2009). The most recent data available for 2014 shows that out of total energy consumption in Croatia, consumption in buildings accounts for as much as

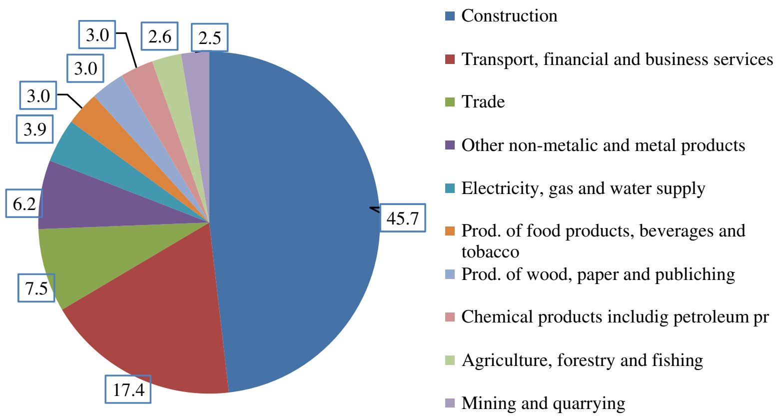

Figure 2. Structure of total gross output induced by investment energy efficient renovation, by industries, in %. Source: Authors.

42.3% (Ministry of Construction and Physical Planning, 2014). According to the Draft of the Energy Strategy of the Republic of Croatia, energy efficiency policy in the residential sector shall be based on raising public awareness on possible savings and incentives to plan and build residential buildings in harmony with the principles of energy efficiency. This energy efficiency package, among others, includes financial incentives for implementation of energy efficiency measures through the Environmental Protection and Energy Efficiency Fund.

Initial specific energy consumption in residential buildings of different ages in the Continental Croatia is presented in Table 4. As data for Zagreb are not available, the reference area for buildings in Zagreb relates to Continental Croatia. Residential buildings built after 1987 are about 25% more energy efficient than the older buildings (built before 1970).

If average consumption per square metre (on heating, cooling, lighting and hot water) is multiplied by the average size of a dwelling unit, the result is annual energy consumption per dwelling unit. To estimate the average annual expenditures of households on energy used, average annual consumption per dwelling unit is multiplied (average consumption from Table 4) by an average of 0.50 HRK. According to estimations, the average household in Continental Croatia would spend approximately 10,000 HRK annually for heating, cooling, hot water preparation and lighting of the building (Table 5). If energy consumption for cooking and use of various home appliances is added (based on official data from energy balances), then the average household expenditure on energy used could be estimated to be approximately 13,700 HRK on an annual level, or approximately 1150 HRK on a monthly basis.

Data on energy consumption in residential buildings in the Zagreb are presented in Table 6. Data are collected by way of a survey which covered only the region of Zagreb and can be assumed as more reliable. Data points to the conclusion that average energy consumption per m2 in residential dwellings in Zagreb amount to 180 kWh.

4. Methodology

4.1. Net present value of energy efficient renovation investments

The economic impacts of investing in energy renovation of buildings are analysed from two different perspectives: from the viewpoint of owners and the viewpoint of overall society.

Table 4. Specific annual energy consumption for reference residential building, kilowatt hour (kWh) per m2, Continental Croatia.

	Age	Total area		kWh per m^2					
		m^2 Mio	% of Croatia	Heating	Cooling	Hot water	Lighting	Used energy	Delivered energy
Houses	Before 1970	24,5	63.5%	330.8	0.0	14.8	13.2	358.7	358.7
	1970–1986	25,6	64.8%	277.5	0.0	15.0	9.5	302.0	302.0
	1987–	12,7	64.9%	242.9	0.0	15.1	9.4	267.5	267.5
	Total	62,8	64.3%	291.3	0.0	14.9	10.9	317.0	317.0
Multifamily				Heating	Cooling	Hot water	Lighting	Used energy	Deliveredenergy*
dwellings	Before 1970	12,9	63.5%	143.0	19.9	16.0	21.8	200.6	267.6
	1970–1986	13,4	64.8%	93.9	27.0	16.0	18.9	155.7	232.9
	1987–	6,7	64.9%	37.6	25.2	16.0	19.9	98.7	101.6
	Total	33,0	64.3%	101.7	23.9	16.0	20.2	161.7	219.9

*Delivered energy according to the reference building besides energy used includes energy losses in production and distribution of energy.
Source: EIHP, 2014 http://www.mgipu.hr/doc/Propisi/EIHP-014-0185-01-06_vi%C5%A1estamb.pdf.

Table 5. Households expenditures on energy used in residential dwellings, Continental Croatia.

		Delivered Energy kWh per m^2	Costs per m^2	Average size of unit (in m^2)	Average annual consumption per unit in HRK
Houses	Before 1970	358.7	179.35	70	12,555
	1970–1986	302	151	96	14,496
	1987–	267.5	133.75	104	13,910
Multifamily dwellings	Before 1970	267.6	133.8	1,424	190,531
	1970–1986	232.9	116.45	1,123	130,773
	1987–	101.6	50.8	923	46,888
Average houses and multifamily dwellings		250.6	125.3	80.9	10,137
Cooking and home appliances		45	44.1	80.9	3,568
Total energy in residential buildings		295.6	169.4	80.9	13,704

Source: Authors.

Table 6. Energy consumption in residential buildings in Zagreb.

Energy sources	Number of households	Residential area (m^2)	Energy consumption (MWh)	Consumption per m^2 (kWh/m^2)	Structure of energy	Prices HRK/kWh
Centralised heating system	92,146	5,038,332	1,052,244	208.85	31.7	0.425
Natural gas	131,664	9,268,878	1,556,681	167.95	46.9	0.42
Liquid fuel	22,242	1,855,537	311,632	167.95	9.4	0.71
Wood	19,492	1,638,704	275,216	167.95	8.3	0.3
Electricity	14,810	731,655	122,879	167.95	3.7	0.98
Total	280,354	18,533,107	3,318,652	179.07		0.45*

*Average price is calculated as weighed average of energy prices and weights are derived from structure of energy consumption.

Source:http://www.eko.zagreb.hr/UserDocsImages/dokumenti/energija/-024%20Program%20energetske%20u%C3%84%C5%A4inkovitosti.pdf

Owners of dwellings are primarily concerned with financial savings in the future due to lower energy consumption and value of investments in energy efficient renovation. In addition, the renovation may also yield other benefits (Kuckshinrichs et al., 2010), including an increase in the value of the building, an increase in the expected life of the building and an increase in comfort for the inhabitants. According to the theory, the value of the dwelling is determined by the present value of the future rental income. In the Croatian case, more than 90% of dwellings are occupied by their owner and that income should be imputed. According to the national accounts methodology, imputation for dwelling services for new EU member states is based on cost principle (consumption of fixed capital and imputed net operating surplus) and not on actual income. In principal, energy renovation measures do not affect the useful life of the building because they comprise only improvements of the insulation of walls and roof and the installation of more energy efficient windows and doors which have service life shorter than building life. Net present value (NPV) of investment from an owner perspective is therefore primarily determined by future energy savings and the following formula is applied:

$$NPV_{i,N} = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t} = R_0 + \sum_{t=1}^{N} \frac{R_t}{(1+i)^t} \qquad (1)$$

Where:

R_0 is the initial investment.

R_1 to R_N are the yearly savings as a sum of the energy savings costs.

N is the expected lifetime of the measure.

i is the discount rate.

Other assumptions are the following:

Lifetime for packages of measures is 20 years, which is average period proposed by EU regulation[1],

- Discount rate used is 4% as proposed in Guide to Cost-benefit Analysis of Investment Projects, Economic appraisal tool for Cohesion Policy 2014–2020.
- The residual value of the measure is zero.
- Energy prices are assumed constant in real terms (constant 2014 prices).

As this article is primarily focused on urban areas, NPV is calculated for multi-apartment buildings, having in mind construction period (three periods depending on the available data on reference building) and region (Continental and Adriatic Croatia). All calculations are based on three different energy renovation types. Marks A, B and C refer to the expected energy consumption after renovation and depend on building envelope renovation (wall, roof and floor insulation and windows).

4.2. Socioeconomic impacts

As stated in literature review, energy efficient renovation could potentially affect various socioeconomic variables. In the article, other benefits are quantified in three areas: economic activity and employment, fiscal impact assessment and environmental impact measured by reduction of CO_2 emissions. Other positive externalities as an improvement in the quality of life, energy security and power reduction cannot be quantified without more detailed structural surveys which are not available.

Estimation of overall socioeconomic impact of the energy efficient renovation of urban areas was based on input–output technique. An input–output analysis is based on a static presentation of structural relationship among economic sectors developed by Leontief (1986). It is mainly oriented to the estimation of the impact of final demand on domestic output, value added and employment and is the most appropriate method applied for identification of supply chains on domestic and international market.

In the input–output framework, matrix A presents technical coefficient matrix (ratios of inputs of each industry in the gross output of the certain industry), x is vector of gross output and y vector of final demand. The following set of equations can be derived:

$$Ax + y = x \tag{2}$$

$$x - Ax = y \tag{3}$$

$$(I - A)x = y \tag{4}$$

The solution of this linear equation system is:

$$x = (I - A)^{-1} * y \tag{5}$$

Matrix algebra is further used in multiplying matrix of unit inputs (domestic and intermediate consumption, employment and value added) by total of domestic gross output induced by foreign demand:

$$V = v(I - A)^{-1} * y \tag{6}$$

V is value of inputs (vector of value added, intermediate consumption and employment) and v is technical input coefficient (input component per unit of output - V/Y).

Vector Ax reflects the requirements for intermediates, while vector y represents the exogenous aggregate final demand (value of investment in energy efficient renovation in this study). The matrix (I-A) is usually called the Leontief matrix. On the diagonal of this matrix the net output is given for each sector with positive coefficients (revenues) while the rest of the matrix covers the input requirements with negative coefficients (costs). The Leontief inverse $(I\text{-}A)^{-1}$ reflects the direct and indirect requirements for intermediates. The notion of multipliers rests upon the difference between the initial effect of an exogenous change in final demand and the total effects of that change on domestic economy. An investment multiplier for energy efficient renovation is defined as the total value of production in the terms of gross output of all domestic sectors that is necessary to satisfy an additional unit in the value of initial investment.

Energy efficient renovation of residential and public buildings directly induces additional demand for the construction industry which is a labour intensive activity. Unlike construction of new multi-apartment buildings, the renovation of existing buildings is more attractive for the engagement of small and medium companies and crafts active in regional market. As a positive result of the project, the following effects on employment should be expected:

- Direct impact – an increase of GVA and employees directly engaged in the renovation – employment in construction industry (e.g., wall and roof insulations) and associated services (e.g., energy audits, design and supervision);
- Indirect impact – an increase of indirect employment in industries which produce materials and equipment which construction companies use as intermediate consumption in the reconstruction work (construction materials, transport, etc.).
- Induced employment – as a result of increased number of employees, which are directly and indirectly engaged by the projects, total disposable income and consequently overall personal consumption of households are increasing which induces additional demand and employment in industries which produce goods and services for consumption of households.

An additional positive impact on employment arises from the spending of money saved on energy, on other types of products. As production of energy is more capital intensive, a decrease in the number of people employed in the energy sector is generally significantly lower than the increase in employment in other sectors of the national economy. In the case of Croatia, it is to be expected that energy savings will not significantly affect domestic employment in the energy sector, because of a high share of imported energy products, which are to be reduced.

Table 7. Net present value of investments in energy efficient renovation from the viewpoint of owners.

Region/ Renovation measures	Energy delivered	Savings, in kwh per m²	Investment per m²	Average energy prices HRK per kwh	Discount rate	Annual savings in HRK	NPV	NPV/INV (in%)
Continental	*Multi-apartment building constructed before 1970, current consumption* = **245**							
Label C	126	119	1,093	0.45	4.0	53.6	365	-33
Label B	91	154	1,526	0.45	4.0	69.3	-584	-38
Label A	18	227	2,346	0.45	4.0	102.0	-960	-41
Continental	*Multi-apartment building constructed 1971–2005, current consumption* = **214**							
Label C	106	108	957	0.45	4.0	48.6	-296	-31
Label B	73	141	1,336	0.45	4.0	63.5	-474	-35
Label A	19	195	2,034	0.45	4.0	87.9	-840	-41
Continental	*Multi-apartment building constructed after 2005, current consumption* = **82**							
Label C	71	11	1,398	0.45	4.0	4.9	-1,332	-95
Label B	58	24	1,665	0.45	4.0	10.8	-1,519	-91
Label A	15	67	2,864	0.45	4.0	30.1	-2,455	-86
Adriatic	*Multi-apartment building constructed before 1970, current consumption* =**187**							
Label C	72	115	1,309	0.55	4.0	63.5	-446	-34
Label B	52	135	1,317	0.55	4.0	74.1	-309	-23
Label A	40	147	1,326	0.55	4.0	80.9	-226	-17
Adriatic	*Multi-apartment building constructed 1971–2005, current consumption* = **100**							
Label C	52	48	1,283	0.55	4.0	26.3	-829	-70
Label B	42	58	1,291	0.55	4.0	31.8	-858	-66
Label A	36	64	1,256	0.55	4.0	35.3	-776	-62
Adriatic	*Multi-apartment building constructed after 2005, current consumption* = **63**							
Label C	45	18	1,462	0.55	4.0	10.0	-1,326	-91
Label B	43	20	1,850	0.55	4.0	10.8	-1,703	-92
Label A	35	28	1,678	0.55	4.0	15.6	-1,466	-87

Source: Authors.

5. Results

5.1. Net present value of energy efficient renovation investments

As presented previously, energy consumption in dwellings makes up a significant proportion of the total energy consumption in Croatia. The additional feature of urban areas is related to the presence of older and energy inefficient buildings. Contrary to the other building areas, reconstruction of older parts of towns are frequently regulated by laws regarding the protection of historical and cultural heritage which significantly reduce the potential scope of energy efficient measures and increase the value of investments. From the owners' perspective, the return period of investments in energy savings in urban areas is relatively long, and due to income and credit constraints it is not reasonable to expect that owners will find it profitable to finance energy saving renovations without public support. Results on expected NPV of investments are presented in Table 7. It can be seen that energy efficient renovations in general are not financially viable from the viewpoint of owners, although significant energy saving is expected. NPV for all renovation measures, regions and construction periods of buildings are negative. The higher energy savings are expected in Continental Croatia due to the less favourable weather conditions. In the continental part of Croatia, most apartments use district heating and natural gas as a primary energy source for heating and average energy prices are lower in comparison to Adriatic Croatia, where more households are reliant on electricity.

In order to promote energy efficient renovations of dwellings, the Croatian Government adopted a programme of reconstruction for multi-apartment buildings in the period to 2020, which determine grant schemes for investment in measures which decrease energy consumption of dwellings. All Croatian territory is eligible for grants of 40% of investment value, while households in the less-developed areas in Croatia can apply for additional government funds of up to 80% of investment value.

5.2. Socioeconomic impact of energy efficient renovations

5.2.1. Increase of gross value added and employment

As stated previously, renovation programme induce an increase in the demand for production units directly engaged by investors, mainly construction companies. Therefore, due to higher output, the construction industry will need additional intermediate inputs like insulation and other construction materials, wood products or transport services. All those industries included in the supply chain of the construction industry will increase their intermediate consumption of various products used in their production processes. Increase of direct and indirect demand affects additional demand for labour, but also induces public revenues in the form of value added taxes (VAT), other taxes on goods and services, direct taxes on income and profits and social security contributions.

According to the results of input–output model, direct increase of GVA, gross output and employment multipliers of the energy saving investment in energy efficiency of buildings are estimated to be between 2.5 and 2.9.

Based on multipliers calculated from the Croatian input–output table, an investment of 1 million euros results in approximately 29 persons employed. In comparison to results in similar studies for developed European countries, the expected impact of investments in Croatia on job creation is more intense. Factors behind that conclusion are lower levels of development, lower prices and lower labour productivity of the Croatian economy in comparison to more developed countries.

Regarding distribution by economic activity, the most important positive impact is expected for the construction industry, transport, trade and production of other non-metallic and metal products which are industries most affected by recession (presented by Figure 2).

5.2.2. Increase of government revenues

Additional government revenues related to refurbishment programmes is estimated using an open input–output model which was extended to present all the relevant sources of public revenues. Different types of revenues are estimated separately:

- VAT directly related to the investments;
- Taxes on wages and salaries including social security contributions;
- All other government revenues (excises, taxes on income and wealth, taxes on goods and services excluding VAT, other taxes and non-tax revenues).

Investment in energy efficient renovations in Croatia was subject to the standard 25% VAT rate. However, construction companies have the right to decrease tax obligation for VAT paid on intermediate goods and services. On the other hand, VAT obligation on indirect and induced deliveries spread over entire economic system and should be also included in estimate of total VAT related to initial investment. The weighted average rate (WAR) of VAT is applied on increase of tax base (including indirect and induced demand), calculated by input–output approach.

Table 8. Direct, indirect and induced impact of energy efficient investment of 1 mil. euro (VAT excluded.)

	Domestic gross output	Domestic gross value added	Employment (number of persons employed)
Direct (mil. euros)	0.95	0.35	11.5
Indirect (mil. euros)	0.82	0.34	9.6
Induced (mil. euros)	0.64	0.32	8.0
Total (mil. euros)	2.41	1.02	29.1
Multiplier	2.53	2.91	2.53

Source: Authors.

Table 9. Estimate of public revenues related to energy efficient renovation per investment of 1 mil. euro.

Revenue types	HRK, in 000	EUR, in 000	Share in gov. revenues	Share in GVA
Taxes on wages and salaries including social contributions	1,418.8	189.2	44.8	18.6
VAT	1,098.2	146.4	34.7	14.4
Other government tax and non- tax revenues	651.3	86.8	20.6	8.5
TOTAL	3,168.2	422.4	100.0	41.5

Source: Authors.

Income tax from increased employment is also based on input–output approach which is able to quantify total number of persons employed in relation to increased investment activity. Each job directly related to the energy efficient renovation project makes 2.53 additional employment in the overall economy (the employment multiplier is presented in Table 8). The income tax of the employment is based on total number of newly created jobs and effective income tax rates including social security contributions. Calculation is done separately for construction industry which is characterised by below average levels of wages and salaries and government revenues from employment in rest of the economy where the average ratio of taxes and contributions in gross wages is applied. All other government revenues including excises, taxes on income and wealth, other taxes on goods and services and other revenues are based on effective implicit tax rates in terms of GVA.

In some scientific research (Rosenow et al., 2014) additional benefits for government sector as avoided cost of unemployment and health impacts are also included. Table 9 presents results on estimated government revenues related to energy efficient renovation investments (in terms of additional amount of revenues in HRK per million euro invested).

5.2.3. Reduction of air pollutants emissions

In economic terms, costs related to emission of air pollutants are regarded as negative externality. Climate change as a consequence of emissions has a significant impact on overall society. Measurement of externalities is related to numerous theoretical and empirical difficulties which are beyond of the scope of this article. According to the literature, marginal damage of the emissions has to be equal to the marginal abatement costs and because of that in long-period external costs related to the marginal damage of emissions is expected to increase (Kuckshinrichs et al., 2010).

The quantification of the economic value of reduction of air pollutants' emissions is based on expected energy savings, emission factors per energy source and average investment costs. Energy consumed by households should be transformed to primary energy

Table 10. Energy consumption and CO_2 emission by energy source.

	Primary energy factor	CO_2 emission, $kgCO_2/GJ$	Energy consumption in households in GWh*
Coal	1.082	105.13	58.3
Wood	1.111	8.08	3,802.8
Natural gas	1.097	61.17	6,955.6
Liquid fuel	1.14	83.21	2,719.4
Electricity	1.614	65.22	6,941.7
District heat energy	1.53	100.69	1,791.7
AVERAGE/TOTAL	1.3	60.00	22,269.5

*1 gigawatt hour (GWh) = 3,600.00 gigajoules (GJ).
Source: Energy balances, EIHP (2014).

using appropriate factors (primary energy factors for Croatia are based on Ministry of Construction and Physical Planning data (MGIPU, 2015). According to expected energy savings (Table 10) and structure of multi-family buildings by region and construction year, it could be expected that energy savings in terms of energy delivered could amount to approximately 130 kWh/m2 on annual level.

If primary energy factor (including transformation and transportation losses) is taken in consideration total savings of primary energy per m2 could be estimated at 169 kWh/m2. Investment in energy efficient renovation can be estimated on approximately 1500 HRK (200 EUR) which means that 5000 m2 of useful areas of multi-family buildings could be renovated costing 1 million euros. If the renovated area is multiplied by primary energy savings, the result of 845 MWh (or 3042 GJ) is the estimate of total primary energy savings per million of euro invested. Reduced CO2 emissions per 1 million euros invested in energy efficient renovation could be an estimated at 182.5 tonnes which in monetary terms amounts approximately HRK 28,500 (3650 euros).

6. Conclusion

Energy saving renovation has to be viewed not only from owners' perspectives but also from a broader perspective which includes expected benefits for overall society. Due to positive externalities, energy efficient reconstruction of urban areas could speed-up process of realisation of development goals defined by national and European strategic documents. Due to persistent recession in recent years and weak demand on the real estate market, the construction industry in Croatia is the sector which is the most seriously affected and all indicators related to this industry point to a constant decrease of economic activity. Investment in energy saving renovations of Croatian urban areas could potentially induce growth in the construction sector and in overall economic activity.

Returns in the long-term, high investment costs, insufficient disposable income of households, indebtedness and financial constraints are the main factors which negatively affect the attractiveness of energy savings projects from the owners' viewpoint. It is not expected that owners will undertake those projects to a significant extent without government support. On the other hand, due to positive impacts of those projects on employment, government revenues, import dependence and protection of the environment, energy efficient renovation projects could be very important for society.

According to the results based on input–output methodology, the total multiplier of the funds invested in energy saving renovations of Croatian urban areas is in the range between

2.5 and 2.9, meaning that one unit of initial investment through direct, indirect and induced effects significantly contribute to the GDP growth and employment and induce almost three times higher value of gross output on the national level. Total public revenues including indirect and induced effects of energy efficient renovations are estimated to be higher than 40% of investment value. It means that government grant levels up to 40% of investment could significantly improve financial viability from owners' perspectives and not cause a deterioration of public deficit. In combination with EU funds, government funds allocated to energy efficient programmes could induce a broad range of other positive impact including environment protection and overall quality of life.

Note

1. According to Annex 1 to Commission Delegated Regulation (EU) 480/2014, the recommended reference period for energy efficiency investments is from 15–25 years.

Disclosure statement

No potential conflict of interest was reported by the authors.

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