ISSN 2029–9990 JOURNAL OF SUSTAINABLE ARCHITECTURE AND CIVIL ENGINEERING 2014. No. 2(7)
DARNIOJI ARCHITEKTŪRA IR STATYBA

Concept of Smart City: First Experience from City of Riga

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crossref http://dx.doi.org/10.5755/j01.sace.7.2.6932

Growing concern of smart city development and urban resilience has become increasingly embedded in urban planning, national security and energy policy. One of the main city documents focused on actions and measures to be implemented in City is Sustainable Energy Action Plan. Taking into account specifics of modern cities and future city development at Smart City level the existing Sustainable Energy Action Plans should be enhanced. Nowadays it is necessary to bring existing standalone energy actions at cross sector level in order to ensure urban resilience. Currently there are 3414 cities across the Europe and eastern partners which already have developed Sustainable Energy Action Plan. The paper draws attention to areas with high impact to smart city development. In terms of Smart Cities the most powerful actions are those which directly affect at least these three sectors – energy, ICT and transport.

Paper provides some Good Practice examples from city of Riga. The losses of the heat transmitted to consumers by JSC "Rigas Siltums" – main heat supplier of Riga have been decreased by 667 thous. MWh or 2.45 times in comparison to year 1996/1997. Following the completion of reconstruction of the boiler houses, construction of a biofuel fired water heating boiler, construction of the biofuel fired cogeneration plant, installation of flue gas condensers for biofuel fired boilers at the DHP the share of biofuel utilisation within the fuel balance of the JSC „RĪGAS SILTUMS" will reach 20.4 % in fiscal year 2013/2014. The total energy produced from renewable energy sources since 01.01.1996 until 8.04.2014 is 920463.107 MWh.

The project "Heat meters automatic remote reading system" proved to be a successful and reliable solution for the control and accounting of consumed heat, as well as related tasks enabling "online communication" with 8000 individual heating units throughout the Riga city.

Development and introduction of electric cars and filling station infrastructure in Riga was one more step on the way to the SMART CITY status. Despite a fairly long payback period electric cars are quite beneficial solution for some companies whose activities are related with vehicles' high mileage within the city as LLC "Rigas Satiksme".

Keywords: *smart city, sustainable resources, urban resilience.*

1. Introduction

During recent years, people have become aware that environment in the city is comprehensive resource that requires smart management. This has lead to increased need for use of sustainable resources and development of sustainable cities with integrated smart disciplines – economics, energies, technologies, architecture and politics. Major attention must also be paid to city resilience planning due to its importance for any city's development as well as the national securitization process by becoming better prepared and more responsible for national risk management. City security and public resilience have become increasingly embedded in urban planning, national security and energy policy (Coaffee J., 2008). City designers should remember that a smart city involves not only smart technologies, but also smart economy, governance, mobility, living, environment and people (Giffinger *et al.,* 2007). The key concepts of urban resilience are sustainability and adaptation to climate changes (Leichenko R., 2011). By words "city resilience" typically is understood – sustainable energy management, securing stable energy supply, reducing energy consumption, developing renewable energy sources (Coaffee J., 2008) and also security policy focused on terrorist hazards and natural disasters (Collier *et al.,* 2013).

This paper explains the synergy between main city dimensions such as energy, economics and stakeholders and different urban sector development levels. The aim of this paper was to draw attention to areas with high impact to smart city development process.

2. City strategic energy action plan

Modern cities can achieve EU20-20-20 goal only by improvements in all major sectors such as buildings, energy and transport. Each European City is free to choose their approach for achievement of EU20-20-20 target. The main document which defines actions and measures to be implemented in each City in order to reach CO_2 reduction by 20 % is Sustainable Energy Action Plan (SEAP). According to Covenant of Mayor (www.covenantofmayors.eu) data there are 3414 cities across the Europe and eastern partners which already have Sustainable Energy Action Plan.

Typical Sustainable Energy Action Plan is focused on standalone actions such as insulation of buildings, use of efficient lighting, local renewable energy sources and etc.

Nowadays the existing SEAP should be enhanced taking into account requirements for Smart Cities. Although there is no global definition of Smart City (Neirotti *et al.,* 2014) the Smart Cities general concept can be characterized as improvement of urban performance by implementation of information and communication technologies (ICT) and by engagement of stakeholders. In addition more cross-sector energy actions should be introduced. Currently there are activities to start standardization activities in field of sustainable development and smart cities (Marsal_Llacuna *et al.*, 2014).

Efficiency and impact of each energy action should be evaluated on 3D scale taking into account sector, city dimension and implementation scale. The major city dimensions which characterize each energy action are "energy and technology", "economics and finance" and "organization and stakeholders". Interaction between city dimensions and scale for each sector is shown in Fig. 1. Each indicator impact is evaluated at implementation scale. This approach enables us to understand whether the implementation of actions is proportional to the city's scale and dimension in each sector.

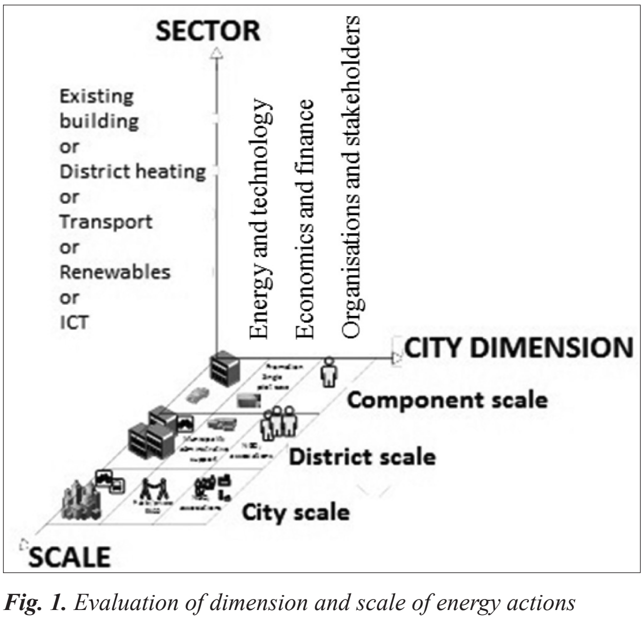

Fig. 1. *Evaluation of dimension and scale of energy actions*

For example, if city wants to realize existing building renovation at city scale the "economics and finance" and "organization and stakeholders" should be addressed at proper level. The public/private finances should be used including ESCO (Energy Service COmpany) model and active work with wide range of stakeholder groups is necessary.

Example of "energy and technology" indicator of building renovation process at different scale is shown in Fig. 2.

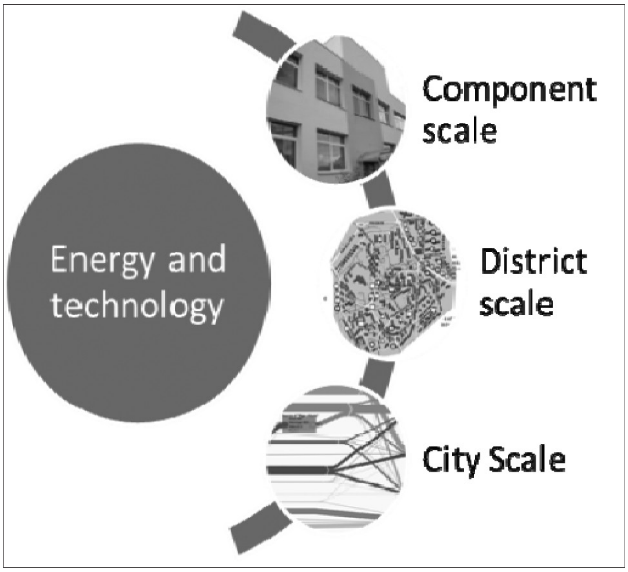

Fig. 2. *Example of building renovation process on "energy and technology" dimension*

In case of building renovation the component scale includes single building renovation. The district scale may include grouped building renovation. According to Borodinecs *et al.* (2013) the estimated savings can be about 10 % due to grouping development, compared to the component scale renovation. The city scale renovation can include analysis of different building renovation scenarios and future city energy flow planning.

As mentioned above, nowadays cross-sector energy action is one of main parts of Smart City. As a rule the cross sector action needs to have information and communication technologies. As an example of cross sector action smart electricity grids supporting filling of electric cars can be mentioned. Such solution enable charging load of electric vehicles (EV) to be shifted to off-peak periods, thereby significantly reducing both generation and network investment needs and enables customers to schedule charging intelligently (Morgan, 2012).

3. Designing of smart city

Urban growth and social changes is a rapid and never ending process nowadays. Adapting to the challenges require ways for efficient development of smart city. The models of smart cities should contain a lot of important compounds: social network, economics, community capacity, infrastructure, geographical location of city ecosystem services, political will and history also (Collier *et al.,* 2013). The development process must be related to civil protection, risk assessment and evaluation of the post risk strategies. The plans should cover all city communications (heat, gas and water networks and distribution systems, starting from protection of the sources until the end consumer). Only the synergy between all compounds can guarantee resilient evolution of intelligent and smart environment. Of course, the urban communities must be central component of stakeholders in evolution process.

It is essential to provide possibilities of sharing the experience about smart city design and planning between cities and communities. Most successful and beneficial projects have to be repeated and recreated widely in Europe considering local differences in technical features of infrastructure. In terms of Smart Cities the most powerful actions are those which directly affect at least these three sectors – energy, ICT and transport. Dissemination of such projects across the Europe will be possible due the fact that the projects have already been approved and implemented in other cities. Also energy saving potential can be assessed more accurately and possible shortcomings or limitations considered due to existing experience. It can be called Good Practice, which in the context of INTERREG IVC programme is defined as an initiative (e.g. methodologies, projects, processes, techniques) undertaken in one of the programme's thematic priorities which has already proved successful and which has the potential to be transferred to a different geographic area. Proved successful is where the good practice has already provided tangible and measurable results in achieving a specific objective. The Good Practice examples and detailed descriptions could be found following the link – http://i4c.eu/ficheGoodpractices.html?id=234**.**

4. Cross-sector actions in district heating

District Heating network

The Joint Stock Company „RĪGAS SILTUMS" is the biggest District Heating Company in Latvia and in the Baltic countries which is engaged in the production, transmission, distribution and sales of heat, the simultaneous production of heat and generation of power in cogeneration plants, as well as the servicing of district heating networks and systems in Riga city. Heat is produced in 43 heat sources, including 5 District Heating Plants (DHP) and 38 automated gas-fired boiler houses (BH).

Security of district heating and amount of transmission heat losses directly depend upon the technical condition of heat networks and their elements. In the result of the work invested over a long period of time the losses of the heat transmitted to consumers of city of Riga have decreased by 667 thous. MWh or 2.45 times in comparison to year 1996/1997 (Fig. 3.).

During last fiscal year the Joint Stock Company implemented large scale reconstruction of a section of the district heating network main pipeline section M-1 with the total length of 1228 m along Brīvības street, where the obsolete pipelines were replaced by new 600 mm pre-insulated pipelines, which were installed according to the non-channel technology and equipped with a special alarm system which permits to find the location of a damage in a fast and accurate manner and connected to the automatic remote reading system. Co-financing of the European Union Cohesion Fund was used for implementation of this project.

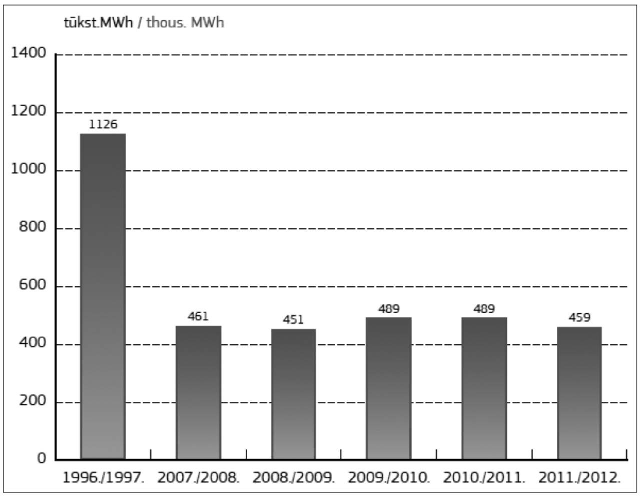

Fig. 3. *Heat losses in district heating network [Source: ANNUAL REPORT, JSC „RĪGAS SILTUMS", 2012]*

Heat production from renewable energy sources

For the future sustainable development of the district heating system, a few important production development projects have been implemented during the last years, which will allow to achieve considerable savings of fuel and to diversify the fuel, thus improving security of heat supply.

The reconstruction of the boiler house at Gaileņu street 14 was implemented in fiscal year 2011/2012. The obsolete water heating boilers were replaced and two water heating condensation type boilers with the heating capacity of 1.8 MW were installed. Condensation type boilers provide the operational efficiency of boilers which is 7–15 % above that of traditional boilers.

The Joint Stock Company, complying with the principle of economic profitability and state support for use of renewable energy resources in energy, plans to expand the use of bio-fuel in heat supply and to reduce heat losses in the district heating transmission; co-funding of the European Union funds will be used for these purposes also in future. According to the current trends of the JSC „RĪGAS SILTUMS" in the upgrading of the heat sources the share of natural gas is to be decreased by increasing the share of biofuel in the fuel balance and the Technologies ensuring the highest possible efficiency of the operation of facilities are to be used.

The construction of the biofuel fired cogeneration plant of DHP "Ziepniekkalns" with heat capacity up to 22 MW and the electrical capacity up to 4 MW was completed in February 2013. The co-financing of the Cohesion Fund of the European Union has been granted for the implementation of this project. It is planned to use biofuel, i.e. wood chips, in this cogeneration plant. The implementation of this project will result in the increase of the share of biofuel in the fuel balance of the JSC „RĪGAS SILTUMS" by 4.7 %.

Modernisation of the DHP „Zasulauks", which includes construction of a biofuel fired water heating boiler with the heating capacity of 20 MW which will operate at a high degree of efficiency and automation, without permanent operating personnel was completed in May 2013. The implementation of this project will result in the increase of the share of biofuel in the fuel balance of the JSC „RĪGAS SILTUMS" by 6.3 %.

The implementation of the project „Installation of flue gas condensers for biofuel fired boilers at the DHP „Vecmīlgrāvis" within the framework "Measures for improving efficiency of district heating systems" of the operational program "Infrastructure and Services" in April 2014 will result in the increase of the share of biofuel in the fuel balance of the JSC „RĪGAS SILTUMS" by 1 % on average.

Following the completion of implementation of the above referred projects the share of biofuel utilisation within the fuel balance of the JSC „RĪGAS SILTUMS" will reach 20.4 % in fiscal year 2013/2014 (Fig. 4.). The total energy produced from renewable energy sources since 01.01.1996 until 8.04.2014 is 920463.107 MWh.

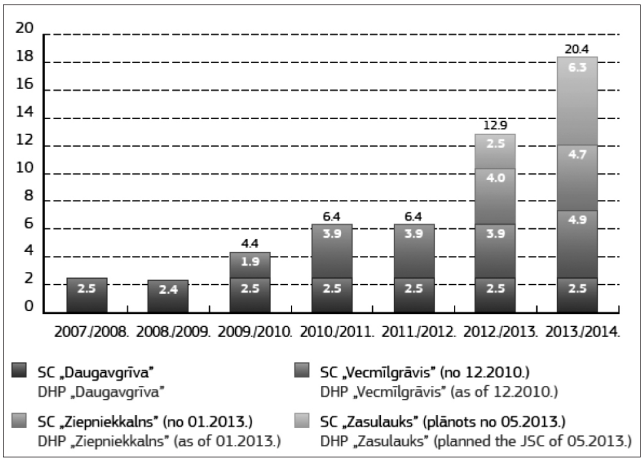

Fig. 4. *The increase of the share of biofuel utilisation in heat sources, % [Source: ANNUAL REPORT, JSC „RĪGAS SILTUMS", 2012]*

Heat meters automatic remote reading system in JSC "Rigas siltums» - Riga city.

There are four main steps. Each building with heat substation and heat meter is equipped with automatic remote reading system, which is used for data reading of heat consumption (in accordance with client need, it can be connected to other data reading, such as cold, hot water or electricity). In addition, there is an antenna placed outside of a building. The data transfer is done by radio waves to special transponders and base stations (not only radio waves, but also GSM or fixed data connection can be used) Figure 5.

Further all data by fixed network is transferred to central data base. From this point, there are two possibilities how the data can be used – Web interface, where operators can use the information by connection points or by clients, for example in on-line form all heat meters can be read. Second option is related to commercial readings such as invoice preparation. Data is collected in Oracle data base and then after processing all the invoices can be generated. All data from all 8000 heat meters can be accessed in three hours.

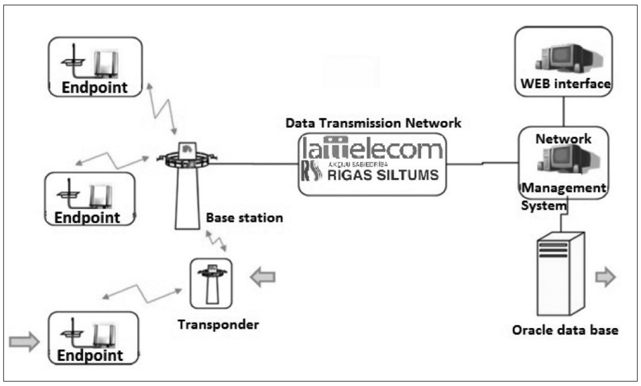

Fig. 5. *Automatic remote reading system concept*

Before implementation of this system employees of the heat supply company JSC "Rīgas siltums" had to read data from meters on the first day of each month directly in each object and form report on energy consumption. Afterwards employees have to enter received readings into the data base. Automatic meter remote reading system makes records for all heat meters data in a given time by writing in the current system, excluding human factors on current data quality and minimizing potential errors. Reading data at a specific time enables accurate heat data analysis and evaluation of each user's heat consumption dynamics. This system can be linked to other IT systems for technical, analytical or customer services needs. Total contract amount was 1.87 million LVL excluding VAT, or 2.26 million LVL with VAT.

The main benefits of implementing this practice are as follows:

- Operative information on heat loses and operation of heat meters. The potential heat problems can be quickly identified and remedied, improving the quality of services;
- Less time-consuming billing;
- A smaller amount of error due to automatic data entry;
- Broader customer service options;
- Optimization of human resources.
- Possibility to prevent theft of heating unit equipment
- Transmission of conjugate data such as state of alarm surveillance system of pre-insulated district heating pipes

5. Cross-sector actions in transport sector

Urban growth and social changes nowadays is a rapid process. Adapting development and introduction of electric cars and filling station infrastructure in Riga was approved by Riga City Council in the Riga City Sustainable Energy Action Plan 2010–2020th (SEAP). With the acceptance of Riga City Council Riga Municipal Limited Liability Company "Rigas satiksme" has attracted on lease agreement basis five electric cars for use of its technical services, whose daily work is connected to monthly run in average 2000km. Because of relatively high cost of introduction of electric cars, it pays off only with relatively high mileage. For a majority of PHEV (plug-in hybrid electric vehicles) designs and vehicle classes, PHEVs show a payback period of less than 6 years. However, many of the common components of TCO (e.g. maintenance costs, title and registration renewal costs, and salvage value) are not represented in all studies, and payback period is shown to vary between 6 and 12 years (Baha M. Al-Alawi, Thomas H. Bradley, 2012).

In 2013 the state was supported introduction of electric cars and development of filling stations infrastructure (Fig.6.) in co-financing from Climate Change Financial Instrument. After this Riga City Council has taken the next step and has sponsored project "Electric fast filling station placement schemes for the development of Riga" realization. It should be noted that the government is interested in promoting the use of electric cars, improving urban air quality and mitigation of global climate change.

Fig. 6. Scheme of fast charging points distribution in development stage in Riga.
[Source:http://www.latvenergo.lv/portal/page/portal/Latvian/latvenergo/main_page/korp_atbildi/UZLADES_PUNKTU_KARTE/]

Selected electronic car type is manufactured by the Finnish company "Valmet Automotive", designed from Norway, and already passed performance tests in the Nordic countries. This type of car is well known in Europe as several thousands are already sold. These cars are front – wheel driven, with two front seats and 800 litres car trunk. With one charging time the electric car is able to go 120–150 km, the time spent for one charge is 6–8 hours, and this type of car can develop a speed of 112 km / h. The warranty period is two years or 150 000 km. Charging is carried out in the normal grid with capacity 220V.

6. Conclusions

The smart city development process is a complex process affected by a wide range of different factors. The most important parts are economic, politic and social sectors and the engagement of wide range of stakeholders, which should be dynamic, flexible and ready to changes.

Currently there are 3414 cities across the Europe and eastern partners which already have developed Sustainable Energy Action Plan. The overall aim of these plans is to reduce energy demand and to provide the smart use of resources and make the basic contribution in advancement of cities environment, climate and community health. Taking into account the modern requirements to City energy consumption and CO2 emissions, the standalone energy actions should be integrated at cross sector level.

In order to insure urban resilience, all energy actions should be adequately addressed at all city dimensions and scale. Only the synergy in these areas guarantees the evolution of intelligent and smart environment.

As an example of cross-sector actions is introduction of information and communication technologies in city's infrastructure providing an opportunity for development of urban resilience.

JSC "Rigas Siltums" takes part in the development of "Riga City Sustainable Energy Action Plan for Smart Cities 2014–2020" to significantly exceed the 2020 targets: increase energy efficiency and share of use of renewable energy sources and to further reduction of CO2 emissions.

District heating network is a subject of constant improvement and in the result of the work invested over a long period of time the losses of the heat transmitted to consumers of city of Riga have decreased by 667 thous. MWh or 2.45 times in comparison to year 1996/1997.

Following the completion of reconstruction of the boiler houses, construction of a biofuel fired water heating boiler, construction of the biofuel fired cogeneration plant, installation of flue gas condensers for biofuel fired boilers at the DHP the share of biofuel utilisation within the fuel balance of the JSC „RĪGAS SILTUMS" will reach 20.4 % in fiscal year 2013/2014. The total energy produced from renewable energy sources since 01.01.1996 until 8.04.2014 is 920463.107 MWh.

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Acknowledgment

This paper is prepared under EU Seventh Framework Programme (FP7) project "Strategies Towards Energy Performance and Urban Planning" http://www.stepupsmartcities.eu/. Authors wish to thank project partners for contribution to project development and support in understanding of Smart Cities and Sustainable Energy Action Plan.

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Received 2014 04 22

Accepted after revision 2014 05 29

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