INTEGRATING SUSTAINABLE ENERGY ACTION PLANS FOR ISLAND MUNICIPALITIES – CASE STUDY OF KORCULA

by

Nikola MATAK [a*], ***Goran KRAJAČIĆ*** [a], ***and Ana Marijja PILATO*** [b]

[a] Department of Energy, Power Engineering and Environment, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Zagreb, Croatia
[b] City of Dubrovnik Development Agency, Dubrovnik, Croatia

Original scientific paper
DOI: 10.2298/TSCI151127109M

The goal of the European Union is to reduce CO_2 emissions by 20% till 2020. This objective is transferred to municipalities through the Covenant of Mayors initiative which was established by the European Commission in 2008. In line with this, this paper presents an integration of Sustainable Energy Action Plans on the Croatian island of Korcula. This was developed through a methodology that uses factors, derived from the statistic, that have an influence on the energy consumption. Energy consumption and the Baseline CO_2 emissions inventory for municipalities on Korcula in the public sector, households, tertiary sector and road transport are calculated. Total CO_2 emissions for listed sectors in baseline 2012 are 42,923 tCO_2, and with recommended actions and measures this can be reduced by approx. 22% till 2020. There are planned joint actions, so all municipalities on the island can cooperate together to maximise their limited financial and human capacities. There has been suggested the establishment of action group for actions implementation which will include representatives from municipalities and other stakeholders. Investments for measures in household sector in joint and individual approach was compared and it was concluded that achieving economy of scale with an integrated approach would accelerate their implementation. The integrated approach enables small neighbouring municipalities to develop one strategy and act together towards achieving goals taken by submitting to the Covenant of Mayors.

Key words: *Covenant of Mayors, CO_2 emissions inventory, island of Korcula, individual approach, integrated approach, comparison*

Introduction

The Covenant of Mayors initiative was established by the European Commission in 2008, after the adoption of the 2020 EU Climate and Energy Package, to help municipalities in the implementation of sustainable energy policy [1]. The goal of the initiative is to reduce CO_2 emissions by 20% till 2020 which is in accordance with the EU 20-20-20 goal. This is the biggest initiative in the Europe of this type which gathered 6,620 municipalities and more than 211 million citizens in November 2015 [1]. In the process are also included Covenant supporters, coordinators and others, which help municipalities to bring and implement sustainable energy action plans (SEAP). Their number was more than 370 [1]. Most of the municipalities have less than 50,000 residents and they make out more that 88% of the initiative.

* Corresponding author; e-mail: nikola@sdewes.org

In Croatia, the initiative gathers 60 municipalities, which included 8 of the 10 largest cities, and more than 2.5 million citizens [2].

Local energy planning, that the Covenant of Mayors is supporting, has not been thoroughly analysed in the literature [3], even though local authorities can have a significant influence on the reduction of energy consumption and GHG emissions [4]. An energy policy that is focused on utilizing the strong potential of renewable energy and energy efficiency can strengthen local capacities for energy production [5]. Recommendations for further research in this area are given in [6] and they include the development of standardised methodologies for tracking emissions on a local level, the introduction of different indicators, a collection of microclimate data and support for involving citizens and stakeholders. Lack of communication and information available to the citizens has been pointed out as the main issue, but once citizens were properly informed they strongly supported activities carried out by the Covenant initiative. Regarding the development and implementation of SEAP in rural communities, main issues, needs and priorities are given and explained in several cases in [7].

The most important steps in developing SEAP according to [8] are the analysis of the present situation, present and future energy and CO_2 balance and estimation of reduction potential; a strategy to reach targets, with targets' definition, measures and implementation plan; and a regular plan's monitoring. Estimation of current energy consumption and emissions status can be done with a developed method for tracking GHG emissions in cities [9], or using a system which is developed for countries [10]. Each of these methods requires large amounts of input data and neither is adjusted to smaller municipalities that are mostly joining the Covenant [2], as it is the case in this paper. A methodology that characterises energy systems at the regional level and that takes into account policy background, energy uses, infrastructures, market behaviour and community attitude for sustainable development is developed in [11]. A lack of good input data is analysed in [12] where it is identified to being a big problem. Methodology and a tool for the calculation of energy consumption and GHG emissions for the development of sustainable local energy and climate plans are tested and presented in [13]. Methods for assessing energy consumption and emissions for residential sector are developed in [14]. For estimation of GHG emissions from statistical data available in Finland, Monni and Syri [15] developed a methodology that could be altered and used in other cases. Estimation of emissions from public buildings could be done based on methodology presented in [16] and for road traffic, a methodology is developed in [17]. Municipal policy support for the bioenergy projects in the area of direct support of innovation, infrastructure, regulation (protection and standards) and public engagement in the case of Norway is show by Rygg in [18]. On the other hand, problems with lack of municipal support and the role of public administration which has to set example to private sector in reducing GHG emissions is analysed in [19], and problems with lack of citizens support and development of sustainable urban mobility plans in transport sector that are not connected with Covenant is pointed in [20]. More tools and methods for small municipalities that are developing SEAP needs to be developed, according to Amorim in [8], since they play an important role in the local energy planning [21]. One of the tools that can be helpful for local governance officers in local RES planning is developed in [22].

When looking at emissions reduction, implementation of energy efficiency and renewable energy sources, it is shown in [23] that large cities and more urban areas have a higher potential for reduction of emissions and energy efficiency, but small municipalities can implement more renewables. Choice of actions and measures for reduction of CO_2 and implementation of renewables was analysed in [24] and new methodology for selection of actions is proposed in [25]. Penetration of more renewables could be increased with the implementation of smart grid technology similar to one described in [26]. One of the key measures that are implemented in all municipalities is the replacement of public lightning and it is recommended to follow the methodology developed in [27] when dealing with this measure. The selection of most cost effective measures and ones that should be implemented later is given in [28]. Finally, tracking the emission reduction can be done with different types of indicators that are introduced in [29] and [30] where are given indexes for tracking the current sustainability status of the local communities. Another index that could be used is the SDEWES index [31] and [32] which tracks seven different types of sustainability in cities.

Municipalities can join the Covenant individually or jointly with neighbouring municipalities – denoted option 1 and option 2, respectively. Joint SEAP is targeting neighbouring municipalities with less than 10,000 inhabitants and urban agglomerations with suburbs and gravitating satellite administrative areas [33]. There are currently 71 groups of municipalities that have made a joint approach, of which 65 have joined according to the option 2 [33]. Municipalities, which jointly approached, did not try to integrate individual approach to get joint SEAP, as it is done in this paper. Generally, all documents and tasks in joint option 2 are done shared for all municipalities that are in the group, except submission of SEAP city council approval. This is different from the individual and joint approach option 1 where almost everything is done individually, as shown in tab. 1. This paper will compare individual and joint measures developed in SEAP since it has been noticed that there could be achieved benefits for small municipalities if they decide to join the initiative together.

This paper presents indicators that are used for the calculation of baseline emissions inventory and compares the two different types of the joining the Covenant of Mayors initiative, individual and joint approach. Firstly, it will be described the process of joint approach to the Covenant of Mayors, with outlining the four characteristic phases:
– initiation phase,
– planning phase,
– implementation phase, and
– monitoring and reporting phase.

Then factors used for the calculation of energy consumption and emissions for the area chosen are presented. Main results in the form of the emissions calculated with the presented factors are given and possible reductions in CO_2 emissions are presented by sectors. Comparison between the two different types of the approaches in the initiative for the presented case is given together with a discussion on the best way for small municipalities to join the initiative. Finally, in the conclusion, main results of the joint approach are presented, differences between joint and individual approach are outlined with the possibilities for future work in the area.

Table 1. Differences in the ways of joining the initiative [33]

	Individual SEAP	Joint SEAP option 1	Joint SEAP option 2
CO_2 emissions reduction target	Individual	Individual	Shared
Emission inventory	Individual	Individual	Shared
SEAP actions	Individual	Shared	Shared
SEAP city council approval	Individual	Individual	Individual
SEAP template submission	Individual	Individual	Shared
SEAP document submission	Individual	Shared	Shared
Signatory profile in the website	Individual	Individual	Shared

Methods

Here are described the factors that are used for the creation of baseline emissions inventory and the method that is used for the development of the joint SEAP. There are four phases in the joint SEAP process and they will be shortly described. Everything starts with municipalities signing the Covenant Adhesion Form, but this time as a part of the group of municipalities instead of an individual. According to the joint approach by option 2, group of municipalities is making one BEI and one SEAP which has to contain joint measures. In the initiation phase, it is important to secure political commitment with the signing of the Covenant. Administrative municipal structures should be adapted to address all necessary challenges and organized in action group which will include representatives from all municipalities, regional authority, local action group, regional and local development agencies, different associations, citizens and other stakeholders from the municipalities that have decided to join together in the group. There should be selected coordinator of the group and external support from the educational, scientific and the developing institutions should be secured. The coordinator of the group should be chosen from the regional authority/agency that is responsible for all municipalities included in the joint approach, rather than from the one of the municipalities. It is very important that the SEAP is compliant with other strategic documents and initiatives of the local government and administrative departments.

Calculation BEI and SEAP

Planning phase comes second with the development of BEI and SEAP. There needs to be chosen baseline year for SEAP and data on the energy consumption collected or calculated. Data are estimated according to the methodology described below. Sectors of energy consumption are divided into public buildings, public lighting, households, commercial, public transport, government vehicles and other road transport. Energy consumption of commercial and household sector is estimated for all fuels except electricity for which data was provided. Consumption of other fuels was calculated from county level by using many statistical parameters. Consumption of biomass was estimated with factor f_1 shown in eq. (1), where USP_{opc} is a total living area in the municipality, USP_{zup} in the county, PNS_{opc} is an area of abandoned apartments in the municipality and PNS_{zup} in the county. Factor f_1 represents the ratio of the heating area that is used in county and municipality:

$$f_1 = \frac{USP_{\text{opc}} - PNS_{\text{opc}}}{USP_{\text{zup}} - PNS_{\text{zup}}} \tag{1}$$

The second factor used for estimation of biomass is f_2 shown in eq. (2), where S_{opc} is a number of citizens in the municipality and S_{zup} in the county. This factor gives the ratio between a number of the citizens that live in the municipality and the county:

$$f_2 = S_{\text{opc}} / S_{\text{zup}} \tag{2}$$

Consumption of biomass is estimated with eq. (3), where B_{zup} is consumption of biomass in the county:

$$B_{\text{opc}} = \frac{f_1 + f_2}{2} \times B_{\text{zup}} \tag{3}$$

Factors used for estimation of fuel oil and liquefied petroleum gas (LPG) in households are shown in eqs. (4)-(6). Factor f_3 is calculated with eq. (4), where N is a number of tourists overnight stays in municipality and county. This factor represents the ratio between tourist overnight stays in the municipality and in the county:

$$f_3 = N_{\mathrm{opc}} / N_{\mathrm{zup}} \tag{4}$$

Factor f_4 is calculated according to eq. (5), in which NS is a number of settled apartments, PNS is a number of temporarily settled apartments, SOR is a number of apartments for recreation and rest, SIT is a number of apartments for renting to tourists, and SOD is a number of apartments for other activities. Factor f_4 represents the ratio between a number of apartments in the municipality and the county that are used at least for a couple of months during the year:

$$f_4 = \frac{NS_{\mathrm{opc}} + PNS_{\mathrm{opc}} + SOR_{\mathrm{opc}} + SIT_{\mathrm{opc}} + SOD_{\mathrm{opc}}}{NS_{\mathrm{zup}} + PNS_{\mathrm{zup}} + SOR_{\mathrm{zup}} + SIT_{\mathrm{zup}} + SOD_{\mathrm{zup}}} \tag{5}$$

Factor f_5 is calculated in a way shown in eq. (6), where OS is a number of well-equipped apartments, those that have kitchen and bathroom and toilet. It represents the ratio of well-equipped apartments in the municipality and in the county:

$$f_5 = OS_{\mathrm{opc}} / OS_{\mathrm{zup}} \tag{6}$$

Consumption of LPG in households in the municipality is calculated by eq. (7):

$$UNP_{\mathrm{opc}} = \frac{f_1 + f_2 + f_3 + f_4 + f_5}{5} \times UNP_{\mathrm{zup}} \tag{7}$$

Consumption of fuel oil in households is calculated by eq. (8):

$$LO_{\mathrm{opc}} = \frac{f_1 + f_2 + f_3 + f_4 + f_5}{5} \times LO_{\mathrm{zup}} \tag{8}$$

Consumption of LPG and fuel oil in the commercial sector is estimated by eq. (9):

$$USL_{\mathrm{opc}} = \frac{f_2 + f_3}{2} \times USL_{\mathrm{zup}} \tag{9}$$

Consumption in other road transport is estimated by eq. (10), in which BV is a number of vehicles of a specific type in the municipality, SPG is a specific consumption of that type of vehicle in the municipality, and PBK is the average number of yearly passed kilometres of that type of vehicle. Consumptions are separately calculated for diesel and petrol fuel, and there were 4 types of vehicles: mopeds and motorcycles, cars, light trucks (< 3.5 tonnes) and heavy trucks:

$$P_{\mathrm{G}} = \sum_{\mathrm{tip}=1}^{4} \frac{BV_{\mathrm{tip}} \times SPG_{\mathrm{tip}} \times PBK_{\mathrm{tip}}}{100} \tag{10}$$

Calculation of CO_2 emissions is compliant with Intergovernmental panel for climate change (IPCC) and used emission factors are shown in tab. 2. A tool used for emissions calcu-

Table 2. CO_2 emission factors used for calculation [41]

Fuel type	CO_2 emission coefficient [gkWh^{-1}]
Electricity	310
LPG	227
Fuel oil	279
Petrol	249
Diesel	267
Biomass	0.468

lation is ICLEI Europe's basic greenhouse gas inventory quantification tool. For electricity emission factor, it is used national factor for 2012 [34] since that year is chosen for baseline year. Measures proposed for reduction of CO_2 emissions are chosen according to the measures and actions from [35] and [36], other measures are selected from standard measures from the Croatian Environmental Protection and Energy Efficiency Fund (EPEEF) [37]. National action plan for renewable energy sources [38], energy strategy of the Republic of Croatia [39], programme of energy renovation of family houses [40], SEAP [1] of other Adriatic municipalities and guidebook [41] were used for selection of additional measures. Production of electricity from photovoltaics was estimated by using PVGIS calculator [42].

Approval, implementation and monitoring of plan

Approval of the plan by the municipal council is a most important step for SEAP implementation. With joint approach according to the option 2 municipalities on the island are making a commitment that they will together act towards the achieving goals taken by joining the initiative. For the monitoring of the action plan every two years, there should be submitted a monitoring report to the Covenant of Mayors Office. At least every four years, action group must submit monitoring emissions inventory (MEI) and action group with representatives of the municipalities is responsible for SEAP implementation.

Results

The results of the described methodology are tested in the case of the island of Korcula and main outcomes are presented. Energy consumption for the baseline year with emissions of CO_2 is calculated. Local energy production and the potential for implementation of RES are analysed. There are presented measures for the reduction of the emissions for at least 20% till 2020. This was done so that results could be compared with the results of the individual approach to the initiative that the municipalities located on the island have done. In the last paragraph, the cost of measures and potential for investment is compared between joint approach for all public authorities on the island and individual joining. This was done for the selected measures from the household sector because they are most common for the reduction of CO_2 emissions.

Case of the Korcula island

The island of Korcula is located in the south of Croatia in Dubrovnik-Neretva County and is the sixth island by size in Croatia with an area of 279 km^2 [43]. Administratively it is divided into one city and four municipalities which together have 15,521 inhabitants. Municipalities that are located on the island are Vela Luka, Blato, Smokvica and Lumbarda, and the City of Korcula which is the largest local administration on the island. Municipalities of Vela Luka, Blato and Smokvica, and the City of Korcula have developed SEAP with help from UNIZAG FSB and this paper is used to compare two different ways to join the initiative, and integration of individual SEAP.

Local energy consumption and production

Final energy consumption of the island of Korcula in 2012 was estimated at 176 GWh and by sector and fuel type is shown in tab. 3. If we look at this consumption by sectors, highest consumption has the sector of the other road transport, 78,788 MWh and his share is 44.68%. It is followed by the households with a share of 37.53% and the commercial sector with 15.16%. Public sectors have shares lower than 1%, and together they have a share of 2.63%. By fuel type, highest consumption is of electricity with a share of 32.92%. It is followed by diesel, 27.99% and petrol with 17.66%. On the island of Korcula, there are not located big power plants or similar facilities. According to the available data, the only energy produced on the island was from solar collectors for heating of the hot water and in 2012, it was estimated at 78 MWh. In the City of Korcula is installed PV plant Gojko Arneri with 50 kW of installed capacity, but it was not operational in 2012. The average yearly value of insolation at the horizontal surface is from 1.5 to 1.55 MWh/m^2, and for optimal slope, from 34° to 36°, this is from 1.69 to 1.93 MWh/m^2, which represents big solar potential. Wind potential also exists, but the law is very restrictive regarding construction of wind farms on islands. Biomass from wood is mostly used because 30% of the households is heating on it. Since agriculture is very important on the island there should be tested the potential of producing energy from leftovers after production of wine and olive oil. Geothermal energy has a low gradient but it could be used for ground source heat pumps [44].

Table 3. Energy consumption by sector and fuel type

Sector/Fuel type [MWh]	Electricity	LPG	Fuel oil	Biomass	Petrol	Diesel	Total
Public buildings	595	309	336	–	–	–	1,240
Public lightning	1,680	–	–	–	–	–	1,680
Households	34,384	4,423	4,924	22,440	–	–	66,171
Commercial	21,630	997	4,343	–	–	–	26,733
Government vehicles	–	–	–	–	59	444	502
Public transport	–	–	–	–	–	1,220	1,220
Other road transport	–	–	–	–	31,088	47,701	78,788
Total	58,052	5,729	9,603	22,440	31,146	49,365	176,335

Baseline emissions inventory

Total emissions in the analysed sectors on the island of Korcula for 2012 were 42,923 tCO_2, from which 1,328 tCO_2 was from public sector giving it a share of 3.1%. For each sector, share of the emissions is given in fig. 1. Emissions, consumption of energy, energy intensity, the share of the emissions and average emissions per resident are shown over fuel type in tab. 4. Most of the emissions, 17,996 tCO_2, comes from the electricity consumption and they have a share of 41.8%. It is followed by diesel and petrol fuel with shares of 30.7% and 18.1%. Average energy consumption per resident on the island of Korcula is 11,361 kWh, which is lower than national average without industry, air, railroad and sea transport, that is 12,814 kWh [45, 34].

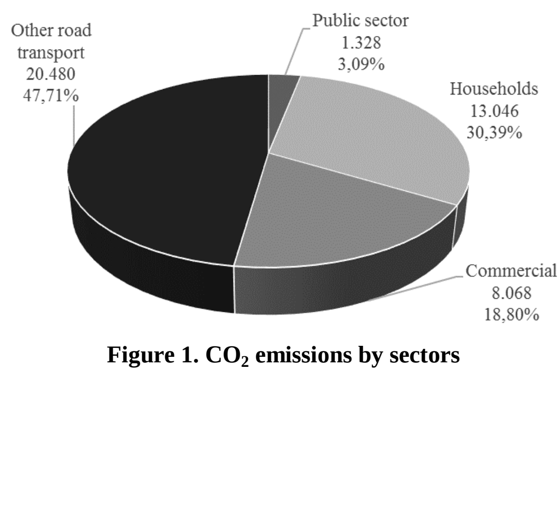

Figure 1. CO_2 emissions by sectors

Average emissions per resident on the island are 2.774 tCO_2 which is also lower than the national average from the energy sector, 3.956 tCO_2 [46]. This had to be taken with reservation because some sectors like industry, other transport, agriculture and construction are not taken into account in the SEAP.

Table 4. Emissions, energy consumption, emissions share, average emissions and energy consumption by fuel type

Fuel type	Emissions [tCO_2]	Consumption [MWh]	Emissions share [%]	Average emissions [tCO_2 per resident]	Average consumption [MWh per resident]
Electricity	17,996	58,052	41.80%	1.159	3.740
Fuel oil	2,676	9,603	6.21%	0.172	0.619
Diesel	13,169	49,365	30.68%	0.848	3.181
Petrol	7,770	31,146	18.10%	0.501	2.007
LPG	1,301	5,729	3.02%	0.084	0.369
Biomass	11	22,440	0.02%	0.001	1.446
Total	42,923	176,335	100.00%	2.765	11.361

Actions and measures for the reduction of CO_2

For the reduction of CO_2 34 measures were selected on the island and they are going to be listed in tab. 5. In the public sector, there were selected 11 measures and their contribution to reductions of CO_2 by 2020 is 416 tCO_2 which will result in a reduction from baseline year for 31.36%. Modernization of the public lighting will be contributing mostly to the reduction of CO_2 emissions because of necessary reconstruction of lightning in the City of Korcula. In the household sector, nine measures were selected. They will reduce emissions by 25.37% in this sector by 2020, compared to the baseline year. This reduction will be mostly contributed by replacement of inefficient indoor lighting and replacement of household devices with more efficient ones, for which EPEEF gives subsidies [37]. In the commercial sector, measures will bring a reduction of emissions by 1,032 tCO_2 till 2020. This reduction is mostly related to the reduction of electricity consumption and the local production of electricity from PV systems. Measures for the road transport sector will reduce emissions by around 22.92%. This is mostly achieved by introduction of the biofuels and the eco-driving education.

Table 5. Measures

Name of the measure	Energy saved/produced [MWh]	Emissions reduced [tCO_2]
For the public sector		
Replacement of existing lights with more efficient ones	54.8	16.99
Introduction of solar collectors for hot water and heating	41.1	12.74
Replacement of fuel oil boilers with biomass/heat pumps	101	26.79
Insulation of buildings external envelope and roofs	49.59	15.37
Replacement of external woodwork in public buildings	12.39	3.84
Education of public employees	61.99	19.22
Introduction of small PV systems on roofs	67.4	20.9
Implementation of green public procurement	9.92	3.07
New vehicles according to green public procurement	71.8	23.93
Biofuel in public transport	Fuel replacement	65.11
Modernization of public lightning	672.04	208.33
Total	1,142	416.3

Table 5. Continuation

Name of the measure	Energy saved/produced [MWh]	Emissions reduced [tCO_2]
For the residential sector		
Replacement of existing lights with more efficient ones	4,433	1,374
Co-financing of solar collectors for citizens	393.75	122.06
Co-financing of replacement of el. boilers with heat pumps	175.95	54.54
Insulation of buildings external envelope and roofs	316.68	98.17
Replacement of external woodwork in households	105.55	32.72
Replacement of appliances with more efficient ones	3,438	1,066
Education of citizens and organization of energy days	1,323	261
Introduction of small PV systems on the roofs	594	184.14
Organization of energy cooperatives for citizens	379.08	117.51
Total	11,159	3,310
For the commercial sector		
Replacement of existing lights with more efficient ones	598.82	185.6
Organizing apartment renters into energy cooperative	147.03	44.38
Construction of large PV plants on island	1,460	452.6
Insulation of buildings external envelope and roofs	667.26	201.39
Replacement of external woodwork in buildings	166.81	50.35
Introduction of small PV systems on the roofs	102.3	31.71
Installation if reactive power compensators	213.94	66.32
Total	3,356	1,032
For the transport sector		
Promotion of the car sharing model on the island	588.15	152.88
Promoting the purchase of electric vehicles	1,333	346.54
Construction of bike paths and	49.74	12.93
Introduction of 10% biofuels in the transport	Fuel replacement	1,888
Promotion of public transportation	2,353	611.53
Promotion of electric bicycles with solar chargers	2,531	657.82
Eco driving education of drivers	3,939	1,024
Total	10,794	4,694

Comparison of expenses for individual and joint measures

Several measures were compared from the household sector in tab. 6:
- co-financing of replacement of el. boilers with heat pumps,
- insulation of buildings external envelope and roofs,
- replacement of external woodwork in households, and
- introduction of small PV systems on the roofs.

The biggest investment of individual measures does not cross 65,000 € which is a small amount for potential investors. With joint planning, smallest amount is around 150,000 €. Even though this is still relatively small amount it is 3 times bigger than largest individual and therefore 3 times more interesting to the potential investors. This shows that more municipalities in the area should join to make the measures more economical. Integration of four SEAP and adding one more municipality into the initiative with this method shows a good potential. Therefore, it is suggested to the small municipalities, with a similar background to integrate their current SEAP with neighbouring local authorities to achieve benefits that this approach provides. The second step that is suggested is the integration of

SEAP with Sustainable Urban Mobility Plan since this would additionally improve local energy planning on islands where transport is the biggest emitter of CO_2.

Table 6. Comparison of action costs in individual and joint SEAP

	1	2	3	4
City of Korcula [47]	59,600 €	63,600 €	63,600 €	40,000 €
Municipality of Lumbarda	–	–	–	–
Municipality of Smokvica [48]	11,900 €	15,900 €	15,900 €	26,500 €
Municipality of Blato [49]	35,800 €	47,700 €	47,700 €	40,000 €
Municipality of Vela Luka [50]	47,700 €	47,700 €	47,700 €	40,000 €
The island of Korcula	155,000 €	175,000 €	175,000 €	146,500 €

Conclusions

Integrated SEAP gives small municipalities possibility to make one strategic document with common goals, which enables them to have less utilization of their limited human and financial resources. For the implementation of more complex measures, this removes administrative boundaries and supports mutual communication and cooperation between neighbouring municipalities. There can also be achieved knowledge transfer between more advanced municipalities in the area to ones less advanced.

There was analysed consumption in four municipalities and one city on the island of Korcula. Final energy consumption in baseline 2012 was estimated to be 176 GWh and this comes from seven analysed sectors. Electricity is most common used fuel with a share in consumption of 32.92%, but most energy is consumed in road transport sector. Total emissions from analysed sectors are 42,923 tCO_2, which means that each citizen emits 2,765 tCO_2 yearly. Total reduction of emissions which can be achieved by proposed measures is 9,453 tCO_2, which is a reduction of 22.02% till 2020 which is shown on fig. 2.

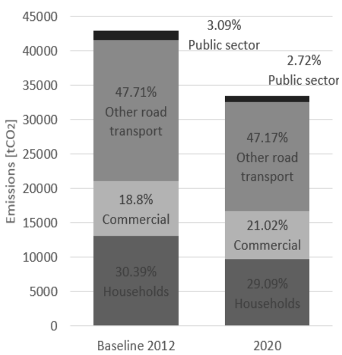

Figure 2. CO_2 emissions by sectors in 2012 and 2020

The integrated approach in the Croatian case for rural municipalities can be easily done with local action groups (LAG) [51]. There is currently 61 LAG and they are covering almost all territory in Croatia, except large cities. Their task is to encourage local sustainable development so that development of SEAP could be an additional tool which will bring them closer to achieving their goals. One of the biggest advantages of an integrated approach is a joint planning of measures that are increasing and thus achieving possibility to aces EU funds and simplifies planning process. With joint procurement, there can be achieved economy of scale which will reduce expenses. Educational activities are easier to plan on the island scale and there is achieved the easier transfer of knowledge between municipalities. This also simplifies procedures for construction of larger RES plants that are crossing the border of one municipality. With a joint approach to the Covenant of Mayors, small municipalities which do not have enough human or financial capacity are joining their capacities and can more efficiently act on the reduction of CO_2 emissions, an increase of energy efficiency and penetration of RES.

Acknowledgment

The presented work is a result of the research activities in BEAST and Meshartility projects which have received funding from the Intelligent Energy Europe Programme of European Commission.

References

[1] ***, Covenant of Mayors, http://www.covenantofmayors.eu
[2] Kona, A., *et al*., Reducing Greenhouse Gases Emissions through Sustainable Energy Action Plans at Local Level, The Common Platform Proposed by the Covenant of Mayors Initiative and its Potential Impact in the South East European Countries, *Proceedings of the 1st South East Europe Conference on Sustainable Development of Energy, Water and Environment Systems*, Ohrid, Macedonia, 2014
[3] Neves, A. R., *et al.*, A Methodology for Sustainable and Inclusive Local Energy Planning, *Sustainable Cities and Society, 17* (2015), Sep., pp. 110-121
[4] Comodi, G., *et al.*, Local Authorities in the Context of Energy and Climate Policy, *Energy Policy, 51* (2012), Dec., pp. 737-748
[5] Hasovic, Z., *et al.*, Impact of New Power Investments up to Year 2020 on the Energy System of Bosnia and Herzegovina, *Thermal Science, 19* (2015), 3, pp. 771-780
[6] Pasimeni, M. R., *et al*., Scales, Strategies and Actions for Effective Energy Planning: A Review, *Energy Policy, 65* (2014), Feb., pp. 165-174
[7] Marinakis, V., *et al.*, Local Communities Towards a Sustainable Energy Future: Needs and Priorities, *International Journal of Sustainable Energy, 34* (2015), Mar., pp. 1-17
[8] Amorim, E. V., Sustainable Energy Action Plans: Project Management Intercomparison, *Procedia Technology, 16* (2014), Nov., pp. 1183-1189
[9] ***, World Resources Institute, C40 Cities Climate Leadership Group, ICLEI – Local Governments for Sustainability, Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, 2015
[10] ***, Institute for Global Environmental Strategies (IGES), 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Hayama, Japan, 2006
[11] Cosmi, C., *et al.*, A Holistic Approach to Sustainable Energy Development at Regional Level: The RENERGY Self-assessment Methodology, *Renewable & Sustainable Energy Reviews, 49* (2015), Sep., pp. 693-707
[12] Azevedo, I., *et al.*, Mobilizing Cities Towards a Low-carbon Future: Tambourines, Carrots and Sticks, *Energy Policy, 61* (2013), Oct., pp. 894-900
[13] Di Leo, S., *et al.*, Energy Systems Modelling to Support Key Strategic Decisions in Energy and Climate Change at Regional Scale, *Renewable & Sustainable Energy Reviews, 42* (2015), Feb., pp. 394-414
[14] Swan, L. G., Ugursal, I. V., Modeling of End-use Energy Consumption in the Residential Sector: A Review of Modeling Techniques, *Renewable and Sustainable Energy Reviews, 13* (2009), 8, pp. 1819-1835
[15] Monni, S., Syri, S., Weekly Greenhouse Gas Emissions of Municipalities: Methods and Comparisons, *Energy Policy, 39* (2011), 9, pp. 4755-4765
[16] Oliver-Sola, J., *et al.*, Energy and Environmental Evaluation of Municipal Facilities: Case Study in the Province of Barcelona, *Energy Policy, 61* (2013), Oct., pp. 920-930
[17] Nejadkoorki, F., *et al.*, An Approach for Modelling CO_2 Emissions from Road Traffic in Urban Areas, *Science Of The Total Environment, 406* (2008), 1-2, pp. 269-278
[18] Rygg, B. J., Paving the Way for Heat. Local Government Policies for Developing Bioenergy in Norway, *International Journal of Sustainable Energy Planning and Management, 4* (2014), pp. 57-70
[19] Brandoni, C., Polonara, F., Technical and Economic Aspects of Municipal Energy Planning, *International Journal of Sustainable Development and Planning, 7* (2012), 2, pp. 221-236
[20] Brandoni, C., Polonara, F., The Role of Municipal Energy Planning in the Regional Energy-planning Process, *Energy, 48* (2012), 1, pp. 323-338
[21] Sperling, K., *et al.*, Centralisation and Decentralisation in Strategic Municipal Energy Planning in Denmark, *Energy Policy, 39* (2011), 3, pp. 1338-1351
[22] Kyriakarakos, G., *et al.*, A Fuzzy Cognitive Maps Decision Support System for Renewables Local Planning, *Renewable & Sustainable Energy Reviews, 39* (2014), Nov., pp. 209-222
[23] Pablo-Romero, M. P., Understanding Local CO_2 Emissions Reduction Targets, *Renewable and Sustainable Energy Reviews, 48* (2015), Aug., pp. 347-355

[24] Fiaschi, D., *et al.*, A Case Study for Energy Issues of Public Buildings and Utilities in a Small Municipality: Investigation of Possible Improvements and Integration with Renewables, *Applied Energy, 97* (2012), Sep., pp. 101-114
[25] Dall'O, G., *et al.*, A Multi-Criteria Methodology to Support Public Administration Decision Making Concerning Sustainable Energy Action Plans, *Energies, 6* (2013), 8, pp. 4308-4330
[26] Batas-Bjelić, I. R., *et al.*, Integrating the Flexibility of the Average Serbian Consumer as a Virtual Storage Option into the Planning of Energy Systems, *Thermal Science, 18* (2014), 3, pp. 743-754
[27] Beccali, M., *et al.*, Improvement of Energy Efficiency and Quality of Street Lighting in South Italy as an Action of Sustainable Energy Action Plans, The Case Study of Comiso, *Energy, 92* (2015), 3, pp. 394-408
[28] Stephan, A., Stephan, L., Life Cycle Energy and Cost Analysis of Embodied, Operational and User-transport Energy Reduction Measures for Residential Buildings, *Applied Energy, 161* (2016), Jan., pp. 445-464
[29] Neves, A. R., Leal, V., Energy Sustainability Indicators for Local Energy Planning: Review of Current Practices and Derivation of a New Framework, *Renewable and Sustainable Energy Reviews, 14* (2010), 9, pp. 2723-2735
[30] Doukas, H., *et al.*, Assessing Energy Sustainability of Rural Communities using Principal Component Analysis, *Renewable and Sustainable Energy Reviews, 16* (2012), 3, pp. 1949-1957
[31] Kılkıs, S., Composite Index for Benchmarking Local Energy Systems of Mediterranean Port Cities, *Energy, 92* (2015), 3, pp. 1-17
[32] Kılkıs, S., Sustainable Development of Energy, Water and Environment Systems Index For Southeast European Cities, *Journal of Cleaner Production, 130* (2015), Sep., pp. 222-234
[33] ***, Covenant of Mayors Office, Quick Reference Guide: Joint SEAP, Brussels, Belgium, 2014
[34] ***, Energy Institute Hrvoje Pozar, Energy in Croatia 2012 Annual Energy Report, Ministry of Economy, Zagreb, Croatia, 2014
[35] Kolega, V., *et al.*, The Program of Energy Efficiency in Final Energy Consumption of Dubrovnik-Neretva County 2014-2016 (in Croatian), North-west Croatia REA, Zagreb, Croatia, 2013
[36] Kolega, V., *et al.*, The Plan of Energy Efficiency in Final Energy Consumption of Dubrovnik-Neretva County 2014 (in Croatian), North-west Croatia REA, Zagreb, Croatia, 2014
[37] ***, Croatian Environmental Protection and Energy Efficiency Fund, http://fzoeu.hr/
[38] ***, Ministry of Economy, National Renewable Energy Action Plan for 2020 (in Croatian), Zagreb, Croatia, 2013
[39] ***, Ministry of Economy, Labour and Entrepreneurship, Energy Strategy of the Republic of Croatia, Zagreb, Croatia, 2009
[40] ***, Ministry of Construction and Physical Planning, Programme of Energy Renovation of Family Houses from 2014 to 2020 (in Croatian), Zagreb, Croatia, 2014
[41] ***, European Commission, How to Develop a Sustainable Energy Action Plan − Guidebook, Publications Office of the European Union, Luxemburg, 2010
[42] ***, PV Potential Estimation Utility, http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php
[43] ***, Korcula Island, http://www.korculaotok.com/otok_korcula.asp
[44] Bačan, A., *et al.*, Dubrovnik-Neretva County-The potential of Renewable Energy Sources (in Croatian), Energy Institute Hrvoje Pozar, Zagreb, Croatia, 2012
[45] ***, Croatia Bureau of Statistics, http://www.dzs.hr
[46] ***, Energy Institute Hrvoje Pozar, Energy in Croatia 2013 Annual Energy Report, Ministry of Economy, Zagreb, Croatia, 2015
[47] Krajačić, G., *et al.*, Sustainable Energy Action Plan of the City Korčula, Korčula, Croatia 2014
[48] Krajačić, G., *et al.*, Sustainable Energy Action Plan of the Mun. of Smokvica, Smokvica, Croatia, 2014
[49] Krajačić, G., *et al.*, Sustainable Energy Action Plan of the Mun. of Blato, Blato, Croatia, 2014
[50] Krajačić, G., *et al.*, Sustainable Energy Action Plan of the Mun. of Vela Luka, Vela Luka, Croatia, 2014
[51] ***, Croatian Rural Development Network, http://www.hmrr.hr/en/leader/lags-in-croatia

Paper submitted: November 27, 2015
Paper revised: April 4, 2016
Paper accepted: April 4, 2016