Civil Society for Sustainable Energy - Local to National in Eastern Europe – SELNEE

Review of climate action and transition to sustainable energy in Korosten Town, Ukraine

Analysis of SEAP of Korosten till 2020

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Disclaimer

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[1] https://www.inforse.org/europe/SELNEE.htm and https://rea.org.ua/projects/472/

Introduction

Since 2016, Ukraine is starting the public discussions and development of the strategic documents with the scenarios of energy transition towards 100% renewable energy till 2050. To follow this process as one of the elements of the transition Ukrainian cities are planning sustainable energy development according to the Sustainable Energy and Climate Action Plans (SECAPs).

The critical review of the SECAPs with respect to following of the general renewable energy transition trend, adequate estimation of financial possibilities and budget of the city to achieve respective targets, variety of different measures and their prioritization, identification of possible drawbacks is the crucial part of the energy transition process.

Current report is aimed on the detailed critical review of SEAP[2] for Korosten[3] city, overview of general process of the SECAP development in Ukraine and analysis of targets for other chosen list of the cities with own SECAPs and their comparison with Korosten SECAP. The outcome of such analysis is identification of targets in Korosten SECAP, the adequacy of their level and methodological issues, identification of the drawbacks and ways to eliminate them in the updated versions of SECAP. This process serves for the municipality as the independent view of consultant which may be used as substantiation of the future efforts for SECAP upgrade and development of SECAP till 2030 (ongoing) and 2050.

[2] http://korosten-rada.gov.ua/ekonomichniy-rozvitok/energetichniy-menedzhment/plan-diy-zi-stalogo-energetichnogo-rozvitku-m-korosten-do-2020-roku-(pdser)/
[3] http://korosten-rada.gov.ua/

The development of SECAPs in Ukraine

The process of developing Sustainable Energy Action Plans (SEAP) in Ukraine has been started in 2005 by few cities (Kamianets-Podilskyi, Zhytomyr) which joined the Covenant of Mayors initiative of the EU. This process got accelerated from 2012 with the establishment of the international programme "Covenant of Mayors" in Ukraine[4]. The development of SEAP (later SECAP) with setting of CO_2 reduction targets till 2020 (until 2030 for SECAP) is the obligatory requirement of programme participants. Currently the programme covers 246 independent signatories (and more than 100 individual cities, starting from small villages, finishing with Kyiv city) with 20 million inhabitants (half of Ukrainian population) and cumulative effect of 12.7 million t CO_2 reduction till 2020.

City-participants may establish a broader set of targets, including renewable energy input (share) in GFEC/TPES and energy saving/energy efficiency input. The horizon for target setting is also not limited to 2020, some cities already have approved SECAPs till 2030 and made drafts till 2050. Targets on renewable energy sources (RES) and energy efficiency may be specified in SECAP supplementing the main target of CO_2 reductions. Some of the cities-announced also the target of 100% RES till 2050 (7 cities) and are currently developing the respective plans till 2050.

Comparison of SEAP/SECAP of 8 selected cities in Ukraine

The approved SEAPs/SECAPs for 8 cities-participants chosen for brief analysis is presented below for information purposes and comparison of their targets with the Korosten SEAP targets.

Each of the chosen cities is somewhat unique and, at the same time, has common features with Korosten city. For example, Bakhmut city with respect to scale and investment possibilities is close to Korosten and, like Korosten, already has a moderate share of biomass in heating and cooling sector (DH only) (at least 25% for 2016). Opposite to Korosten, Bakhmut is only 20 km from the military action zone in the Eastern part of Ukraine (Donetsk region).
Kyiv city is chosen more due to its enormous scale to demonstrate the scaling of

[4] http://www.com-east.eu/en/about-us/covenant-of-mayors-east/ukraine

SECAP.

Zhytomyr is the centre of population of Zhytomyr region, where Korosten is located (100 km distance) with similar social-economy conditions, biomass potential, climate, transport infrastructure, energy balance structure.

Kamyanets-Podilsky is the first signatory of Covenant of Mayors among all cities in Ukraine and, like Korosten, is also strongly focusing on biomass in district heating as one of the elements for achieving SECAP targets.

Another four presented cities – Lviv, Poltava, Chortkiv, Trostyanets have approved plans (by the City Council resolutions) towards 100% RE in 2050, and the last two ones (Chortkiv, Central-Western Ukraine (Khmelnytskyi region) and Trostyanets, North-Eastern Ukraine (Sumy region)) has already approved SECAPs till 2030 with setting respective RES targets.

City	**Population, ths. people**	**Targets**		
		Renewable energy	Energy efficiency	CO_2 reduction
Bakhmut[5]	70-100[6]	20% by 2020*	-21% by 2020 to 2012	-21% by 2020 to 2012
Kyiv[7]	2 820	27% by 2020*	-21% by 2020 to 2013	-34% by 2020 to 2013
Zhytomyr (100 RE)[8]	272	n/a	n/a	-21.4% by 2020 to 2010
Kamianets-Podilskyi (100 RE)[9]	99	20% by 2020 (GFEC)	-20% by 2020 to 2012	-20% by 2020 to 2012

[5] http://artemrada.gov.ua/documents/%D0%B1%D0%B0%D1%85%D0%BC%D1%83%D1%82/6-%D1%81%D0%BE%D0%B7%D1%8B%D0%B2/20161123-%E2%84%96694-1698

[6] Due to closeness to military activity zone, the population varies over time (even during one year)

[7] http://kmr.ligazakon.ua/SITE2/l_docki2.nsf/alldocWWW/B82B5358289E8EE7C22582B2003F090F?OpenDocument

[8] http://misto-em.org.ua/wp-content/uploads/2018/04/Zhytomyr_SEAP.pdf

[9] https://merp.org.ua/articles/635-2016-11-09-11-12-13.html
https://www.slideshare.net/ssusera8a419/ss-48242357

Lviv (100RE)[10]	758	11% by 2020 (GFEC)	-20% by 2020 to 2007-2009	-21% by 2020 to 2009
Poltava (100 RE)[11]	295	n/a	n/a	-22.4% by 2020 to 2010
Chortkiv (100 RE)[12]	29	3% by 2030 (GFEC)	-28% by 2030 to 2013	-32% by 2030 to 2013
Trostianets (100 RE)[13]	21	28% by 2030 (GFEC)	-42% by 2030 to 2013	-58% by 2030 to 2013
Korosten[14]	**65**	**12.6% by 2020 (GFEC)**	**-22% by 2020 to 2012**	**-21% by 2020 to 2012**

* - only for heating and cooling for residential buildings (individual and DH) and for transport sectors.

The most detailed and high-quality SEAPs/SECAPs, according to analysis, are for Kyiv, Bakhmut, Chortkiv, Trostianets cities. In these SEAPs/SECAPs most of inherent drawbacks of Korosten SECAP are not present. They have transparent justification of base year, division of energy for GFEC/TPES, clear, non-double interpretation targets in relative and absolute values and their cross-checking through the different parts of document, detailed investment plans.They can be used as example for future development of SECAPs for other cities, including Korosten.

As for the targets, it may be seen that the majority for SECAPs analyzed have their targets for all three components (RES/energy efficiency/CO_2 reduction)

[10] https://city-adm.lviv.ua/lmr/business/2113-prohrama-staloho-enerhktychnoho-rozvytku-do-2020-roku
[11] https://www.slideshare.net/jalyna/2020-71736156
[12] https://mycovenant.eumayors.eu/docs/seap/22851_1508708347.pdf
[13] http://trostyanets-miskrada.gov.ua/viewpage.php?page_id=544
[14] http://korosten-rada.gov.ua/ekonomichniy-rozvitok/energetichniy-menedzhment/plan-diy-zi-stalogo-energetichnogo-rozvitku-m-korosten-do-2020-roku-(pdser)/

around 20% till 2020 (range 3-28%). In this context, Korosten is in the middle of the range, having 12.6% RES, 22% energy efficiency, 21% CO2 reduction.

Analysis of Korosten SEAP till 2020

For the analysis of Korosten SEAP, the latest publicly available version of the SECAP from the web site of the Korosten City Council is used (dated 2015)[15].

The document accounts for 22 pages (Ukrainian version), is bilingual (English and Ukrainian) and contains general description of the base energy and infrastructure state of the city, energy balance of the city, CO_2 cadastre, justifications of base year chosen for target setting, the targets itself, sources of investments and plan of targets performance monitoring. The targets are set for three components – energy efficiency, renewable energy and CO_2 reduction. The effect for each of the components are calculated on the level of each individual measure, consuming subsector and cumulative for the city. The investment part estimates the total investments needed for the implementation of each measure and specifies respective sources of financing.

The document is in general high-quality, robust and logically finished, the data is presented in transparent manner, the energy indicators and technical data are clearly indicated and could be cross-checked through the different parts of document. However, the analysis of the document reveals some drawbacks. The results of the analysis are described below.

The essential information of current state of energy sector in the city is presented in Table 3.2. It contains the full energy balance of the city specified for the different sectors and energy carriers. It is not clear, however, what is the energy type considered here – final energy (GFEC) or primary energy (TPES). Table sums up different components (for example, electricity shall be, probably, in GFEC and natural gas shall be probably in TPES). The figures are used then for CO_2 emissions calculation (usually on basis of TPES, as CO_2 emissions arising from primary fuel combustion, which is attributable to TPES), but at the same time, the

[15] http://korosten-rada.gov.ua/ekonomichniy-rozvitok/energetichniy-menedzhment/plan-diy-zi-stalogo-energetichnogo-rozvitku-m-korosten-do-2020-roku-(pdser)/

heading of the Table contains wording “consumption”. This is considered as drawback and shall be altered in future SECAP.

Table 3.2 of the Korosten SEAP

Table 3.2.

Consumption of energy resources by selected sectors in 2008-2014, in aggregated units, MW*hour

#	Sectors included into BEI	2008	2009	2010	2011	2012	2013	2014
1. Municipal buildings, equipment/facilities								
1.1.	Natural gas	2 325,2	2 102,7	2 144,5	1 443,4	296,1	746,3	579,2
1.2.	Electricity	2 434,8	2 524,6	2 268,3	2 345,7	2 230,6	2 036,4	2 179,4
1.3.	Water supply and sewerage	162,5	207,1	170,4	166,9	131,0	147,7	159,2
1.3.1.	Water supply	81,7	123,8	103,7	102,8	77,3	86,9	89,4
1.3.2.	Sewerage	80,8	83,3	66,7	64,1	53,7	60,7	69,8
1.4.	Heat	18 026,5	16 282,0	18 866,2	18 049,8	17 420,6	18 162,6	13 524,5
1.5.	Coal	0,00	0,00	1 259,28	35,28	36,00	37,44	36,00
1.6.	Wood	0,00	0,00	34,84	0,00	34,84	0,00	17,42
Subtotal		**22 949,0**	**21 116,4**	**24 743,5**	**22 041,0**	**20 149,1**	**21 130,3**	**16 495,7**
2. Residential buildings								
2.1.	Natural gas	242 637,0	237 143,1	241 767,2	236 141,9	248 099,3	242 392,5	229 471,1
2.2.	Electricity.	41 574,0	43 624,0	49 659,0	46 848,0	52 199,0	54 257,0	53 771,0
2.3	Water supply and sewerage	2 330,4	2 861,6	2 785,5	2 756,0	2 664,9	2 894,4	3 025,4
2.3.1	Water supply	1 238,2	1 803,4	1 798,1	1 760,8	1 640,2	1 778,4	1 795,3
2.3.2	Sewerage	1 092,3	1 058,2	987,4	995,1	1 024,7	1 116,0	1 230,1
2.4.	Heat	102 526,9	114 562,0	131 411,3	126 237,3	143 581,5	129 694,5	109 246,8
Subtotal		**389 068,4**	**398 190,7**	**425 623,0**	**411 983,2**	**446 544,8**	**429 238,4**	**395 514,2**
3. Municipal street lighting								
3.1.	Electricity	1 132,90	1 131,70	1 323,90	1 476,40	1 423,80	1 156,50	1 118,20
Subtotal		**1 132,90**	**1 131,70**	**1 323,90**	**1 476,40**	**1 423,80**	**1 156,50**	**1 118,20**
4. Transport								
4.1.	Liquefied gas	734,3	1101,5	1285,0	1468,6	1468,6	2478,3	2478,3
4.2.	Diesel fuel	4948,6	4398,7	4398,7	4178,8	4178,8	2199,4	2199,4
Subtotal		**5682,9**	**5500,2**	**5683,8**	**5647,4**	**5647,4**	**4677,6**	**4677,6**
5. Industries outside ETS								
5.1.1	Heat	18 229,8	20 945,3	23 782,2	22 858,3	24 270,1	21 930,8	17 239,0
5.1.2	Water supply	457,9	714,1	673,6	715,1	667,1	710,5	686,5
	Subtotal	**18 687,73**	**21 659,40**	**24 455,78**	**23 573,46**	**24 937,20**	**22 641,37**	**17 925,59**
	Total	**437 520,92**	**447 598,38**	**481 829,98**	**464 721,37**	**498 702,26**	**478 844,26**	**435 731,40**

SEAP does not contain the classical clear division of energy flows (in GFEC and TPES) for three sectors - electricity, heating and cooling and transport. Specification per different primary energy carriers as per these three subsectors is present. This is considered as drawback and shall be altered in future SECAP.

The SEAP informs that 2012 is chosen as base year “…which is explained by the availability of complete and reliable information for that period with regard to consumption of all types of energy resources, …, the period is most representative concerning the specific economic situation”. However, according to evidence, (Table 3.2 of SEAP), all necessary energy data is available on the same level of details for the longer period (2008-2014) without any explanation, why information for one year is less reliable than for another one. Regarding the argument on economic situation, only 2014 year could be considered as non-appropriate (characterized by rapid macroeconomic recession in Ukraine due to different external factors not connected with activities in Korosten city). All other years may be included as candidates for base year on equal basis with 2012, including, for example, 2013, which is more close to the document development

period and has more conservative data on energy consumption (less energy consumption in comparison with 2012).

The analysis of provided data on energy balance of the city revealed that 2012 year has the maximum energy consumption/production for considered period (2008-2014) and for each of the subsectors separately. If energy consumption/production compared to the year with minimum consumption (2008), 2012 has +61,000 MWh (+12%), which could not be justified only by different climate between two years (colder winter in 2012) or economic situation. Energy used for heating is almost same level for 2008 and 2012. It could be clearly detected, that the presented increment occurred due to additional electricity consumption mainly in sector of households and municipal lighting and by small increasing of heat energy utilization in commercial sector (+6,000 MWh, +1.2% from total).

The choice of base year, relative to which all targets are then set (in %), could have major impact on the targets ambition level and efforts needed for achievement with the respective outcomes. In this particular case, wrong choice may take place, as according to the provided data 2012 is so-called “peak” energy year among all others in period 2008-2014. This is one of the drawbacks of the SECAP, however later on (in Table 4.2 of SECAP), the double presentation of targets (both in relative (%) and in absolute (MWh and t CO_2) values) for all three components takes place, so basically this drawback does not affect the final quality of target setting. Still, it is recommended to include additional justification for base year choice or critically revise it. The issue can be addressed taking as baseline the average weighted energy indicators for the latest 5-10 year period (normalized for climate conditions) or, in case of 1-year baseline, take the most conservative (and timely closest to the SEAP development) year with less energy consumption.

According to the energy balance provided in Table 3.2, the heating and cooling sector plays, as expected, the major role in total energy production/consumption for the considered period. For the 2012 year, category “heat energy” is accounted for ca. 170,000 MWh (depending on annually changed climate conditions, this figure varies between 130,000 and 175,000 MWh, so the provided base figure for 2012 is close to maximum heat output) out of 498,702 MWh (34%) total energy.

Ca. 248,000 MWh (the largest input among all other consumers) is consumed as natural gas by category "residential buildings" for different purposes, out of which at least 2/3 (another 167,000 MWh – estimation of the authors, 33% from total energy) is used for heating and cooling. Another ca. 24,000 MWh (5% from total energy) is consumed by commercial sector (category "industries outside ETS").

Therefore, total energy production/consumption for heating and cooling in Korosten city is 170,000+167,000+24,000 =361,000 MWh (72% from total energy). Some of the small consuming subsectors (small commercial and budget consumers with self-heating) are neglected here as they are less than 0.5% from total energy balance of the city. The remaining 28% of energy (ca. 137,000 MWh) is divided between electricity and transport. 5,647 MWh (1.1% from total energy) is energy in transport sector (data of Table 3.2), all remaining energy is electricity.

These facts are based only on data analysis of energy balance provided in SECAP. They stipulate that the priority of measures and main focus of energy transition of the SECAP shall be as follows: starting with high-consuming energy sector, which is heating and cooling, then electricity, then transport.

With respect to CO2 calculation, the total CO2 emissions of the city is linked to the different types of energy consumed/categories of consumers and accounted for 148,352 t CO2 for 2012. No critical omissions or drawbacks are detected in CO2 calculations, except of the possible minor drawback in emission factor for electricity (grid emission factor) provided in SECAP mentioning IPCC but without any link to IPCC. In fact, IPCC usually provides and updates emission factors from primary fuel combustion, not grid emission factors (which are attributable to final energy and depends on energy/fuel mix of each country usually hardly known by IPCC). Then, based on these factors, one may recalculate respective grid emission factors for each country using the UNFCCC (CDM/JI) methodologies and data on energy mix of respective country.

As for the Ukrainian grid emission factor (GEF), there were number of international projects aimed on the determination of GEF[16][17], set of Resolutions

[16] Lahmeyer, 2010: http://encon.sumdu.edu.ua/doc/methodics/Baseline_Study_Ukraine_Final_English.pdf
[17] EBRD, 2008: https://www.ebrd.com/downloads/about/sustainability/cef.pdf

of the National DPF during First Kyoto crediting period[18], self-calculated GEFs on the level different JI projects during 2008-2012[19], which contains different indicators from 0.807 to 1.227 t CO_2/MWh(el). It is recommended to use these publicly available sources for grid emission factor. In general, however, the grid emission factor used in SECAP could be considered as appropriate, as its value is between those mentioned above, but requires clear link to the source for consistency. This may be considered only as minor drawback of SECAP.

The SECAP section with targets clearly indicates the figures of targets set (in relative values (%) and then with detalization in absolute values in Table 4.2). The following targets are set (citation):

- "reduction of CO_2 emissions until 2020 in the selected sectors by 20.77%" (absolute value later in document - 30,815 t $CO_{2\text{-eq}}$/year – auth.);
- "increase of the share of renewable energy by 12.6 %" (absolute value later in document - 18,752 MWh/year - auth);
- (later in document – auth.) – "reduction of energy consumption by 111,251 MWh/year" (-22% to base year – estimation of author, relative figure is not specified throughout text of SECAP).

Setting targets for three independent indicators – GHG emission reductions, RES and energy efficiency are absolutely appropriate and correspond to the EU practice, national practice and other Ukrainian SECAPs practice and is strong side of the Korosten SECAP.

The somewhat unclear statement here relates to usage of wording "by" (Ukrainian "на") for RES share. This may create double interpretation of target setting and meanings. For example, it means either "increasing of RES share for 12.6% from current base level (2012 level)" or "increasing of share of RES to the level of 12.6% from all energy in 2020".

Consequently, it is unclear, what is the base figure for 12.6% share of RES. For double check, there is an absolute figure – 18,752 MWh of RES energy in 2020, which is 3.7% from total energy in 2012 and 5% from total energy in 2020 (taking into account reduction of energy consumption on 22% due to energy

[18] Latest Resolution of National DFP (2011, valid): http://search.ligazakon.ua/l_doc2.nsf/link1/FIN64245.html
[19] List of JI projects: https://ji.unfccc.int/JI_Parties/DB/E6OJWRL8OP3UCSQ2FVQZX7TT3CL1PV/viewDFP

efficiency measures). It is also unclear what the share of RES is in the base (2012) year. It could be only estimated with high uncertainty. For example, according to the regular Ukrainian-Energy Community Progress Reports, the share of RES for power, heating and cooling and transport in Ukraine is publicly available[20]. The latest figures for 2017 are: 7.6% in heating, 8.5% in power, 2.44% in transport. If taking these figures as baseline for Korosten city, then 12.6% RES share in 2020 is appropriate (most probably, accidentally): 7.6% (average weighted for all sectors/ categories in 2012) + 5% (measures during 2012-2020)=12.6%. However, according to Ukrainian Progress Reports for 2012-2013 (periods corresponding to the Korosten base year), the respective figures for Ukraine were 2.99%, 6.42%, 0.55%. This differs a lot with 2017 levels. That is why, it is not clear from what base mentioned 12.6% is taken. This is major drawback of the SEAP and shall be altered in futures SECAPs. At the same time, the presence of absolute value for RES partly solves the situation, but double check of two values – relative and absolute - detects inconsistency between them. On the basis of principle of equality for all data, it is still unclear, which value is right, and which is not.

For consistency, it is useful also to fix any energy targets separately for TPES and for GFEC to avoid any misunderstandings. It is not clear, which energy type relates to which target just like it is unclear for the base 2012 year (see explanations above).

With respect to CO_2 reduction, Table 4.1 contains comprehensive details on sectors/consumer categories where the reductions will take place. The main focus on CO_2 reductions in absolute values is foreseen in household sector (consumer category “residential buildings”) - 24,238 t CO_2 reduction, -18% to 2012 levels, 77% from total planned reductions for all sectors/consumers of the city. The sector with the highest relative reduction is “Industries out of ETS” (-54% reduction to 2012 levels). The distribution of reduction inputs between sectors/consumers shall be estimated as appropriate, the main focus is on the most CO_2 intensive sectors.

[20] Ukrainian two-years Progress Reports in Energy Community on share of RES in power, heating and cooling and transport: https://www.energy-community.org/implementation/Ukraine/reporting.html

The Table 4.2 contains detalization of effects of each individual measure for three components – energy efficiency/saving, RES input, CO_2 reduction and the aggregated values for the city. In addition, the investments necessary for each individual measure and for consumer category are presented.

The main input to all three SEAP targets makes household sector (category "residential buildings"):

Item	Total cost of implementation, (thousand UAH)	Expected energy saving, MW-hour/year	Renewable energy generation, MW-hour/year	CO_2 emission reduction (tons/year)
Absolute input of "residential buildings"	163,316.20	84,956.89	15,891.88	24,238.01
Total for SECAP	222,104.24	111,251.50	18,752.29	30,815.24
Relative input of "residential buildings" to SECAP	**73.5%**	**76.4%**	**84.7%**	**78.7%**

The absolute record for investments among all measures for SECAP is for the measure "Deep thermal modernization of pilot residential buildings (OSBBs)" – 93 million UAH out of 160 million UAH for consumer category (58%) and 222.1 million total investments for all measures (42%). The measure has relatively low effect on CO_2 reduction considering such investments – 4,107 t CO_2/year out of 24,238 for sector (17%) and 31,815 total SEAP reductions (13%), the energy saving effect for the measure is 11,344 MWh/year.

The minimum cost with the maximum energy saving effect is for the measure "Motivation of residents to use energy saving devices and domestic appliances in their households". The essence of the measure is replacement of most inefficient lighting (incandescent light bulbs) and electric appliances (old and non-labelled) in private households on energy efficient ones. Total investments are 1.2 million

UAH, energy saving effect – 6,700 MWh/year. The input of effect from the measure in total SEAP energy saving effect is 6%.

The absolute record on energy saving effect among all measures of SECAP is for the measure "Implementation of energy saving measures in private premises (apartments)". This measure essence is "basic" thermo-modernization of the most energy inefficient apartment parts (windows, glazing, doors, basic wall heat insulation). The energy saving effect is tremendous 46,557 MWh/year (54% for category "residential buildings" and 41% from total energy saving effect of SECAP), CO_2 reduction – 13,590 t CO_2 (57% and 44% respectively) and investments needed - 24.35 million UAH (15% and 11% respectively). This is the most efficient measure of SECAP with respect to both investment-effect ratio and absolute energy savings.

The absolute record on renewable energy input among all measures in SEAP is for the measure "Replacement of natural gas with alternative fuels in residential buildings". This means basically replacement of small-scale gas boilers for private households to biomass (or other alternative fuel) boilers. The investment needed amounts to 16.5 million EUR, and the respective effects are 2,505 t CO_2 reductions and 12,404 MWh/year renewable energy output (out of 18,752 MWh/year from all renewable energy measures in SEAP (67%)).

It is necessary to mention, that CO_2 reduction for thermo-modernization and for boilers replacement are related as per 1.64 factor. This is questionable, because in both cases CO_2 emissions from baseline scenario (fuel subject to replacement/saving is natural gas) and project scenario (biomass has nearly-zero CO_2 emissions same as direct fuel/energy saving) are on the almost same level. The possible reasons of such situation: under alternative fuels SECAP may include not nearly-zero CO_2 emission fuels (for example, non-zero emission peat or electricity), the efficiency of new alternative fuel installations may be lower than baseline gas installations, differences in energy types (for themomodernization – GFEC, for boilers – TPES). This issue is considered as minor SECAP drawback, as it requires additional explanations.

Another important measure for category "residential buildings" is "Transition of boiler stations into alternative fuels". This means fuel switch/replacement of

district heating gas boilers on medium scale (400 MW_{th} – 2 MW_{th} – information from heat supply company) biomass boilers (feedstock – wood pellets, agro pellets, residual wood logs – information from heat supply company), working for the group of multi-apartment households for the densely-populated districts of the city. The investments needed are 27 million UAH and respective effects are 3,486 MWh/year renewable energy output and 704 t CO_2/year reductions.

The investment-effect ratio for this measure is at first glance much higher than for small-scale boilers replacement in private households. However, reconstruction of district heating is strategic measure of the city with additional social-economy multiplication effects. It is aimed on provision of renewable energy to large condominiums (multi-apartment households), which has limited number of other alternatives. The measure appears much cheaper if compared with real possible alternatives (for example, switch to individual electric heating or individual gas boilers per each apartment, installation of centralized heat pump/solar collector, combined schemes). In addition, this measure includes reconstruction/optimization of the district heating network attributable to respective gas-to-biomass switching boiler houses, which increases its total costs. City has established international cooperation for implementation of this measure (financing programmes of EBRD, NEFCO, UNDP, GIZ), so the probability of its implementation is very high.

The district heating (DH) network planned partly reconstruction for the whole city (not only for biomass boiler houses) including automation and energy management system implementation is included in subsector “Industries outside ETS” (# 5.1, 5.2, 5.6), where the cumulative energy saving effect is ca. 15,300 MWh/year (almost 5 times higher than for DH boilers fuel switch), CO_2 reduction – 3,100 MWh/year and respective investments – around 7.1 million UAH. It is attributable to those boiler houses which are subject to fuel switch and for those which are not. This measure inclusion is absolutely appropriate and has the second highest energy saving indicator after “Implementation of energy saving measures in private premises (apartments)” (basic thermo-modernization – see above). If not included, it makes much less sense in fuel switch to overrate heat output for new biomass boilers, which will work for inefficient non-reconstructed

network. This complex approach is detected also in other group of measures and is definitely the strong side of the SEAP.

The minor drawback of the presented set of measures is absence of any relative indicator, which could contribute much to easiness of comparison between their effects. Such indicator may be ratio "investments/CO_2 reduction". It is commonly used when analysing and comparing different measures between each other and prioritizing among them. It could be easily obtained from the presented absolute values.

The general outcome from the Table 4.2 is that the presented division of input from each individual measure and each sector/category is appropriate. The priorities are set according to right logic – the higher is the energy intensity of the sector/consumer, the more measures and investments are put there. According to the estimation, about 90% of cumulative effects from all measures are in heating and cooling sector, 8-9% - in electricity, 1-2% - in transport, which is right priority.

Measures of SEAP are complex, connected with each other, which is clearly seen for example, from that set of measures in different subsectors aimed on district heating system reconstruction. For example, measures # 1.1, 1.3, 1.4 are aimed on reduction of energy (mainly heat) consumption (thermomodernization of buildings, installation of heat substations, energy management systems) of public buildings, including those connected to DH network Measures # 5.1, 5.2 are aimed on DH network reconstruction, rehabilitation and optimization, measure # 5.6 - on the improvement of energy management system of DH company. All these measures are on the demand side, while measures # 2.4 and # 1.7 (replacement of gas boilers on biomass boilers) – on supply side. They are connected with each other to link decreasing demand to the supply from biomass boilers planned for installation (to avoid overestimation of the capacity of biomass boilers). Above-mentioned issues are definitely strong side of SECAP, contributing to the transparency and easy monitoring of measures and implementation according to fixed indicators.

The strong side of SECAP is also choice of biomass as major RES type in heating and cooling sector as a feasible alternative with multiplication effects for the city

and citizens. From the other hand, 67% of RES input is coming only from one individual measure "Replacement of natural gas with alternative fuels in residential buildings" in one subsector (consumer category "residential buildings"), which reduce diversity and may be considered as weak side.

SECAP also considers heat pumps and solar heating installation (#1.5 and #1.6) in municipal sector (public buildings). The respective effect in CO_2 reductions is 47 t CO_2 and 18 t CO_2 respectively out of 2380 t CO2 for municipal sector measures (2% and 0.7% respectively) with the respective investments of 1.4 million UAH (3.3% from total investments of all measures for municipal sector).

As for the performance monitoring, the city publishes the regular (each two years) detailed progress monitoring reports (inn Ukrainian) of SECAP's implementation. According to the latest report (2018), the following aggregated results of SEAP implementation have been achieved:

Item	Planned (2015)	Achieved (2018)	Difference Achieved – Planned	Ratio Achieved/ Planned
RES, MWh	18,752	2,746*	-16,006	15%
Energy efficiency, MWh	111,251	121,518	10,267	109%
CO_2 reduction, t CO_2	30,815	26,710	-4,105	87%

* - only one measure "Transition of boiler stations into alternative fuels" has been partly implemented

The target on energy efficiency till 2020 already overachieved in 2018 (109%), mostly due to much higher (+31%) implementation rate in residential buildings – 112,179 MWh (implemented) against 84,956 (planned). The target on CO_2 reduction is in good progress – 87% in 2018 out of 2020 level, so it will be most probably achieved in 2020.

The targets on RES are seriously underachieved – the performance in 2018 is on the level of 15% from planned 2020 indicators. The measure "Replacement of natural gas with alternative fuels in residential buildings", which, according to the plan, should bring the major contribution (67%) to the cumulative RES

output. However, this has been completely suspended in the monitoring report (and probably not implemented at all). At the same time, the planned measure "Transition of boiler stations into alternative fuels" (basically meaning the replacement of natural gas boilers for biomass boilers in DH sector of the city) has been partly realized with total output of 2,746 out of planned 3,486 MWh/year (79% from planned). This numbers show good dynamics, so it will be most probably implemented in full scale till 2020, as it is also connected with the international cooperation of the city. For 2018, this is the only implemented measure contributing to renewable energy targets of SEAP. No other measures contributing to renewable energy targets have been reported as implemented. This creates a high risk that RES targets will be not achieved till 2020.

The reasons of the reported situation of the RES targets' underachievement are the following:

- SEAP planning mistakes, leading to lack of diversity of measures contributing to cumulative RES target: reclining too much on one single measure in one single subsector "Replacement of natural gas with alternative fuels in residential buildings", overestimation of the effect, which does not happen;
- Opposition and unconfidence of population to replace their existing boilers with new technology – small-scale biomass household boilers, which require more action and knowledge of operator;
- Practical absence of forceful instruments of municipality to make population to implement the measure;
- Strong initiative and priority of individuals (population) to implement energy efficiency measures at first, and switching to renewable energy sources only after the effect from energy efficiency measures will arise;
- Lack of investments for implementation of all measures planned in SEAP;
- Peculiarities of investment management of municipal and state funding with prioritizing of available funds direction on energy efficiency, while financing of renewable energy on "residual principle";
- Lack of cooperation with international financing programmes, which has main focus on increase of the renewable energy share. The existing programs (EU/UNDP/GIZ/E5P) have main focus on energy efficiency in all

sectors and renewable energy in district heating only, but not on renewable energy for individual heating.

RES measures in SEAP

# (in SEAP)	RES type	Energy produced, MWh/year (thermal)	CO_2 reduction, t CO_2	Investments, ths UAH
2.4	Individual biomass boilers	12,404	2,505	16,500
2.5	DH biomass boilers	3,486	704	26,986
1.7	Municipal biomass boilers	1,540	311	440
1.6	Solar heating (public buildings)	85	18	1,424
1.5	Heat pumps (public buildings)	207	48	1,383
TOTAL		17,722*	3,586	46,733

* this figure does not include additional effects included in municipal sector energy efficiency measures resulting in total 18,752 MWh.

The overall situation may be will be better, when the funding section of SECAP will be elaborated in more detail. The section contain cumulative figure of total investments needed (222.1 million UAH), and enumerate potential funding sources, but does not specify the real possibilities of each mentioned funding source, what is the sector of their main focus (especially for international ones) and possible distribution between them. If the SEAP had some kind of transparent “investment plan”, indicating (for example, on annual basis) which measure will be implemented in which year and how much funding is needed for implementation, then it would be much easier to reveal the reasons of underfunding of one group of measures, or overfunding of another ones. This may be considered as minor drawback and may be it will be fixed for the future SECAP (till 2030).

Summary

On the basis of the analysis made, the following strengths and weaknesses of SEAP could be specified.

Strengths	**Weaknesses**
Availability of clear energy balance of the city per main sectors, consumer categories and fuel types for period 2008-2014	Insufficient and non-transparent justification of base year choice
Ambitious targets set taking into account relatively small city scale and limited internal-budget investment possibilities	Absence of clear division of energy between 3 energy consuming sectors: heating and cooling, electricity, transport
Setting of targets for all three components – renewable energy, energy efficiency, CO_2 reduction in both relative and absolute values	Mixed considerations of different energy types (GFEC and/or TPES)
Right choice of priorities – main focus on cheapest measures with highest effects in most energy intensive sectors (90% of effects – in heating and cooling sector)	Contradictions between absolute and relative targets for RES (unknown base for 12.6% RES)
Biomass considered as major renewable energy source in heating and cooling sector	Non-diversified measures for RES – more than 67% from total input is coming from one measure - gas boilers switch in residential sector, in combination with lack of forceful instruments of municipality to make population implement the measure
Specification of all indicators/effects for each individual measure, subsector, consumer category and then aggregated for the city	Minor drawbacks in CO_2 emissions/reductions calculations (no link for applied grid emission factor, different CO_2 reduction effects for close measures)
Complex approach, different measures in different subsectors are	No comparison/prioritizing between measures according to relative

connected, complementing each other, increasing cumulative SEAP effect	indicators (for example, “investments/CO_2 reduction”)
Easiness of performance monitoring according to established indicators for each individual measure	Lack of transparent investment plan, where the measures, funding and implementation deadlines would be indicated
Steadfast position of the city for long-term cooperation with international financing programmes to attract external investments, understanding limited internal investment possibilities	