Prof. Nela Vlahinić-Dizdarević, Ph.D.
University of Rijeka, Faculty of Economics
I. Filipovića 4, Rijeka
Tel. ++385 51 355 166 Fax: ++385 51 212 268
nela@efri.hr

Duško Radulović, MSc.
Energo Rijeka
Dolac 14
Tel.: +385 51 353 006 Fax.: +385 51 353 007
dusko.radulovic@energo.hr

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ENERGY EFFICIENCY AND URBAN ENERGY MANAGEMENT: THE CASE OF THE CITY OF RIJEKA[1]

ABSTRACT

The aim of the paper is to analyse costs and benefits of the investments in improving energy efficiency of the public sector. We analyse feasibility and environmental impacts of the investments in public lighting and solar electricity production in the case of the city of Rijeka in order to see the economic and environmental acceptability of these investments. The paper also includes the wider methodological framework by explaining different approaches in the measurement of the energy efficiency. The changes in energy efficiency and energy intensity in Croatia during the 1995-2008 period are discussed and connected with the structural changes in Croatian economy during the transition process.

Key words: *energy efficiency, energy intensity, Croatia, city of Rijeka*

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1. INTRODUCTION

Today the issue of energy efficiency has become a crucial topic in public, academic and business discussions. Policy makers have become aware of the importance of energy efficiency because it offers a powerful and cost-effective tool for achieving a sustainable energy future. Improvements in energy efficiency can reduce the fuel costs and increase competitiveness, decrease the need for investment in energy infrastructure and achieve environmental benefits by reducing greenhouse gases emissions and local air pollution. There is a wide scope of public policies in order to increase energy efficiency, but there are some important market barriers to energy efficiency. Proponents of pro-active energy-efficiency policy argue that these barriers have led to substantial misallocation of resources and underinvestment in energy-efficient technology. Therefore public policies are necessary to reduce the economic distortion caused by the market's failures.

In new circumstances that are burden with climate changes, new environmental regulation and liberalization of energy markets, local governments are also encouraged to implement energy management. Recent developments in European cities, empowered by signing of the Covenant of Mayors indicate that local government's power can become significant factor in the decision making policy for energy management and sustainable development.

Therefore the aim of this paper is to analyse costs and benefits of the investments in improving energy efficiency of the public sector. We analyse feasibility and environmental impacts of the investments in public lighting and solar electricity production in the case of the city of Rijeka. Financial analysis together with the energy consumption and environmental impact research will be carried out in order to see the economic and environmental acceptability of these investments. The paper will also include the wider methodological framework by explaining different approaches in the measurement of the energy efficiency. We shall also analyse the changes in energy efficiency and energy intensity in Croatia during the 1995-2008 period and relate them with the structural changes in Croatian economy during the transition process.

2. ENERGY EFFICIENCY: DEFINITION AND MEASUREMENT

Increased energy efficiency can be achieved by new technologies. A technology that yielded true cost savings would stimulate the demand for energy services and induce a «rebound effect» that would partially offset the direct energy savings generated by enhanced energy efficiency. This effect is caused by more efficient technologies that lead to increased use of energy, which is known as "macroeconomic feedback" (Howarth, 1997) or rebound effect. In extreme cases, the resulting growth in energy services might more than offset the direct effects of enhanced technologies so that improved energy would paradoxically lead to increased energy use (Brookes, 1990; Saunders, 1992).

Energy intensity measures are often used to measure energy efficiency and its change over time. Energy intensity is the most commonly used basis for assessing trends in energy efficiency since a truly technical definition of energy efficiency can only be obtained through measurements at the level of a particular process or plant. Energy intensity is thought to be inversely related to efficiency, the less energy required to produce a unit of output or service, the greater the efficiency. A logical conclusion, then, is that declining energy intensities over time may be indicators of improvements in energy efficiencies (Nanduri, 1998, p. 10)

Still, energy-intensity measures are at best just a proxy for energy efficiency. The reason is that energy intensity may mask structural changes that are not "true" efficiency improvements. Energy intensity is defined as the ratio of energy consumption to some measure of demand for energy services, usually gross domestic product (GDP). Primary energy intensity measures how much energy is required by each country or region to generate one unit of GDP. It is therefore more an indicator of "energy productivity" than a true indicator of efficiency from a technical viewpoint. Its level reflects the nature of the economic activity (the "economic structure"), the structure of the energy mix, the climate, and the technical energy efficiency. Trends in energy intensities are influenced by changes in the economic and industrial activities of the country ("structural changes"), the energy mix, and the efficiency of end-use equipment and buildings. GDP can also be calculated using purchasing power parities rates (PPP) in order to reflect differences in general price levels. Using PPP rates instead of exchange rates increases the value of GDP in countries with low costs of living, and therefore decreases their energy intensities. Energy intensities at PPP are more relevant as they relate the energy consumption to the real level of economic activity. The use of PPP greatly improves the comparability of energy intensities between countries with different levels of economic development because it narrows the gap between countries, compared to the use of exchange rates. The intensities are measured at constant prices and exchange rates: therefore, the use of purchasing power parities changes the magnitude of the indicators but does not affect the trends. (World Energy Council, 2008)

Its interpretation is sometimes questionable for countries where part of their economic activity is informal and is not accounted by the GDP, and where the use of traditional fuels is significant, as their consumption is not usually well monitored. Indicators of energy intensity are useful, but one should bear in mind that the underlying components are critical to interpretation. Without a structural context, these indicators can be misleading and lead to incorrect conclusions. The structural context is also important because it shows where policy might or might not be directed. Generally, an increase in energy efficiency is when either energy inputs are reduced for a given level of service, or there are increased or enhanced services for a given amount of energy inputs.

There are more approaches in measuring energy efficiency (EIA, 2010):

Market-basket approach estimates energy-consumption trends for a controlled set of energy services (the market basket) with individual categories of energy services controlled relative to their share in the index. This method of indexing is a type of "bottom-up" approach.

Comprehensive Approach attempts to take all energy use into account. The comprehensive approach starts the measurement process with the broadest available measures of energy use and demand indicators available. Over time, changes in such measures reflect changes such as changes in behaviour, weather, structure, and energy efficiency. The effects, unrelated to changes in energy efficiency, are then removed. This approach can be thought of as a "top-down" approach.

Factorial Decomposition Approach applies Laspeyres indices to decomposing changes in energy use to produce growth rates of change in energy use for a particular effect. Energy use is decomposed into an activity effect, structural effect, and an intensity effect. Each of these effects is measured by holding the other two constants. This approach is used by the International Energy Agency.

Divisia Index Approach is used to decompose time trends into the different factors such as structural and intensity. The results may measure energy savings over time and uses time trend data. (Boyd et.al., 1988)

The ODYSSEE project is using an alternative indicator, called ODEX (ODYSSEE index), which replaces the overall energy intensity to monitor energy efficiency trends in the EU. It measures the energy efficiency progress by main sector (industry, transport, households) and for the whole economy (all final consumers). For each sector, the index is calculated as a weighted average of sub-sectoral indices of energy efficiency progress; sub-sectors being industrial or service sector branches or end-uses for households or transport modes. The sub-sectoral indices are calculated from variations of unit energy consumption indicators, measured in physical units and selected so as to provide the best "proxy" of energy efficiency progress, from a policy evaluation viewpoint. The weight used to get the weighted aggregate is the share of each sub- sector in the total energy consumption of the sub –sectors considered in the calculation.

ODEX indicators represent a better proxy for assessing energy efficiency trends at an aggregate level (e.g. overall economy, industry, households, transport, services) than the traditional energy intensities, as they are cleaned from structural changes and from other factors not related to energy efficiency (more appliances, more cars…). For example, a value of ODEX equal to 90 means a 10% energy efficiency gain.

The weighting system used to calculate ODEX has been defined in such a way that ODEX is equal to a rate of energy savings, i.e. the ratio between the actual energy consumption (E) of the sector in year t and actual energy consumption (E) without energy savings (ES):

$$ODEX = (E/(E+ES)) * 100.$$

The energy savings are calculated as the sum of energy savings of each underlying sub-sector /end-use without:

$$ODEX = E/(E+ES) * 100$$

There is a wide scope of public policies in order to increase energy efficiency, but there are some important market barriers to energy efficiency. Understanding these barriers or failures have come from many disciplines, including economics, engineering, sociology, anthropology and psychology. Important differences in opinion remain regarding the nature of these barriers and whether they constitute an appropriate justification for government intervention. The efficiency gap, a phrase now widely used in the energy-efficiency literature, refers to the difference between levels of investment in energy efficiency that appear to be cost effective based on engineering-economic analysis and the (lower) levels actually occurring (Golove and Eto, 1996). Efficiency programs help correct market failures that inhibit consumers and businesses from investing money in efficiency measures that require an up-front investment to deliver lasting benefits. Examples of these market failures include (Howland and Murrow, 2009):

- *Liquidity Constraints* – when a consumer or business has inadequate access to capital to purchase efficient equipment or improve building energy performance

- *Split Incentives* – when the owner of a piece of equipment or building (the landlord) does not pay the energy bill and is thus unlikely to invest in efficiency improvements that would benefit the resident/renter

- *Information Problems* – when purchasers do not know the future energy costs of a product or property and are thus unlikely to invest in the more efficient option with a higher upfront cost

- *Behavioural Problems,* such as bounded rationality – when the complexity of a decision is beyond the ability of a consumer to make an economically optimal choice

Proponents of pro-active energy-efficiency policy argue that these barriers have led to substantial misallocation of resources and underinvestment in energy-efficient technology. Therefore public policies are necessary to reduce the economic distortion caused by the market's failures. An opposite group of economists grants the existence of market failures, but they argue that they do not provide sufficient conditions for intervention. This group argues that a cost/benefit or net social welfare analysis is necessary to determine whether any proposed policy intervention is appropriate. A third group argues that the market as currently structured is functioning efficiently and any intervention will necessarily reduce overall social welfare. However, the most of economists believe that government intervention in the energy service markets and pro-active energy-efficiency policies will lead to increased energy efficiency.

3. ENERGY EFFICIENCY IN CROATIA

3.1. Economic growth and structural changes

During the 1990s Croatia has experienced the sharp decline in industrial production and GDP, high unemployment, public and current account deficits. Macroeconomic crisis known as transition depression has been especially deep for all Southeast European countries but the year 2000 was the turning point for the economic growth and much more favourable macroeconomic environment. Relatively high rates of GDP growth after 2000 in Croatia were the result of high consumption and investments, while exports stagnated and imports increased due to poor competitiveness and strong national currency. Such a growth model based on domestic consumption and cheap imports inevitably led to deindustrialization. Table 1 shows the GDP structure according to the share of gross value added.

Table 1 The structure of gross value added by the NCEA (at current prices), 1998-2005

	1998	2000	2002	2005
A Agriculture, hunting and forestry	7.7	7.2	6.7	5.4
B Fishing	0.2	0.2	0.2	0.2
C Mining and quarrying	0.5	0.6	0.5	0.7
D Manufacturing	17.9	17.6	15.6	14.9
15 Manufacture of food products and	3.4	3.2	3.1	3.0
beverages	0.3	0.5	0.4	0.3
16 Manufacture of tobacco products	0.4	0.3	0.3	0.3
17 Manufacture of textile	0.9	0.8	0.8	0.6
18 Manufacture of wearing apparel,				
dressing and	0.3	0.3	0.3	0.2
dyeing of fur				
19 Tanning and dressing of leather,	0.6	0.5	0.5	0.5
manufacture of				
luggage, handbags, saddlery, harness and	0.3	0.4	0.4	0.3
footwear	1.0	1.0	1.0	0.9
20 Manufacture of wood and or products of				
wood	2.3	2.6	1.2	1.5
and cork, except furniture				
21 Manufacture of pulp, paper and paper	2.2	2.3	1.5	1.2
products	0.5	0.4	0.4	0.4
22 Publishing, printing and reproduction of	0.9	1.0	1.1	1.1
recorded				
media	0.3	0.2	0.3	0.2
23 Manufacture of coke, refined petroleum	1.0	0.9	1.2	1.2

products and nuclear fuel 24 Manufacture of chemicals and chemical products 25 Manufacture of rubber and plastic products 26 Manufacture of other non-metallic mineral products 27 Manufacture of basic metals 28 Manufacture of fabricated metal products, except machinery and equipment 29 Manufacture of machinery and equipment n.e.c. 30 Manufacture of office machinery and computers 31 Manufacture of electrical machinery and apparatus 32 Manufacture of radio, television and communication equipment and apparatus 33 Manufacture of medical, precision and optical instruments, watches and clocks 34 Manufacture of motor vehicles, trailers and semi-trailers 35 Manufacture of other transport equipment 36 Manufacture of furniture, manufacturing, n.e.c. 37 Recycling	0.6 0.2 0.7 0.3 0.1 0.2 0.8 0.5 0.1	0.5 0.2 0.6 0.2 0.1 0.1 0.8 0.5 0.1	0.5 0.2 0.6 0.4 0.2 0.1 0.8 0.5 0.1	0.5 0.2 0.6 0.3 0.1 0.1 0.8 0.5 0.2
E Electricity, gas and water supply	2.7	2.5	2.2	2.3
F Construction	5.6	3.9	4.6	6.3
G Wholesale and retail trade, repair of motor vehicles, motorcycles and personal and household goods	10,0	8.6	11.0	11.1
H Hotels and restaurants	2.6	2.8	3.5	3.7
I Transport, storage and communication	7.1	8.1	7.5	7.8
J Financial intermediation	3.6	3.8	4.1	5.0
K Real estate, renting and business activities	8.3	8.6	12.1	13.4
L Public administration and defence, compulsory social Security	8.5	8.3	5.7	4.9

M Education	3.6	4.3	3.4	3.5
N Health and social work	4.1	4.7	4.0	3.8
O Other community, social and personal activities	2.0	2.5	2.6	2.6
P Private households with employed persons	0.0	0.2	0.2	0.1
Q Extra-territorial organizations and bodies	-	-	-	-

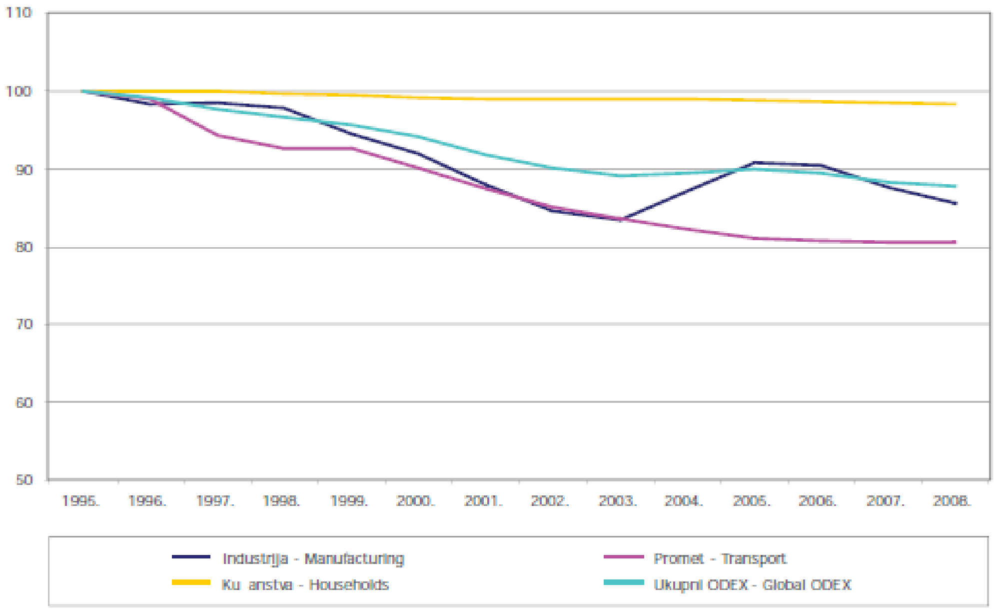
Source: Statistical Yearbook 2003 and 2009

Data presented in table 1 confirm the hypothesis on deindustrialization in Croatia. The share of manufacturing has been decreasing during the whole period mostly due to the decrease in chemical and oil industry, food and textile industry. On the other hand, services have increased considerably, mostly real estate, renting and financial intermediation. Although Croatia is developing and transition country, it shows similar economic structure to developed countries with dominant service sector that makes up to 60% of its GDP. These similar structural characteristics are the consequence of completely different reasons. Privatisation process in Croatia has resulted with brown-field investments in service sector, especially telecommunications and financial sector, because of the high profits in these oligopolistic markets. On the other hand, the industrial production dropped sharply due to the closure and restructuring of heavy industry which was the biggest energy consumer. Uncompetitive position of Croatian industry has been additionally enforced by strong national currency and extensive trade liberalisation which led to further decline in industrial production.

3.2. Energy efficiency and energy intensity

As in most EU member countries, Croatian economy has also recorded an increase in energy efficiency, which is measured by decrease in ODEX index. In the period from 1995 till 2008 the ODEX index decreased by 12.3 % for the whole Croatian economy.

Figure 1 Energy efficiency index ODEX for all sectors in Croatian economy, 1995-2008



Source: Ministry of economy, labour and entrepreneurship, 2009

The decrease in ODDEX index, i.e. increase in energy efficiency, is mostly the result of increased energy efficiency in transport (19.4 %) and industry (14.5), while in households there have been no considerable changes. Although these trends are positive, there are some important underlying reasons that are not related to positive structural changes. As we have already explained, the industrial production in Croatia dropped sharply due to the closure and restructuring of heavy industry which was the biggest energy consumer and thus the energy consumption in industry decreased considerably. An important problem that negatively impacts the competitiveness of Croatian industry is related to higher energy prices for industry in comparison to prices for households. During the 90s in most transition countries industrial tariffs used to be higher than residential tariffs, which is in sharp contrast with the situation in Western Europe where industrial tariffs have been on average two-third of the price charged to households, reflecting the relative costs of supplying these two customer categories (Broadman et.al., 2004: 171). Regarding electricity, prices for industry in EU-27 in 2009 are even 23.8% lower than prices for households, while in EU-27 gas industry the relationship between industry and households prices is even more favourable for industry and is 26.15% lower than for residential costumers (Eurostat, 2010). Despite regular increases in household tariffs in Croatia, cross-subsidisation still exists from industry to households and latest increase in gas prices for Croatian industry has further deteriorated its competitiveness. Croatian energy policy should tackle this problem, but it should include support measures to neutralize the negative economic impact of cost-reflective energy prices on socially vulnerable households[2] (Vlahinić-Dizdarević, Žiković, 2010).

Another way of describing the energy efficiency is by measuring energy intensity. The energy intensity gives the ratio of totally consumed energy and gross value added for the year observed. Table 1 shows the energy intensity of selected new EU members and Croatia in the period 1996-2007.

Table 2 Energy intensity of Croatia and some new EU members, 1996-2007 (kgoe/1000 €)

Country	1996	2000	2004	2007
EU 27	211,58	187,39	184,88	169,39
Czech R.	720,84	659,13	660,22	553,16
Hungary	608,01	480,82	430,93	400,76
Poland	684,11	488,96	442,10	400,10
Slovakia	895,81	796,21	727,77	538,64
Slovenia	357,78	299,77	290,00	253,29
Bulgaria	1790,36	1360,65	1137,74	1016,29
Rumania	1078,84	920,26	773,64	655,59
Croatia	406,21	392,39	366,68	335,53

Source: Eurostat, 2010

According to presented data, all observed countries have decreased their energy intensity. This is very important because it directly increases the competitiveness of goods and services due to lower energy costs. The lowest level of energy intensity has been recorded in Slovenia and then in Croatia. The average annual decrease in Croatian energy intensity accounts 1.72 per cent, which represents the slowest decrease in all mentioned countries. On the other hand, Bulgaria has most intensively decreased its energy intensity for more than 5 per cent annually, but its level of energy intensity is still very high.

[2] These measures may combine social support for households that suffer from energy poverty with support for increased energy efficiency.

Despite relatively low energy intensity in Croatia comparing with the new EU members, but still higher than the average for EU 27, Croatia's estimated energy saving potential is significant – in the range of 25% of total primary energy supply (OECD/IEA, 2008). These savings can be reached economically on both supply and demand side. Declaratively, the government has put high priority on enhancing energy efficiency, but the impact on energy intensity in the particular sub-sectors, as well as in the whole economy, has been limited. The largest saving potentials are in transport sector, especially in road transport, and in building sector. Estimates indicate that more than 83% of existing buildings have inadequate thermal insulation and that average consumption is about 50% higher than in existing buildings in Germany (OECD/IEA, 2008). Despite many national programmes that are focusing energy efficiency and renewable energy, both vertical and horizontal, the level of renewable investments has remained limited. However, there are significant potentials for increasing energy efficiency on the local level, as it will be indicated in the following chapter.

4. Energy management in the City of Rijeka

Quality energy management in the city becomes not only matter of future prosperity but also a matter of economic, social and intellectual development of each urban area. Several European cities already have imposed strong will and high standards in energy management, in order to diminish GHG emissions and support control of climate change. Some cities, like Helsinki seeks to reduce CO_2 emissions per capita by 39 percent by the year 2030 in relation to 1990 level (http://www.ytv.fi/climatechange). Other European cities, like Freiburg or Barcelona, set up similar goals to be achieved.

Republic of Croatia considers sustainable development and future national and community energy consumption planning as a matter of national priority. Project "Systematic energy management in cities and counties of the Republic of Croatia" organized by United Nations development program (UNDP) Croatia, with support from Croatian Government, started in year 2006. Results of the project indicate that without local community's support for energy efficiency, relevant changes in city energy consumption behaviour could not be done. Croatian pioneer city in energy efficiency and energy management is the city of Rijeka.

Similar to other European former heavy industrialized cites in the 20th century, with population around 150.000 people, Rijeka is trying to implement sustainable energy action plan combining three mayor goals to be achieved by the year 2012. Those goals are (City of Rijeka, 2008):

- o to increase energy efficiency by 10 percent
- o to increase use of renewable energy by 10 percent
- o to diminish CO_2 emissions in public transportation by 10 percent.

City of Rijeka has majority of ownership in regional energy company of Energo, gas and district heating distributor and public lighting management company. Also, city of Rijeka was among the first European cities that signed the CoM and become a member of European energy cities association "Energie-Cites", in 2007. Several sustainable energy projects in the city of Rijeka have been done in last five years like: building of gas distribution network and automatic control of district heating plants, energy consultancy and energy auditing of building, metering and cost allocation for district heating or cogeneration, but in this paper further analysis were made on public lighting and renewable energy production with photovoltaic system.

4.1. Sustainable public lighting

Public lighting in urban areas represents significant cost to municipality year budget, taking approximately three or four percent of the city total electricity consumption. The city of Rijeka starts in 1998 with energy efficiency public lighting project. The main objectives of the project were reduction of energy consumption in public lighting and diminishment of lighting pollution. Other objectives were promotion of energy efficiency methodologies, monitoring and public lighting management.

Project was divided into three different phases: a) management of the project and development of Geographic information system (GIS) infrastructure; b) investment and maintains (financial) planning; c) measurement and evaluation of the project. The fourth phase, communication campaign, started by the end of 2007 in order to disseminate the information of the project and to promote this project methodology to other municipalities in the region. Public lighting solutions in the city of Rijeka where recognized worldwide as energy efficient and sustainable public lighting. (http://www.philips.com/lighting)

Table 3: Public lighting in the City of Rijeka, 2003-2008

Year	Number of public lights in city of Rijeka	Total	Average

	Total	EE* public lights	%	Non EE* public lights	%	electricity consumption in public lighting per year (kWh)	year electricity consumption per public light (kWh)
2003	11.572	6.627	57%	4.945	43%	8.643.000	746,89
2004	11.920	7.511	64%	4.393	36%	8.570.000	718,96
2005	12.141	8.309	68%	3.832	32%	8.635.000	711,23
2006	12.459	9.233	74%	3.226	26%	7.720.000	619,63
2007	12.627	9.695	77%	2.932	23%	8.284.000	656,05
2008	12.765	10.185	80%	2.580	20%	8.322.000	651,94

Source: Energo Ltd., (2008), Public lighting year report, Rijeka.
*EE – energy efficiency

Modernization includes the replacement of environmentally unacceptable lamps by those with less installed power and better illumination characteristics. Old non energy efficient mercury bulbs were replaced with more efficient sodium lamps. Also, control of the light flow was improved plus late night hour's reduction of damping consumption was implemented, especially when traffic intensity is rare. All those changes contribute to a large savings in maintenance because sodium lamps have almost 100 percent longer lifetime then mercury lamps and lower electric consumption for 30 percent. As an added value, efficiency of the entire system was improved. Significant fact represents average efficiency per public light, which is 94,95 kWh per year in 2008 in relation to year 2003. That is 13 percent of efficiency improvement directly linked with costs saving for electricity. Today's average price for public lighting in Croatia is 1,5 cents per kWh, VAT included (http://www.hep.hr/opskrba/uravnotetenje.aspx). From now on, savings on total electricity consumption (revenues), without any new investment in Rijeka's public lighting are approximately 150.000 Euro per year.

In the beginning of 2003 there were 11572 public lights in the city of Rijeka and only 57 percent of them were energy efficient. During the period of six years, city of Rijeka invested in new public lighting more than 2.500.000 EUR. Today Rijeka's public lighting represent almost 13000 lights, 150 km of electricity grid with total installed power of 2,4 MW.

Table 3 brings financial analysis of this project with horizon period of 20 years, as well as predicted depreciation period. Net present value of this project is negative while internal rate of return (IRR) is only 0,81 percent which brings conclusions that this project is hardly feasible concerning only benefits from electricity consumptions efficiency.

Table 4: Feasibility of investments in energy efficiency public lighting in the city of Rijeka (in €)

INVESTMENT					
Number of EE lights	10.185				
Average price per 1 EE light	245,46€				
Average efficiency per light in kWh/a	94,95				
Total consumption in kWh/a	8.500.000				
Price of 1kWh of electricity	0,15				
Depreciation and horizon period (years)	20				
Depreciation per year (EUR)	125.000				
TOTAL INVESTMENT	2.500.000				
INCOME STATEMENT -years		**2009**	**2010**	**2011**	**…2028**
REVENUES		148.372	148.372	148.372	148.372
COSTS (Maintains 0,05% of invest.)		12.500	12.500	12.500	12.500
EBITAD		135.872	135.872	135.872	135.872
DEPRECIATION		125.000	125.000	125.000	125.000
EBIT (OPERATING PROFIT)		10.872	10.872	10.872	10.872
INTERESTS		0	0	0	0
EBT		10.872	10.872	10.872	10.872
-TAX		0	0	0	0
NET INCOME		10.872	10.872	10.872	10.872
CASH FLOW					
NET INCOME + DEPRECIATION		135.872	135.872	135.872	135.872
INVESTMENT	-2.500.000				
TAX (CAPITAL LOSS)	0				
NET PRESENT VALUE	**-1.259.689**				
PAYBACK PERIOD IN YEARS	**18,40**				
INTERNAL RATE OF RETURN	**0,81%**				

Source: The authors' research results

Other important aspect of this investment represents diminishment of GHG emission in Rijeka's public lighting. Table 4 indicates fact that almost 100 tons of CO_2 is reproduced less per year than in year 2003, when there were almost 1.200 more lights in the City. There were several methods for calculation of CO_2 emissions but presented data in table 4, took factor of 0,53 kg of CO_2 emission for 1 kWh of spent electricity (NN 113/08, 91/09).

Table 5: Public lighting emission of CO_2 in the city of Rijeka, 2003-2008

Year	Number of public lights in city of Rijeka	Total year public light CO_2 emission (t)	Average year CO_2 emission per public light (t)
2003	11.572	4.581	0,3959
2004	11.920	4.542	0,3810
2005	12.141	4.577	0,3770
2006	12.459	4.092	0,3284
2007	12.627	4.391	0,3477
2008	12.765	4.411	0,3455

Source: Energo Ltd., (2008), Public lighting year report, Rijeka

Average year emission of CO_2 per city light is also dropping from 0,3959 t in year 2003 to 0,3455 t in year 2008, which represents significant improvement of 14,6 percent. Only in year 2006 average CO_2 emission fell to 0,3284 t per light which is better then other years, mostly due to a higher number of substitutions of mercury 400W bulbs with sodium bulbs with 250W but with additional energy adjustment reduction up to 150W power. Those results lead to conclusion that energy and sustainable urban development are mutual ongoing processes influenced one by another. Side effects of this project, as an added value, were also: positive reactions of citizens and media plus good public image.

Thus we can conclude that development of technology and massive interest for green energy in future will provide fair costs of investments for eligible pay back period. Analysis of energy efficiency public lighting in the city of Rijeka demonstrates long term fulfilment of city energy needs and environmental issues.

4.2. Solar energy for City electricity

Renewable energy sources such as sunlight, wind power and bio-mass already represent new energy force for the future. Several changes took place in energy sector as a result of renewable energy and implementation of new clean technologies. The use of renewables offers the opportunity to diminish energy dependence, reduce the emission of CO_2 and create new employment.

Different types of solar collectors are used to meet different energy needs. Passive solar building designs capture the sun's heat to provide space heating and light. Photovoltaic cells convert sunlight directly to electricity. Croatian national energy strategy supports production of renewable energy through subventions called Feed-in tariff (NN 68/01, 177/04, 76/07) for every registered renewable energy power plant. Production of electricity from sun power is categorized in three tariffs, with different selling price, dependable upon installed power of the plant.

City of Rijeka declared to support renewable energy use by investing in photovoltaic energy plants up to 30 kW of installed power on public buildings roofs. First solar power plant already produce electricity since May 2009 installed on City Council upper terrace, in the centre of Rijeka. Total installation has power of 9,9 kW and predicted year electricity production will be around 13.000 kWh. Table 5 demonstrate feasibility of that investment. Today's market price of investment is approximately 46.560 EUR. Given items in table demonstrate positive net present value and solid 9,17 percent of IRR. Calculations were made with the feed-in tariff selling price of 0,51 EUR per kWh of electricity which will be distributed to the grid, for the next 12 years, according to the Croatian regulations. After that period all produced electricity will be used inside the building for domestic needs. Depreciation period of the plant is 20 years, but after that period efficiency of the plant will decrease only 80 percent of energy production, so energy production will not be lost, newer less future revenues in the year 2029 will be 1.554 EUR.

Table 6: Feasibility of investments in renewable solar energy in the city of Rijeka (in €)

INVESTMENT					
Photovoltaic -equipment	43.560				
Price of 1kW peak power	4.400				
Connection costs	3.000				
Power installed in kW	9,9				
Feed-in tariff selling price of kWh	0,51				
Actual purchase price of kWh	0,15				
Depreciation and horizon period (years)	20				
Depreciation per year	2.328				
Total Investment	46.560				
INCOME STATEMENT - years		**2010**	**2011**	**2012**	**… 2029**
REVENUES		6.523	6.458	6.393	1.544
Revenues from electricity sales		6.523	6.458	6.393	0
Revenues from electricity produced		0	0	0	1.544
COSTS		233	233	233	233
Other costs		0	0	0	0
Maintenance costs (5% of investment)		233	233	233	233
EBITAD		6.290	6.225	6.160	1.312
DEPRECIATION		2.328	2.328	2.328	2.328

EBIT (OPERATING PROFIT)		3.962	3.897	3.832	-1.016
INTERESTS		0	0	0	0
EBT		3.962	3.897	3.832	-1.016
-TAX		0	0	0	0
NET INCOME		**3.962**	**3.897**	**3.832**	**-1.016**
CASH FLOW					
NET INCOME + DEPRECIATION		6.290	6.225	6.160	1.312
INVESTMENT	-46.560				
TAX (CAPITAL LOSS)	0				
NET PRESENT VALUE	**441**				
PAYBACK PERIOD	**7,67**				
INTERNAL RATE OF RETURN	**9,17%**				

Source: The authors' research results

Environmental issue of Rijeka's solar investment also has huge impact on sustainable development. Renewable electricity year production of 13.000 kWh will preserve 6,8 tons of CO_2 emissions to atmosphere. In next 20 years that amount will raise up to 123 tons of CO_2 emissions saved form polluting. Those results, similar to public lighting project, also lead to conclusion that energy sustainable development is possible.

Other conclusion refers to Feed-in tariffs lasting period because they are "start-up" type of subventions, designed only to develop renewable energy market in Croatia. The research results demonstrate that besides GHG emission free status, investment in solar energy is respectably cost effective only with subvention on selling electricity price. Consequently, worldwide demand for solar equipment will continue to grow plus further technology development will lead to fair price of solar equipment which is going to become feasible investment, without need for national subventions.

5. Conclusion

The analysis shows that Croatia has experienced the increase in energy efficiency in the period 1995-2008, mostly as the result of increased energy efficiency in transport (19.4 %) and industry (14.5), while in households there have been no considerable changes. Although these trends are positive, there are some important underlying reasons that are not related to positive structural changes. During the 1990s the industrial production in Croatia dropped sharply due to the closure and restructuring of heavy industry which was the biggest energy consumer and thus the energy consumption in industry decreased considerably. Still, despite relatively low energy intensity in Croatia comparing with the new EU members, although higher than the average for EU 27, Croatia's estimated energy saving potential is significant – in the range of 25% of total primary energy supply. These savings can be reached economically on both supply and demand side. Declaratively, the government has put high priority on enhancing energy efficiency, but the impact on energy intensity in the particular sub-sectors, as well as in the whole economy, has been limited. Despite many national programmes that are focusing energy efficiency and renewable energy, both vertical and horizontal, the level of renewable investments has remained limited. However, there are significant potentials for increasing energy efficiency on the local level, as we have indicated in our research.

The instability of energy market and environmental issues has brought out to surface the importance of local government management in order to establish sustainable energy development of urban areas. Considering all presented facts, it can be assumed that investments in green energy will represent an important factor in future economy and development of local community. Because of the increasing demand for energy in public sector and due to the urban lifestyle, additional infrastructure has to be built in order to meet a high level of public services. Further conclusion indicates that energy planning initiatives, undertaken by the local community government and networking established through Covenant of Mayors, becomes operating management issue for local sustainable energy development.

Our research results on two energy projects in the Croatian city of Rijeka (energy efficiency public lighting and sun power electricity production) show that local community efficiency and renewable energy projects could be feasible and environmentally friendly at the same time.. Positive net present value for renewable energy projects indicate the importance of feed-in tariff selling price and significant IRR. Thus, negative net present value in energy efficiency public lighting has important benefit in significant diminishment of CO_2 emissions.

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