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Quality of Living and Sustainability Indictors – City of Ljubljana, Vision 2050[5]

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Abstract: *The greatest challenge of future development of urban areas has been related with the sustainability issues. Unfortunately, sustainability issues and related costs of resources, including energy, occupy minds only of minority in the society. In the process of transition toward low carbon society many countries have set indicative targets which are revealing desired momentum of change but only at the national level. The absence of clear and direct transformation of national targets into implementation programmes at the local level was the crucial reason why many previous goals have not been achieved. Within the paper, six main sustainability indicators related to the quality of living in urban areas have been described and discussed. Indicators have been tested and customised during the analysis of future development challenges of the Slovenian capital, City of Ljubljana. Results of the analysis show that suggested indicators may be used in the process of municipal energy planning. During the research work, technology and sector oriented bottom up reference energy and environmental system model of City of Ljubljana has been developed. It is the first so complex reference energy and environmental system model that has been developed on the municipal level in the Southeast Europe.*

Keywords: *Sustainability indicators, Quality of living, Energy models, Urban infrastructure, Municipal energy planning, Ljubljana*

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Kvalitet življenja i indikatori održivosti – Ljubljana, vizija razvoja do 2050

Apstakt: *Najveći izazovi budućeg razvoja urbanih područja su povezani sa pitanjima održivosti. Nažalost, pitanja održivosti i troškovi za resurse, uključujući i energiju, ne predstavljaju teme koje u dovoljnoj meri zanimaju većinu građana. U procesu tranzicije prema niskokarbonskom društvu i ekonomiji mnoge države postavljaju indikativne ciljeve koji prestavljaju željeni impuls promene, ali samo na državnoj razini. Odsustvo jasne i neposredne strategije za transformaciju nacionalnih ciljeva u implementacijske programe na lokalnoj razini prestavlja presudni razlog zašto većina prethodno zadanih ciljeva nije ostavrena. U okviru ovog rada opisano je šest glavnih indikatora održivosti koji se odnose na kvalitetu življenja u urbanim sredinama. Indikatori su testirani i prilagođeni tokom analize budućih razvojnih izazova slovenačkog društva i grada Ljubljane. Rezultati provedenih analiza potvrđuju da se predloženi indikatori mogu koristiti u procesima planiranja razvoja lokalne energetike. Tokom istraživačkog rada razvijen je model referentnog energetskog i ekološkog sistema grada Ljubljane u cilju sistematičnog vrednovanja razvojnih izazova i utecaja na životnu sredinu. Razvijeni model prestavlja prvi kompleksni model referentnog energetskog i ekološkog sistema za ocenu razvojnih izazova na gradskom nivou u jugoistočnoj Evropi.*

Ključne reči: *Indikatori održivosti, Kvaliteta življenja, Energetski modeli, Urbana infrastruktura, Planiranje lokalne energetike, Ljubljana*

1. Introduction

During recent decades the world has experienced unprecedented urban growth and according to the United Nations Human Settlements Programme urban areas are responsible for around 75% of the world’s energy consumption and for almost 80% of the world's CO_2 emissions. According to (United Nations Population Division, 2008) in 2008, for the first time in history, the world's population was evenly split between urban and rural areas. It is important to emphasise that more developed nations were about 74% urban, while only 44% of residents of less developed countries lived in urban areas. Also, according to (United Nations Population Division, 2008) the urbanization is occurring rapidly in many less developed countries and by 2030, it is expected that cities will house 60% of the world’s population – equivalent to the total global population in 1987.

According to European criteria, cities are a basic element of modern societies and states, namely about 80% of European population live in urban areas. Issues related to the sustainable and climate friendly development are positioned very high on the political agenda in the European Union (EU) and have great potential for inter-urban cooperation and knowledge sharing. The local authorities play an essential role in functioning of local energy system, both as the policy makers and as owners of large number of public buildings and infrastructure (Beke-Trivunac & Jovanović, 2013). Local energy solutions are a vital part of the future secure and efficient energy supply on the municipal level and that is the reason why new, tailor-made models for specific local conditions are a necessary premise to achieve set targets. Energy is an essential factor in overall efforts to achieve sustainable development (Vera & Langlois, 2007). Excellent example of research and review of renewable energy strategies for sustainable development and perspectives of converting present energy systems into a 100% renewable energy system can be found in (Lund, 2007) and (Lund & Mathiesen, 2009). According to (Lund, 2007), 100% renewable energy system is possible but large-scale renewable energy implementation plans must include strategies for integrating renewable sources in coherent energy systems influenced by energy savings and energy efficiency measures. Unfortunately, cities often do not have sufficient financial or human resources, by which they could take over a more active role in the improvement of the quality of living. The most frequent mistake in the sustainable urban development is related with the *copy-paste* planning where peculiarities of own city are ignored and proposed solutions are blind copies of foreign strategies and solutions. Each city is different and has to develop its own strategy for its sustainable and climate friendly development. It has to be emphasised that the cooperation with other cities and exchange of experiences is more than desirable and it has to be stimulated, but concrete solutions have to be based on priorities and peculiarities of each individual city. Excellent example of the method for selecting and calculation indicators of sustainable development, needed for determining the level of sustainable development, expressed through sustainability index of residential buildings can be found in (Vučićević, Jovanović, Afgan, Turanjanin, 2014).

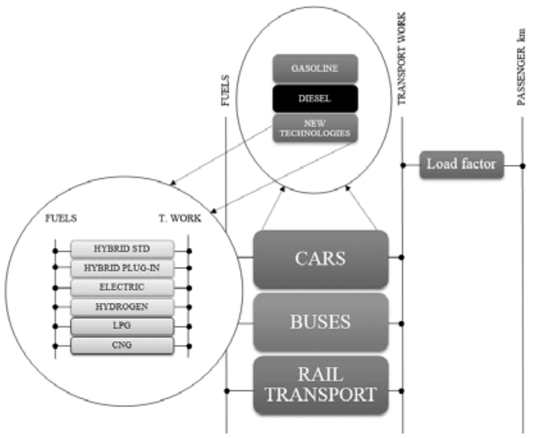
This paper presents the overview of the most important targets and challenges for the future development of the City of Ljubljana. Also, within the paper six main sustainability indicators related with the quality of living in urban areas have been described and discussed. Indicators have been tested and customised during the analysis of future development challenges of the Slovenian capital, City of Ljubljana. During the research work, technology and sector oriented bottom up reference energy and environmental system model of City of Ljubljana has been developed. It is the first so complex reference energy and environmental system model that has been developed on the municipal level in the Southeast Europe.

2. Methodology – energy, environment and sustainability in urban areas

During the last decade several new concepts of energy planning and energy forecasting have emerged, such as decentralized planning, energy conservation through improved technologies, waste recycling, forecasting models, integrated energy planning and introduction of renewable energy sources as presented in (Connolly, Lund, Mathiesen, & Leahy, 2010) and (Weijermars, Taylor, Bahn, Das & Wei, 2012). Nowadays, energy systems have become more complex and application of new statistical and information technology is essential. Transition from traditional methods of energy planning and the use of newly developed methods for integrated resource planning have enabled the tools to research and combine a vast array of often contradict sectorial goals into one structured energy system on a national, regional or municipal level (Avetisyan, Bayless, & Gnuni, 2006) (Ćosić, Krajačić, & Duić, 2012) (Milan, Bojesen, & Nielsen, 2012) (Pusnik, Sucic, Urbancic, & Merse, 2012) (Hamdan, Ghajar, & Chedid, 2012). Development of the electricity smart grids is recognised as an important element in the process of transformation towards new and low carbon energy systems (Blumsack, & Fernandez, 2012). However, electricity smart grids must be coordinated with the utilisation of RES being converted into other forms of carriers than electricity including heat and bio fuels as well as energy conservation and efficiency improvements (Lund, Andersen, Østergaard, Mathiesen, & Connolly, 2012).

Within the research work technology and sector oriented bottom up reference energy and environmental system model of City of Ljubljana (REES-MOL) has been developed. REES-MOL was developed in MESAP environment and it was used for calculation of energy and emission balances together with all related costs for both scenarios. The MESAP standard software is a platform for building customer-specific strategic information systems. The core of MESAP is a powerful database that gathers all the information in a central data pool. The simulation model of MESAP (Modular Energy System and Planning) environment is called PlaNet and consists of two independent modules: a module which balances flows of energy (end-use and supply) and the module for calculating macroeconomic costs linked to selected commodity flows. The MESAP is a linear accounting model with flexible data structure and it can be adapted to the level of aggregation and accommodated to any reasonable level of detail. Scenario-based planning was integrated into the MESAP environment, allowing integration of past, present and planned (calculated) data in a comprehensive overall system. According to (Connolly et al., 2010), MESAP can be used in national or regional energy system modelling and it has no limitations regarding the scenario timeframe or time-step. Combined with its open structure, this makes MESAP a very suitable modelling tool for small municipal energy systems where many peculiarities have to be taken into account. MESAP supports a technology-oriented modelling approach where several competitive technologies that supply energy services are represented by parallel processes. The volume of a service supplied by a technology (e.g. heat) is defined by market shares that split the service demand between competitive processes or technologies. Parallel competitive technologies have been included in the model, as presented in Fig. 1.

Figure 1. Modelling approach - parallel technologies, model REES-MOL



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In the Slovenian case, MESAP has been used in the process of the national energy strategy development where all above mentioned functionalities have been tested (Al-Mansour, Merse, & Tomsic, 2003) (Ministry of Economy, 2010). During the development of the REES-MOL model, trade-off between the simulation and optimisation approach has been done, favouring presentation of relations between controls and their final effects rather than the elusive optimality of results which can be misleading for municipal energy systems.

2.1. Sustainability issues in urban areas

Sustainable and climate friendly development of urban infrastructure in a narrower sense means, that the city does not postpone current problems into the future. In a broader sense it means responsible behaviour of all municipal structures, from the city administration to each individual citizen. According to (Birnera & Martinot 2005), this can come through changes in regulation, taxes, subsidies, access to capital and provision of trusted information, as well as marketing and campaigning to raise the awareness and encourage consumers to make choices that are both economically and environmentally acceptable. According to (The Economist Intelligence Unit, 2008), decisions and concrete actions of individual persons have greater power than capability of municipal administration to interfere with their actions. In the framework of sustainable and climate friendly development of urban areas, the most often highlighted problems are efficient spatial planning, efficient and secure energy supply and efficient public transport. Energy efficiency is a red line, which connects all the above mentioned areas.

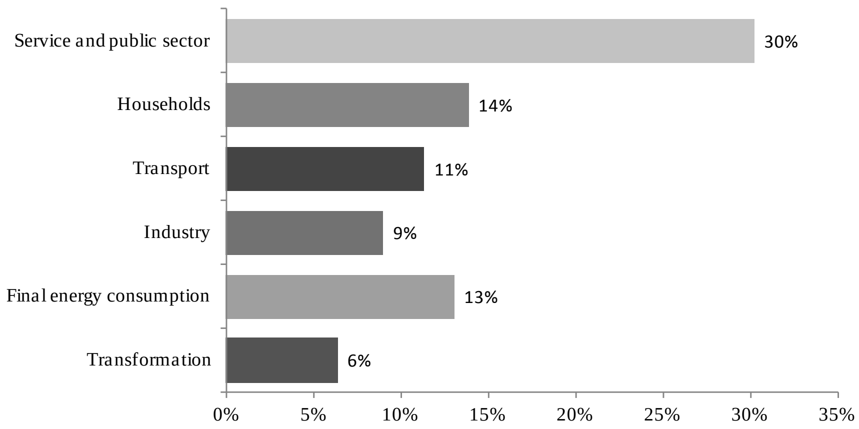
Transition from environment unfriendly fossil fuelled urban economy to sustainable and climate friendly urban development requires design and formation of policies and solutions, which will be based on excellent knowledge of development alternatives and awareness about new opportunities in exploitation of urban environment as an energy system. Looking long term, in sustainable development of urban areas, renewable energy sources do not have an alternative. For example, in the field of wastes treatment, eastern European capitals are experiencing great changes, former and unsustainable practice of waste disposal has been transformed to ecologically more acceptable ways of waste management. Awareness and susceptibility for new approaches in waste treatment is one of the key factors for the success of programmes of sustainable waste management in the transition toward *zero-waste* society (Wien Energie, 2010) (The Economist Intelligence Unit, 2009).

Harmonization of interests between the state, cities and citizens forms a solid base, which is necessary for the development of sustainable urban infrastructure. According to (United Nations Human Settlements Programme, 2011), future challenges of the development of sustainable urban infrastructure in Europe are closely connected with the competitiveness of cities and have to consider trends of population ageing and consequent mobility reduction.

3. Case study - future development challenges of the Slovenian capital, City of Ljubljana

Each European capital has its own consumer culture and historic heritage, which is more or less different from others and which has to be considered in the design of the sustainable development strategy. For example, City of Ljubljana is special by its geographic and population smallness, which on one side does not allow the same as to other, larger cities to achieve effects of economy of scale. At the same time, due to the same reason Ljubljana is essentially more flexible regarding the selection of strategy for gaining support of citizens for development projects, connected with the sustainable urban infrastructure and climate friendly development. Estimated annual cost without taxes and duties of final energy consumption in all buildings owned by the City of Ljubljana (museums, theatres, galleries, schools, sport facilities, office buildings, kindergartens, etc. – all together 318 buildings and surface area of 524983 m^2) in 2008 amounted to 5.9 million EUR2008, or 1.9% of annual budget of City of Ljubljana (Sucic, Cesen, Stanicic, Merse, Urbancic, Pusnik, & Bevk, 2011).

Figure 2. Sectoral shares of final energy consumption in Ljubljana in the final energy consumption in Slovenia, reference year 2008



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Also, Ljubljana has a significant share in the energy use and CO_2 emissions in Slovenia. In 2008 (the reference year for the study), final energy consumption amounted to 29.0 PJ or 13% of the entire final energy consumption in Slovenia and that is why the transition to the sustainable excellence of the Slovenian capital cannot be only an issue of the municipality but it is also a national issue. Ljubljana's sectoral shares of final energy consumption in Slovenian final energy consumption are shown in Fig. 2. In 2008 the consumption in the transport sector was 10.1 PJ, in services and public sector 6.6 PJ, in households sector 6.5 PJ and in the industry 5.8 PJ. The biggest share was contributed to liquid fuels (46%), electricity contributed 21%, gaseous fuels 16%, district heating also 16% and renewable energy sources only 1% (Cerkvenik, Persovsek, & Podboj, 2010).

During the research work two scenarios of sustainable development of City of Ljubljana up to the year 2050 have been developed, namely Reference Scenario and Sustainable Excellence Scenario. Reference Scenario foresees fulfilment of already accepted environmental goals and legislative obligations as well as achievement of at least 50% reduction of CO_2 emissions of City of Ljubljana up to the year 2050 in comparison with the reference year 2008. Scenario Sustainable Excellence is a vision of ambitious transition of City of Ljubljana to the low carbon capital. In the framework of the Sustainable Excellence Scenario (further on Scenario -80%) an 80% reduction of CO_2 emissions is foreseen up to the year 2050 in comparison with the reference year 2008.

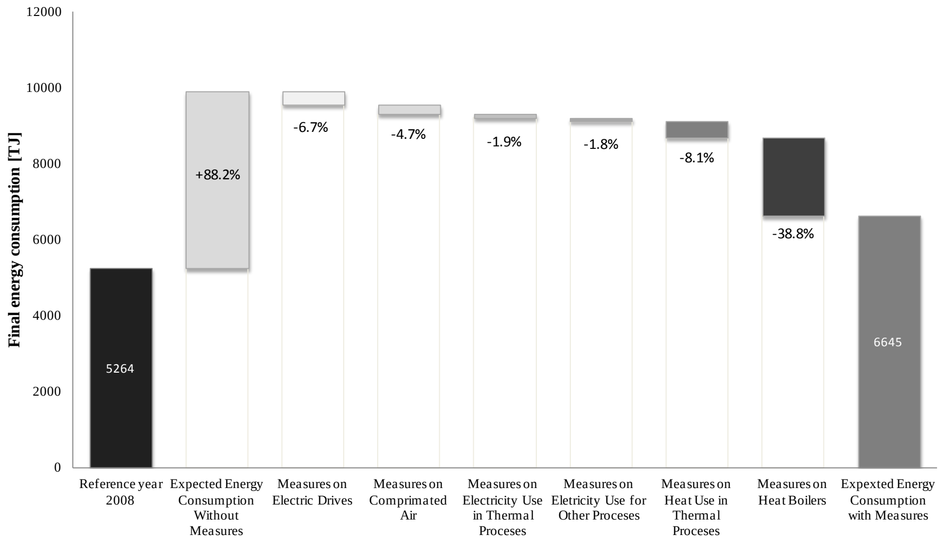
A very important assumption in both scenarios is that comfort of residents, users of services in the urban area remains the same or it even increases with the use of new technologies and change in consumption patterns. Quality of infrastructure, services and living in urban area is one of key factors for strengthening the city competitiveness.

3.1. View to 2050 – key findings, results and discussion

Already for some years, Ljubljana is characterised by the continuous improvement of quality of living. The term quality of living is used to evaluate the general well-being of individuals and societies and it is used in a wide range of contexts, including the fields of international development, healthcare and politics (Mercer, 2011).

According to the Scenario -80%, it is possible to significantly improve energy efficiency and reduce CO_2 emissions caused by industry (despite industrial growth) in Ljubljana by the year 2050 in comparison with the reference year 2008, Fig. 3.

Figure 3. Calculated energy savings in industry by measures, Scenario -80%



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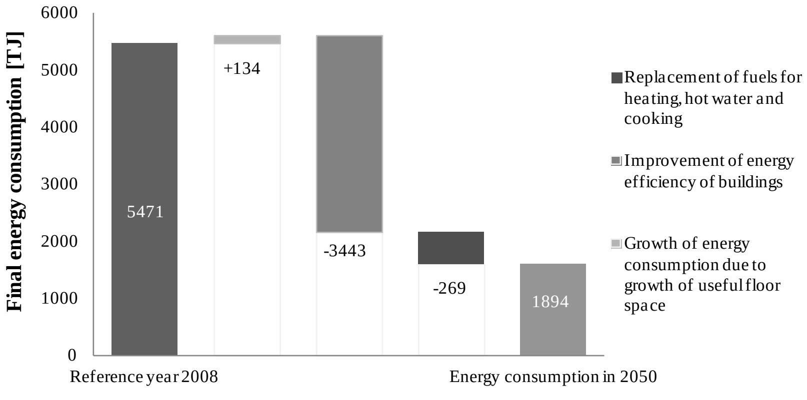
By the year 2050, final energy consumption in households can be reduced to 1.9 PJ or for 65% in comparison with the reference year. The most important lever for achieving these effects is the increase of energy efficiency in buildings, Fig. 4.

Figure 4. Calculated energy savings in households



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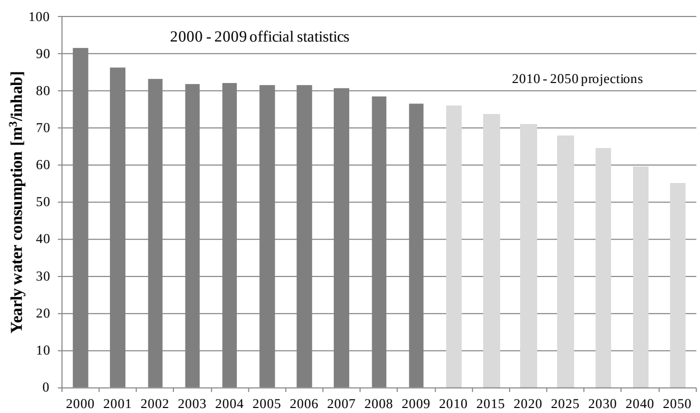
According to the Scenario -80%, the final energy use in passenger transport in the City of Ljubljana can be reduced for 61%, and CO_2 emissions for 71%, in comparison with the reference year 2008. Reductions are a consequence of infrastructural measures, behavioural changes and introduction of new transport technologies.

Analysis has shown that it is possible to considerably reduce losses in Ljubljana water supply system (Fig. 5) with an extensive renovation of distribution pipelines and implementation of modern technologies of pressure and flow regulation. According to the calculations, water loses in Ljubljana water supply system in 2050 will not exceed 5% of all pumped water.

Figure 5. Yearly water consumption [m^3/inhab] in City of Ljubljana for the period 2000-2050



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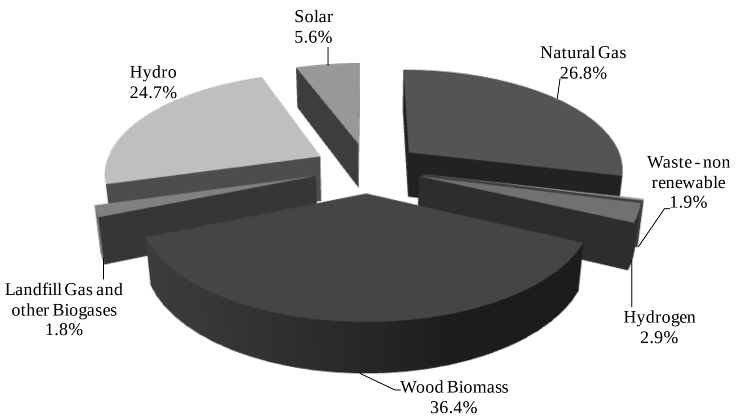
To achieve both scenarios, Ljubljana has already fulfilled an important infrastructure pre-condition, namely well-functioning district heating and cooling system. To ensure additional positive effects in the Scenario -80%, an upgrade of both systems was foreseen, as well as introduction of micro district cooling system. According to the calculated projections, electricity production in City of Ljubljana will increase, especially due to the new hydro power plants on Sava River and in 2050 it will cover almost 60% of Ljubljana electricity needs. In 2050, 69% of electricity produced in Ljubljana will be from renewable energy sources, Fig. 6.

Figure 6. Structure of electricity produced in City of Ljubljana in 2050, Scenario -80%



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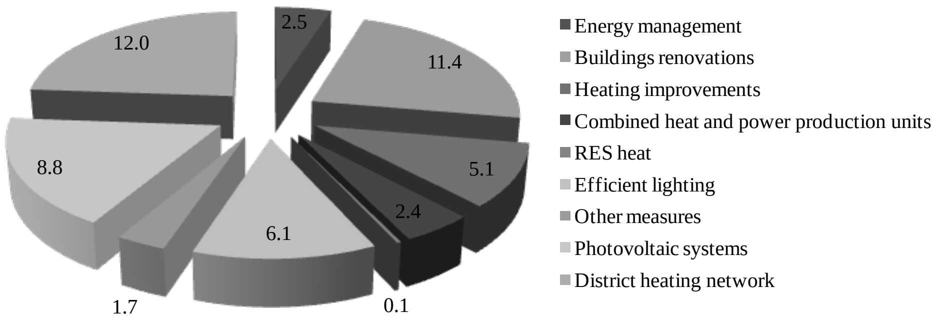
Accelerated development of energy efficiency and exploitation of renewable energy sources is a key element of transition to the low carbon society and in the case of City of Ljubljana it can become a crucial driver for additional development and growth. Performed analysis clearly confirmed that with correctly set goals and developed implementation mechanisms, Ljubljana could become regional leader in sustainable and climate friendly development. Estimated savings represent an excellent business opportunity for extension of economic activities in Ljubljana and especially for future synergic cooperation of public enterprises from the Public holding Ljubljana (District heating, Natural gas distribution, Waste treatment and Water supply) and Ljubljana Electricity Distribution Company. Also, key findings from the presented research work were the main trigger for the city administration to successfully apply for financial assistance through the European Investment Bank (EIB) ELENA financing facility. ELENA is abbreviation for the European Local ENergy Assistance and it is run by the EIB, and funded through the European Commission's Intelligent Energy Europe (IEE) programme. According to the proposed energy retrofit programme of public buildings in the City of Ljubljana, total foreseen investments are estimated on 50.7 million EUR. The foreseen investment structure is given in Fig 7. Estimated results of the proposed investment programme are final energy savings of about 79 GWh per year. The energy savings will result in emission reduction of 24500 t CO_2 per year (Merse, 2012).

Figure 7. Foreseen investment structure of the energy retrofit programme of public buildings in Ljubljana (Merse, 2012)



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4. Sustainability indicators in urban areas

While sustainable development is a common goal for nations, communities, and companies, its quantification remains difficult. Since human activities are closely linked to energy use, the energy system is a good candidate for providing a small, manageable list of interlinked indicators, with the ability to track sustainability. According to (Kemmler & Spreng, 2007), the most important sustainability issues are related to the production and use of energy. Excellent research work with the practical case study on how sustainability indicators can be used for the evaluation of the future development challenges can be found in (Jovanović, Afgan, Radovanović, & Stevanović, 2009). According to (Kemmler & Spreng, 2007), sustainability indicators can be divided into three main areas: economy, environment and society. Also, there are cases where sustainability indicators are divided into four areas: economy, resources, environment and society (Afgan, Carvalho & Hovanov, 2000). In the presented research work, the following set of six leading indicators was proposed:

- CO_2 emissions in the buildings sector – Environment (CO_2em),
- Share of renewable energy sources in gross final consumption for heating and cooling – Economy/Resources (RES share),
- Final energy consumption for heating in domestic buildings per square meter of useful floor area – Economy (FEHpm^2),
- Other consumption of energy in the households per capita – Economy (OthEnpCap),
- Final energy consumption in service and public sector per square meter of useful floor area – Economy (FESpm^2),

- Share of final energy consumption in buildings in the total final energy consumption (including industry and transport) – Economy (FEbuilShare).

The first indicator is suitable for monitoring progress toward GHG target. The second indicator is suitable for monitoring progress towards RES target and others toward energy savings target. An important criterion in the definition of indicators was that they could be used for the analysis of the policy and technology driven improvements.

4.1. Key findings, results and discussion, Ljubljana – buildings sector

Consumption of the buildings sector (households, services (public and private sector)) in 2008 was 13.1 PJ, which is 45% of the total final energy consumption in the City of Ljubljana. Electricity contributed 31%, district heating 29%, liquid fuels 21%, gaseous fuels 15% and renewable energy sources 3%.

During the definition of both future development scenarios regarding the buildings sector in the City of Ljubljana the following energy efficiency measures were taken into account:

- Comprehensive refurbishment of existing buildings,
- Optimisation of heating systems,
- Purchase of new boilers and heat pumps,
- Use of solar systems and heat pumps for water heating,
- Low energy or passive standard for new buildings,
- Purchase of more efficient household appliances,
- Use of more efficient lighting and
- Implementation of energy management systems.

Effects of these measures have been evaluated through the proposed set of indicators. According to the calculations, CO_2 emissions related to the buildings sector can be reduced by 81%, the share of renewable energy sources for heating and cooling can be increased from 5% to 67%, intensity of energy use for heating in households can be reduced by 81%, intensity of use of other energy in households can be reduced by 12%, and final energy consumption in services per square meter of useful floor space can be reduced by 49% up to 2050.

Comparison between indicators and national targets shows that target for CO_2 emissions is achievable in the City of Ljubljana taking into account only the buildings sector, where emissions in 2020 were 40% lower than in 2008. The share of renewable energy sources in 2020 in the City of Ljubljana is much lower than the national target, although it increased by 85% compared to 2008. Energy savings target can also be reached since the energy consumption in services per square meter decreased by 22% until 2020 and energy consumption for heating in households per square meter decreased by 41%, while other energy use in households per capita remained constant.

Table 1. Projected development of selected sustainability indicators for Ljubljana from 2008 to 2050

	Units	*2008*	*2010*	*2020*	*2030*	*2050*
CO_2em	[kt CO_2]	309	289	187	104	58
RESshare	[%]	5%	7%	9%	14%	67%
FEHpm^2	[kWh/m^2]	155	144	92	45	30
OthEnpCap	[kWh/cap]	2301	2303	2297	2213	2031
FESpm^2	[kWh/m^2]	256	247	200	161	130
FEbuilShare	[%]	54%	56%	53%	48%	45%

Source:Author

5. Conclusion

Presented research work confirms that the transition from environment unfriendly fossil fuelled economy to sustainable and climate friendly urban development requires new approaches, which must be based on excellent knowledge of alternative possibilities of development and especially awareness about new opportunities in exploitation of urban environment as an energy system. Successful sustainable and climate friendly development strategy of urban areas must be adaptive and must rely on the empirical data. Also, the sustainable transformation of each urban area has to be based on its own strategy, which is developed through the process of learning by own experiences and already executed, successful programmes and projects in a broader environment. The long-term transition towards the low-carbon society requires exploitation of renewable energy sources to a considerably greater extent, and conditions for this must be provided by the comprehensive and adaptive energy policy.

The most obvious result of sustainable urban planning is the continuous improvement of the quality of living, which directly affects attractiveness of the city and consequently enables economic growth of urban areas. With sustainable urban policy it is possible to ensure the optimal living environment, which will be adapted to the needs of citizens.

National goals of sustainable development are determined at the state level, but huge amount of implementation activities are actually going on at the local level and that is why cities need enough manoeuvre space for the efficient execution of sustainable development policies. Unfortunately, it often happens that efforts or measures of different state ministries related to the same urban area contradict each other. Complementation and harmonization of interests between the state, cities and citizens is a necessary precondition for the sustainable development of urban areas.

Presented research work clearly confirms that sustainability indicators can be used for monitoring and measuring the progress of transition toward low carbon society. However, having in mind the recommendations from (Vučićević et al., 2014) additional research work has to be done to investigate if the described approaches can be upgraded. Also, additional research challenges are related with the new trends in urban energy systems modelling.

Finally, it has to be emphasized that even the most advanced energy and environmental polices need informed and motivated citizens who will make energy efficient decisions and sustainably change already established energy consumptions patterns.

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