Final Report

SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN (2030) – STATUTORY CITY OF LIBEREC

ENVIROS, s. r. o. – February 2018

STATUTORY CITY OF LIBEREC

Document name	Sustainable Energy and Climate Action Plan (2030) – Statutory City of Liberec
Reference number	ECZ17040
Volume number	Volume1 of 1
Date	February 2018

Authors:

Ing. Jiří Spitz, ENVIROS, s. r. o. – Project Manager
Ing. Vladimíra Henelová, ENVIROS, s. r. o.
Ing. Helena Bellingová, ENVIROS, s. r. o.
Ing. Michael ten Donkelaar, ENVIROS, s. r. o.
Ing. Karel Pejchal, ENVIROS, s. r. o.
Ing. Eva Havlíčková, CDV, v. v. i.
RNDr. Leoš Pelikán, CDV, v. v. i.
Ing. Libor Špička, CDV, v. v. i.
Ing. Otakar Hrubý, HO Base

Approved by:

Ing. Jaroslav Vích – Executive Director

Client´s address: Statutární město Liberec
Nám. Dr. E. Beneše 1
460 59 Liberec I.

Contact person: Ing. Stanislava Mimrová
Phone.: +420 485 243 503
E-mail: mimrova.stanislava@magistrat.liberec.cz

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PICTURES

ATTACHMENTS

Attachment A – Sustainable Energy and Climate Action Plan (2030) – Statutory City of Liberec – Base Emission Inventory (in Czech)

Created with the support of the Ministry of the Environment and the State Environmental Fund

February 2018

1. FOREWORD

Dear Ladies and Gentlemen,

By developing this document, the City of Liberec joined the large family of European cities that recognize their co-responsibility for addressing the issue of global climate change, and try to behave to solve this problem in practice.

Although the project initially had faced a certain mistrust of some politicians, eventually its implementation was successful. I feel happy because it is a chance for our City to start developing with greater regard to environmental context and global responsibility.

The document itself, naturally, cannot improve the situation but it is the first essential step. If there is a political will, Liberec can become a model City in the field of CO_2 reduction actions within a few years. There are capable people here and there are subsidy programmes. What we need is just political support and the work on the respective projects can start.

I would like to thank the whole team of authors for their efforts and believe that their endeavour was not in vain. Now, the more difficult stage is ahead of us that is to start and implement new projects. It will not be easy, like any change. However, I believe that in few years, the topics that we now speak about only in a low voice or are subject to certain downplaying will become a natural thing.

If any of you who will read this text would like to participate actively in the implementation of this plan, please contact me, or the Strategic Development Department staff.“

Mgr. Jan Korytář

Deputy Mayor for Economy, Strategic Development and Subsidies

2. EXECUTIVE SUMMARY

Commitments Resulting from the City of Liberec Joining the Covenant

The Covenant of Mayors is a European Initiative aimed at local and regional authorities that voluntarily commit themselves to improving energy efficiency and using renewable energy sources on the territory they manage. The Covenant signatories commit themselves to meet and exceed the EU target of reducing CO_2 emissions by 20% by 2020 and by 40% by 2030.

It follows from the Covenant, supporting materials, examples of other cities and methodological recommendations that for successful joining the Covenant of Mayors, the City must secure a series of actions that have not had to be taken so far:

a) To set (calculate) a possible target by 2020 and 2030 (the need to reduce CO_2 emissions in the City by implementing Sustainable Energy and Climate Action Plan in the areas of activities related with the mandate of the city). **CO_2 emissions in the included sectors must be lower at least by 20% by 2020 and by 40% by 2030 compared to the baseline year.**

b) To prepare a baseline emission inventory as a basis for the Sustainable Energy and Climate Action Plan;

c) To develop the Action Plan in line with the European Commission methodologies;

d) To ratify this commitment and Action Plan by procedures used;

e) To adapt the administrative structure of the City and allocate (reallocate) human resources so that the needed actions can be taken;

f) After submitting the Action Plan, an implementation report is to be presented at least every two years for the purpose of evaluation, monitoring and verification (there is a need for the City to have mechanisms for monitoring and evaluating the SECAP performance – in necessary formats);

g) To organize Energy Days or Covenant of Mayors Signatory Days in cooperation with the European Commission and other stakeholders enabling thus the citizens to benefit directly from the opportunities resulting from more intelligent energy use;

h) To inform local media about the progress of the Action Plan on a regular basis – to set monitoring the performance of activities and projects to allow submitting the reports;

i) To take part in annual conference of EU Mayors on Sustainable Energy in Europe;

j) To disseminate the message of the Covenant in appropriate fora and, above all, encourage other mayors to join the Covenant.

The Statutory City of Liberec officially joined the Covenant of Mayors on 28 January 2016. For the knowledge of the situation, the Baseline Emission Inventory (BEI) in 2000, and interim emissions inventories for 2005, 2010 and 2015, were worked out for the city. The inventories are prerequisite for the Action Plan development, as they will provide insight into the nature of CO_2 producing entities in the City helping thus choose the appropriate actions. The inventory performed in the following years will enable to determine whether the actions ensure a sufficient reduction of CO_2 emissions and whether further actions are necessary. The city has to achieve the formal commitment to CO_2 reductions exactly through the Sustainable Energy and Climate Action Plan (SECAP) implementation.

Current Development in CO_2 Emissions in the City

The baseline year against which the CO_2 reduction target is designed, was recommended and set for 2000. The City aimed to set the emission inventory for 1995 but failed to provide reliable and complete fuel, heat and electricity consumption data in the required classification to sectors included.

The fuel and energy consumption inventory was first developed for the City as a whole, then it was narrowed in line with the European Commission (EC) methodology just for the sectors (so called sectors included) that can be impacted by the City activities. The final consumption of these sectors included **make 60% of the fuel and energy consumption in the City in total**.

For 2000, the Statutory City of Liberec will evaluate CO_2 reduction resulting from actions designed and demonstrate achieving the established CO_2 reduction target.

Tab. 1 Sectors included in SECAP in line with EC methodology

Sectors included	Included in the inventory	Note
Municipal buildings, equipment/facilities	YES	These sectors include all energy consumption in buildings, facilities and appliances, which is not included in other sectors – e.g. energy consumption in drinking water treatment, wastewater treatment, etc.
Tertiary (non-municipal) buildings, equipment/facilities	YES	
Residential buildings	YES	
Municipal public lighting	YES	
Urban road transportation: municipal fleet (e.g. municipal cars, waste transportation, police and emergency vehicles	YES	This part includes emissions of all transport of these vehicles.
Urban road transportation: public transportation	YES	
Urban road transportation: private and commercial transportation	YES	It includes part of passenger transport on the roads owned by the City.
Urban rail transportation	YES	This sector includes urban rail transport in the City, e.g. tramways, metro and local trains.

CO_2 emissions in the above mentioned (so called included) sectors amount to 474 983 t/year in 2000. Of the sectors included, the highest fuel and energy consumption as well as the highest CO_2 emissions are in residential buildings – housing (54%) and tertiary sector (31%).

Tab. 2 Baseline CO_2 Emission Inventory in the City of Liberec (BEI - t/year)

Consumption sector	CO_2 emissions in 2000	Share of sector in CO_2 emissions in total
Municipal buildings, equipment/facilities	35,122	7.39%
Tertiary (non-municipal) sector buildings, equipment/facilities	144,918	30.51%
Residential buildings	258,396	54.40%
Municipal public lighting	3,811	0.80%
Municipal fleet	96	0.02%
Public transport	11,133	2.34%
Private and commercial transport	20,905	4.40%
Agriculture, forestry, fishing	602	0.13%
Total	**474,983**	**100.00%**

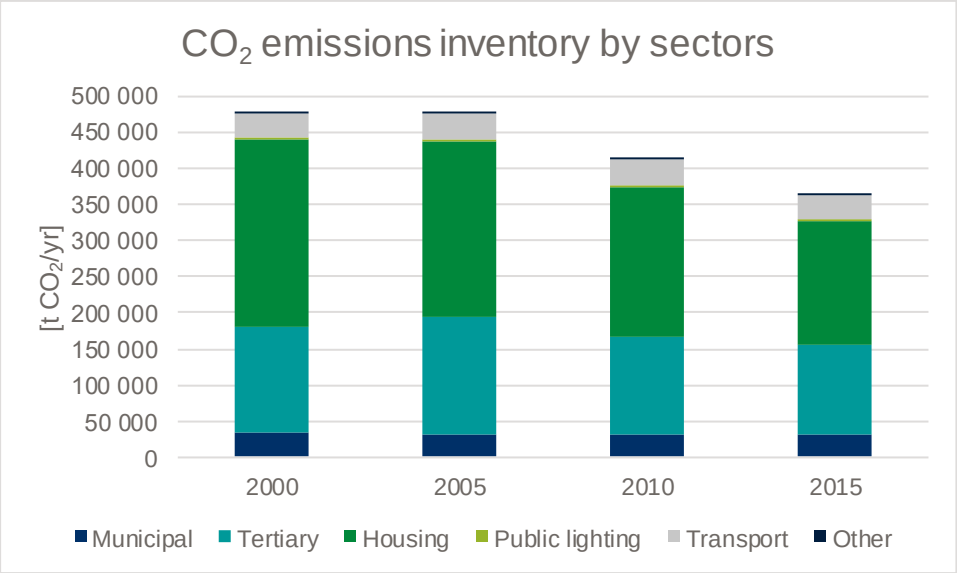
Development in CO_2 Emissions from 2000 to 2015

In order to determine the development in CO_2 emissions, the consistent methodology was used to work out an interim inventory of final fuel and energy consumption and an interim Monitoring CO_2 Emission Inventory (MEI) in 2005, 2010 and 2015:

Tab. 3 Development in CO_2 emissions from 2000 to 2015

Emissions of CO_2	BEI 2000	MEI 2005	MEI 2010	MEI 2015
Municipal buildings, equipment/facilities	35,122	32,704	31,747	32,484
Tertiary (non-municipal) sector buildings, equipment/facilities	144,918	161,264	135,740	131,323
Residential buildings	258,396	243,151	206,010	176,175
Municipal public lighting	3,811	3,800	3,961	3,769
Municipal fleet	96	129	100	101
Public transport	11,133	8,308	9,894	8,468
Private and commercial transport	20,905	25,179	24,420	24,999
Agriculture, forestry, fishing	602	682	649	652
Total	**474,983**	**475,218**	**412,522**	**377,971**
Development compared to the CO_2 baseline inventory	0.00%	0.49%	-13.15%	-20.42%

Fig. 1 Development in CO_2 emissions from 2000 to 2015



From 2000 to 2015, CO_2 emissions in the City declined by 20.4%. This decline is particularly due to a very favourable development in heat and natural gas consumption and thus CO_2 emissions in the sector of residential buildings (housing). The decline results especially from thermal insulation and retrofit of residential buildings – both private and municipal ones. We can see a favourable development also in the area of other tertiary sector buildings, while in the sector of municipal buildings, the reduction of energy consumption didn´t occur until 2015. The decreasing national emission factor for electricity consumed, declining as a result of changes to the structure of electric energy production in the CR, as well as the growing proportion of electricity generated in the City contribute to CO_2 reduction. In the installations allowed by the methodology – e.g. electric energy production in Termizo plant or Teplárna Liberec (Liberec Heating Plant) cannot be included in the local electricity produced because both sources belong to the Emission Trading System and the Methodology for Creating the Inventory excludes their inclusion.

The emission reduction by more than 20% from 2000 to 2015 constitutes an indicator of a likely CO_2 reduction in the Statutory City of Liberec in the sectors that are dealt with SECAP by more than 20% from 2000 to 2020 (**i.e. the 2020 commitment will be met**).

In order to reduce CO_2 emissions by 40% by 2030 compared to 2000, it was necessary to analyse many so far not implemented measures for using renewable energy and improving energy performance of buildings, their potential costs and also the opportunities for their enforcing and funding.

Attainability of 2030 CO_2 Reduction Target of the Statutory City of Liberec

The scenario of a potential development of CO_2 emissions by 2030 comprises both potential development and new construction by 2020 in sectors, and expected development in fuel and energy consumption of existing equipment/facilities and residential buildings. This development includes also the planned CO_2 reduction actions. The designed scenario of emission development for 2020 and 2030 shows a potential CO_2 reduction in the City of Liberec by more than 22% by 2020 and without additional actions by 25% by 2030. **Fulfilling the commitment by 2020 is thus presumable; meeting it by 2030 requires looking for additional actions for CO_2 reduction.**

Tab. 4 CO_2 Emission Inventory in 2000, 2005, 2010, 2015, 2020 and 2030 (scenario based on actions, t CO_2/y

	BEI 2000	MEI 2005	MEI 2010	MEI 2015	2020	2030
Municipal	35,122	32,704	31,747	32,484	28,646	26,671
Tertiary sector	144,918	161,264	135,740	131,323	130,488	121,888
Households	258,396	243,151	206,010	176,175	168,630	114,101
Public lighting	3,811	3,800	3,961	3,769	3,693	1,804
Transport	32,134	33,615	34,414	33,568	29,814	24,913
Agriculture	602	682	649	652	652	652
Reduction due to renewable electricity production	0	0	0	0	0	-18,002
Total	**474,983**	**475,216**	**412,521**	**377,971**	**361,924**	**272,027**

Fig. 2 CO_2 Emission Inventory in 2000, 2005, 2010, 2015, 2020 and 2030 (scenario based on actions)

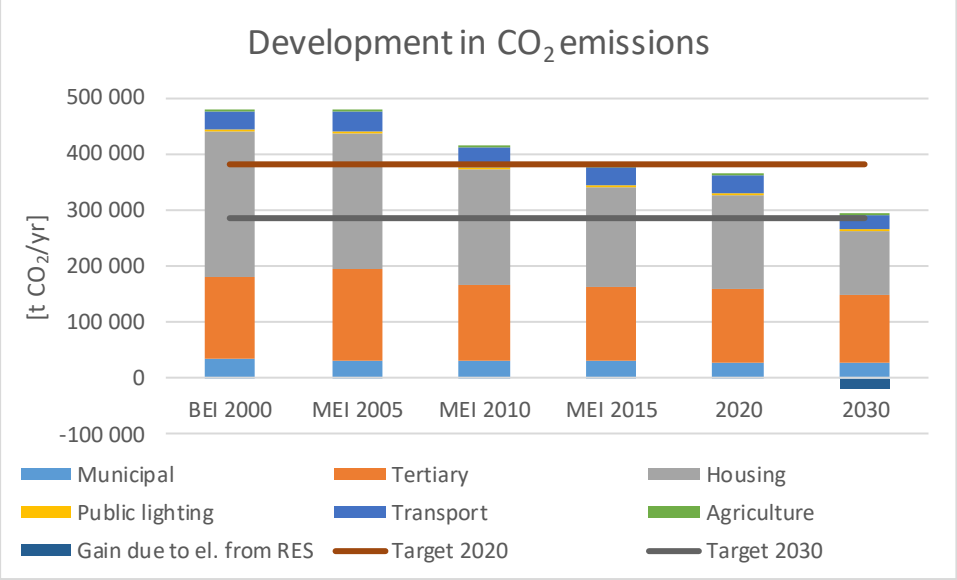
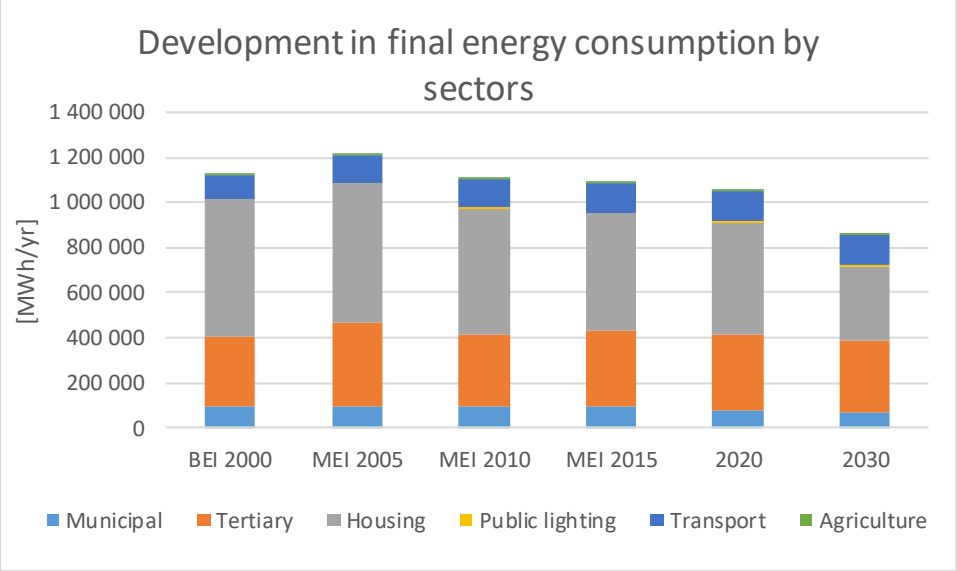


Fig. 3 Development of final energy consumption in sectors included, classified by sector



Actions to Reduce Emissions by 2030

The essence of the membership in the Covenant is to implement particular selected projects of the City leading to at least 20% reduction by 2020 and 40% reduction by 2030 compared to the baseline year for which the emission inventory was worked out. The projects and actions, which will lead to achieving the required CO_2 reduction, are contained in the Sustainable Energy Action Plan.

These projects and actions included in SECAP relate to the areas, which the City can influence by its activities – i.e. the areas of buildings (residential, public, and/or other), street lighting and transport, improvement of the City administration in the field of fuel and energy consumption, support of information activities, support of activities and awareness in the residential sector.

In the Tables below, you can see the summary of all measures/actions and the overview of the measures/actions designed in the Action Plan. The table shows both the particular technical measures for the municipal buildings arising from the analysis of buildings and their documents and constitute mostly the own design of the SECAP author/s, and other actions recommended to implementation in the City in the transport, residential buildings and tertiary sectors. Measures to promote renewable electricity and heat production that has a zero emission factor per electricity or heat unit produced are of great importance. In addition to technical measures, the plan recommends many organizational actions (e.g. introduction of energy management).

Benefits of technical measures are mentioned in the development scenarios.

Tab. 5 Benefits of measures implemented after 2015

	Implementation costs incl. VAT		By 2020			By 2030		
			Energy savings	Renewable energy production	Reduction of CO_2 emissions	Energy savings	Renewable energy production	Reduction of CO_2 emissions
	[thousand CZK]	[€]	[MWh/y]	[MWh/y]	[t/y]	[MWh/y]	[MWh/y]	[t/y]
Municipal buildings and equipment/facilities	44,286	1,207,676	5,540.7	0.0	1,189.9	5,540.7	0.0	1,189.9
Other tertiary sector	0	0	0	0.0	0.0	0	0.0	0.0
Residential buildings	61,704	2,468,148	1,815.3	0.0	805.5	1,815.3	0.0	805.5
Street lighting	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Industry	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Transport	0	0	0	0.0	0.0	0	0.0	0.0
Local electricity production	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Local heat and cold production	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**105,990**	**3,675,824**	**7,356.0**	**0.0**	**1,995.4**	**7,356.0**	**0.0**	**1,995.4**

Tab. 6 Benefits of measures planned by the city

Measures planned by the city	Implementation costs incl. VAT		By 2020			By 2030		
			Energy savings	Renewable energy production	Reduction of CO_2 emissions	Energy savings	Renewable energy production	Reduction of CO_2 emissions
	[thousand CZK]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]	[t/y]	[t/y]
Municipal buildings and equipment/facilities	540,622	20,897,434	7,462.5	0.0	1,676.4	8,518.0	0.0	2,066.1
Other tertiary sector	117,941	4,494,451	1,345	0.0	537.7	1,345	0.0	537.7
Residential buildings	0	0	0,0	0.0	0.0	0.0	0.0	0.0
Public lighting	1,456	54,820	28,4	0.0	17.2	28.4	0.0	17.2
Industry	0	0	0,0	0.0	0.0	0.0	0.0	0.0
Transport	0	0	0	0.0	0.0	0	0.0	0.0
Local electricity production	0	0	0,0	0.0	0.0	0.0	0.0	0.0
Local heat and cold production	0	0	0,0	0.0	0.0	0.0	0.0	0.0
Other	0	0	0,0	0.0	0.0	0.0	0.0	0.0
Total	**660,018**	**25,446,706**	**8,835.5**	**0.0**	**2,231.3**	**9,891.0**	**0.0**	**2,621.0**

Tab. 7 Benefits of measures designed

Measures designed	Implementation costs incl. VAT		By 2020			By 2030		
			Energy savings	Renewable energy production	Reduction of CO_2 emissions	Energy savings	Renewable energy production	Reduction of CO_2 emissions
	[thousand CZK]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]	[MWh/y]	[t/y]	[t/y]
Municipal buildings and equipment/facilities	288,987	11,542,646	2,791.4	0.0	971.4	8,591.4	0.0	2,556.6
Other tertiary sector	255,236	10,218,979	877	0.0	296.9	22,875	0.0	8,897.6
Residential buildings	7,057,546	265,418,540	7,622.6	0.0	2,782.5	160,394.4	0.0	58,523.5
Public lighting	158,835	6,353,414	96.8	0.0	58.4	3,226.5	0.0	1,948.0
Industry	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Transport	2,555,200	114,768,000	1,617	0.0	5,841.7	17,425	0.0	14,141.3
Local electricity production	221,006	8,839,927	0.0	0.0	0.0	-166.0	28,256.6	18,001.7
Local cold and heat production	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**10,536,811**	**417,141,505**	**13,004.7**	**0.0**	**9,950.9**	**212,346.0**	**28,256.6**	**104,068.7**

Tab. 8 Overview of measures implemented in municipal buildings after 2015

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Broumovská Primary School – complex thermal insulation, heating system retrofit, ventilation with heat recovery	25,410	182.3	182.3	139,395
Regional Hospital – replacement of windows in Pavilions A, O, and D	18,876	57.0	57.0	330,962
Regional Hospital – liquidation of the incinerator and laundry	0	950.6	950.6	0
Total (for specific investments – average)	**44,286**	**1,189.9**	**1,189.9**	**37,219**

Tab. 9 Overview of measures planned for municipal buildings

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Primary School - 5. května Street – both buildings, window replacement, thermal insulation, retrofit of source, heating system and remote control & monitoring, ventilation with heat recovery	50,820	100.5	100.5	505,672
Sedmikráska Kindergarten - Vzdušná Street, thermal insulation, window replacement, heating remote control & monitoring, ventilation with heat recovery	13,068	11.2	11.2	1,170,269
Kindergarten – Klášterní Street, Husova Street, thermal insulation, window replacement, heating remote control & monitoring, ventilation with heat recovery	7,260	11.2	11.2	650,149
Nad Přehradou Kindergarten– window replacement, heating remote control & monitoring, ventilation with heat recovery	7,260	11.2	11.2	650,149
Primary School – Orlí Street – complex thermal insulation, heating remote control & monitoring, ventilation with heat recovery	17,424	57.6	57.6	302,686
Primary School - Švermova Street – thermal insulation, ventilation with heat recovery, and new LED lighting	30,492	95.9	95.9	317,821
Primary School - U Soudu Street – kitchen insulation	7,260	28.8	28.8	252,239
ZOO – condensing boilers in Lidový dům and three pavilions (Elephant Pavilion, Tropic Pavilion and Workshop Pavilion)	3,252	23.3	23.3	139,696
ZOO – Elephant Pavilion insulation	7,986	27.9	27.9	286,066
ZOO - LED light fittings – Elephant Pavilion	653	8.4	8.4	77,922
Regional Hospital -– steam boiler and pipeline distribution replacement by hot water systems	58,080	849.8	849.8	68,345
Primary School - náměstí Míru – complex thermal insulation, heat source replacement	34,999	61.4	61.4	570,380
Primary School - náměstí Míru - ventilation with heat recovery	13,228	6.7	6.7	1,979,235
Botanic garden – boiler room retrofit	5,054	49.9	49.9	101,222
F. X. Šalda Small Theatre (Malé divadlo F. X. Šaldy) - thermal insulation, heating system retrofit, Integrated Room Control (IRC)	21,780	26.7	26.7	816,941
F. X. Šalda Small Theatre (Malé divadlo F. X. Šaldy) - thermal insulation, heating system retrofit, Integrated Room Control g controls (IRC)	24,684	105.5	105.5	233,894
Primary School – Oblačná Street - window replacement and attic floor insulation, heating remote control & monitoring, ventilation with heat recovery	8,712	19.2	19.2	454,029

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Beruška Kindergarten - Na Pískovně Street – complex thermal insulation, ventilation with heat recovery	74,052	38.4	38.4	1,929,625
Pastelka Kindergarten – building envelope insulation, heating remote control & monitoring, ventilation with heat recovery	58,080	15.8	15.8	3,665,552
Primary School – Husova Street – building envelope partial insulation (roof insulation made in 2016), ceiling above the basement insulation, heating remote control & monitoring, ventilation with heat recovery	43,560	76.8	76.8	567,537
Primary School - Křižanská Street, Heřmánkova Street – complex thermal insulation, LFO boiler replacement by a heat pump, heating remote control & monitoring, ventilation with heat recovery	24,793	32.3	32.3	768,598
Klubíčko Kindergarten – Jugoslávská Street – completion of window replacement, building envelope insulation, new heat source and controls, ventilation with heat recovery	8,712	11.2	11.2	780,179
Primary School - Česká Street – gymnasium thermal insulation	5,808	7.0	7.0	832,191
Swimming pool retrofit (solar panels, wastewater heat recovery, heat pump after the heat recovery	13,605	0.0	422.0	32,239
Total (for specific investments – average)	**540,622**	**1,676.4**	**2,098.4**	**257,635**

Tab. 10 Overview of measures designed for municipal buildings

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Primary School, Kaplického Street – building envelope and roof insulation, ventilation with heat recovery	11,616	0.0	28.8	403,582
Primary School - Sokolovská Street - building envelope and roof insulation, ventilation with heat recovery	24,684	0.0	115.1	214,403
Primary School – Barvířská Street – building envelope insulation and window replacement, heating system retrofit, heating remote control & monitoring, ventilation with heat recovery	23,232	0.0	105.5	220,135
Primary School – Ještědská Street – building envelope and flat roof insulation, ventilation with heat recovery, heating remote control & monitoring, ventilation with heat recovery	34,848	0.0	89.3	390,090
Rolnička Kindergarten – building envelope insulation, heating remote control & monitoring, ventilation with heat recovery n	4,356	0.0	10.1	433,433
Pohádka Kindergarten - Strakonická – building envelope and roof insulation, original window replacement, heating remote control & monitoring, ventilation with heat recovery	11,616	0.0	22.3	520,119
U Bertíka Kindergarten – Údolní Street – window replacement and attic floor insulation, heating remote control & monitoring, ventilation with heat recovery	4,356	0.0	8.4	520,119
Kindergarten - Pod Ještědem Street – building envelope insulation, heating remote control & monitoring, ventilation with heat recovery	3,630	0.0	22.0	165,179
Special Purpose House (Dům zvláštního určení) - Nad Sokolovnou and Česká Streets – building envelope insulation	14,520	0.0	86.3	168,159
ZOO – Giraffe Pavilion insulation	3,920	0.0	14.0	280,864
ZOO - LED light fittings in other pavilions	2,352	0.0	30.2	77,922
Regional Hospital – Pavilion A – building envelope insulation	34,848	0.0	173.7	200,625
Regional Hospital – thermal insulation of Pavilion B including window replacement	52,272	0.0	172.3	303,375
LED lighting in schools	16,006	0.0	221.8	72,150
Compulsory renovation of non-compliant sources not replaced in municipal buildings so far	24,684	0.0	189.8	130,030
Energy management implementation	960	0.0	971.4	988
EPC in municipal buildings – buildings with natural gas	4,409	0.0	65.3	67,511
EPC in municipal buildings – buildings with district heating	16,678	0.0	230.2	72,451
Total (for specific investments – average)	**288,987**	**971.4**	**2,556.6**	**113,037**

Tab. 11 Overview of measures planned in tertiary sector

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Regional Science Library – lighting retrofit	2,425	33.6	33.6	72,150
Regional Office - lighting retrofit	10,972	152.1	152.1	72,150
Grammar School – Jeronýmova Street – window replacement	21,780	44.3	44.3	492,173
Centre for Intervention and Psychosocial Services of the Liberec Region – complex thermal insulation	5,808	19.1	19.1	303,293
Regional Office – building of the Research Institute of Engineering Machines) – complex thermal insulation	36,300	157.3	157.3	230,706
APOSS Liberec - Zeyerova Street – complex thermal insulation	4,356	8.5	8.5	511,955
Secondary School of Gastronomy and Services	36,300	122.8	122.8	295,592
Total (for specific investments – average)	**117,941**	**537.7**	**537.7**	**219,329**

Tab. 12 Overview of measures designed in tertiary sector

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Improvement of energy efficiency of natural gas fired boilers in other tertiary sector	130,000	120.0	2,400.9	54,145
Excluding remaining coal fired boilers from the tertiary sector	2,000	22.4	447.6	4,469
Light replacement by LED lighting in the tertiary sector	20,000	154.4	5,148.1	3,885
Regional Office – cooling retrofit	9,396	0.0	169.0	55,582
Replacement of electrical appliances	23,000	0.0	428.7	53,656
Convection heater replacement by heat pumps	5,500	0.0	236.3	23,273
Uran building - complex thermal insulation – building envelope and roof including windows	65,340	0.0	67.0	975,224
Total (for specific investments – average)	**255,236**	**296.9**	**8,897.6**	**28,686**

Tab. 13 Overview of measures implemented in households after 2015

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Subsidies for solid fuel boiler replacement - 2016	23,615	268.7	268.7	87,902
Subsidies for solid fuel boiler replacement - after 2016	38,089	536.9	536.9	70,948
Total (for specific investments – average)	**61,704**	**805.5**	**805.5**	**76,603**

Tab. 14 Overview of measures designed in households

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Thermal insulation of residential buildings	4,533,354	1,389.2	27,783.5	163,167
Thermal insulation of family houses	1,680,192	765.9	15,317.9	109,688
Excluding remaining coal boilers from households	450,000	317.3	6,346.1	70,909
Old gas boilers replacement in households	240,000	72.0	2,398.5	100,061
Light fitting replacement by LED in households	13,000	173.3	3,465.5	3,751
Replacement of domestic electrical appliances	85,000	64.9	1,298.0	65,483
Convection heater replacement by heat pumps	56,000	0.0	1,913.9	29,260
Total (for specific investments – average)	**7,057,546**	**2,782.5**	**58,523.5**	**120,593**

Tab. 15 Overview of measures planned in public lighting

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Public lighting retrofit in Dr. Milady Horákové, Dělnická, Havlíčkova, Hradební, Hřbitovní, Kollárova, Melantrichova, Šlikova, Tylova, U Monstrance and U Potůčku Streets – in total 109 street lights	1,362	15.7	15.7	86,604
Public lighting retrofit in Červeného and Rybničná Streets – in total 10 street lights	94	1.4	1.4	64,888
Total (for specific investments – average)	**1,456**	**17.2**	**17.2**	**84,779**

Tab. 16 Overview of measures designed in public lighting

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Public lighting retrofit	158,835	58.4	1,948.0	81,539
Total (for specific investments – average)	**158,835**	**58.4**	**1,948.0**	**81,539**

Tab. 17 Overview of measures designed in transport

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Greening public transport	48,500	0.0	2,103.5	23,057
Greening municipal fleet and municipal institutions´ fleet	15,175	23.0	23.2	653,531
Other IAT & freight actions	The costs depend on type and scope of measures taken – from low-cost ones (e.g. low-emission zones identification) to high-cost ones (e.g. Park & Ride facilities)	5,498.0	11,413.0	Combination of low-cost and high-cost measures
Eco driving	150	320.7	601.6	249
Construction of transport hubs	Tens of millions of CZK	It depends on the number and particular localities.	It depends on the number and particular localities.	High-cost measure
Cycling support	Minimum variant CZK 475,000 thousand	Under favourable weather conditions, a moderate reduction of emissions can be expected	Under favourable weather conditions, a moderate reduction of emissions can be expected	High-cost measure
Walking & cycling support	42,500	Under favourable weather conditions, a moderate reduction of emissions can be expected	Under favourable weather conditions, a moderate reduction of emissions can be expected	High-cost measure
Car sharing support	CZK 20 – 34 thousand to equip one vehicle with necessary monitoring technologies	Benefits can be identified on the basis of a transport survey – sufficient data are not available in the CR yet	Benefits can be identified on the basis of a transport survey – sufficient data are not available in the CR yet	Medium-cost measure
Increasing the smoothness of IAT & freight in the built-up area	Minimum CZK 1,000 – 1,500 thousand	Increased traffic fluency will result in significant reduction of emissions	Increased traffic fluency will result in significant reduction of emissions	High-cost measure
Construction of Liberec centre – Rochlice tram line	2,400,000	0	It depends on a particular tramway track variant and bus line changes	It depends on a particular tramway track variant and bus line changes

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Total	**minimum 2,982,700**	**minimum 5,841.7**	**minimum 14,141.3**	

Tab. 18 Overview of measures designed for electricity supply

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
ZOO – PV – Elephant Pavilion	726	0.0	6.0	120,250
PV electricity production in municipal buildings	9,000	0.0	163.0	55,211
PV electricity production in residential buildings	100,000	0.0	1,346.9	74,242
Cogeneration (CHP) in the tertiary sector	11,280	0.0	942.1	11,974
PV electricity production in the tertiary sector	100,000	0.0	1,346.9	74,242
Green electricity	0	0.0	14,196.7	0
Total (for specific investments – average)	**221,006**	**0.0**	**18,001.7**	**12,277**

Tab. 19 Summary of benefits of all measures

Measure	Implementation costs incl. VAT		By 2020			By 2030		
			Energy savings	Renewable energy production	Decline of CO_2 emissions	Energy savings	Renewable energy production	CO_2 emissions reduction
	[thousand CZK]	[MWh/y]	[MWh/y]	[thousand CZK]	[MWh/y]	[MWh/y]	[thousand CZK]	[MWh/y]
Municipal buildings and equipment/facilities	873,896	33,647,756	15,795	0	3,838	22,650	0	5,813
Other tertiary sector	373,177	14,713,430	2,222	0	835	24,220	0	9,435
Residential buildings	7,119,250	267,886,688	9,438	0	3,588	162,210	0	59,329
Public lighting	160,291	6,408,234	125	0	76	3,255	0	1,965
Industry	0	0	0	0	0	0	0	0
Transport	2,555,200	114,768,000	1,617	0	5,842	17,425	0	14,141
Local electricity production	221,006	8,839,927	0	0	0	-166	28,257	18,002
Local heat and cold production	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Total	**11,302,819**	**446,264,035**	**29,196**	**0**	**14,178**	**229,593**	**28,257**	**108,685**

Tab. 20 Resulting CO_2 emissions after inclusion benefits of all actions

Resulting emission reduction compared to 2000		BAU scenario [t CO_2/y]	CO_2 Emissions [t/r]	Emission reduction [%]	Exceeding the commitment [t/y]
CO_2 emissions	2000	474,983	474,983	0.00%	
	2005	475,218	475,218	-0.05%	
	2010	412,522	412,522	13.15%	
	2015	377,971	377,971	20.42%	
	2020	375,286	361,108	23.97%	
	2030	382,450	273,765	**42.36%**	**11,225**

It is clear from the Table that in full implementation of all designed measures, the commitment to reduce emissions would be exceeded by 11 278 t of CO_2 /year.

Adaptation measures

The proposal for adaptation measures is based on the analysis of risks and impacts of climate change. For the city of Liberec, there is a significant risk of intense rainfalls, which is why water and water retention measures are proposed.

Tab. 21 Indicative estimate of cost of adaptation measures within the property of the city 2015 – 2030 (in CZK thousand)

Measure type	Estimated cost of implementation of the measure [thous. CZK]
Sun shielding	6,000
Rainwater management	4,000
Green roofs	3,000

Measure type	Estimated cost of implementation of the measure [thous. CZK]
Rain gardens	2,000
Sinking tunnels	12,000
Total cost of all measures	**29,000**

SECAP Management

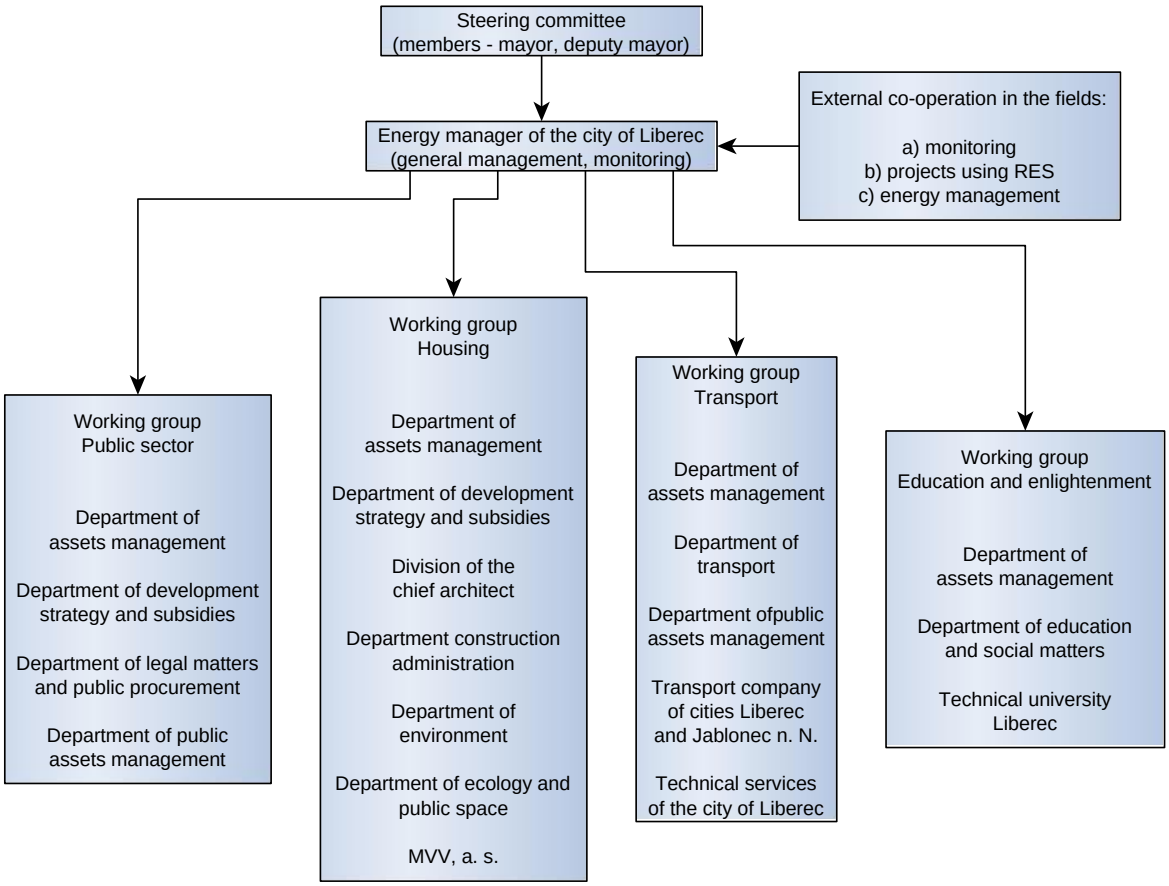
First, the City of Liberec should establish a separate job – **Energy Manager of the City of Liberec**. This job should fall under the Assets Management Department, the Building and Facility Management Division. For the SECAP implementation, the Steering Committee composed of the City Council should support this Department.

Based on the activities proposed, we can consider creating four working groups:

- Public sector
- Housing
- Transport
- Training and awareness raising

The Figure below shows the designed structure of securing SECAP implementation for the mentioned working groups:

Fig. 4 Organization chart of securing SECAP implementation (included departments and institutions)



SECAP Implementation and Monitoring

The City must submit the monitoring template in English every two years as of the date of the SECAP presentation. As reporting, including emission inventory once in two years, could exert too much pressure on human as well as funding resources, a Covenant signatory can decide to work out respective emission inventories once in four years and submit an activity report every two years. Nevertheless, the signatories must prepare a complete report every four years. The following Table shows clearly a timeline for SECAP progress reporting**, the time is counted as of the date of joining the Covenant.**

Tab. 22 Timeline for SECAP progress reporting

Reporting Template Sections		Reporting Requirements		
		Within 2 years	Within 4 years	Within 6 years
	Strategy *Reporting all changes to the original strategy and updating human and funding resources.*	✓	✓	✓
MITIGATION	**Emission Inventory** *Final energy consumption and CO2 emission inventory by energy carrier and by sector for the last monitored year.*	✓ (BEI)	✖	✓ (MEI)
MITIGATION	**Mitigation Actions** *Providing information on the Action Plan section concerning mitigation including individual actions.*	✓	✓ (min. 3 key actions)	✓
ADAPTATION	**Adaptation Scoreboard** *Description of the adaptation status and completeness degree of actions within the adaptation cycle.*	✓	✓	✓
ADAPTATION	**Risks & Vulnerabilities** *Report on climate risks, vulnerability and impacts your City faces.*	✓	✓	✓
ADAPTATION	**Adaptation Actions** *Information on adaptation action plans and individual adaptation actions.*	✖	✓ (min. 3 key actions)	✓

SECAP Funding

Implementation of an Action Plan cannot be successful without funding resources. Improving energy efficiency, reducing CO_2 emissions and adapting to climate changes have link to the need of substantial investments, particularly in pursuit of ambitious commitments of the Covenant of Mayors.

Investments to Energy Efficiency Projects are subject to an investment budget and thus have to stack up to the competition of many other investment projects across the whole spectrum of City activities. Investments to energy efficiency and climate protection as ones of few investment projects have the potential to return invested resources to the City budget (by reducing energy bills) and thus reduce the necessary amount of operating resources. Since budget resources are limited, the City should continually search for other possible funding.

Resources necessary for the implementation of projects under the Covenant must be included in annual budgets by individual City Departments in Liberec. Regarding the long-term funding of the commitment, a long-term agreement of political parties is recommended to avoid problems after electing a new City Council.

Possible funding resources of measures under the Action Plan involve:

- City budget
- External funding resources, including:
  - Operational programmes (OPE, IROP, OPEI, OPT) for 2014+
  - Other EU mechanisms (JESSICA, ELENA, JASPERS, IEE)
  - Other international funding (e.g. Norway Grants – further calls are expected at the turn of 2018 and 2019)

- State programmes (e.g. Green Savings, State Housing Development Fund)
- EU funding through private financial institutions
- Energy Performance Contracting

We can find the funding schemes recommended by the Covenant Office at http://www.paktstarostuaprimatoru.eu/support/funding-instruments_cs.html.

Benefits of Joining the Covenant of Mayors and SECAP Preparation

In case of the City´s joining the Covenant of Mayors, one of the major requirements is to manage systemically fuel and energy consumption issues. Energy consumption drives the production of CO_2 emissions and production of air pollutant emissions as well as the costs incurred by the City, inhabitants and entrepreneurs to secure fuel and energy supply. Energy costs is one of the largest items of the company´s management. Through the elaborated Sustainable Energy and Climate Action Plan and because of joining the Covenant of Mayors, the City will gain above all:

- Fuel and energy costs reduction – the implementation of both prepared and designed measures in municipal buildings and equipment/facilities will result in reduction of fuel and energy costs of the City. The City is advised to introduce energy management to monitor these benefits and use existing data for combined fuel and energy purchase.
- Access to selected funding resources available particularly to the Covenant signatories. These and other resources will be used for the preparation, design and implementation of measures under SECAP.
- Reduction of air pollutant emissions – as a consequence of the fact that the designed actions contribute not only to the reduction of fuel and energy consumption as well as CO_2 emissions in the City of Liberec but also to the reduction of other pollutant emissions.
- Management improvement – energy efficiency improvement is not strictly a technical issue. Gaining and sustaining control over energy consumption is primarily a role of the management. The main feature of the Covenant implementation is therefore a clear organizational ensuring of fuel and energy consumption monitoring (and performing emission inventories). Such management also allows planning better energy costs, monitoring economic benefits of investments, evaluating them and using them in further decision making.
- Use of innovative potential – activities and projects under SECAP designed in the area of R&D projects will contribute to the implementation of advanced and timeless solutions that create space for advanced and energy efficient technologies. Emphasizing energy efficiency, fuel and energy minimization and renewable sources use in the City – particularly in all new built-up areas or in brownfield solutions - create new jobs. In search for new and novelty investment intentions, the City can involve also potential for human resources existing in University faculties and Technology.
- Risk mitigation – prevention of risks of infrastructure damage and disruption of City functioning due to extreme weather impacts caused by climate change.
- Preparation to climate change – curbing extreme weather consequences, if they cannot be prevented.
- Improvement of land use planning with respect to climate change impacts.

3. GENERAL SUSTAINABLE ENERGY AND CLIMATE STRATEGY OF THE STATUTORY CITY OF LIBEREC

With its area of 106.1 km^2 and 102 835 inhabitants, the Statutory City of Liberec is the fifth largest city in the Czech Republic. The following map shows its location in the region:

Fig. 5 Cadastral area of the Statutory City of Liberec

Source: © OpenStreetMap contributors, RÚIAN

3.1 Vision

The Statutory City of Liberec intends to offer its inhabitants good living conditions and the environment of high quality, which is open for a long-term reliable, safe and cost-effective way of fuel, energy and waste management in accordance with principles and needs of sustainable development as well as the needs of the City adaptation to climate change.

3.2 General SECAP Strategy

On 28 January 2016, the Statutory City of Liberec officially joined the Covenant of Mayors and became its signatory. The essence of the membership in the Covenant is to implement particular selected projects of the City, which will lead to at least 20% CO_2 reduction by 2020 and 40% reduction by 2030 compared to the baseline year for which the CO_2 Emission Inventory was worked out. Further, the City will implement the projects that will reduce ongoing climate change impacts on the City infrastructure and functioning.

Although the Statutory City of Liberec does not fall into the areas where air pollutant limit values are significantly exceeded, air quality limit values (suspended particles PM_{10}, benzo(a)pyrene, ozone) in the City are occasionally exceeded. SECAP therefore proposes, as a priority, such actions that contribute both to CO_2 reduction and to reduction of air pollutant emission.

Projects and strategies included in SECAP concern above all areas, the City can influence by its activities. We can list the areas of buildings (residential, public, and possibly other buildings), public lighting, utilization of other City services (cleaning of public areas, waste treatment), transport, improving the City administration in the field of fuel and energy consumption, support of information activities through cooperation with the Smart City Initiative, and support of activities and awareness in the residential sector.

3.3 Integration of SECAP and Other Development Strategies of the City

SECAP is prepared in accordance with strategic and development goals of the Statutory City of Liberec and in accordance with the principles of environmental protection, particularly the air. The key documents, defining the future City development, are as follows:

a) **Update of the Statutory City of Liberec Development Strategy 2014 – 2020,** as a key document determining the development of the Statutory City of Liberec, includes strategic goals in the City development i.e. in the sectors included in SECAP (housing, public services and other tertiary sector, transport). Actions designed under SECAP are completely in line with the goals of the updated Strategy, especially with the global goal 2: „Balanced and sustainable economic development is based on use of modern technologies and cooperation of individual entities with universities and research centres. A high-quality and well-educated workforce finds not only a job but also adequate cultural and social activities“ The SECAP implementation, its evaluation and updating as well as designing new projects and activities presuppose cooperation among others with representatives of private entities and the University. Many activities designed in the Statutory City of Liberec Strategic Plan offer opportunities for the implementation that will enable the City to achieve the CO_2 reduction targets (new house building solutions, brownfield regeneration, retrofit of existing buildings, infrastructure, etc.).

b) **Integrated Development Plan for Liberec – Jablonec nad Nisou Territory** – actions designed in SECAP are chosen to be in line with the Integrated Plan targets.

c) **Land Use Planning of the City of Liberec, 2002** – SECAP takes into account the process of the Land Use Planning (LUP) preparation and its latest updating (Draft Liberec Land Use Planning, 2016). Some recommendations come out from the Draft Land Use Planning. In the residential sector, the BAU scenario takes into consideration the assumption of construction corresponding with the population of 103 666 in 2030, which envisages reducing the size of a census household and increasing housing standards. The Planning foresees an existing housing estate retrofit to prevent their decline. The Draft LUP reflects the fact that the use of energy produced from waste (alternative source) encounters a problem with insufficient heat consumption during summer. In summer, heat production in the waste-to-energy plant exceeds the DHS demand and heat must be wasted uneconomically in cooling towers.

d) **Sustainable Urban Mobility Plan for Liberec – Jablonec nad Nisou** – this document development is a currently ongoing process. The aim of the Plan is to create a sustainable transport system to be available for all target groups, and to improve transport safety.

e) **Air Quality Improvement Scheme – Zone Northeast - CZ05** – Even though Liberec ranks among areas with rather better air, there are still occasionally exceeded air pollutant concentration limits, and/or the numbers of days allowed with exceeded limits of these concentrations. To improve the situation, the Scheme includes actions aimed at air quality improvement. The majority of actions reducing air pollutions simultaneously have a positive impact on CO_2 greenhouse gas emissions. SECAP is therefore in accordance with the Air Quality Improvement Scheme and supports the implementation of a number of actions designed in the Scheme.

f) **Municipal Energy Strategy (MES) of the City of Liberec (2002)** – the 2002 MES is still a valid document. In 2010, proceeded a partial update of the MES, resulting particularly from the substantially more regressive DHS development than foreseen in the 2002 MES. In 2016, due to repeated non-compliance of the existing 2010 MES with the real status, a new update was initiated which has not been approved yet as a basis for a definite new Land Use Planning completion. The updated MES covers in particular changes in the City heat supply after 2015, sections of the original MES having relatively lasting validity are being adapted or supplemented only minimally. The MES is the main conceptual document in the area of energy supply and use in the City.

Ad a) **Update of the Statutory City of Liberec Development Strategy 2014 – 2020** comes from five strategic goals:

1. Economic development – supporting small and medium-sized enterprises, promoting employment, supporting knowledge economy, diversifying local economy.
2. Social development and health – better employment rate through better education and training, supporting social inclusion and equal opportunities for all people in all areas of life, developing civil society.
3. Availability and mobility – transport availability, transport planning, traffic calming, transport safety, technical infrastructure and utility network availability.
4. Attractive City – service and information availability, natural and physical environment, architecture, tourism, culture.
5. Environment – environmental quality, quality of air, drinking water resources, waste treatment, renewable energy sources.

Ad b) **Integrated Development Plan for Liberec – Jablonec nad Nisou Territory** focuses on the following five strategic goals, for the SECAP related areas it mentions also specific targets and actions:

1. Sustainable mobility
   - improving the territory mobility (transport availability and services)
     - regional road network
     - development of tram lines
   - increasing the share of sustainable forms of transport in the area
     - improving conditions for mobility participants
     - eliminating adverse impacts of transport on the environment and public health
2. Social cohesion and health care
3. Competitive economy
4. Healthy environment and natural potential protection

- improving reliability of technical infrastructure and air quality
    - ensuring drinking water supply for the inhabitants
    - optimizing energy, heat, hot water supply and increasing the stability and capacity of energy networks
    - retrofit and construction of sewage networks
    - developing telecommunication and information technologies and networks
    - introducing energy efficiency measures
    - removing excessive dust sources
- minimizing environmental risks and taking care of natural environment
    - improving the quality of public areas and green spaces
    - reducing flood risks including revitalizing watercourses
    - reducing human impact on the environment

5. Quality territory administration and territorial development management
    - efficient territory administration
        - improving communication of public administration with the public
        - continuous and coordinated planning of land use development
        - introducing modern systems and methods of public administration management

Ad d) **Sustainable Urban Mobility Plan for Liberec – Jablonec nad Nisou** – the project goals of the entire Sustainable Mobility Plan (for all types of transport) are as follows:

- to approve the implementation document of a long-term development strategy – Sustainable Mobility Action Plan
- to ensure the availability of the transport system for all target groups
- to improve safety and efficiency of transport
- to reduce energy consumption, air pollution, noise and vibration levels
- to contribute to making the urban space more attractive and to improving its quality

Ad e) **Air Quality Improvement Scheme – Zone Northeast - CZ05** contains measures particularly for transport, DHS and small sources for household heating (so-called local ovens). They are:

- preference of public transport
- integrated public transport systems
- investments in transport infrastructure
- construction and retrofit of tramway and trolleybus lines
- construction of P&R parkings
- support of heat source replacement in households
- development of environmentally friendly energy infrastructure, expansion of natural gas networks and heat supply systems

Ad f) **Municipal Energy Strategy (MEC) of the City of Liberec (2002)** – designed measures concern among others:

- improving efficiency of energy sources, reducing their emissions and improving their operation efficiency
- retrofitting and optimizing heat grid operation
- retrofitting, optimizing and developing electricity and gas distribution grids
- using renewable energy sources
- energy savings in housing and tertiary sectors
- optimizing the structure of energy carriers consumed in the city

3.4 SECAP Priorities

SECAP Priorities – Sectors

CO_2 emission inventory based on the final fuel and energy consumption served for setting priorities in CO_2 emissions reduction. Individual sectors included in the SECAP, their shares in the final fuel and energy consumption as well as their shares in CO_2 emissions have been analysed. The potential for emission reduction in these sectors has been then calculated and will be implemented using actions designed.

Fig. 6 Sectoral breakdown of CO_2 emissions in 2000 – sectors included in SECAP

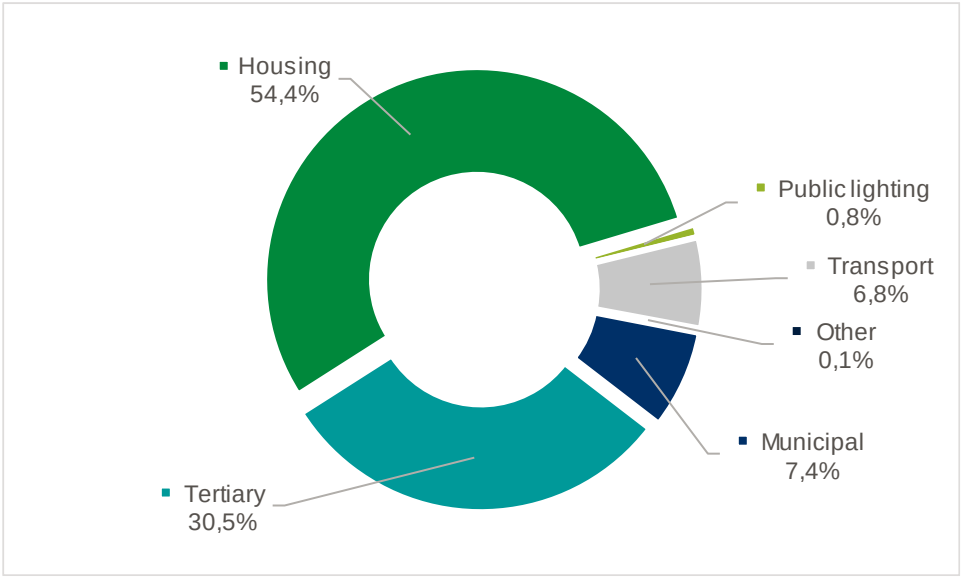


Fig. 7 Sectoral breakdown of final energy consumption in 2000 – sectors included in SECAP

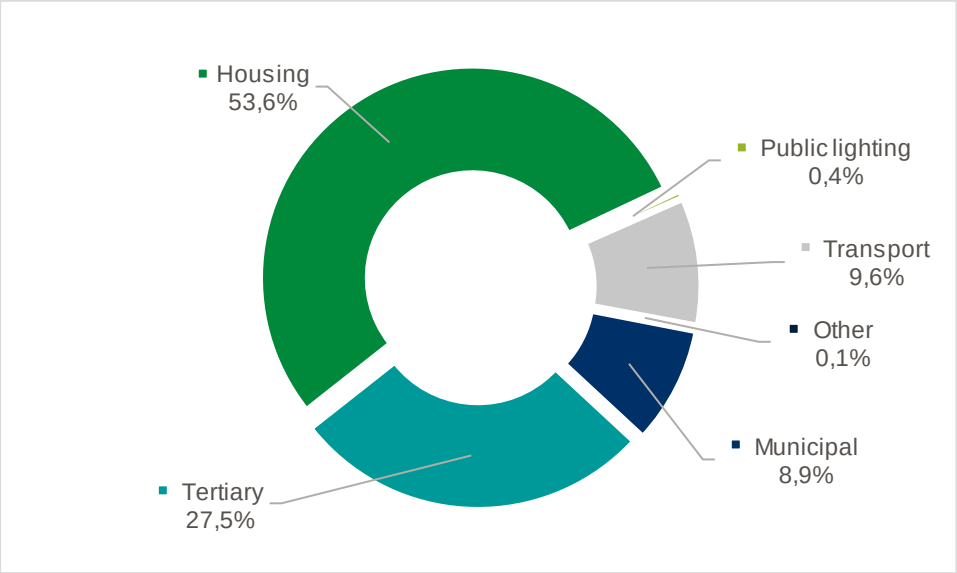
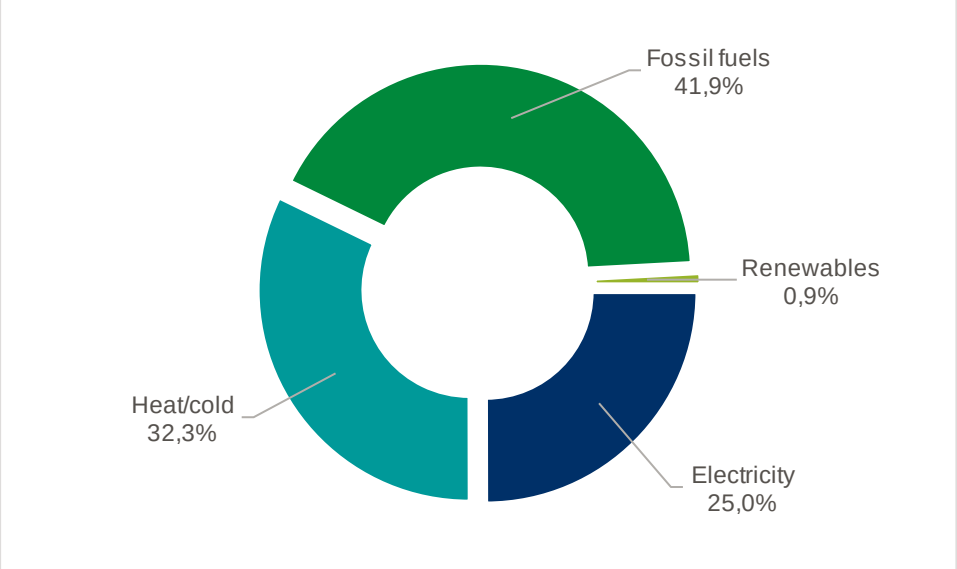


Fig. 8 Breakdown of the final energy consumption of sectors included in SECAP by energy carriers in 2000



It follows from the above-mentioned charts that the residential sector, followed by the tertiary sector (except for the municipal property) have the decisive impact on both the final energy consumption and CO2 emissions. Municipal buildings and equipment/facilities account for 7% of emissions and for 9% of the final energy consumption. In terms of energy carriers, fossil fuels have the largest share of the final energy consumption, followed by heat while electricity has the smallest share.

Given the potential of the City to impact individual sectors and their energy consumption, the design of the Action Plan measures pays the greatest attention to municipal buildings and equipment/facilities. However, with regard to the share of emissions, the potential for savings in the housing, tertiary and transport sectors is calculated, taking into account opportunities of using renewable energy sources and increasing local electricity production as well.

4. BASELINE CO_2 EMISSION INVENTORY (BEI) AND DEVELOPMENT TILL 2015

4.1 Sectors Included in BEI

Compilation of a Baseline Emission Inventory is a key step for preparing a quality Sustainable Energy and Climate Action Plan. However, developing an emission inventory in such a long-term horizon is also extremely demanding for data inputs. For creating an initial inventory, the methodology recommends using the year 1990 as a baseline. In the Czech Republic however, in the course of 1990s, an extensive restructuring of the energy sector took place, followed by separating the distribution activities of distribution energy companies from business activities (so called „unbundling“) in the first decade of the 21 century. In some cases, it is almost impossible to gain historical energy supply data because original companies supplying certain areas with energy do not exist any more.

The procedure of developing the emission inventory complied with the JRC methodology requirements. The calculations proceeded in the following order:

- final energy consumption
- CO_2 emissions or CO_2 equivalent corresponding to this final consumption
- local renewable electricity production and corresponding CO_2 emissions or CO_2 equivalent
- local district heating and cooling, combined heat and power generation (CHP) and corresponding CO_2 emissions or CO_2 equivalent

CO_2 emission inventory covered the entire cadastral area of the Statutory City of Liberec. For the comparison of the emission target group, CO_2 emissions from the entire fuel and energy consumption in the Statutory City of Liberec were first recorded. Afterwards, the total final consumption was reduced by consumption of sectors that do not belong to the inventory in accordance with the Covenant of Mayors Methodology. The fuel and energy consumption in the sectors included was then used to calculate CO_2 emissions using emission factors adhering to IPPC. Emission factors for electricity and DHS were set from the actual fuel mix for their production.

The emission inventory was worked out for the years:

- 2000 – baseline, reference year of the emission inventory
- 2005
- 2010
- 2015

The Baseline CO_2 Emission Inventory (BEI) includes only sectors that the Statutory City can influence by its activities, and for which CO_2 reduction actions are integrated in the Sustainable Energy and Climate Action Plan (SECAP) – see the following Table:

Tab. 23 Sectors included in the baseline comparative inventory (JRC methodology)

Sector	Included in the inventory	Note
Final energy consumption in buildings, equipment/facilities and in industry		
Municipal buildings, equipment/facilities	YES	These sectors include all energy consumption in buildings and equipment/facilities that is not included in other sectors – e.g. energy consumption in drinking water treatment, wastewater treatment, etc. Incineration of municipal waste is also included provided it doesn´t serve for energy production.
Tertiary sector (except for the municipal property) – buildings and equipment/facilities	YES	
Residential buildings	YES	
Public lighting	YES	
Industry in emission trading	NO	Emissions from these sources have not been included in the inventory.
Other industry	NO	In case of Liberec, only sources with 100% ownership of the City (NACE 38 – Waste collection, transport and disposal, waste treatment for further use) have been included in industry. Fuel and energy consumption and resulting CO_2 emissions in other industrial sources have not been included in the inventory.
Final fuel and energy consumption in transport		
Urban road transport – municipal vehicles (company-owned vehicles, waste transportation, police and ambulances…)	YES	This section includes emissions of all transport of these vehicles.
Urban road transport: urban public transport	YES	Part of passenger transport on the roads owned by the City.
Urban road transport: passenger and company transport	YES	
Other road transport	NO	This sector includes road transport on roads in the administrative territory of the City, which do not fall under the authority of the City (roads of I, II and III category, expressways and motorways).
Urban rail transport	YES	This sector includes urban rail transport in the City– e.g. tramways, metro and local trains.
Other rail transport	NO	This sector includes long-distance, interurban, regional, and freight railway transport, which we can find in the City. However, this sector does not serve only the City but a wider territory (not included in case of the City of Liberec).
Aviation	NO	Fuel and energy consumption in buildings and transport facilities (airports, ports) will be included in tertiary sector consumption, however, aircraft and mobile device consumption will not be included (not included the City of Liberec).
Boat transport	NO	
Local boat transport	NO	It does not serve as part of urban transport.
Other emission sources (not related to fuel and energy consumption)		
Technological emissions from sources subject to emission trading within the ETS	NO	Not included
Technological emissions from	NO	Not included

Sector	Included in the inventory	Note
sources not subject to emission trading and the ETS Directive		
Agriculture (e.g. fermentation, manure treatment, fertilizer application)	NO	
Wastewater treatment	NO	It concerns non-energy related emissions, e.g. CH_4 and N_2O emissions.
Waste treatment, waste management	NO*	It concerns other emissions, e.g. landfill gas, methane - CH_4 from landfills. Energy consumption of these facilities and associated emissions are included in the category of buildings and facilities/equipment.
Energy production		
Fuel consumption for electric energy production	YES*	Generally, only sources of the capacity of <20 MW_t, which are not subject to emission trading, can be included.
Fuel consumption for heat/cold production	YES*	These sources are included only if the heat supplied by them is consumed in the City. In case of Liberec, fuel consumption and resulting CO_2 emissions from heat supply by distributors to the housing and tertiary sectors (Termizo, etc.) are included.

*) The landfill operation terminated in 2000.

4.2 Final Energy Consumption

4.2.1 Stationary Sources

Final energy consumption of stationary sources was determined using several different data sources as follows:

- In step 1, energy supply in the City by sector was determined. The data came from energy suppliers (GasNet, s. r. o., ČEZ Distribuce, a. s., Teplárna Liberec, a. s.).
- Step 2 embodied in identification of energy consumption in municipal buildings. The data originated from the City and from individual survey performed in municipal institutions.
- Step 3 encompassed an analysis of data analysis the database of significant air pollution sources (Register of Emissions and Air Pollution Sources 1 – 3 – Czech abbrev. REZZO. The Czech Hydrometeorological Institute (Czech abbrev. ČHMÚ) provided these data from the General Operational Register. The data from REZZO 1 and 2 served for specification of fuel consumption of some municipal buildings as well as electricity and heat sources in the City. Solid and liquid fuels consumption in households came from REZZO 3. REZZO is the only available data source on solid and liquid fuel consumption. Final consumption of these fuels comes therefore from this source, in case of REZZO 1 and 2 aggregated by sector. Fuel consumption of boiler rooms/houses operated by housing associations (HA) and apartment owner associations was transferred from the tertiary sector to the residential sector.
- In step 4, the energy consumption in municipal buildings was deducted from the total energy supply to the tertiary sector resulting into the consumption of the part of the tertiary sector, which the City cannot influence.

- In step 5, the electricity consumption for public lighting was determined. The company ČEZ Distribuce, a. s., provided electricity supply at C62d tariff, which serves for public lighting.
- In the last step, the renewable energy consumption was determined. For solar thermal energy, the data on installed sources came from the Guide of Renewable Energy Installations and, above all, from supported projects under the Green Savings Programme. The data on geothermal energy consumption of heat pumps (HP) were calculated from electricity supply in heat pump distribution tariffs. Again, these data provided the ČEZ Distribuce, a. s.

The following four tables show the resulting final energy consumption corrected to normal climatic conditions.

Tab. 24 Final energy consumption in municipal buildings and equipment/facilities (corrected to normal climatic conditions)

Final consumption – municipal property [MWh]	2000	2005	2010	2015
Natural gas	50,078	45,347	44,294	40,398
Electricity	15,583	15,554	18,550	23,515
Heat	33,627	32,965	31,102	29,136
Heating oil	414	392	383	378
Oil	0	0	0	0
Propane - Butane	0	0	0	0
Lignite	0	0	0	0
Bituminous coal	0	0	0	0
Coke	0	0	0	0
Biofuel	0	0	0	0
Solar heat	0	0	0	0
Geothermal heat	0	0	0	0
Total	**99,703**	**94,258**	**94,329**	**93,425**

Source: Calculation of ENVIROS

Tab. 25 Final energy consumption in other tertiary sector (corrected to normal climatic conditions)

Final consumption – other tertiary sector [MWh]	2000	2005	2010	2015
Natural gas	102,595	146,586	125,294	162,105
Electricity	106,314	129,659	130,609	142,131
Heat	90,537	85,902	60,185	34,793
Heating oil	1,620	1,183	1,188	1,111
Oil	0	0	14	89
Propane - Butane	434	392	39	0
Lignite	6,490	9,996	1,887	1,635
Bituminous coal	0	0	0	0
Coke	1,094	731	0	0
Biofuel	0	0	0	0
Solar heat	11	38	37	39
Geothermal heat	87	245	548	704
Total	**309,182**	**374,732**	**319,802**	**342,607**

Source: Calculation of ENVIROS

Tab. 26 Final energy consumption in households (corrected to normal climatic conditions)

Final consumption - households [MWh]	2000	2005	2010	2015
Natural gas	146,792	189,934	172,683	197,414
Electricity	146,358	156,731	154,422	143,503
Heat	239,051	194,753	151,658	102,107
Heating oil	1,764	1,879	1,909	1,562
Oil	0	0	0	0
Propane - Butane	848	1,085	1,213	2,398
Lignite	57,382	47,006	42,407	38,084
Bituminous coal	240	232	236	12
Coke	1,471	949	370	46
Biofuel	9,393	21,245	28,493	24,307
Solar heat	0	0	98	399
Geothermal heat	86	713	2,712	4,394
Total	**603,385**	**614,528**	**556,201**	**514,225**

Source: Calculation of ENVIROS

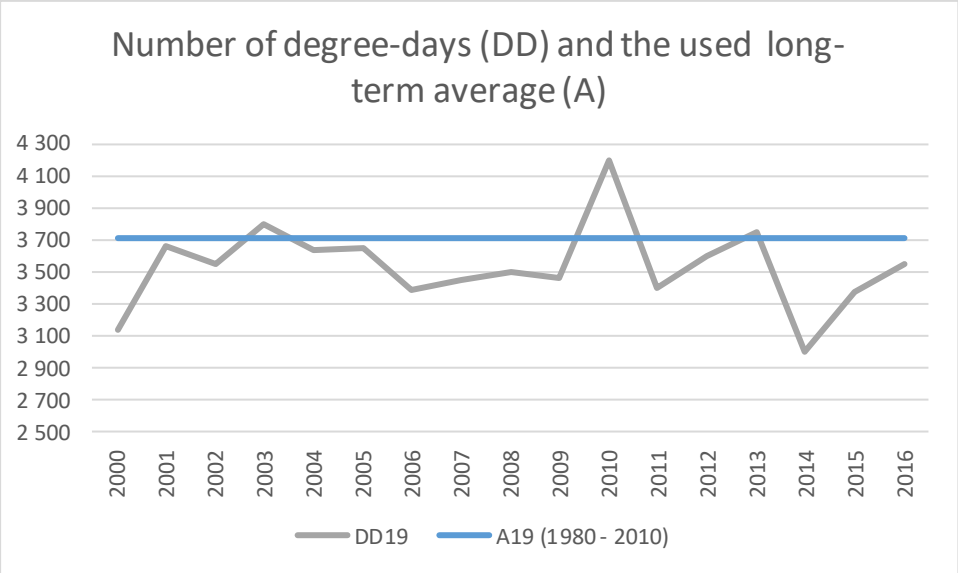
Tab. 27 Final electricity consumption for public lighting

Final consumption – public lighting [MWh]	2000	2005	2010	2015
Electricity	4,554	5,105	5,724	6,242

Source: ČEZ Distribuce, a. s.

The following chart shows the degree-days course and normal conditions used for converting final consumption to normal climatic conditions. The degree-days were calculated for the indoor temperature of 19 °C and the normal conditions were calculated for the period 1980 – 2010.

Fig. 9 Degree-days D_{19} for space heating seasons 2000 – 2015 and the average for 1980 – 2010



The following two charts show the share of sectors included in SECAP in the total final consumption of stationary sources and in total CO_2 emissions of stationary sources.

Fig. 10 Share of all sectors included in SECAP in total fuel and energy consumption

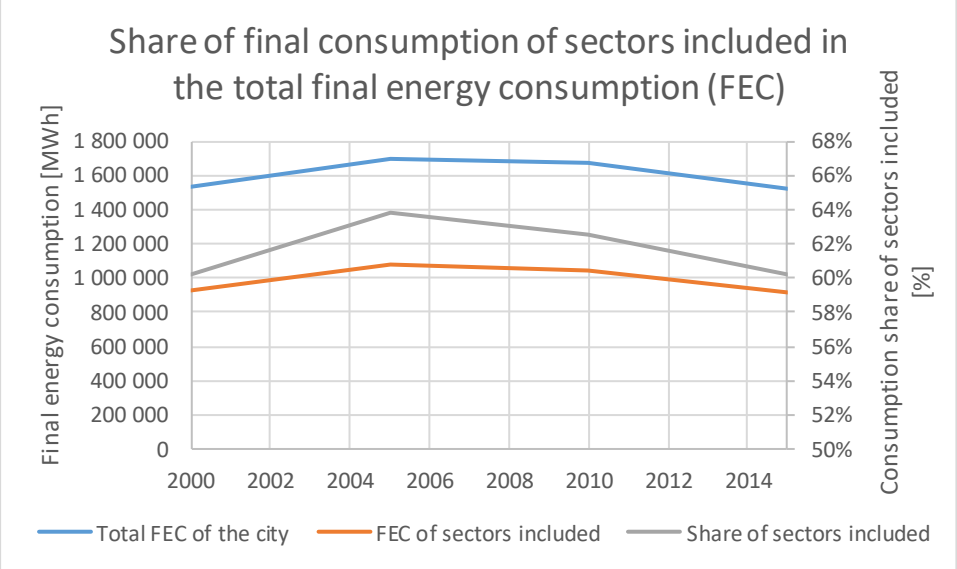
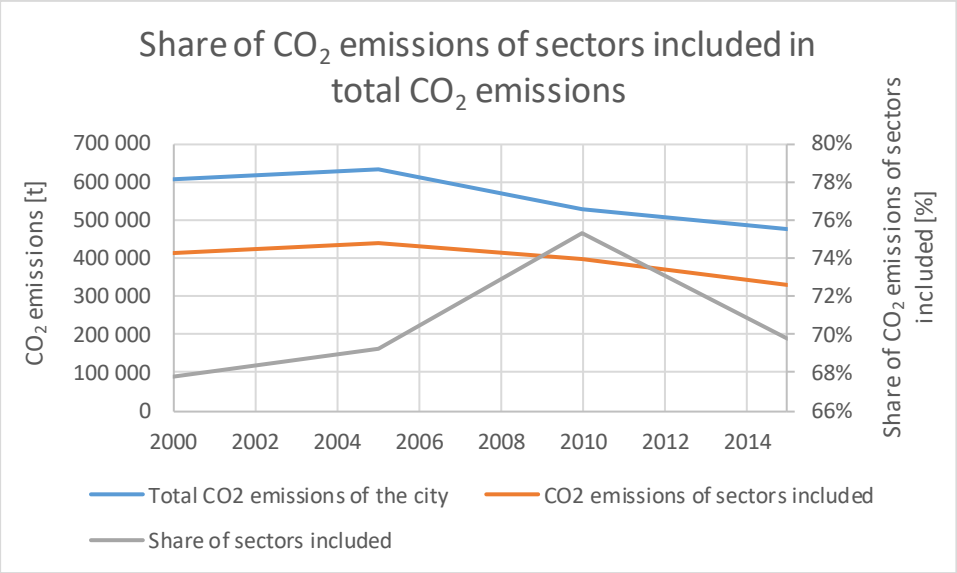


Fig. 11 Share of all sectors included in SECAP in total CO_2 emissions



4.2.2 Mobile Sources

The subject of the analysis was the fleet of the City and its institutions, public transport and passenger and company road transport. Traffic of the municipal fleet and its institutions as well as public transport was evaluated on all roads as the operation of these vehicles is fully under the competence of the City. Traffic of passenger and company transport was evaluated only on urban roads, as the City has no possibility to influence traffic on state and regional roads. The following Table shows the extent of the urban road network.

Tab. 28 Length of urban road network of the traffic model included in evaluation

Roads by current owner	Length of roads 2015 (in km)
State	52.466
Regional	46.607
Urban	338.047
Zero traffic roads	124.880
Sum total	**437.120**

Note: In case of multilane directionally divided roads and complicatedly shaped junctions, each lane (or junction branch) is calculated separately.

4.2.2.1 Description of Mobile Sources in the City of Liberec

The analysis of the municipal fleet and public transport stems from information provided by fleet management institutions. Calculation of road transport proceeded using the traffic model of NDCon, s.r.o., Company. The analysis involved the fleet of the City of Liberec and its institutions, the public transport fleet, and passenger and company urban road transport.

The Fleet of the City of Liberec and its Institutions

- Municipal Authority
- Municipal Police
- Botanic garden

- Data on the fleet of the Social and Healthcare Centre and ZOO were not usable due to their incompleteness.

Public Transport Fleet

The Transport Company of Liberec and Jablonec nad Nisou is the principal public transport provider. Fleet analysis of public transport stems from information provided by the Transport Company of Liberec and Jablonec nad Nisou (DPMLJ).

Passenger and Company Urban Road Transport

In pursuance of the passenger and company urban road transport analysis, a dynamic passenger and company urban road transport structure was determined. Further, the road transport intensity and its development were determined. In order to determine the transport development intensity, it was first necessary to set aside roads from the traffic model according to their administrator. Category I roads are owned by the state (the administration is carried out by the Directorate of Roads and Motorways (ŘSD), category II and III roads are owned by the region (the administrator is the Regional Road Authority of the Liberec Region) and the City thus owns only the roads included in the local road category. Subsequently, the zero-transport intensity roads were removed from the network of sections of the traffic model.

The model used categorizes road transport into passenger and freight vehicles and public transport. The following two Tables show resulting daily transport performance for light and heavy weight vehicle categories.

Tab. 29 Total daily transport performance in the road network evaluated in the light weight vehicle category in thousand vkms

Roads by current owner	2000	2005	2010	2015	2020	2030
National	378.335	472.919	479.539	546.675	669.004	743.637
Regional	68.612	85.765	86.966	95.663	111.818	126.675
Urban	269.408	336.760	341.474	372.207	412.463	480.369
Sum total	**716.355**	**895.444**	**907.980**	**1014.545**	**1193.286**	**1350.681**

Tab. 30 Total daily transport performance in the road network evaluated in the heavy weight vehicle category in thousand vkms

Roads by current owner	2000	2005	2010	2015	2020	2030
National	30.080	49.331	35.074	36.477	41.707	42.463
Regional	3.350	5.494	3.906	3.984	4.167	4.311
Urban	6.743	11.059	7.863	7.942	7.824	8.167
Sum total	**40.173**	**65.884**	**46.843**	**48.403**	**53.697**	**54.941**

The motorways I/14 and I/35 rank among the most busy roads in the cadastre of the City of Liberec. They are followed by the category I road I/14 in the stretch from the GSJ (the grade separated junction) with the motorway I/35 as far as Dr. E. Beneš Square, and also in the stretch from the Tanvaldská GSJ to Vratislavice nad Nisou. Another significantly busy road is the road III/2784 in the stretch from the Doubí GSJ to the roundabout in the crossing of Průmyslová and České mládeže Streets. The busiest local roads are Sousedská and Letná Streets as well as Švermova Street. On all above-mentioned roads, the annual average of daily intensities exceeds the amount of 10 thousand vehicles per day. The transport intensity on motorways is significantly higher than 20 thousands vehicles per day.

4.2.2.2 Calculation of CO_2 Emissions and Energy Consumption in Transport

The energy and emission inventory in baseline scenarios (2000, 2005, and 2010) come from real evaluated subject data and model data created based on results of the national transport census and average dynamic structure of vehicles on roads in the Czech Republic. Energy and emission inventories in 2015 come from the traffic model delivered by the NDCon, s. r. o., in the version dated 19 September 2017. Energy and emission inventories in 2020 and 2030 scenarios consider standard behaviour of evaluated subjects only (e.g., they do not take into consideration a fuel change).

Tab. 31 shows the total annual energy consumption in road transport in the classification by vehicle owner where in case of vehicles owned by the City and its institutions, private and commercial vehicles the consumption is limited to local roads. Tab. 31 indicates the same data, however, not limited by the road category.

Tab. 31 Total annual energy consumption [MWh] in road transport limited to local roads (other transport on City administrated roads)

Vehicles by owner	2000	2005	2010	2015	2020	2030
Vehicles owned by the City and its institutions	147	199	161	161	157	81
Public transport vehicles	14,450	11,571	16,026	15,269	15,613	14,942
Private and commercial vehicles	82,325	98,327	99,419	102,045	112,326	132,087
Sum total	**96,922**	**110,097**	**115,606**	**117,475**	**128,096**	**147,110**

Tab. 32 Total annual energy consumption in road transport on all roads [MWh]

Vehicles by owner	2000	2005	2010	2015	2020	2030
Vehicles owned by the City and its institutions	374	507	410	409	398	206
Public transport vehicles	25,029	20,042	27,759	26,448	27,043	25,880
Private and commercial vehicles	209,253	259,783	258,724	273,158	319,585	361,524
Sum total	**234,655**	**280,331**	**286,892**	**300,014**	**347,027**	**387,611**

Total annual CO_2 emission production in road transport in the same classification and limit as in Tab. 32 showing energy consumption indicated in Tab. 33. Tab. 34 gives the same data, however without limits, categorized by road.

Tab. 33 Total annual CO_2 emission production [t] in road transport (other transport on City administered roads)

Vehicles by owner	2000	2005	2010	2015	2020	2030
Vehicles owned by the City and its institutions	38	51	39	40	39	19
Public transport vehicles	6,427	4,795	5,711	4,888	4,609	4,746
Private and commercial vehicles	20,905	25,179	24,420	24,999	27,576	30,785
Sum total	**27,369**	**30,025**	**30,171**	**29,927**	**32,223**	**35,550**

Tab. 34 Total annual CO_2 emission production in road transport [t]

Vehicles by owner	2000	2005	2010	2015	2020	2030
Vehicles owned by the City and its institutions	96	129	100	101	98	48
Public transport vehicles	11,133	8,307	9,894	8,468	7,982	8,221
Private and commercial vehicles	53,336	66,797	63,684	67,033	78,577	84,413
Sum total	**64,565**	**75,234**	**73,678**	**75,602**	**86,658**	**92,683**

4.3 Local Renewable Energy Production

The Energy Regulatory Office (ERÚ) was the source of local renewable energy production data. For 2015, it provided directly data on renewable energy production, for the previous years the production was calculated from installed capacity according to the licences granted for electricity production and average utilisation factors in the Liberec Region – data also provided by ERÚ.

Tab. 35 Renewable electricity production in the Statutory City of Liberec [MWh]

[MWh]	2000	2005	2010	2015
Wind power plants	0	0	0	0
PV power plants	0	0	68	1,692
Small hydropower plants	1,354	5,923	5,242	2,099
Total	**1,354**	**5,923**	**5,310**	**3,791**

Source of data: Energy Regulatory Office

4.4 Local Combined Heat and Power Generation and Local District Heating and Cooling

4.4.1 Local Combined Heat and Power Generation

In the City, we identified six cogeneration units, which can be included in local combined power and heat generation:

- Swimming pool (since 2013 it has been supplying the North Bohemian Gallery with heat and power),
- Regional Hospital – in 2017, the cogeneration unit was, along with the incinerator and laundry decommissioned without replacement
- Arena,
- Babylon Centrum,
- Wastewater treatment plant – we consider only power generation here, heat is partly consumed for technology and the rest is wasted,
- Primary School – Ještědská Street – this cogeneration unit is not and will not be in operation for economic reasons. Under current conditions, the cogeneration unit is slightly oversized and after thermal insulation of the building, it will become oversized approx. two times. With green bonds for electricity production up to 3,000 hours a year using a cogeneration unit in the school is usually a good option, however, there is no other school in Liberec to use such a big cogeneration unit. The best use of this unit could be in the ZOO, which operates a number of gas boilers.

In order to determine power and heat generation, we had to use more sources of data: ERÚ – licence for power and heat generation, ERÚ – thermal energy price overview classified by price localities, REZZO 2 and data from operators. Classification of fuel consumption for power and heat generation and sometimes the classification directly of power and heat had to be made by expert estimates.

Tab. 36 Local combined power and heat generation in the Statutory City of Liberec [MWh]

[MWh]	2000	2005	2010	2015
NG consumption for heat generation	6,980	10,587	12,531	19,738
NG consumption for power generation	3,422	6,658	8,257	14,186
BG consumption for power generation	1,694	1,694	7,071	7,071
Heat generation	5,303	8,509	9,951	17,046
Power generation	3,287	6,118	9,478	15,045

Source of data: Energy Regulatory Office, REZZO 2, operators, expert estimates of authors

Note: Biogas is generated and used only in the wastewater treatment plant. Here it is captured and partially combusted in the boiler for technology heat generation, water heating and operational buildings heating. The rest is combusted in two cogeneration units; heat from the cogeneration units is not used. Power generated from biogas reduces the local electricity emission factor. The wastewater treatment plant neither takes from nor supplies heat to the grid; for that reason, biogas for heat generation is no longer counted.

Local combined power and heat generation and fuels entering this generation are crucial for determining an emission factor for electricity generated. This fuel mix is more favourable than the fuel mix for electricity generation on the national level – the emission factor is lower. Locally generated electricity is deducted in the inventory from electricity consumed in the sectors included, taken from the grids.

For that reason, it is beneficial to increase combined power and heat generation in sources up to 20 MW_e in the City also in the future.

4.4.2 Local District Heating and Cooling

District heating in Liberec is supplied from the Heating Plant Liberec, plc (Teplárna Liberec, a. s.) (it includes the main source and peak sources) and from the waste-to-energy facility TERMIZO, a. s. Both companies belong to the MVV Energie CZ, a. s. group, which therefore provided the data for both companies together. Emission factors for the heat supplied were provided directly by the heat supplier in the following figures:

Tab. 37 Local district heating in the Statutory City of Liberec

	2000	2005	2010	2015
Heat supply [MWh]	429,897	382,180	291,915	179,824
CO_2 emissions [t]	152,604	138,930	93,584	64,029
Emission factor tCO_2/MWh	0.355	0.364	0.321	0.356

Source of data: Teplárna Liberec, a. s.

There is no centralized cold production and distribution in the City.

4.5 Emission Factors

Fuel emission factors came from the ČHMÚ (REZZO) data:

Tab. 38 Fuel emission factors for stationary sources

Fuel	EF CO_2 [t/MWh]
Natural gas	0.201
Low sulphur fuel oils (sulphur content more than 0,1% and max. 1 %)	0.276
High sulphur fuel oils (sulphur content more than 1 %)	0.276
Medium fuel oil	0.276
Wood biomass *)	0
Coke	0.381
Other liquid fuel	0.276
Heating gas oils (sulphur content max.0,1 %)	0.264
Grade coal	0.357
Propane, butane and mixtures thereof	0.226
Biogas *)	0

Source of data: ČHMÚ

*) We consider sustainable production of these fuels.

Variable emission factors reflect share of bio component in diesel and gasoline:

Tab. 39 Development of emission factors of motor fuels

[t CO_2/MWh]	2000	2005	2010	2015
diesel	0.267	0.267	0.253	0.251
gasoline	0.249	0.249	0.239	0.239

Source of data: CDV

For electricity, we used a variable national factor as shown in the following Table:

Tab. 40 Emission factors for electricity supplied

[t CO_2/MWh]	2000	2005	2010	2015
Emission factor	0.849	0.770	0.720	0.632

Source of data: ČHMÚ, Eurostat, own calculation of ENVIROS

These emission factors for electricity were calculated from energy inventories published by Eurostat.

Tab. 41 - Tab. 45 show the resulting energy and emission inventory of the baseline year 2000.

Tab. 41 Final energy consumption in BEI (in 2000) – EU format

Sector		FINAL ENERGY CONSUMPTION [MWh]															
				Fossil fuels								Renewable energies					Total
		Electricity	Heat/cold	Natural gas	Liquid gas	Heating oil	Diesel	Gasoline	Lignite	Coal	Other fossil fuels	Plant oil	Biofuel	Other biomass	Solar thermal	Geothermal	
BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES																	
Municipal buildings, equipment/facilities		15 583	33 627	50 078	0	414	0	0	0	0	0	0	0	0	0	0	99 703
Tertiary (non municipal) buildings, equipment/facilities		106 314	90 537	102 595	434	1 620	0	0	6 490	0	1 094	0	0	0	11	87	309 182
Residential buildings		146 358	239 051	146 792	848	1 764	0	0	57 382	240	1 471	0	9 393	0	0	86	603 385
Public lighting		4 554	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4 554
Industry	Non-ETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	ETS (not recommended)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Subtotal		272 808	363 215	299 465	1 282	3 798	0	0	63 872	240	2 565	0	9 393	0	11	173	1 016 824
TRANSPORT																	
Municipal fleet							148	226									374
Public transport		7 809					17 220	0									25 029
Private and commercial transport							22 538	59 787									82 325
Subtotal		7 809	0	0	0	0	39 906	60 013	0	0	0	0	0	0	0	0	107 728
OTHER																	
Agriculture, Forestry, Fisheries		524	0	815	0	0	0	0	0	0	0	0	0	0	0	0	**1 339**
TOTAL		**281 141**	**363 215**	**300 280**	**1 282**	**3 798**	**39 906**	**60 013**	**63 872**	**240**	**2 565**	**0**	**9 393**	**0**	**11**	**173**	**1 125 890**

Tab. 42 Local/distributed energy production (renewable energy only) in BEI (in 2000) – EU format

Local renewable electricity plants (ETS and large-scale plants > 20 MWe not recommended)	Renewable electricity produced [MWh]	Emission factor [t/MWh produced]	CO_2 / CO_2 eq. emissions [t]
Wind	0	0,000	0
Hydroelectric	1 354	0,000	0
Photovoltaics	0	0,000	0
Geothermal	0	0,000	0
TOTAL	1 354		**0**

Tab. 43 Local/distributed electricity production in BEI (in 2000) – EU format

Local electricity production plants (ETS and large-scale plants > 20 MW not recommended)	Electricity produced [MWh]		Energy carrier input [MWh]										CO_2 / CO_2 eq. emissions [t]	
			Fossil fuels					Waste	Plant oil	Other biomass	Other renewable	Other		
	from renewable sources	from non-renewable sources	Natural gas	Liquid gas	Heating oil	Lignite	Coal						Fossil sources	Renewable sources
Combined Heat and Power	617	2 670	3 422	0	0	0	0	0	0	1 694	0	0	688	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	617	2 670	3 422	0	0	0	0	0	0	1 694	0	0	688	0

Tab. 44 Local heat/cold production in BEI (in 2000) – EU format

Local heat/cold production plants	Heat/cold produced [MWh]		Energy carrier input [MWh]										CO_2 / CO_2 eq. emissions [t]	
			Fossil fuels					Waste	Plant oil	Other biomass	Other renewable	Other		
	from renewable sources	from non-renewable sources	Natural gas	Liquid gas	Heating oil	Lignite	Coal						Fossil sources	Renewable sources
Combined Heat and Power	0	5 303	6 980	0	0	0	0	0	0	0	0	0	1 403	0
District heating (heat-only)	53 965	375 932											152 604	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	53 965	381 235	6 980	0	0	0	0	0	0	0	0	0	154 007	0

Tab. 45 Emission inventory in BEI – EU format

Sector		CO_2 emissions [t] / CO_2 eq. emissions [t]															
				Fossil fuels								Renewable energies					
		Electricity	Heat/cold	Natural gas	Liquid gas	Heating Oil	Diesel	Gasoline	Lignite	Coal	Other fossil fuels	Biofuel	Plant oil	Other biomass	Solar thermal	Geothermal	Total
BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES																	
Municipal buildings, equipment/facilities		13 042	11 900	10 066	0	114	0	0	0	0	0	0	0	0	0	0	**35 122**
Tertiary (non municipal) buildings, equipment/facilities		88 979	32 039	20 622	98	447	0	0	2 317	0	417	0	0	0	0	0	**144 918**
Residential buildings		122 493	84 594	29 505	192	487	0	0	20 485	79	560	0	0	0	0	0	**258 396**
Public lighting		3 811	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3 811**
Industry	Non-ETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	ETS (not recommended)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Subtotal		228 325	128 533	60 193	290	1 048	0	0	22 802	79	977	0	0	0	0	0	**442 247**
TRANSPORT																	
Municipal fleet		0	0	0	0	0	39	56	0	0	0	0	0	0	0	0	**96**
Public transport		6 536	0	0	0	0	4 598	0	0	0	0	0	0	0	0	0	**11 133**
Private and commercial transport		0	0	0	0	0	6 018	14 887	0	0	0	0	0	0	0	0	**20 905**
Subtotal		6 536	0	0	0	0	10 655	14 943	0	0	0	0	0	0	0	0	**32 134**
OTHER																	
Agriculture, Forestry, Fisheries		438	0	164	0	0	0	0	0	0	0	0	0	0	0	0	**602**
OTHER NON-ENERGY RELATED																	
Waste management																	**0**
Waste water management																	**0**
Other non-energy related																	**0**
TOTAL		**235 299**	**128 533**	**60 356**	**290**	**1 048**	**10 655**	**14 943**	**22 802**	**79**	**977**	**0**	**0**	**0**	**0**	**0**	**474 983**

5. ACTIONS TO REDUCE CO_2 EMISSIONS (MITIGATION ACTIONS)

This Chapter summarizes all 2015 – 2030 implementation actions the benefits of which were included in the Action Plan. The actions are listed by SECAP sector using classification into three categories:

- Actions already implemented after 2015
- Actions planned – these actions are likely to be implemented
- Actions designed – actions recommended for implementation to meet the commitment to reduce CO_2 emissions.

No data on energy savings achieved or achievable were available for the majority of both implemented and planned actions. In case of insufficient documentation, the Action Plan authors had to determine benefits of individual actions and frequently amounts of investments needed.

5.1 "Business as Usual" Scenario

To quantify the CO_2 emission reduction by 2020 and 2030, it is necessary not only to calculate the benefits of individual actions but also to involve the natural development of energy consumption and corresponding emissions resulting from new construction, natural replacement of equipment, individual thermal insulation, etc. This projection of energy consumption and emissions is referred to as "Business as usual" (BAU) scenario and a change of emissions compared to the baseline year in this scenario is to be added to the sum of avoided emissions due to all actions.

We expect future development in the household and transport sectors. In the tertiary sector, the land use planning no longer anticipates a construction of large commercial and warehouse buildings; it envisages only construction of small public amenities. We assume that natural reduction of energy intensity will compensate an increase in consumption due to new buildings. Similarly, in the public lighting sector we expect that newly installed street lights will be equipped with LED sources and increase in consumption resulting from new installations will be compensated by natural replacement of old street lights.

In the household sector, the land use planning envisages the construction and completion of new apartments and conversion of non-residential premises to apartments. By 2030, it expects construction of altogether 2 238 apartments in family houses and 7 027 flats in residential buildings. Due to the legislation stemming from EU Energy Performance of Buildings Directive, all new buildings will have to be in nearly zero energy standard after 2020. The following Table shows an estimate of new apartment energy consumption as well as assumptions used.

Tab. 46 Energy consumption in new dwellings in 2020 and 2030

	Number of new apartments by 2020	Number of new apartments by 2030	Specific consumption of all energy [kWh/m².y]	Area of new apartments [m²]	All energy consumption in 2020 [MWh]	All energy consumption in 2030 [MWh]
Apartments in family houses	825	7,027	30	50	1,238	10,541
Apartments in residential buildings	360	3,238	40	,90	1,296	11,657
Total					**2,534**	**22,197**

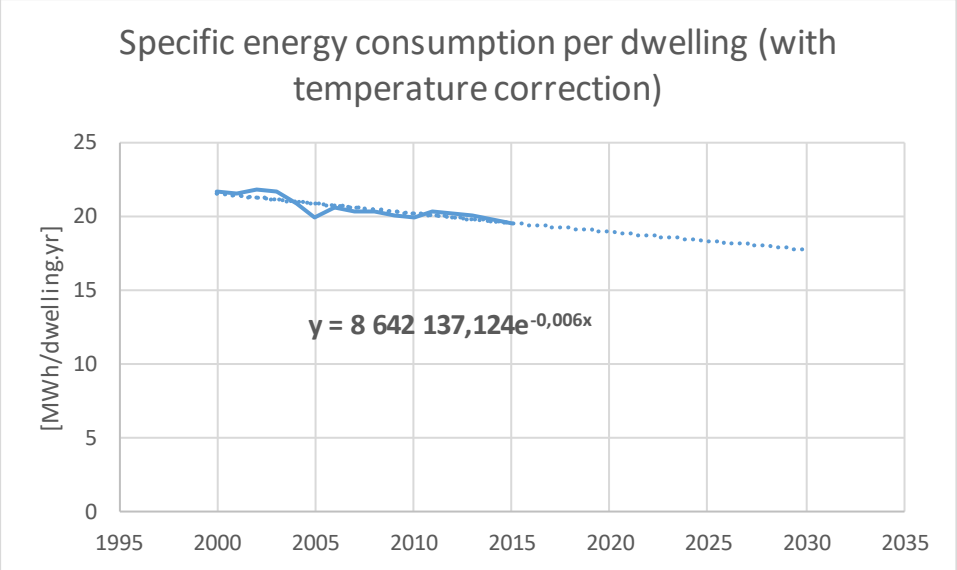
Given that electricity consumption of appliances will prevail over energy consumption for space heating in new buildings, emissions of new buildings are calculated using electricity emission factor.

Tab. 47 Expected CO_2 emissions of new residential buildings

Year	2020	2030
CO_2 emissions of new residential buildings [t/y]	1,530	13,407

The energy consumption decrease in existing dwellings resulting from energy intensity decreasing will counteract the energy consumption increase caused by the new construction. The following figure shows the reduction of specific energy consumption per dwelling from 2000 to 2015.

Fig. 12 Development of specific energy consumption per dwelling in the CR



Source: ODYSSEE Database (http://www.indicators.odyssee-mure.eu/energy-efficiency-database.html)

Using exponential extrapolation of the mentioned reduction, we have deduced that from 2015, energy consumption in apartments will decline by 3.1% by 2020 and by 9.2% by 2030 in the BAU scenario. For the calculation of CO_2 emissions, we consider the structure of energy carriers to be identical with 2015. The following Table shows the resulting CO_2 reduction.

Tab. 48 Expected reduction of CO_2 emissions from existing apartments compared to 2015

Year	2020	2030
Reduction of CO_2 emissions from existing apartments [t/y]	5,488	16,152

Summing up the change to emissions caused by the new housing construction and the reduction of energy performance of existing apartments, we obtain a change to emissions compared to 2015 according to Tab. 49, which shows that a natural reduction of energy performance of households and corresponding emission reduction will slightly outweigh an emission increase from new construction.

Tab. 49 Expected change to CO_2 emissions from households compared to 2015

Year	2020	2030
Reduction of CO_2 emissions from existing apartments [t/y]	-3,958	-2,745

A projection of mobility and fleet development by 2030 was performed for the transport sector. The projection has shown an increase in CO_2 emissions by 2030 which can be seen in the following Table.

Tab. 50 Development of CO_2 emissions in transport in the "Business as usual" scenario

Vehicles by owner	2000	2005	2010	2015	2020	2030
Vehicles owned by the City and its institutions	96	129	100	101	98	48
Public transport vehicles	11133	8307	9894	8468	7982	8221
Private and commercial vehicles on City administrated roads	20,905	25,179	24,420	24,999	27,576	30,785
Total	**32,134**	**33,615**	**34,414**	**33,568**	**35,656**	**39,054**

The following Table shows resulting emissions in the "Business as usual" scenario.

Tab. 51 Total CO_2 emission development in the "Business as usual" scenario

	2000	2005	2010	2015	2020	2030
Municipal	35,122	32,704	31,747	32,484	32,484	32,484
Transport	32,134	33,615	34,414	33,568	35,656	39,054
Households	258,396	243,151	206,010	176,175	172,218	173,430
Tertiary sector	144,918	161,264	135,740	131,323	131,323	131,323
Public lighting	3,811	3,800	3,961	3,769	3,769	3,769
Agriculture	602	682	649	652	652	652
Total	**474,983**	**475,216**	**412,521**	**377,971**	**376,102**	**380,712**

5.2 Energy Efficiency Measures in Municipal Buildings and Equipment/Facilities

5.2.1 Measures Already Implemented (after 2015)

Notes for the Table below and the following similar Tables:

- The emission reduction columns in …. mean **annual** value of emission reduction in the given year. If a measure is implemented gradually, then in 2020 annual emission reduction achieved in this year, and in 2030 the total annual reduction of emissions achieved in comparison with the state before the measure implementation are presented. **These are not cumulative values for the whole period**.
- If the whole measure is implemented by the end of 2020, then it is expected that annual avoided emissions achieved in 2020 **persist** also in 2030.
- The figure in the **Implementation Costs including VAT** column represents investment costs of the **entire** investment even if its part will be realized already in 2020.
- Specific investments to emission reduction are calculated as a quotient of investment costs of the entire measure implementation and the annual avoided emissions after completion of the **whole** measure implementation.
- The figure for specific investments to emission reduction in the line **Total** represents an average value for all measures in the Table. It is calculated as a quotient of the sum of investment costs and the sum of savings achieved in 2030 for all measures in the Table.

Tab. 52 Measures implemented on the municipal property after 2015

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Primary School – Broumovská Street – complex thermal insulation, heating system retrofit, ventilation with heat recovery	25,410	182.3	182.3	139,395
Regional Hospital – replacement of windows in Pavilions A, O, and D	18,876	57.0	57.0	330,962
Regional Hospital – liquidation of the incinerator and laundry	0	950.6	950.6	0
Total (for specific investments – average)	**44,286**	**1,189.9**	**1,189.9**	**37,219**

Primary School – Broumovská Street

The building was partly insulated in 2017. Completing the building insulation is expected in 2018.

- Estimated costs of completing the building insulation in 2018 are CZK 25.41 million
- Saving of operating cost CZK/y 1 137 thousand

After completion of the thermal insulation, the heating system will be retrofitted (heat exchanger and heating system) and ventilation with heat recovery will be installed in classrooms.

Primary School – Broumovská Street

Primary School – Broumovská Street

Regional Hospital – windows replacement in Pavilions A, O, and D

Windows replacement passed in 2015 and 2016.

- Expected costs of completing the building insulation in 2018 are CZK 18.9 million
- Operating costs savings CZK/y 333 thousand

Regional Hospital – decommissioning of the incinerator and laundry

The laundry and incinerator were decommissioned in 2017. Savings come from invoices.

- Reduction of operating costs CZK/y 5.5 million.

5.2.2 Measures Planned by the City

Tab. 53 Measures planned for the municipal property

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
5. května Primary School - both buildings, window replacement, thermal insulation, retrofit of source, heating system and remote control & monitoring, ventilation with heat recovery	50,820	100.5	100.5	505,672
Sedmikráska Kindergarten - Vzdušná Street, thermal insulation, window replacement, heating remote control & monitoring, ventilation with heat recovery	13,068	11.2	11.2	1,170,269
Kindergarten Kláštení - Husova Streets, thermal insulation, window replacement, heating remote control & monitoring, ventilation with heat recovery	7,260	11.2	11.2	650,149
Kindergarten - Nad Přehradou Street – window replacement, heating remote control & monitoring, ventilation with heat recovery	7,260	11.2	11.2	650,149
Primary School – Orlí Street – complex thermal insulation, heating remote control &	17,424	57.6	57.6	302,686

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
monitoring, ventilation with heat recovery				
Primary School - Švermova Street – thermal insulation, ventilation with heat recovery, and new LED lighting	30,492	95.9	95.9	317,821
Primary School - U Soudu Street – kitchen insulation	7,260	28.8	28.8	252,239
ZOO – condensing boilers in Lidový dům and three pavilions (Elephant Pavilion, Tropic Pavilion and Workshop Pavilion)	3,252	23.3	23.3	139,696
ZOO – Elephant Pavilion insulation	7,986	27.9	27.9	286,066
ZOO - LED light fittings – Elephant Pavilion	653	8.4	8.4	77,922
Regional Hospital -– steam boiler and pipeline distribution replacement by hot water systems	58,080	849.8	849.8	68,345
Primary School - náměstí Míru – complex thermal insulation, heat source replacement	34,999	61.4	61.4	570,380
Primary School - náměstí Míru - ventilation with heat recovery	13,228	6.7	6.7	1,979,235
Botanic garden – boiler room retrofit	5,054	49.9	49.9	101,222
F. X. Šalda Small Theatre (Malé divadlo F. X. Šaldy) - thermal insulation, heating system retrofit, Integrated Room Control (IRC)	21,780	26.7	26.7	816,941
F. X. Šalda Small Theatre (Malé divadlo F. X. Šaldy) - thermal insulation, heating system retrofit, Integrated Room Control (IRC)	24,684	105.5	105.5	233,894
Primary School – Oblačná Street - window replacement and attic floor insulation, heating remote control & monitoring, ventilation with heat recovery	8,712	19.2	19.2	454,029
Beruška Kindergarten - Na Pískovně Street – complex thermal insulation, ventilation with heat recovery	74,052	38.4	38.4	1,929,625
Pastelka Kindergarten – building envelope insulation, heating remote control & monitoring, ventilation with heat recovery	58,080	15.8	15.8	3,665,552
Primary School – Husova Street – building envelope partial insulation (roof insulation made in 2016), ceiling above the basement insulation, heating remote control & monitoring, ventilation with heat recovery	43,560	76.8	76.8	567,537
Primary School - Křižanská Street, Heřmánkova Street – complex thermal insulation, LFO boiler replacement by a heat pump, heating remote control & monitoring, ventilation with heat recovery	24,793	32.3	32.3	768,598
Klubíčko Kindergarten – Jugoslávská Street – completion of window replacement, building envelope insulation, new heat source and controls, ventilation with heat recovery	8,712	11.2	11.2	780,179
Primary School - Česká Street – gymnasium	5,808	7.0	7.0	832,191

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
thermal insulation				
Swimming pool retrofit (solar panels, wastewater heat recovery, heat pump after the heat recovery unit	13,605	0.0	422.0	32,239
Total (for specific investments – average)	**540,622**	**1,676.4**	**2,098.4**	**257,635**

5. května Primary School

Windows and doors of the buildings of first school and lower secondary school are, with exceptions, in poor condition, significant energy losses occur, the impossibility of opening some windows make the hygienic conditions worse as the Regional Hygiene Station (KHS) points out in its inspection record in 2016. Altogether, more than 150 windows and 20 doors and door walls need replacement, the basement ceiling and attic floors require insulation. Another proposed measure includes heating system retrofit including heating source replacement, installing remote control & monitoring and ventilation with heat recovery in classrooms. Less exposed parts of the building of the Primary School will be insulated – in Šamánkova Str. B all windows and doors will be replaced by wooden windows of glued profiles.

- Expected costs for first school CZK 23.136 million
- Expected costs for lower secondary school CZK 24.684 million
- Operating costs savings CZK/y 661 thousand

5. května - Lower Secondary school – Masarykova Street

5. května - Primary School – Šamánkova Street

Sedmikráska Kindergarten – Vzdušná Street

This listed building is over a long term included in the plan of modernization consisting of the complete building retrofit. Replacement of windows and parts of roof trussing and roofing is essential for securing energy savings. At the same time, the facade retrofit and insulation of ceiling basement and attic floor as well as installation of heating remote control & monitoring and ventilation with heat recovery in classrooms are expected.

- Expected costs CZK 13.068 million, most of the costs will cover ineligible expense for retrofit of the roof, trussing, tinsmith´s products and facade.
- Operating costs savings CZK/y 73 thousand

Sedmikráska Kindergarten

Sedmikráska Kindergarten

Kindergarten Klášterní – Husova Streets

Measures planned for this building are the same as those for the previous buildings. Replacement of windows and parts of roof trussing and roofing is essential for securing energy savings. At the same time, the facade retrofit and insulation of ceiling basement and attic floor as well as installation of heating remote control & monitoring and ventilation with heat recovery in classrooms are expected.

- Expected costs CZK 7.26 million
- Operating costs savings CZK/y 73 thousand

Kindergarten Klášterní-Husova Streets

Kindergarten Klášterní-Husova Streets

Nad přehradou Kindergarten – Klášterní Street

Measures planned for this building are the same as those for the previous buildings. Completion of replacement of windows and parts of roof trussing and roofing is essential for securing energy savings. At the same time, the facade retrofit and insulation of ceiling basement and attic floor as well as installation of heating remote control & monitoring and ventilation with heat recovery in classrooms are expected.

- Expected costs CZK 7.26 million, most of the costs will be used as ineligible expense for retrofit of the roof, trussing, tinsmith´s products and facade
- Operating costs savings CZK/y 73 thousand

Nad přehradou Kindergarten

Primary School – Orlí Street

Complex building insulation is designed, i.e. insulation of the envelope and roof, replacement of windows and doors, remote heating control & monitoring, installation of ventilation with heat recovery in classrooms. Wiring and lighting will be replaced.

- Expected insulation costs CZK 17.424 million
- Costs savings CZK/y 359 thousand

Primary School – Orlí Street

Primary School – Orlí Street

Primary School – Švermova Street

Panel building insulation is designed, i.e. insulation of the envelope, roof, replacement of windows and doors, heating remote control & monitoring, installation of ventilation with heat recovery in classrooms. Further, wiring and lighting will be replaced by LED technologies.

- Expected insulation costs CZK 30.492 million
- Costs savings CZK/y 598 thousand

Primary School – Švermova Street – swimming pool

New building

Primary School - U Soudu Street – kitchen – 2020 - 2022

Complex building insulation is designed including window replacement.

- Expected insulation costs CZK 7.26 million
- Costs savings CZK/y 180 thousand

U Soudu - kitchen

Retrofit of boiler rooms – installation of condensing boilers in the ZOO (by 2020)

The retrofit encompasses four larger boiler rooms over 100 kW from the 1990s (in Lidový dům and three pavilions – Elephant Pavilion, Tropics Pavilion and Workshop Pavilion). Annual load factor of installed capacity was identified and necessary power of new boilers was derived. Energy savings were calculated from the difference between the efficiency of existing and new boilers. The costs of measures were determined using similar measures implemented – from specific investment per installed unit power.

- Measure costs CZK 3.252 million,
- Gas costs savings CZK/y 153 thousand

Complex insulation of the Elephant Pavilion (envelope, roof and replacement of windows), installation of ventilation with heat recovery, Integrated Room Control (by 2020)

The background data come from a study worked out in 2017, which quantified insulation costs. Comparing the specific indicator showed their slightly underestimation and, therefore, they were increased by 15%. The savings of 60% of current gas consumption for space heating were

determined using an expert estimate, before that an energy balance of individual ZOO pavilions had been compiled (based on measured data of the ZOO) by the SECAP authors.

- Costs of measures CZK 7.986 million
- Gas costs savings CZK/y 184 thousand

Replacement of light fittings by LED in the Elephant Pavilion (by 2020)

The background data are from a study worked out in 2017, which quantified costs of light fitting replacement. Electric energy consumption of individual pavilions is not measured. Electricity savings resulting from LED lighting installation constitutes the savings of 50% of the electricity consumption for lighting. Using the specific investment indicator per unit of energy saved, energy savings were determined.

- Costs of measure CZK 0.653 million
- Electricity costs savings CZK/y 38 thousand

Primary School - Náměstí Míru

The subject of a partial project of retrofit of a larger building involves construction alterations leading to improving thermal insulation properties of buildings – buildings of Primary School, náměstí Míru Nr.175 and 212 – facade insulation, original roof surface above a one-storey extension insulation, completion of replacement of windows and doors, wiring retrofit, heat source replacement.

- Energy savings were calculated to 1 099.2 GJ/y, i.e. 48% savings of existing energy costs
- Operating costs CZK/y 357 thousand
- CO_2 emission reduction 81.42 t/y
- Total expenditures CZK 35 million (project implementation 2018 – 2/2019).

Primary School - Náměstí Míru

Primary School - Náměstí Míru

The measure consists in installation of ventilation with heat recovery in classrooms.

- Costs of measure CZK 13.228 million
- Energy savings 119.7 GJ/y, i.e. 5.22% savings of existing energy costs
- Operating costs savings CZK/y 39 thousand
- CO_2 emission reduction 4.604 t/y.

Boiler room retrofit in the Botanic Garden – 2018

Boiler room retrofit in the Botanic Garden Liberec – replacement of atmospheric boilers by condensation ones including all other related equipment. In particular, it is the installation of gas boilers and connecting them to the existing control, water treatment plant, retrofit of internal gas lines including fittings and safety valves.

- Costs of measure CZK 5.054 million
- Natural gas savings calculated from gas consumption and change of old and new boiler efficiency to 894 GJ/y
- Annual costs reduction CZK/y 295 thousand

F. X. Šalda Small Theatre (Malé divadlo F. X. Šaldy)

Both buildings in Zhořelecká Street will be insulated (building envelope) including windows replacement, further the boiler room will be retrofitted (installation of condensation boilers), respectively heat exchanger station will be retrofitted, installation of Integrated Room Control (IRC), efficient lighting.

- Estimated costs are CZK 46.464 million
- Operating costs savings CZK/y 816 thousand

Small Theatre - hostel

Small Theatre – Administrative Building

Primary School - Husova Street

Windows were replaced in the building in the past (2003). In 2016, the attic floor was insulated. Partial building envelope and basement ceiling insulation is recommended as well as heating remote control & monitoring, installation of ventilation with heat recovery to classrooms.

- Expected measure costs CZK 43.56 million
- Operating costs savings CZK/y 222 thousand

5.2.3 Designed Measures

Tab. 54 Measures designed in the municipal property

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Primary School, Kaplického Street – building envelope and roof insulation, ventilation with heat recovery	11,616	0.0	28.8	403,582
Primary School - Sokolovská Street - building envelope and roof insulation, ventilation with heat recovery	24,684	0.0	115.1	214,403
Primary School – Barvířská Street – building envelope insulation and window replacement, heating system retrofit, heating remote control & monitoring, ventilation with heat recovery	23,232	0.0	105.5	220,135
Primary School – Ještědská Street – building envelope and flat roof insulation, ventilation with heat recovery, heating remote control & monitoring, ventilation with heat recovery	34,848	0.0	89.3	390,090
Rolnička Kindergarten – building envelope insulation, heating remote control & monitoring, ventilation with heat recovery n	4,356	0.0	10.1	433,433
Pohádka Kindergarten - Strakonická – building envelope and roof insulation, original window replacement, heating remote control & monitoring, ventilation with heat recovery	11,616	0.0	22.3	520,119
U Bertíka Kindergarten – Údolní Street – window replacement and attic floor insulation, heating remote control & monitoring, ventilation with heat recovery	4,356	0.0	8.4	520,119
Kindergarten - Pod Ještědem Street – building envelope insulation, heating remote control & monitoring, ventilation with heat recovery	3,630	0.0	22.0	165,179
Special Purpose House (Dům zvláštního určení) - Nad Sokolovnou and Česká Streets – building envelope insulation	14,520	0.0	86.3	168,159
ZOO – Giraffe Pavilion insulation	3,920	0.0	14.0	280,864
ZOO - LED light fittings in other pavilions	2,352	0.0	30.2	77,922
Regional Hospital – Pavilion A – building envelope insulation	34,848	0.0	173.7	200,625
Regional Hospital – thermal insulation of Pavilion B including window replacement	52,272	0.0	172.3	303,375
LED lighting in schools	16,006	0.0	221.8	72,150
Compulsory renovation of non-compliant sources not replaced in municipal buildings so far	24,684	0.0	189.8	130,030
Energy management implementation	960	971.4	971.4	988
EPC in municipal buildings – buildings with	4,409	0.0	65.3	67,511

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
natural gas				
EPC in municipal buildings – buildings with district heating	16,678	0.0	230.2	72,451
Total (for specific investments – average)	**288,987**	**971.4**	**2,556.6**	**113,037**

Primary School – Kaplického Street 2019-2021

Windows were replaced in the building in the past (2010). Insulation of building envelope and flat roof, installation of ventilation with heat recovery to classrooms are recommended.

- Expected measure costs CZK 11.616 million
- Operating costs savings CZK/y 83 thousand

Primary School – Kaplického Street

Primary School - Sokolovská Street – 2020-2022

Windows were replaced in the building in the past (2012). Insulation of building envelope and flat roof, installation of ventilation with heat recovery to classrooms are recommended.

- Expected measure costs CZK 24.684 million
- Operating costs savings CZK/y 333 thousand

Primary School – Sokolovská Street

Primary School - Barvířská Street 2020 - 2022

The recommended actions are insulation of building envelope, replacement of original, not yet replaced, windows, heating remote control & monitoring and installation of ventilation with heat recovery to classrooms. Retrofit of heating system and lighting belong also to commended actions.

- Expected measure costs CZK 23.232 million
- Operating costs savings CZK/y 658 thousand

Primary School – Barvířská Street

Primary School - Barvířská Street

Primary School – Ještědská Street

Insulation of building envelope including replacement of windows and flat roof, installation of ventilation with heat recovery in classrooms are recommended.

- Expected measure costs CZK 34.848 million
- Operating costs savings CZK/y 519 thousand

Primary School – Ještědská Street

Primary School – Ještědská Street

Rolnička Kindergarten

Insulation of building envelope, heating remote control & monitoring, installation of ventilation with heat recovery in classrooms are recommended.

- Expected measure costs CZK 4.356 million
- Operating costs savings CZK/y 66 thousand

Pohádka Kindergarten – Strakonická Street

Insulation of building envelope including replacement of the remaining not replaced windows and flat roof, heating remote control & monitoring, installation of ventilation with heat recovery in classrooms are recommended.

- Expected measure costs CZK 11.616 million
- Operating costs savings CZK/y 130 thousand

Pohádka Kindergarten – Strakonická Street

Pohádka Kindergarten – Strakonická Street

U Bertíka Kindergarten – Údolní Street

Insulation of attic floor, replacement of windows and basement ceiling, heating remote control & monitoring, installation of ventilation with heat recovery in classrooms are recommended.

- Expected measure costs CZK 4.356 million
- Operating costs savings CZK/y 49 thousand

U Bertíka Kindergarten – Údolní Street

Pod Ještědem Kindergarten

Insulation of building envelope, heating remote control & monitoring, installation of ventilation with heat recovery in classrooms are recommended.

- Expected measure costs CZK 3.63 million
- Operating costs savings CZK/y 98 thousand

Special Purpose House (Dům zvláštního určení) – Nad Sokolovnou and Česká Streets

Insulation of building envelope and flat roof is recommended.

- Expected measure costs CZK 14.52 million
- Operating costs savings CZK/y 539 thousand

Nad Sokolovnou Street

Česká Street

Complex Insulation of Giraffe Pavilion (in 2020-2030)

Costs were derived using specific indicator for building space from the measure for the Elephant Pavilion, the savings were determined by means of expert estimate from the actual energy consumption for space heating.

- Measure costs CZK 3.92 million
- Gas costs savings CZK/y 92 thousand

Replacement of Light fittings for LED in Other ZOO Pavilions (by 2030)

An expert estimate was used to find share of electricity consumption in the total electricity consumption, estimate of savings is 50% of the consumption affected. Implementation costs were determined using specific indicator identified from projects implemented (e.g. EPC projects).

- Measure costs CZK 2.352 million
- EE costs savings CZK/y 135 thousand

Insulation of Building Envelope of Regional Hospital Pavilion A

The data came from energy audit recommendation.

- Measure costs CZK 34.85 million
- costs savings CZK/y 1,014 thousand

Insulation of Building Envelope and Replacement of Windows of Regional Hospital Pavilion B

The data are from energy audit recommendation.

- Measure costs CZK 52.27 million
- costs savings CZK/y 1,006 thousand

Pavilion A

Pavilion B

Replacement of Light Fittings by LED in Schools (by 2030)

By expert estimate, the share of electricity consumption for lighting of the total electricity consumption of all municipal schools was determined to 30% and savings of 40% of the consumption affected were estimated. Implementation costs were determined using specific indicator identified from projects implemented (e.g. EPC projects).

- Measure costs CZK 16 million
- EE costs savings CZK/y 1,470 thousand

Compulsory renovation of non-compliant sources not replaced in municipal buildings so far

The measure comprises gradual replacement of hot-water atmospheric natural gas-fired boilers by condensation boilers, which achieve seasonal energy efficiency even over 100%. Since 26 September 2015, it has been not possible to sell gas boilers with seasonal efficiency lower than 86%. This obligation follows from Commission Regulation No.813/2013 and in fact, merely condensing boilers meet it.

Considering existing atmospheric boiler energy efficiency 85% and condensing boiler energy efficiency 95%, the efficiency of heat production from natural gas will thus increase by 10 percentage points.

- Measure costs CZK 24.684 million
- NG costs savings CZK/y 1,103 million.

Energy Management Introduction in Municipal Buildings and Equipment/Facilities

The subject of the measure is to introduce energy management and measures essential for reducing energy intensity. Successive activities should result in working energy management system in all buildings owned by the applicant, complying with requirements of ISO 50001 Standard. The purpose of the measure is particularly the development of documents, organization (definition of processes, responsibilities, information flow, etc.), preparation of systems for energy consumption monitoring and evaluation.

We consider the energy management introduction to be a key measure for the follow-up monitoring of benefits resulting from measures implemented under SECAP.

As part of energy management introduction, it is highly desirable to establish Energy Engineer job in the Municipal Authority of the City of Liberec who will care about proper

energy management and coordinate investments to increase energy efficiency and use of potential for local renewable energy sources.

Activities expected within this measure can be of various scope, for SECAP implementation and monitoring, we consider at least the following ones as appropriate:

- **Establishing municipal Energy Engineer job**
- Collecting data on fuel and energy consumption and costs in one central place, preparing a suitable system linked with other data on buildings
- Implementing a monitoring and targeted energy consumption management system
- Monitoring consumption fluctuations, analysing climate-dependent consumption factors, evaluating fuel and energy savings achieved, particularly in the buildings with investments to energy efficiency
- Identifying other appropriate measures to reduce consumption
- Selecting buildings appropriate to be funded through Operational Programmes, the buildings should utilize potential for savings in line with Programme conditions and criteria for evaluation of applications
- System identification of buildings suitable for RES use
- Ensuring the integration of energy efficiency into designing and planning of all processes, buildings and equipment/facilities
- Providing expert energy trainings to meet identified skills needs
- Leading promotional and advertising campaign
- Monitoring and evaluating the implementation of recommended audits and their updating
- Ensuring continuous meeting of legal requirements for municipal buildings and thermal equipment arising from Act 458/2000 Coll. as amended.

Measure implementation date: as soon as possible, the subsidy application can be submitted to EFEKT Programme, Subprogramme 2, Activity 2D. The nearest term for application submission will be 12/2018. Introduction costs – SW and initial data collection – make approx. CZK 0.96 million. The amount of the subsidy is limited to CZK 0.5 million and the amount of the support to 70% of eligible costs.

The benefits of this measure are often quantified at approx. 3% of annual energy costs. Energy management can often make an Energy Engineer wage, the City of Litoměřice can serve as an example.

EPC in Municipal Buildings

The EPC Projects aim at reducing operating, especially energy costs in buildings (and technological units). Investment as well as non-investment measures are used to achieve fuel and energy savings. The services provided and investment made are gradually repaid (completely or especially) from energy incl. water cost savings, resulting from investment. A specialized Energy Service Company (ESCO) designs and implements an Energy Efficiency Project in buildings and equipment/facilities of a customer (the customer can assign partial measures). The project can include all areas of energy consumption – space heating including heat production and distribution, hot water preparation, cooling, ventilation, lighting, water consumption, etc.

ESCO (Energy Performance Contracting provider) guarantees achieving energy savings – this is contractually anchored along with the compulsory compensation, which ESCO provides in case of failing to achieve the savings. The savings (of fuel, energy, water…) are evaluated by ESCO

for the entire duration of the contract, ESCO reports savings evaluation for the “billing period” (adhering to IPMVP – International Performance Measurement & Verification Protocol), which is usually 1 year.

Currently, it is possible to combine EPC with a subsidy from Operational Programme Environment (OPE). The subsidy is eligible not only for building insulation but also for all measures relating to technical building equipment and RES use under the EPC project. Moreover, the OPE subsidy is 5% higher.

Programme EFEKT (Programme of the Ministry of Trade and Industry) can provide subsidy for analysing the suitability of buildings for energy efficiency projects under EPC.

An Energy Efficiency Project under EPC was applied to 7 primary schools owned by the Assets Management of Líšeň, namely Dobiášova Primary School, Jabloňová Primary School, Ještědská Primary School, Kaplického Primary School, Sokolovská Primary School, Švermova Primary School and Na Pískovně Kindergarten. The period of guaranteed savings terminates in 2019.

The subject of the action is to analyse municipal buildings, namely the previously insulated school buildings (A. Výšina Primary School, Vrchlického Primary School, and Lesní Primary School). Other candidates are buildings intended to apply for OPE (Orlí Primary School, Mírové náměstí Primary School) or other buildings, e.g. Barvířská Primary School (PS), Oblačná PS, Husova PS, Na Výběžku PS, U Školy PS, Frýdlantská Primary Art School or buildings of Jablůňka, Klíček, Kytička, Sluníčko, Stromovka, Delfínek, Malínek Kindergartens.

The subsidy will serve for a detailed analysis of the condition and potential for savings in individual buildings and/or public lighting. The analysis will specify expected amount of investment funds for the installation of proposed measures, estimate their influence on energy consumption and recommend whether the buildings and/or public lighting are suitable for EPC implementation.

The developed analysis shall contain the following information for each building included in the survey:

- Design of appropriate energy efficiency measures;
- Estimate of the amount of investment expenditures for energy efficiency measure implementation (in case energy efficiency measures will be designed);
- Estimate of potential for energy savings (in case energy efficiency measures will be designed);
- Recommendation whether the building is suitable for including in the EPC project.

If the analysis demonstrates the suitability of EPC implementation, the subsidy beneficiary will issue an invitation to tender for providing energy services with guaranteed savings using the EPC methodology.

Period of the measure implementation: 2018 – 2019

Costs of the measure preparation:

- Analysis development CZK 400 thousand
- Tender procedure CZK 500 thousand

Costs of the measure implementation:

- For buildings connected to district heating system:
    - Measure costs CZK 16,7 million

- Heat costs savings CZK/y 1 436 thousand

- For natural gas-heated buildings:
  - Measure costs CZK 4,4 million
  - Natural gas costs savings CZK/y 380 thousand

5.3 Energy Efficiency Measures in Housing Stock

5.3.1 Implemented Measures (after 2015)

Tab. 55 Measures implemented in households after 2015

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Subsidies for solid fuel boiler replacement - 2016	23 615	268,7	268,7	87 902
Subsidies for solid fuel boiler replacement - after 2016	38 089	536,9	536,9	70 948
Total (for specific investments – average)	**61 704**	**805,5**	**805,5**	**76 603**

Subsidies for solid fuel replacement were implemented under the Operational Programme Environment, Specific Objective 2.1. The allocation of funding resources has not been exhausted yet, the receipt of applications continues until the end of 2018. Expected number of supported projects in 2018 is included already in the previous line after 2016.

5.3.2 Measures Designed

Tab. 56 Measures designed in households

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Thermal insulation of residential buildings	4 533 354	1 389,2	27 783,5	163 167
Thermal insulation of family houses	1 680 192	765,9	15 317,9	109 688
Excluding remaining coal boilers from households	450 000	317,3	6 346,1	70 909
Old gas boilers replacement in households	240 000	72,0	2 398,5	100 061
Light fitting replacement by LED in households	13 000	173,3	3 465,5	3 751
Replacement of domestic electrical appliances	85 000	64,9	1 298,0	65 483
Convection heater replacement by heat pumps	56 000	0,0	1 913,9	29 260
Total (for specific investments – average)	**7 057 546**	**2 782,5**	**58 523,5**	**120 593**

5.3.2.1 Specific Measures Designed

Thermal Insulation of Residential Buildings

Thermal insulation of residential buildings includes measures improving operational efficiency of the heating system of the house (thermostatic valves, balancing of the system) and measures

improving thermal resistance of the main building structures (building envelope insulation, windows and doors replacement).

- Energy savings: 83,951 MWh/y (the structure of saved energy carriers is considered the same as the final consumption structure for space heating in 2015)
- Investment costs: CZK 4,53 billion

Activities of the City in this area include:

- Maximum simplification of permitting procedures
- Promotion and awareness raising
- Providing consultancy.

Thermal Insulation of Family Houses

Thermal insulation of family houses includes measures improving operational efficiency of the heating system of the house (thermostatic valves, balancing of the system) and measures improving thermal resistance of the main building structures (building envelope insulation, windows and doors replacement).

- Energy savings: 46,672 MWh/y (the structure of saved energy carriers is considered the same as the final consumption structure for space heating in 2015)
- Investment costs: CZK 1,68 billion

Activities of the City in this area include:

- Maximum simplification of permitting procedures
- Promotion and awareness raising
- Providing consultancy.

Eliminating Remaining Coal Boilers from Households

Eliminating all lignite and bituminous coal-fired boilers and their replacement by gas boilers, heat pumps and biomass boilers. Gas boilers will replace coal boilers in 40% of cases. In locations where gas pipelines are not available, installing heat pumps (in 20% of cases) and biomass boilers (in 40% of cases) comes into consideration.

- Lignite saving: 38,084 MWh/y
- Bituminous coal saving: 12 MWh/y
- Increase in natural gas consumption: 8,206 MWh/y
- Increase in electricity consumption: 1,114 MWh/y
- Increase in biofuel consumption: 10,394 MWh/y
- Investment costs: CZK 450 million.

Activities of the City in this area include:

- Use of the authority to inspect boilers in terms of emissions
- Promotion and awareness raising
- Providing consultancy.

Replacement of Old Gas Boilers in Households

Natural gas consumption in households in 2015 is 197,414 MWh. Deduction of family and residential building insulation leads to the estimate of NG consumption of 161,949 MWh in 2030. The measure applies to the replacement of 70% gas boilers with the consumption of 96 360 MWh and 85% efficiency with condensing gas boilers with 95% efficiency. Energy savings after the complex measure implementation will achieve 11,933 MWh/y. The measure does not apply to newly installed boilers in „subsidies for solid fuel boiler replacement".

- NG savings: 11,933 MWh/y
- Investment costs: CZK 240 million.

Activities of the City in this area include:

- Use of the authority to inspect boilers in terms of emissions
- Promotion and awareness raising
- Providing consultancy.

Replacement of Lighting by LED in Households

The subject of the measure is the gradual replacement of conventional light bulbs and compact fluorescent lamps in households by LED light sources. When replacing a conventional light bulb, electric energy consumption will fall approx. by 80% and when replacing compact fluorescent lamp, the consumption will fall roughly by a half. We assume the share of electricity consumed in lighting 10% of the total electric energy consumption and the share of already replaced light sources 40%.

- Electricity savings: 5,740 MWh/y
- Investment costs: CZK 13 million

Activities of the City in this area include:

- Promotion and awareness raising
- Providing consultancy.

Replacement of Domestic Electrical Appliances

The measure constitutes a partial replacement of domestic electrical appliances by new ones of higher efficiency. We assume that the share of domestic electrical appliances electricity consumption is 30% and that the replacement will save 5% of this consumption.

- Electricity savings: 2,150 MWh/y
- Investment costs: CZK 85 million.

Activities of the City in this area include:

- Promotion and awareness raising
- Providing consultancy.

Replacement of Convection Heaters by Heat Pumps in Households

Based on tariff statistics, electricity consumption for convection heating in 2016 was approx. 43.4 GWh. We assume the 10% convection heater replacement by heat pumps with the heating factor 3.5.

- Electricity savings: 3,170 MWh/y

- Investment costs: CZK 56 million

Activities of the City in this area include:

- Promotion and awareness raising
- Providing consultancy.

5.3.2.2 General comments on the overall potential for energy savings in housing stock

Energy efficiency measures implemented in the housing stock in recent years include especially:

- Retrofit of the existing panel housing stock by thermal insulation, windows replacement, or other energy efficiency measures. Completion of implementation of these measures as well as total retrofit of residential buildings are expected. This type of a measure is advantageous to implement using the loan of the Czech Savings Bank (ČS, a. s.). The Integrated Regional Operating Programme (IROP) also envisages the allocation of funding resources for residential building thermal insulation projects.
- Achievement of significant savings by retrofit of the old housing stock in brick houses requires higher costs than in panel buildings. This type of a measure is advantageous to implement using the loan of ČS, a. s. The 2014+ IROP also envisages the allocation of funding resources for residential building thermal insulation projects.
- Existing subsidy title for energy efficiency measures, which is aimed particularly at the area of CO_2 emission reduction – New Green Savings Programme (NZÚ) can initiate interest in thermal insulation of family houses and RES use in family houses
- Retrofit of heat sources, insulation and retrofit of heating systems, building exchange stations, technical equipment. These measures suitably complement thermal insulation and windows replacement.
- Support of new residential construction for target groups of population (retired, people in need, youth leaving Children´s Homes, socially weaker young families, adult children becoming independent) in low-energy standard.
- Awareness and knowledge of opportunities in measure implementation and their financing – a consulting centre or information database available on the City website.

5.3.2.2.1. Calculation of energy savings potential in residential sector

The energy savings potential in the residential sector was determined for 2030, separately for apartments in family houses and apartments in residential buildings. The energy savings potential calculation stems from specific consumption of the existing housing stock (depending on the construction period) and on expert estimation of the share of already insulated buildings, i.e. the shares of buildings in the original condition and buildings already retrofitted (identified during building inspections).

The first column of the following Table shows the specific energy consumption for space heating in various construction periods, derived from valid standards and empirical studies. The second column displays the specific consumption achieved after implementation of energy efficiency measures until 2015 (with respect to the valid legislation, or more precisely, to standard requirements for the thermal protection of buildings). The last column presents the specific consumption to achieve after implementing energy efficiency measures from 2015 to 2030.

Tab. 57 Energy performance of buildings according to period of construction considering implemented retrofits

PERIOD OF CONSTRUCTION		Specific energy consumption – existing housing stock [kWh/m^2. year]		
		Original in the period of construction	After measures 2015	After measures 2030
Family houses	< 1920	250	145	90
	< 1970	280	145	90
	1971 – 1980	220	130	90
	1981 – 2000	170	100	80
	2001 – 2011	130	95	80
Residential and other buildings	< 1920	170	135	110
	< 1970	170	130	60
	1971 – 1980	170	80	40
	1981 – 2000	160	80	40
	2001 – 2011	110	80	60

Source: ENVIROS, s.r.o.

The potential was calculated from the difference in specific consumptions for space heating of existing buildings and new standard requirements for the thermal protection of buildings. Calculated heat consumption for space heating in 2015 corresponds to energy consumption for space heating data (assumption 60 – 70% of the total consumption) in households.

The potential calculation for 2030 comes from the assumption that buildings retrofits will meet the requirements of 730540-2:2011 CSN Standard and the legislative requirements for energy performance of buildings. According to the current legislation, as of 2021 building retrofits will require achieving cost-optimal specific indicator level, which complies with the requirement of 730540-2:2011 CSN Standard and legislative requirements for energy performance of buildings pursuant to Act 406/2000 Coll. as amended. We assume that in 2030 the buildings retrofits will have to meet the recommendation of 730540-2:2011 CSN Standard and the legislative requirements for energy performance of buildings. The specific indicators used for the reference area then correspond to these values. Apart from the specific indicators, the calculation of energy savings potential took into consideration assumed proportion of retrofitted buildings (classified by the construction period).

Tab. 58 Proportion of apartments with specific indicator value achieved using energy efficiency measures as shown in the following Table

PERIOD OF CONSTRUCTION		Number of apartments	Proportion of insulated apartments		
			Original in the period of construction	In 2015 compared to the year of construction	In 2030 compared to 2015,ie.of the remaining not insulated
Family houses	< 1920	2 327	0	5%	25%
	< 1970	3 190	0	20%	50%
	1971 – 1980	1 034	0	60%	50%
	1981 – 2000	2 160	0	30%	50%
	2001 – 2011	1 509	0	0%	50%
Residential and other buildings	< 1920	3 869	0	20%	40%
	< 1970	8 087	0	50%	50%
	1971 – 1980	8 383	0	50%	25%
	1981 – 2000	8 525	0	50%	25%
	2001 – 2011	2 076	0	0%	25%

Source: ENVIROS, s.r.o.

We see the potential for energy savings especially in the consumption of heat, fuels and energy for space heating, which accounts for in average 60-70% of the total fuel and energy consumption in buildings. The following Table shows efficiency measures for space heating in buildings and their typical benefits.

Tab. 59 Energy efficient measures in buildings of residential sector

Measure	% of savings	Note
Replacement of windows and entrance doors	20%	Depending on the windows type, savings correspond to the replacement of 20 year old windows (U= 2.9 W/m^{2}K), and those in worse condition, by new windows with the total value of U=1.2 W/m^{2}K; replacement of windows by those with even better parameters is possible, and will result in further savings. However, it is advisable to optimize the efficiency measures.
Building thermal insulation - envelope	30%	Savings percentage corresponds to comparing the building with the perimeter walls of THK 35 cm after insulation of THK 15 cm, insulation of higher THK will bring additional savings depending greatly on the work done and ground stripping and thermal bridges solution.
Building insulation - roof, floor, foundations, plinths, etc.	10 – 20%	Roof insulation can be difficult to carry out but brings effect also in summer as protection against overheating (THK 35 cm); insulation of foundations and ground floor contributes greatly to improving thermal comfort.
Heating control system	5 – 10%	Significant savings can be achieved by efficient heating control system and installation of energy efficient equipment, fittings, control valves, insulation of pipelines and fittings in unheated areas, etc.
Ventilation with heat recovery	5%	Energy savings in forced ventilation are dependent on recovery efficiency (about 75% of heat in the exhaust air is used for the intake ventilation air preheating; unlike natural ventilation when this heat is dissipated without use).
Solar heating with heat storage	10%	It represents heat saving for water heating when 60% of its demand covers the solar system. In case of using it for additional heating, the saving will increase by approx. a half (12%).
Total	40 – 50%	Savings proportion (%) achieved by partial measures cannot be added up directly, the proportion is always recalculated after deducting the saving achieved by the previous measure.

Source: ENVIROS, s.r.o.

5.3.2.2.2. Measures used to quantify potential for energy savings in housing stock

Measures improving operational efficiency of heating system of a building

Installation of thermostatic valves wherever the technical design of heating system allows it, can significantly enough increase heating operational efficiency. The valves will limit overheating of individual rooms and allow using both internal end external heat gains, e.g. in case of the facade exposition to insolation. Essential part of the installation is heating system adjustment, especially after additional building envelope insulation. Installing differential pressure controllers in larger heating systems and removing dirt from pipelines strengthens the proper function of the valves. A prerequisite for reduced heat consumption in residential buildings is a sufficient economic incentive of apartment users to energy saving behaviour.

Measures improving thermal resistance of main building structures

Additional roof insulation (residential buildings) or attic floor (family houses, residential buildings). The measures solve insufficient thermal insulation properties of the roof structures and allow remove defects caused by water leakage in flat roofs.

Additional building envelope insulation. A number of technologies suitable for each type of residential building is developed and offered. The additional insulation of the building facade can

increase the thermal resistance of the wall structure to the level recommended by 730540 CSN Standard.

Measures reducing windows and doors thermal losses

Sealing windows and doors. Sealing window and door joints by neoprene seals inserted in grooves milled in a window frame will significantly reduce heat losses due to infiltration, especially in buildings exposed to strong winds. Sealing is applicable in already replaced but leaking windows.

Windows overhaul with special glass installation. If the windows condition does not require their replacing by new ones and their construction does not allow an additional glazing, replacement of inner glass by special glass with reflective coating is possible. The windows overhaul is an acceptable measure for listed buildings.

Windows replacement by plastic ones with increased insulation capacity. If the windows condition requires their replacement by new ones, the recommendation is to use windows of the highest quality. Possible restriction may follow from the protection of ancient buildings.

Gasification of heating systems using solid fuels

Substantially higher operational efficiency of the building heating system, better controllability allowing reduction of gas and electric energy consumption while maintaining a comparable thermal comfort and utilization of inner heat gains and building insolation are the sources of savings after solid fuel replacement. Investment to a more advanced heating system usually brings improving thermal and technical properties of the heated building resulting from the sufficient envelope and roof insulation or additional window sealing.

Retrofit of heating systems and boilers

Older gas boilers with obsolete design have no possibility to modulate their output continuously (automated adaptation to current heat demand of a building or a user) and their overall control cannot respond flexibly to potential changes. A non-insignificant amount of heat produced escapes through a chimney or to the outer space. Advanced low-temperature gas boilers achieve an average operation efficiency round 92%, gas boilers running in condensing mode, i.e. boilers that are moreover capable to utilize energy from steam produced by combustion of gas, have the efficiency above 98% and more, an average annual efficiency is about 96%. Similarly, it applies also to solid fuel boilers that advanced boilers are more efficient, more convenient to operate, or we recommend – especially in new buildings – coal and chiefly firewood gasification boilers with low air emissions. In new buildings, we also recommend pellet boilers.

Renewable sources

It is possible to achieve another savings in hot water consumption – e.g. through installation of solar thermal or PV panels, in cooking, washing, other activities around the house and apartment through replacement of appliances and technologies, retrofit of cooling and air conditioning equipment, etc.

Installation of heat pump

It is a measure suitable especially for family houses after thermal insulation using support under the New Green Savings Programme.

5.3.2.2.3. Quantification of the total saving potential in housing stock

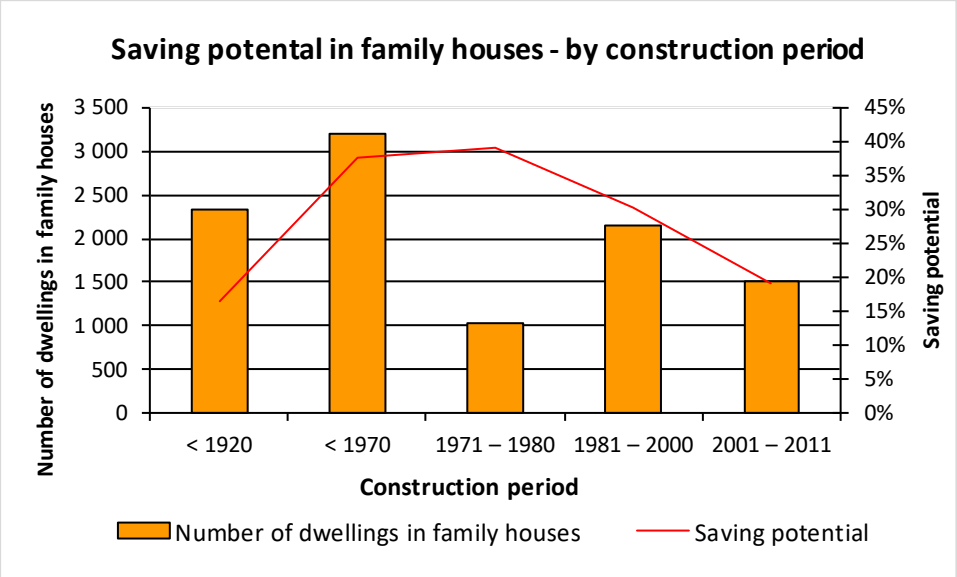
To express the energy savings potential in the housing stock, we created a model that takes account of existing housing stock data (SLBD2011). The data obtained during the local survey in selected localities served for creating factors, which reflect energy savings resulting from already implemented measures.

We estimated the savings potential in 2025 and 2035 using type of existing building stock, assumptions concerning the quantity of buildings retrofitted, construction period, quantity of measures already implemented in the given locality, etc. We used knowledge of energy savings typically achieved to express the energy savings potential in heating in the residential sector. These savings result from the comparison of energy consumption values measured before and after the implementation of measures leading to energy savings in heating, results gained from energy audits and from commonly reported data for the Czech Republic.

Savings potential calculation also reflected that many of the houses are listed buildings that cannot be insulated in the conventional way as other buildings can.

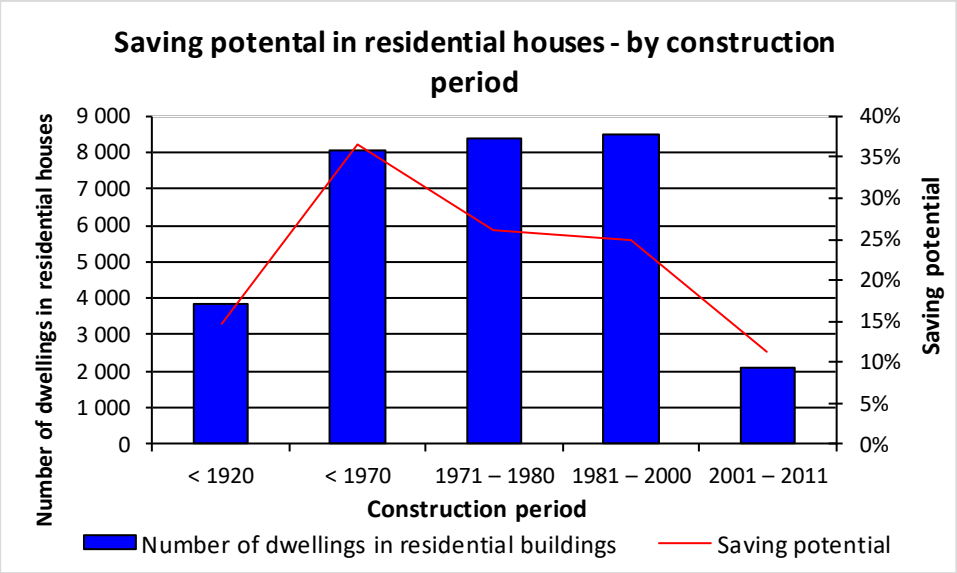
After including individual input data and taking account of other factors (as mentioned above), the energy savings potential for family and residential buildings was calculated. The following charts show the number of apartments built during individual construction periods in the 20th century as well as the savings potential achieved.

Fig. 13 Expected potential for energy savings in heating (apartments in family houses)



Source ENVIROS, s.r.o.

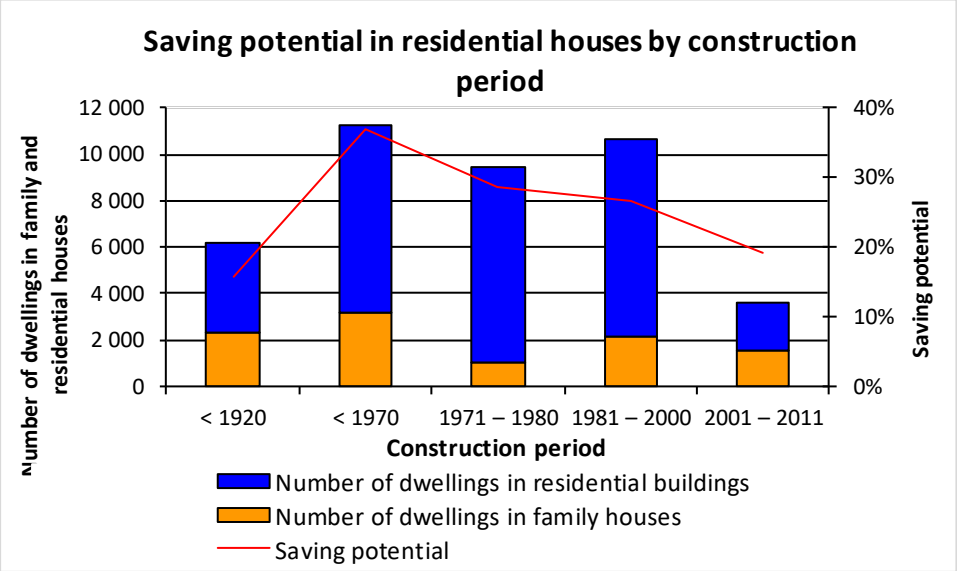
Fig. 14 Expected potential for energy savings in heating (apartments in residential buildings)



Source: ENVIROS, s.r.o.

The expected energy savings in space heating stems from the current retrofit rate of existing buildings and typical parameters of commonly implemented measures in buildings and their technical equipment. The achieved energy savings in heating are expressed separately for family and residential buildings.

Fig. 15 Expected potential for energy savings in heating (apartments in family houses and residential buildings)



Source: ENVIROS, s.r.o.

5.4 Measures in tertiary sector (non municipal)

5.4.1 Measures planned

Tab. 60 Planned measures in tertiary sector

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Regional Science Library – lighting retrofit	2,425	33.6	33.6	72,150
Regional Office - lighting retrofit	10,972	152.1	152.1	72,150
Grammar School – Jeronýmova Street – windows replacement	21,780	44.3	44.3	492,173
Centre for Intervention and Psychosocial Services of the Liberec Region – complex thermal insulation	5,808	19.1	19.1	303,293
Regional Office – building of the Research Institute of Engineering Machines) – complex thermal insulation	36,300	157.3	157.3	230,706
APOSS Liberec - Zeyerova Street – complex thermal insulation	4,356	8.5	8.5	511,955
Secondary School of Gastronomy and Services	36,300	122.8	122.8	295,592
Total (for specific investments – average)	**117,941**	**537.7**	**537.7**	**219,329**

5.4.2 Measures designed

Apart from the municipal property, the following measures were designed:

Tab. 61 Measures designed in tertiary sector

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Improvement of energy efficiency of natural gas fired boilers in other tertiary sector	130,000	120.0	2,400.9	54,145
Eliminating remaining coal fired boilers from the tertiary sector	2,000	22.4	447.6	4,469
Replacement of lights by LED lighting in the tertiary sector	20,000	154.4	5,148.1	3,885
Regional Office – cooling refurbishment	9,396	0.0	169.0	55,582
Replacement of electrical appliances	23,000	0.0	428.7	53,656
Replacement of convection heaters by heat pumps	5,500	0.0	236.3	23,273
Uran building - complex thermal insulation – building envelope and roof including windows	65,340	0.0	67.0	975,224
In total (for specific investments – average)	**255,236**	**296.9**	**8,897.6**	**28,686**

Improving natural gas boiler efficiency in other tertiary sector

The measure consists of the gradual replacement of hot-water atmospheric natural gas boilers by condensing boilers, which achieve seasonal energy efficiency even over 100%. Since 26 September 2015, it has not been possible to sell gas boilers with seasonal energy efficiency of less than 86%. This obligation follows from Commission Regulation No. 813/2013 and it is practically met only by condensing boilers.

Considering energy efficiency of existing atmospheric boilers 85% and energy efficiency of condensing boilers 95%, the efficiency of heat production from natural gas will thus increase by 10 percentage points. However, not all boilers in other tertiary sector will be replaced. Boilers built in the period 2010 – 2015 due to the switch from district heating to natural gas, that account for 30% of all boilers in the tertiary sector, will not be replaced by 2030.

- Natural gas savings: 11 945 MWh/y
- Investment costs: CZK 130 million

Activities of the City in this area include:

- Use of the authority to inspect boilers in terms of emissions
- Promotion and awareness raising
- Providing consultancy.

Eliminating remaining coal boilers from tertiary sector

Excluding all lignite and bituminous coal-fired boilers and their replacement by gas boilers, heat pumps and biomass boilers. Gas boilers will replace coal boilers in 40% of cases. In locations where gas connections are not available, installation of heat pumps (in 20% of cases) and biomass boilers (in 40% of cases) comes into consideration.

- Lignite saving: 1,635 MWh/y
- Bituminous coal saving: 12 MWh/y
- Increase in NG consumption: 482 MWh/y
- Increase in EE consumption: 65 MWh/y
- Increase in biofuel consumption: 610 MWh/y
- Investment costs: CZK 2 million

Activities of the City in this area include:

- Use of the authority to inspect boilers in terms of emissions
- Promotion and awareness raising
- Providing consultancy.

Replacement of lighting by LED in tertiary sector

The subject of the measure is the gradual replacement of conventional light bulbs and compact fluorescent lamps in the tertiary sector by LED light sources. Replacing conventional light bulbs will reduce electricity consumption by approx. 80% and replacing compact fluorescent lamps will reduce the consumption roughly by a half. We assume the share of electricity consumed for lighting 20% of the total electric energy consumption and the share of already replaced light sources about 20%.

- Electricity savings: 8 527 MWh/y

- Investment costs: CZK 20 million.

Activities of the City in this area include:

- Promotion and awareness raising
- Providing consultancy.

Retrofit of cooling in the Regional Office building

The Regional Office building uses the compressor cooling system. Its assumed cooling factor is approx. 3.5. The sizing of the installed cooling capacity depends on the course of thermal load from sunlight in March – September (the influence of heat transfer due to higher summer temperatures is negligible).

The intensity of solar radiation on the south-oriented vertical surface in the Czech Republic is 1.4 x higher in June than in March. The maximum thermal load and thus the maximum cooling capacity are calculated as cool production divided by 7 months, multiplied by 1.2 (an average load is 1.2 x lower in March and 1.2 x higher in June) and divided by 12 h/d and 30 days in a month.

According to the YORK Company, the lowest operational temperature of heating water is 75 °C. At this temperature, we can consider a single-stage absorption chiller with the cooling factor of about 0.7.

As heat for the absorption chiller operation would be a ballast from the supplier´s (TERMIZO, a. s.) point of view, the installation of a two-stage chiller with the cooling factor of about 1.3, however significantly more investment demanding, is not the option.

Specific investment costs of the absorption chiller installation including cooling towers and accessories make approx. 11,500 CZK/kW of cooling capacity.

Summer heat supply is supposed to be approx. 4 months, i.e. 122 days and about 12 hours/day, in total 1,464 h/y. The total cold production by existing compressor chiller takes 2,562 h/y. The cold production by absorption chiller thus will be 1,464/2,562 against the existing chiller production.

Reduction of electric energy consumption of the existing compressor chiller is expressed as cold production in the absorption chiller divided by 3.5. The expected electric energy price (payment for reserved power not included) is approx. 1,700 CZK/MWh.

Electric energy consumption for cooling:	490 MWh/y
Cold production by compressor chiller:	1,715 MWh/y
Maximum cooling capacity of absorption chiller:	0.817 MW
Investment costs:	CZK 9,396 thousand
Cold production by absorption chiller:	980 MWh/y
Heat consumption of absorption chiller:	1,400 MWh/y
Reduction of electricity consumption of compressor chiller:	280 MWh/y
Electricity cost savings:	476 thousand CZK/y
Simple payback period:	19.7 y

Since heat used for the absorption chiller would be normally wasted, we can use all savings of electric energy for compressor chiller for the calculation of CO_2 emission reduction that achieves 169.1 t/y.

Activities of the City in this area comprise:

- Including the obligation to assess the possibility of using heat from district heating system for air conditioning into the local regulations
- Promotion and awareness raising
- Providing consultancy

Replacement of electric appliances in tertiary sector

The measure consists of a partial replacement of electric appliances by new, more efficient ones. We assume that the share of electricity consumption for electric appliances in the tertiary sector is about 10% and that savings may achieve 5% of this consumption.

- Electricity savings: 710 MWh/y
- Investment costs: CZK 23 million.

Activities of the City in this area include:

- Promotion and awareness raising
- Providing consultancy.

Replacement of convection heaters by heat pumps in tertiary sector

Based on the statistics, energy consumption for convection heating in the C45D tariff rate was about 13.7 GWh in 2016. We assume that approx. 40% of this consumption, i.e. 5.48 GWh, serves for convection heating. We suppose the replacement of 10% of convection heaters by heat pumps with expected heat factor of 3.5.

- Electricity savings: 391 MWh/y
- Investment costs: CZK 5.5 million.

Activities of the City in this area include:

- Promotion and awareness raising
- Providing consultancy.

Uran

It is a building with asbestos insulation, its future is not quite clear. Insulation of building envelope including replacement of windows and flat roof are recommended.

- Expected measure costs CZK 54,45 million
- Operation costs savings CZK/y 390 thousand

Uran

5.5 Measures in public lighting

5.5.1 Planned measures

Tab. 62 Measures planned in public lighting

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Retrofit of public lighting in Dr. Milady Horákové, Dělnická, Havlíčkova, Hradební, Hřbitovní, Kollárova, Melantrichova, Šlikova, Tylova, U Monstrance and U Potůčku Streets – in total 109 street lights	1,362	15.7	15.7	86,604
Retrofit of public lighting in Červeného and Rybničná Streets – in total 10 street lights	94	1.4	1.4	64,888
Total (for specific investments – average)	**1,456**	**17.2**	**17.2**	**84,779**

5.5.2 Designed measures

Tab. 63 Measures designed for public lighting

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Retrofit of public lighting	158,835	58.4	1,948.0	81,539
Total (for specific investments – average)	**158,835**	**58.4**	**1,948.0**	**81,539**

Retrofit of public lighting

Public lighting in Liberec comprises 14,026 pcs of streetlights and 13,382 light places and their number is continuously increasing. The oldest lights date back to 1967. For the time being, sodium lamps are predominant in public lighting. This technology has developed in recent decades and is still relatively efficient, but another potential for savings in public lighting is mainly

in LED technology. Liberec has already experience with LED lighting but the replacement of the old streetlights could proceed significantly faster. Currently, in lighting retrofitting, whether planned by the City or due to refurbishment of low voltage distribution systems of ČEZ Distribuce, a. s., Company, the used up lights are mostly replaced simply by new ones with the original light source. For this reason, we found the great energy savings potential here.

To achieve the SECAP goals, ideally all discharge lamps should be replaced by LED streetlights by 2030. This would mean to replace approx. 1,000 lights annually. The newly built lighting should be equipped merely by LED light sources.

Preparation of projects for the replacement of sodium lamps by LED streetlights. LED lights can be equipped with individual control (individual streetlight control, not using central power distribution box).

The system controls the power of streetlights depending on time

- 100% to 22:00
- 75% between 22:00 – 23:00
- 50% between 23:00 – 04:00
- 75% between 04:00 – 05:00
- 100% from 05:00 o´clock

This control brings another savings amounting to 25% compared to LED lights without control. If technically possible, we recommend adding the control.

Public lighting in Liberec uses different types of streetlights with different light source power. Using energy assessments performed so far, we can estimate an average electricity saving to 0.239 MWh/y and average CO_2 emission reduction to 0.144 t/y when replacing one streetlight. The total potential for CO_2 emission reduction makes about 1,940 t CO_2/y when replacing all existing discharge lamps.

We cannot quite easily estimate the costs. They depend on whether we replace also poles or just streetlights. The replacement of streetlights is naturally less demanding, however, often the situation requires the complex replacement. Based on energy assessments performed, we can estimate the average investment costs of replacement of just a streetlight to CZK 12,500.

- The complete replacement of discharge lamps would thus request investments amounting to approx. CZK 169 M
- At current electricity prices, the measure itself is economically irrecoverable; the real payback period is approx. 58 years.

5.6 Measures in transport

5.6.1 Measures implemented by the City (2000 – 2015)

Measures implemented by the City between 2000 and 2015 concerned mainly cycling.

5.6.1.1 Support of cycling

In 2000:

- Liberec – Hrádek n/N cycle path, stretch through the City centre along the Nisa river (3 km) and Hrádek n/N – Germany border stretch
  (CZK 22 million)

In 2011:

- „Viadukt“ cycle path (along Jungmannova and Švermova Streets) (CZK 3,716,120)

In 2014 – 2015:

- Vratislavická cycle path + Zones tempo 30 – Rochlice housing estate (CZK 19,121,094)

5.6.1.2 Greening traffic of the fleet of the City and its institutions

The City bought one electric bike for its employees in 2016.

5.6.2 Measures planned by the City (2017 – 2023)

The City of Liberec is currently developing a **Sustainable Urban Mobility Plan Liberec – Jablonec nad Nisou**. The purpose of the Plan is to create a sustainable transport system so that it is available to all target groups, further to improve the transport safety, increase passenger as well as freight transport efficiency, and in the field of the environment protection, to reduce air pollution, noise level and energy consumption. The document comes from existing planning documents and it will serve as a basis for preparing traffic and regulatory plans.

As a basis for a design section, a **Traffic Behaviour Survey** is under development for all kinds of transport and a **Traffic Model** will be prepared for all kinds of transport. The design section contains the **Public Transport Development Plan for 2017 – 2023;** its developing will finalize the **Sustainable Development Framework (SUMF).** The 2nd phase of the work will result in the **Cycling Development Plan for Liberec – Jablonec nad Nisou for 2017 – 2023** as a part of the **Sustainable Development Plan (SUMP**). Both outcomes of the sustainable mobility planning are a prerequisite for using European Structural and Investment Funds (ESIF) for co-financing integrated and individual transport projects by 30 June 2023, particularly a prerequisite for approving applications for support of projects of both cities from the Operational Programme Transport 2014 – 2020 and Integrated Regional Operational Programme.

5.6.2.1 Support of Cycling

At present, the following new stretches of cycle path projects are under preparation:

- Cycle path Odra Nisa, stretch JBC – Vratislavice, Nová Pasířská along the Nisa river to OK Liberecká (CZK 3.5 million)
- Cycle path Košická – Poštovní náměstí (part of Odra- Nisa), implementation 2018 (CZK 22 million)
- Cycle path Hrazená – Barvířská (part of Odra- Nisa), implementation 2018-2019 (CZK 2 million)
- Cycle path around Slovan on the left bank of the Nisa (Odra-Nisa) (CZK 5 million)
- Cycle path behind the WWTP (continuation Odra- Nisa), implementation 2019 (CZK15 million)
- Cycle path around Denso premises, implementation 2019 (CZK 1 million)

Other planned cycle paths and cycle lanes are included in the Sustainable Mobility Plan Liberec – Jablonec nad Nisou (SUMF, 2017-2023).

As a part of the Cycling Development Plan 2017 – 2023, calming measures according to the Wide-spread City Calming Study are planned and a comprehensive system of calming traffic within the studied area is designed. For local roads besides this network, the predominance of non-traffic function is assumed, above all residential, and it is advisable to apply a form of widespread calming the traffic (2018). Further, it is planned to allow the two-way passage of cyclists through one-way streets in the area concerned and to implement approved modifications of traffic signs.

5.6.2.2 Support of pedestrian traffic

These measures supported the creation of conditions for safe and comfortable movement of pedestrians and runners in all parts of the City as well as using public transport. Without the possibility to walk safely and comfortably to their destination or a public transport stop, the residents are more motivated to use cars to move around the city.

In 2017, the City approved the project „Improving Traffic Safety in Liberec – four localities“:

- Improving traffic safety in Liberec – Husova - Svobody – Hrubínova Streets: 31/ 5/2017 – 30/11/2017, total costs CZK 8,861,410.99, of which the EU contribution CZK 7,311,071.84 and national public resources CZK 1,290,189.15
- Improving traffic safety in Liberec – building a pavement and traffic lights Kunratická Street: 11/12/2015 – 30/11/2017, total costs CZK 5,435,932.75, of which the EU contribution CZK 3,388,488.11 and national public resources CZK 597,968.50
- Improving traffic safety in Liberec – Dr. Milady Horákové Street, Hradební – U Potůčku section 1/6/2017 – 30/11/2017, total costs CZK 15,362,881.56, EU contribution CZK 5,462,310.60, national public resources CZK 963,937.17
- Improving traffic safety in Liberec – Uralská, Zhořelecká, Krajinská, Průmyslová, Horská, Žižkovo náměstí A Kubelíkova – Řepná 15/5/2017 – 30/11/2017, total costs CZK 14,100,899.06, EU contribution CZK 8,189,945.95, national public resources CZK 1,445,284.58.

5.6.2.3 Greening public transport

By the end of 2018, DPMLJ plans to purchase 17 CNG buses (IROP call, LDIP, total expenditures CZK 130,873,600, EU subsidy CZK 91,834,000), further, a renewal of 10-20 vehicles of the fleet is planned. DPMLJ plans to purchase five electric buses with facilities, the year of acquisition depends on the resources availability. .

5.6.2.4 Greening municipal fleet and municipal institution´s fleet

Currently, a purchase of two passenger electric cars and one CNG passenger car is being prepared with expected co-financing from resources of the **National Programme Environment (call 13/2016, the Ministry of the Environment of the Czech Republic). Total project costs: max. CZK 2,404,700.**

At present, almost all municipal vehicles run on gasoline, only three run on diesel. The subsidy was approved 28 August 2017. The vehicles are expected to be put into service 31 May 2018.

5.6.2.5 Parking and navigation systems

Currently, a conceptual design of a parking information system in Liberec has been developed. It defines the interest area of the project with aim to optimize the traffic in the City centre in relation to parking. That means to provide drivers entering the City centre with practical information to make decisions on parking and eliminate their travelling and searching parking facilities as well as with traffic guidance reducing the passage through individual parts of the City centre.

The project implementation will:

- Reduce time losses due to excess travelling when searching a free place to park
- Reduce exhaust gas
- Improve comfort in individual passenger transport
- Reduce critical situations in transport
- Ensure the ability of the City of Liberec to monitor and evaluate traffic data in real time and predict further development.

Expected project costs: CZK 7,935,994 excluding VAT (85% subsidy: Operational Programme Transport, 15% co-finance: the City of Liberec).

At the same time, the City submitted an application for the complex reconstruction amphitheatre area in Liberec and building of a „Park and Ride“ facility at the ZOO entrance and Lidové sady tram terminal station to the individual IROP call (123 parking places for cars, 32 parking places for bicycles).

5.6.2.6 Hub construction

By 2020, the City plans to construct a public transport hub at the Liberec bus and train stations (change to public trams and buses) – Integrated Land Development Programme – IROP project. Currently, the project documentation is under development. The project will involve also a “Park and Ride” parking house, electric vehicle charging station and parking places for bicycles). The construction of the hub at the bus station, including the parking house and the bus station facilities will create conditions for passengers to travel in such comfortable way they are justified to require. Further, the parking facility capacity will raise to approx. 225 parking places. The hub construction will also provide a modern facility of corresponding capacity for bus transport workers.

5.6.2.7 Further measures

- The Municipal Authority of Liberec has established the Department of Transport Accessibility which three employees as of 1 January 2018.
- The Liberec Region Office has established its own road transport facility.

5.6.2.8 Sources

- Information provided by the Municipal Authority of Liberec
- http://www.liberec.cz/cz/
- http://www.chytrenacestu.cz/
- https://liberec.dopracenakole.net

5.6.3 Measures planned

Tab. 64 Measures planned in transport

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
Greening public transport	48,500	0.0	2,103.5	23,057
Greening municipal fleet and municipal institutions´ fleet	15,175	23.0	23.2	653,531
Other actions influencing individual car transport & freight transport	0	5,498.0	11,413.0	0
Eco driving	150	320.7	601.6	249
Construction of transport hubs	0	0.0	0.0	0
Cycling support	47,500	0.0	0.0	0
Walking & cycling support	42,500	0.0	0.0	0
Car sharing support	0	0.0	0.0	0
Increasing the smoothness of individual car transport & freight transport in the built-up area	1,375	0.0	0.0	0
Construction of Liberec centre – Rochlice tram line	2,400,000	0.0	0.0	0
Total (average for specific investments)	**2,555,200**	**5,841.7**	**14,141.3**	**180,690**

Greening public transport

Despite gradual reducing emissions caused by public transport, the public transport counts for up to 9% of total CO_2 emissions produced by transport in the cadastral areal of the City of Liberec. The purpose of this measure is to extend such vehicles in the public transport system, which have lower emission characteristics than conventional vehicles using diesel as a fuel. We can classify CNG buses and electric buses as this kind of vehicles.

The CNG bus is a relatively widespread and well-known technology (it has been applied for approx. 20 years in the Czech Republic). On the contrary, the electric bus is a relatively new technology and we can expect its growth in coming years. Using electric buses constitute the most significant contribution to reducing CO_2 emissions. Public transport operates also CNG buses. In the year 2016, the shares of vehicles by fuel were 39.7% of diesel vehicles and 60.3% of CNG vehicles.

The disadvantage of existing electric vehicles available is their low distance travelled, which does not allow the whole-day vehicle operation on its line and it is thus necessary to deploy them on segmented courses. Deployment of more electric buses is depends on the implementation of a supporting technology allowing continuous charging, e.g. during the stay in the terminal station.

The difference in CO_2 emissions of CNG and diesel buses is not as considerable as in pollutants affecting the human health. In particular, the significant decrease in other pollutant emissions, as among others PM, NO_x, polyaromatic hydrocarbons is important.

In terms of CO_2 reduction, electric drive, which has no direct CO_2 emissions at the point of consumption, is highly effective.

Air quality impact after implementing the mentioned measures will be undeniable.

Estimation of the impact of the measures on CO_2 emissions:

In assessing the impact of the electric bus introduction on CO_2 emissions, we made the assumption on keeping the same number of vehicles and their length categories. We used manufacturers´ data for calculation of electricity consumption, and results of vehicle testing in real traffic for other energy carriers. Considering an average consumption of approx. 1.1 kWh/km, the complete replacement of buses could result in energy consumption reduction by approx. 14,878 MWh. Assuming an average consumption of approx.1.3 kWh/km, then the consumption reduction could reach 14,023 MWh in 2030. When using emission factors mentioned in the SEAP Methodology (which, however, include neither the energy mix change nor technology improvement), CO_2 reduction would be approx. by 2,290 t (when considering an average consumption of approx.1.1 kWh/km) and by 1,917 t (when considering an average consumption of approx. 1.3 kWh/km) in 2030.

Other benefits:

Reduction of pollution load in the surroundings by BaP and other PAH as well as PM, NO_x and unburnt hydrocarbons produced by combustion engines. Reduction of noise load especially near the stops.

Indicators at the measure level:

- Reduction of CO_2 emissions (g/vkms)
- Proportion of transport performance by electric and gas-powered vehicles (percentage).

Measure implementation costs:

Costs of vehicle purchase. The purchase price of CNG and electric buses is generally higher than of conventional vehicles. The difference in the purchase price is usually dependent on the size of the order, or more precisely, on the number of vehicles purchased.

Based on the announcement of individual bus type prices in 2011 for the reasonable profit calculation, made by the Ministry of Transport in line with Government Regulation No. 493/2004 Coll., we assume the following prices of vehicles with length from 10.7 – 13 m:

- CZK 4,920,000 – low-floor bus with a diesel engine
- CZK 5,800,000 – low-floor NG bus
- CZK 8,500,000 – electric bus (the price of vehicles operated in DP Ostrava, the length 10.5 m)

The quoted prices are merely theoretical and indicative; it always depends on the specific conditions and negotiations between the customer and the supplier.

Costs of CNG infrastructure building:

- The amount of the investment is dependent on the filling station capacity, technology used and many other aspects. Based on implementations, we can derive the usual price to range from 6.5 to 15 million CZK. If the investor is a private entity and the Transport Company (DP) only purchases fuel from it, the amount of the investment is spread into the fuel price. Costs of workshop and garage equipment (CNG operation): This includes mainly the installation of gas leakage detectors, efficient ventilation, adjustment of wiring and equipping the workshops with antistatic tools. The amount of the investment depends on the size of buildings, number of vehicles, existing ventilation system, etc.

Costs of building the infrastructure for electric bus charging:

- The amount of the investment will depend on the particular way of vehicle charging and operating. The charging infrastructure depends on the network density and charging

station power. The usual price of chargers ranges in hundreds of thousands of CZK and depends on the technology used and performance. The costs can significantly rise in case it is necessary to strengthen the distribution grid.

Identified costs of introduction of electric operation (we must deduce the price of the diesel bus CZK 4.9 M from the price of the electric bus):

- For 105 buses in total: CZK 378 million = EUR 14.5 million.

Position of the City and requirements for the activity of the City when implementing the measures:

- The Statutory City of Liberec is a shareholder of DPMJL (the Transport Company of Liberec and Jablonec Cities).

Available funding resources:

- Integrated Regional Operational Programme (IROP)
- Other operational programmes according to current calls
- Contributions from gas companies.

Activities of the City include:

- Purchase of vehicles with alternative drive
- Construction of filling or charging station.

Greening municipal fleet and municipal institutions´ fleet

Municipal fleet and that of municipal institutions account for the production of transport CO_2 emissions within the cadastral area of Liberec. It is advisable for the City and its institutions to set an example for the citizens and other institutions in terms of greening their fleet.

The purpose of this measure is to expand those vehicles, which have lower emission characteristics than conventional vehicles that use diesel or gasoline as fuels. Such vehicles include LPG, CNG, and hybrid and electric vehicles. In terms of reducing CO_2 emissions, electric cars make the greatest contribution.

The share of these vehicles in the fleet should be at least 25% (according to the Public Administration´s fleet replacement by "environmentally friendly" vehicles Programme). That´s why we propose to replace 25% of vehicle stock for these vehicles by 2020. In 2030, this share should be 50%. A disadvantage of current electric vehicles is their low distance travelled that is not critical in the urban traffic with available charging points.

The difference in CO_2 emissions of CNG and gasoline or diesel engines is not as considerable as of pollutants affecting human health. In particular, a significant reduction of other pollutant emissions as among others PM, NO_x, polyaromatic hydrocarbons is important.

Estimation of the impact of the measure on CO_2 emissions:

In terms of CO_2 emission reduction, electric drive, which does not produce any CO_2 emissions at the point of consumption, is significantly more efficient.

The estimate considers the replacement of the Municipal Authority´s vehicles older than 15 years by 2020 and 2030. Replacing conventional vehicles by electric ones, can lead to **energy savings amounting approximately to 141 MWh in 2020 and 55 MWh in 2030**. When using emission factors mentioned in the SEAP Methodology (which, however, include neither the energy mix change nor technology improvement), **reduction of CO_2 emissions by 23 t in 2020 and by 0.22 t in 2030** would be reached.

Other benefits:

- Reduction of pollution load in the surroundings by both BaP and other PAHs and by PM, NO_x and unburnt hydrocarbons produced by combustion engines.

Indicators at the measure level:

- Reduction of CO_2 emissions (g/vkms)
- Share of transport realized by electric and gas vehicles (percentage).

Measure implementation costs:

- For instance 18 x electric vehicle of low and lower middle category **CZK13.14 million = € 505 thousand** 3 x electric vehicle of light truck category **CZK 2.7 million = €102 thousand**

  Note: The price of electric vehicles is constantly changing and it is probable that it will be significantly lower in several years.

Position of the City when implementing the measures, and requirements for the activity of the City in implementing the measures:

- The statutory City of Liberec is a founder of the Municipal Authority and subordinate institutions

Available funding resources:

- IROP – Specific Objective 1.2 – Low-emission vehicles and related filling stations
- Ministry of the Environment in the Framework of Clean Mobility
- Ministry of Industry and Trade – current programmes
- Operational Programme Transport

Activities of the City in this field include:

- Purchase of electric or NG vehicles
- Construction of charging stations for electric vehicles (the first public charging stations exists from 3/2017 in the OC Nisa parking facility. The CNG filling station also already exists – ČSAD Liberec premises).

Other measures related to individual car and freight transport

The measure consists in restricting the entrance to the City centre or its selected parts, namely in accordance with the limits on technical parameters (weight, emissions), only at a certain time of day, or on payment the entrance fee. The combination of these approaches is also possible. **Low-emission zones (LEZ)** are City areas with limitations to vehicles whose emissions do not comply with the required level. The Act No. 201/2012 Coll. On Air Protection and the subsequent Government Order set the rules for establishing LEZ.

In practice, it should not be only a stand-alone measure. In order to achieve the highest impact possible, low-emission zones should be part of a larger comprehensive set of measures.

Since a low-emission zone usually covers only a part of the city, its preparation is worth paying considerable attention. The effects of the low-zone implementation will depend on its spatial extent, application of exceptions, and way of application and control activities. An inappropriately defined zone could cause undesired increase in load on the inner-City roads serving as bypass roads.

Park & Ride and Kiss & Ride systems. Park & Ride have the significant potential for improving air quality especially in areas along radial roads. The condition of meeting this potential is to ensure sufficient capacity of parking facilities in each of the decisive radial routes and a high-quality guidance system. The location of all parking facilities must be chosen so that the change to public transport lines (preferably the rail transport) is quick and comfortable. The charges for using a parking facility should be set so that the system is cost-effective for drivers while reflecting the parking facility location (the closer to the City centre, the higher the price). Establishing Kiss & Ride facilities will enable a short-term stop (up to 5 min.) of passenger vehicles again near the significant public transport hubs for the purpose of dropping off or picking up other persons. In this manner, car sharing by more persons is encouraged when a driver carries another person or persons to a public transport point allowing them a change to public transport and then proceeds by his car to the destination of his/her journey.

Public transport quality improving includes a wide range of activities that will make public transport more attractive for different groups of passenger. The City can achieve this by means of improved comfort (improving cross-connections of individual lines, adherence to timetables, high-quality information systems for passengers on stops/stations and in vehicles during the journey, availability of mobile phone applications providing the passengers with on-line information e.g. on actual vehicle positioning). Another way is to improve overall vehicle environment (sufficient capacity, comfort of indoor environment, cleanliness, heating and air conditioning, Wi-Fi availability, etc.).

Ensuring public transport preference is a very important tool for increasing the speed of surface transport. The low speed and a risk of blocking a vehicle in congestion are among the main reasons for not using public transport by the inhabitants. The goal is to give priority to public transport vehicles over individual transport and increase thus the attractiveness of public transport for passengers.

The expected impact of the measure is a decrease in travel volumes of both passenger vehicles and heavy trucks, switching of part of passengers to public transport and replacement of vehicles by energy and environmentally efficient ones. This will result in reducing energy intensity of transport and in reducing CO_2 emissions as well as other pollutants.

Estimation of the impact of the measure on CO_2 emissions:

- As foreign experience and national feasibility studies (see Špička et al., 2011, 2013a, 2013b) show, introducing LEZ does not change the overall transport performance on City roads in most cases. The impact of the measures is observable especially in the change to dynamic structure of vehicles. Impact modelling results show that implementing measures could **save approx. 5,498 t CO_2 in 2020 and 5,915 t CO_2 in 2030.**

Other benefits:

- Reduction of imission load of limited harmful substances produced by combustion engines. Reduction of noise load, increased safety.

Indicators at the measure level:

- Reduction of individual car transport volume (vkms)
- Reduction of freight transport volume (vkms).

Measure implementation costs:

- It is not possible to quantify the costs without giving specific form and scope of the measures. They include especially costs of traffic signs, information campaigns and administrative cost (emission plaques, entrance permission, exceptions to restrictions,

administrative fees, etc.). In case of the charged entrance, dominate the costs of building the necessary infrastructure (tollgates, CCTV, IT equipment, etc.).

Position of the City when implementing the measure, and requirements for the activity of the City in implementing the measure:

- The Municipal Authority is the initiator and implementer of this measure.

Activities of the City in this field include:

- Construction of transport hubs
- Parking strategy
- Introduction (or extension) of restricted entrance zones
- Increasing the public transport attractiveness

Eco-driving

The aim of the measure is to improve driving skills of drivers of public transport and of institutions established and administered by the City while reducing fuel consumption.

Estimation of the impact of the measure on CO_2 emissions:

- The estimation of an impact of eco-driving follows from data presented in scientific literature. Zarkadoula et al. (2007), Beusen et al. (2009), and Strömberg & Karlsson (2013) indicate that while adhering to eco-driving principles, car drivers can reduce average fuel consumption by 5.8%, bus drivers by 4.35 – 6.8%. According to results of the study by Sullman et al. (2015), professional bus drivers, after training on eco-driving simulator, can reduce consumption by up to 11.6% and after further improvement by up to 16.9%. When considering the upper limit, adhering to eco-driving principles could result in achieving **energy savings amounting approx. to 1,465 MWh in 2020 and to 1,296 MWh in 2030 with bus drivers of diesel and CNG vehicles (6.8%) and approx. 11 MWh in 2020 and 6 MWh in 2030 with car drivers.** When using emission factors mentioned in the SEAP Methodology (which, however, include neither the energy mix change nor technology improvement), **CO_2 emissions would be reduced by 318 t in 2020 and by 279.5 t in 2030 with bus drivers (6.8%) and by 2.7 t in 2020 and by 1.4 t in 2030 with car drivers.**

Other benefits:

- Lower costs of fuel purchase
- Reduction of imission load of further pollutants produced by combustion engines
- Increased transport safety

Indicators at the measure level:

- Number of trained drivers (percentage)
- Total reduction of an average fuel consumption per transport volume unit and given type of vehicle (l/vkms; m^3/vkms; kWh/vkms)

Implementation measure costs:

- In case of theoretical training, it is a low-cost measure; the costs consist only of the course price and possible costs of incentive programmes for drivers. Practical training generates other significant costs.

Theoretical training 4 hours + voluntary drives, 30 persons – CZK **1,000/person = CZK 30 thousand = EUR 1,100**

Theoretical training + short practice in actual traffic (30 persons) – **CZK 40 – 60 thousand**

All-day or half-day intensive training – a group of 2-3 participants, each with its own instructor and driving the whole day/half a day. CZK 6,000 per person (half-day training) up to CZK 10,000 (all-day training). **It means, 30 persons = CZK 180 – 300 thousand =**
EUR 6,600 – 11,000.

Source: http://www.ecodrive.cz/

Position of the City when implementing the measure, and requirements for the activity of the City in implementing the measure:

- The Municipal Authority is the initiator and implementer of this measure. The implementation itself then should fall under respective institutions established by the Municipal Authority. As a positive example, we recommend to realize the Eco-driving Introduction Pilot Programme exactly for the drivers of Municipal Authority vehicles and DPMLJ drivers.

Available funding resources:

- City budget
- European Social Fund – Operational Programme Employment

Activities of the City in this field include:

- Providing professional driver training in skills that support eco-driving principles
- Implementation of incentive programmes for drivers to increase the interest to adhere to eco-driving principles.

Construction of transport hubs

The purpose of the measure is to support especially the development of electric traction of the City public transport. For this reason, the City should implement transport hubs in suitable locations at the outskirts of the city. They should ensure a comfort change from suburban lines, which will terminate in these points instead of driving into the Central Bus Station (ÚAN) in the City centre, to electric traction of the City public transport. This will reduce an accumulation of suburban and public transport lines. Transport capacity saved then can be allocated to increase a frequency of connections serving suburban zones.

Estimation of the impact of the measure on CO_2 emissions:

- Given the planned transport hub construction, for the time being it is not possible to quantify annual savings of CO_2 emissions from exhaust gas. The evaluation is possible only having knowledge of the new draft timetables, which will make evident the changes of public transport lines.

Other benefits:

- Reduction of other pollutant emissions incl. solid particles.
- Spaces for promotion of alternative transport modes (bicycle parking, K&R…)

Indicators at the measure level:

- Transport volume transferred from suburban transport to electric public transport (vkms; or persons transported)
- CO_2 emissions saved as a difference between the saved capacity of suburban buses and increased need of capacity in the electric traction (t).

Measure implementation costs:

- We cannot estimate the amount of funding resources in advance, but it will be at least tens of millions of CZK. The amount of the costs will depend on the winning technical solution of individual hubs as well as on the extent of accompanying measures on tram radials.

Position of the City when implementing the measure, and requirements for the activity of the City in implementing the measure:

- Ensuring conditions for construction
- Reinforcing backbone lines (increasing ordered capacity)

Available funding resources:

- State Fund for Transport Infrastructure
- Swiss-Czech Cooperation Programme – Partnership Fund
- Regional Operational Programme

Activities of the City in this field include:

- Upgrading connecting lines of public transport – increasing travel speed, increasing preferences at junctions with traffic lights, increasing the connectivity to other public traffic lines by constructing adequately designed platforms (edge-edge transfer), etc.
- Ensuring attractive intervals and a sufficient number of connections on backbone lines serving the hubs.

Support of cycling

Within this measure, we intend to support the purpose-built cycle paths, cycle lanes, equipping public buildings with places for safe bicycle storage. The support of cycling can also involve introducing “Bike & Ride” system.

Cycling is environmentally friendly transport with a positive impact on human life. It also has a significant relaxation role. For this reason, the goal is to build a network of comprehensive routes ensuring a quick and safe connection of important destinations, not only recreational ones, but especially for regular commuting between homes and working places or schools. The support of cycling requires making the existing cycle path network denser, connecting properly the transport sources and destinations. In non-built-up areas, it is appropriate to separate cyclists from motorised traffic wherever there is high traffic intensity. In built-up areas it is recommended to keep cyclists rather in the main traffic but to ensure safety for them, for instance by means of reserved lanes. In addition, cyclists need a place where to put safely their bikes.

"Bike & Ride" (B & R) system follows the principle that a cyclist rides a bicycle covering the part of his/her journey from home to a B & R facility or to a parking bike facility. After parking the bicycle, he/she will change to a public transport vehicle and proceed as far as his destination. This system aims to ensure safe parking of bicycles especially at terminal stations and important interchange public transport hubs, shopping centres, multipurpose buildings and large sports facilities. Existing parking facilities or municipal public spaces should be prefered.

The measure is intended to make cycling more attractive even for inhabitants less physically fit who would like to use a bike to commute to work, but covering the whole stretch from their homes to work on a bike means a great physical burden for them. Another option is a combination of B & R and P & R systems (see relevant measure) in locations where these options coincide. In this case, the bike dock/storage would be located directly in the parking facility.

The last appropriate activity is to support bike sharing or electric bike sharing.

According to OBIS Handbook (see literature), the appropriate number of bicycles in the bike sharing system is 28 pieces for 20 thousand inhabitants, and the number of docks where a bike can be borrowed, is four.

Estimation of the impact of the measure on CO_2 emissions:

- It cannot be determined without a survey of changes to traffic behaviour.

Other benefits:

- Reduction of imission loads in the surroundings of BaP and other PAHs, and also PM, NO_x , and unburnt hydrocarbons produced by combustion engines
- Improving the physical condition of inhabitants.

Indicators at the measure level:

- Number of cyclists measured by a counter at a representative stretch of a cycle path/year.

Measure implementation costs:

- Cycle path – new construction – **CZK/km 6,032,667 = EUR 223 thousand** (source – The Directorate of Roads and Motorways (ŘSD) pricelist: https://www.rsd.cz/wps/wcm/connect/7c1f90d3-acfd-4d6c-97d8-3641c3ad8778/Cenove_normativy_2016-ceny.pdf?MOD=AJPERES)
- Cycle lane: 1 km – **CZK 51 thousand = EUR 1,900** - expert estimate of Transport Research Centre (CDV)
- Automated bike parking/tower: 117 bikes (according to Bike Tower Hradec Králové, source: http://www.prerov.eu/filemanager/files/file.php?file=30065)
    - Construction costs – CZK 10 million = EUR 370 thousand
    - Monthly expenses - CZK 6,390
    - Monthly revenue summer months – CZK 12 thousand
    - Monthly revenue summer months – CZK 5 thousand
- Bike sharing: Costs of bike sharing system operation per year in Plzeň (107 bikes) :
    - Initial costs – CZK 300 thousand = EUR 11 thousand
    - Annual operation – CZK 600 thousand

Position of the City when implementing the measure, and requirements for the activity of the City in implementing the measure:

- The City is in charge of establishing and upgrading the supporting infrastructure for cyclists. In case of bike sharing, the City can provide free a land for a dock operation and a financial support.

Activities of the City in this field include:

- Construction of places and buildings for bike storage
- Implementation of reserved cycle lanes
- Construction of a bike sharing network

Support of pedestrian traffic and running

The purpose of this measure is to support reducing the car transport volume by creating conditions for safe and comfortable movement of pedestrians and runners in all parts of the City as well as to support using public transport. Without a possibility to reach their destination or a public transport stop safely and comfortably, the inhabitants are more motivated to use their passenger vehicles for their usual travelling round the City, which results to increase in air imission load from car transport. The measure focuses on a strong protection and improvement of walking opportunities in the city. In the city, a pedestrian always encounters other traffic systems and is the most vulnerable traffic participant. The key element of the measure is therefore to ensure and increase the pedestrian and runner safety, or more precisely, to enable safe walking around all the important destinations in the city.

It is necessary to check whether there are any collision points on the main walking routes with increased risk of a pedestrian's or runner's collision with motor vehicles and if so, to eliminate these collisions. It follows from the experience that a safe movement of pedestrians can usually be achieved using measures requiring relatively low investments (i.e. speed limits for motor vehicles, installation of traffic lights, pedestrian crossings, etc.)., however, also investment-demanding measures can be taken e.g. by building a missing pavement in a certain section.

In order to ensure a transport role of pedestrian traffic it is necessary to gradually create a network of protected corridors for walking, i.e. local streets for pedestrians, constructionally and organizationally adapted, enabling non-collision, safety and comfortable reaching necessary destinations in the city. The City must ensure good accessibility of all public transport stations and stops and all substantial traffic destinations (important working places, shops, schools, offices, health facilities, recreation areas, etc.). It is necessary to calm traffic in spaces with high concentrations of pedestrians and in the neighbourhood of key destinations, or directly to implement pedestrian zones here or to extend pedestrian spaces excluding car transport. Apart from creating pedestrian interconnections through existing barriers, it is naturally necessary to apply continuously the requirement to maintain the existing common pedestrian routes passable, especially in terms of public transport, services and public facilities. It is essential to build a sufficient number of safe passages across planned line constructions (roads and railways), to prevent creation of closed premises (i.e. fenced residential units) on traditional pedestrian routes, and to maintain existing arcades and passages.

Estimation of the impact of the measure on CO_2:

- It cannot be determined without a survey of changes to traffic behaviour.

Other benefits:

- Reduction of pollution loads in the surroundings of both BaP and other PAH, and PM, NO_x, and unburnt hydrocarbons produced by combustion engines.
- Reduction of noise load.
- Improving the physical condition of inhabitants

Indicators at the measure level:

- Automated counting of pedestrians on a representative stretch – number of pedestrians/year

Measure implementation costs:

- Low to medium – they cannot be clearly determined since each sub-measure included has its own set of costs which depend on many aspects, especially on the scope (route length, arrangement of the urban area, etc.).

Position of the City when implementing the measure, and requirements for the activity of the City in implementing the measure:

- The City is in charge of establishing and upgrading the infrastructure for pedestrians.

Available funding resources:

- IROP
- CIVITAS

Activities of the City in this field include:

- Identification of collision points
- Speed limits for vehicles, installation of traffic lights and pedestrian crossings in collision points
- Additional building of missing pavements
- Calming of spaces with a high concentration of pedestrians, or implementation of a pedestrian zone
- Building of safe passages across line constructions and closed premises.

Support of car sharing

Car sharing is one of a series of mobility management strategies. It provides advantages of using a vehicle while reducing disadvantages associated with high dependence on cars. Car sharing typically consists of a provider – a professional company (preferably established by the public sector) with centralized booking system, collection of vehicle operation data and service billing. The company members are the clients who have at their disposal the infrastructure, consisting of a fleet and parking places in key areas within the catchment area. The car sharing company has a formalized relation with the state administration, public transport providers and vehicle manufacturers. The vehicles of the car sharing company are available at many places in the City even for a short time usage (usually one hour and more) and are available for the whole day (24 hours a day, 7 days a week). Payments depend on the vehicle usage time and the distance travelled. In this respect, the payment for using a vehicle is similar to payments for public transport.

Since 2013, the “Autonapůl” company in Liberec operates car sharing providing three vehicles, but with the low demand only, and so support by means of advertising activities, reserving parking facilities, etc., is necessary.

Estimation of the impact of the measure on CO_2:

- It cannot be determined without a survey of changes to traffic behaviour.

Other benefits:

- Reduction of imission loads in the surroundings of both BaP and other PAHs, and PM, NO_x, and unburnt hydrocarbons produced by combustion engines.

Indicators at the measure level:

- Reduction of CO_2 emissions (g/vkms)
- vkms/year covered by car sharing users

Measure implementation costs:

- http://www.autorentalnews.com/article/story/2009/09/how-to-run-a-successful-carsharing-operation/page/2.aspx

Position of the City when implementing the measure, and requirements for the activity of the City in implementing the measure

- The City is in charge of establishing parking places for car sharing vehicles the parking zone.

Available funding resources

- The City of Liberec.

Activities of the City in this field include:

- awareness campaign
- support to increasing the number of vehicles in the car sharing system
- parking places reserved for car sharing vehicles
- parking price advantage for car sharing users
- a preferential lane allowing to car sharing vehicles to benefit
- interconnection with public transport, vehicles parked at public transport stations/stops
- discount on prepaid public transport fare

Improving the fluency of individual car and freight transport in the built-up area

The purpose of the measure is to improve the fluency of traffic, which will lead to a significant reduction of fuel consumption and thus reduction of CO_2 emissions, mainly as a result of reducing intensity and duration of peak hours and congestions, and also of reduced number of take-offs and stopping-downs. The City can achieve this by:

Extending dynamic control and intelligent traffic systems:

- directing the traffic flow by telematics systems
- removing bottlenecks
- dynamic control of junctions
- information for drivers when entering the City

Support of navigation systems:

- establishing telematics navigation systems
- mobile phone applications

Estimation of the impact of the measure on CO_2:

- We cannot quantify it, as the scenario requires a comprehensive transport model considering all ITS measures.

Other benefits:

- Ideally, a well developed intelligent transport management system should:
  - reduce congestions at least to 50% compared to the existing state
  - reduce the time of searching the destination at least by 20%

- reduce the travel time at least by 10%
- increase the number of applications users at least by 30%

- Reduction of imissions loads in the surroundings of both BaP and other PAHs, and PM, NO_x and unburnt hydrocarbons produced by combustion engines. Reduction of noise load caused especially when the vehicles take-off and creep forward.

Indicators at the measure level:

- Reduction of CO_2 emissions (t)
- Reduction of delays at intersections with traffic lights
- Reduction of congestions in the centre
- Time of searching the destination when parking
- The number of parking applications users

Measure implementation costs:

- We cannot estimate the amount of funding resources in advance; it will be at least CZK **1 – 1.5 million.** The price for a parking application and the introduction of sensors to parking places ranges **approx. from CZK 6 to 8 thousand for one parking place,** the price of an **information panel** for drivers ranges from approx. **CZK 150 to 200 thousand**

  An example:

  Equipment of one intersection by a dynamic control system using telematics systems ranges from USD 10,000 to 120,000, i.e. **approx. CZK 220,000 – 2,640,000** according to Advanced Signal Control Technology Guidelines (2016).

Position of the City when implementing the measure, and requirements for the activity of the City in implementing the measure:

- The Statutory City of Liberec is the owner of local roads and streets.

Available funding resources:

- IROP
- SFDI
- Operational Programme Transport

Activities of the City in this field include:

- Installation of telematics systems for traffic control at main and problematic intersections in the City centre
- Installation of information panels for drivers
- Development of smart parking application
- Advertising of smart parking application.

5.6.4 Electromobility

The measure design does not include yet the development of electromobility outside the municipal property and public transport. Considering the electric vehicle prices, problems with a low battery capacity and insufficient infrastructure, the start of electromobility on a mass scale is difficult to predict. We can expect that electric vehicles appear first in the tertiary sector (also as pick-ups) and only later in households.

Electric vehicles constitute a clear contribution to eliminating pollutant emissions (NO_X, dust particles) and reducing noise. Their contribution to reducing CO_2 emissions is not too big yet. The emission factor for motor fuels is round 0.27 t CO_2/MWh. The local emission factor for electricity is about 0.6 t CO_2/MWh. Just because the fact that energy efficiency of electric vehicles is 2.0 – 2.5 times higher than efficiency of vehicles with combustion engines, replacing conventional vehicles by electric vehicles will result in a slight reduction of CO_2 emissions. With decreasing share of coal in energy mix of electricity production, the emission factor for electricity will decrease as well. Then the contribution of electric vehicles to reduction of CO_2 emissions will be more significant.

The capacity of distribution grid will be absolutely the biggest obstacle to mass development of electromobility. In particular, the fast-charging stations constitute large power capacities, which the existing networks may not be able to handle. The collaboration of the City with the distribution company will be essential.

5.7 Measures in local electricity generation

5.7.1 Designed measures

Tab. 65 Measures designed in local electricity production

Measure	Implementation costs incl. VAT [thousand CZK]	Reduction of CO_2 emissions in 2020 [t/y]	Reduction of CO_2 emissions in 2030 [t/y]	Specific investments in emission reduction [CZK/t CO_2]
ZOO – PV – Elephant Pavilion	726	0.0	6.0	120,250
PV electricity production in municipal buildings	9,000	0.0	163.0	55,211
PV electricity production in residential buildings	100,000	0.0	1,346.9	74,242
Cogeneration (CHP) in the tertiary sector	11,280	0.0	942.1	11,974
PV electricity production in the tertiary sector	100,000	0.0	1,346.9	74,242
Green electricity	0*)	0.0	14,196.7	0
In total (for specific investments – average)	**221,006**	**0.0**	**18,001.7**	**12,277**

*) The purchase of green electricity does not depend on investment costs, however, green energy is more expensive compared to the current rate by CZK 300 per MWh at present. For the mentioned reduction of CO_2 emissions, the annual additional costs would be approximately 7 million CZK.

Installation of PV panels on the Elephant Pavilion roof (in 2020-2030)

The roof area of the Elephant Pavilion is 634 m^2. We consider installation of PV panels of about 80-100 m^2 with the intention to consume all the energy produced in the ZOO. With the yearly load factor of the PV system 900 h/y, the electric energy production would be 10.1 MWh.

- Measure costs CZK 0.726 million
- EE costs savings CZK/y 27 thousand

PV electricity production in municipal buildings

The installation of PV systems on municipal building roofs constitutes an opportunity of fossil fuel savings. With the right design of the installed capacity, the photovoltaic system serves for covering the own electricity consumption without a threat of flows towards to the distribution grid.

When covering 3% of the total area of approx. 10 000 m^2 of roofs on suitable municipal buildings (nursing homes, hospitals), the annual electricity production would achieve 270 MWh, which accounts for 1% of electricity consumption in municipal buildings.

- Electricity savings: 270 MWh
- Investment costs: CZK 9 million

Activities of the City in this field include:

- The measure falls within the authority of the City.

PV electricity production on residential buildings

The measure supposes installation of PV systems on roofs of family houses and residential buildings. If 10% of all family houses are covered with PV systems with the panel surface area of 6 m^2 and if 10% of all residential buildings are covered with the panel surface area of 30 m^2, 2,480 kWp with the annual electric energy production of 2,231 MWh would be installed.

- Electricity savings: 2,231 MWh
- Investment costs: CZK 100 million.

Activities of the City in this field include:

- Promotion and awareness raising
- Providing consultancy.

Installation of cogeneration units in tertiary sector (except municipal buildings/facilities)

The installation of cogeneration units with the total power of 1.5 MW_t in the existing gas boiler rooms would result in the electricity production of 2,422 MWh intended for the own consumption at the same heat supply, while the natural gas consumption will be increase by 2,588 MWh. The potential of 1.5 MW_t seems technically feasible; its realization is dependent on the operation economy, especially on the amount of the green bond announced by the Energy Regulatory Office (ERÚ).

- Increase in natural gas consumption: 2,588 MWh
- Electricity production: 2,422 MWh
- Investment costs: CZK 35 million.

Activities of the City in this field include:

- Promotion and awareness raising
- Providing consultancy.

PV electricity production in tertiary sector

This measure considers installation of PV systems on the tertiary sector building roofs. Due to the lack of data on surface areas of buildings in the tertiary sector, we set the area of collectors by an expert estimation. We expect to install 2,480 kWp panels with the annual electricity production of 2,231 MWh.

- Electricity savings: 2,231 MWh
- Investment costs: CZK 100 million.

Activities of the City in this field include:

- Promotion and awareness raising

- Providing consultancy.

Purchase of green electricity

In purchasing green electricity, the City has a great potential for reducing CO_2 emissions. Assuming the implementation of all measures in the municipal property, the electricity consumption in municipal buildings and facilities/equipment would be 23,515 MWh/y in 2030. In case of purchasing the whole amount as green electricity, the savings would be 14,197 tCO_2/y. The purchase of green electricity requires no investment costs; however, green electricity is more expensive than conventional electricity. Currently, green electricity is by CZK/MWh 300 more expensive compared to electricity in the corresponding rate. This would entail the additional costs of green electricity purchase amounting to approx. CZK 7 million per year.

5.8 General recommendations

5.8.1 Support of the use of heat from waste-to-energy plant

At present, Liberec consumes heat from the Termizo waste-to-energy plant. The plant incinerates more or less a constant amount of waste. This means that energy production is not dependent on heat consumption. Termizo covers almost its all-annual heat consumption, only in winters; peak sources cover peak heat supply. In summer, the plant generates excess heat, which has to be wasted in cooling towers.

It is therefore desirable to support the use of heat from the waste-to-energy plant and strive to avoid disconnection of users. DH system disconnection will result in CO_2 emission increase since the plant will continue in incinerating the same quantity of waste and not consumed heat will have to be produced in a different way, usually generating additional CO_2 emissions.

In 2015, the waste-to-energy plant supplied heat of about 180,000 MWh. Even in case of disconnecting all heat consumers from the DH system, the plant would continue producing CO_2 emissions because the waste must be burnt. Disconnecting all heat consumers and switching to gas would lead to additional CO_2 emissions amounting to 40,200 t/year. This is 10.6% of the current production of CO_2 emissions per year. It would be the consequence of DH system disintegration.

The City should therefore determine the obligation to include the assessment of the possibility of connecting to the DH system as part of the project documentation of new buildings. Further, it should also make more difficult the possibility to disconnect existing consumers from the DH system.

The City in the collaboration with MVV, a. s., prepares the GreenNet project, which aims to revitalize the DH system (approx. 300 million CZK). The revitalization of heat feeders will result in reducing heat losses. However, with the current heat surplus from the waste-to-energy plant this will have only a little effect. The decrease in losses will be effective only when the plant supplies all the heat produced to the grid. Due to ongoing thermal insulation, the heat demand will be decreasing and heat surplus will be increasing. From the long-term point of view, this project will not particularly contribute to reducing CO_2. This is another reason to strive for connecting new buildings to the DH system.

5.8.2 Land use planning, urban planning and new construction

In the field of new construction, especially support to low-energy standard or also passive standard of municipal buildings comes into consideration. Other measures are as follows:

- Support of new residential construction in low-energy and passive standards (considering economic benefits) – A values according to Energy Performance Certificate;
- Support of new construction in the tertiary sector in low-energy standard, without electricity demand for air conditioning;
- Use of DH and RES – especially in new commercial buildings;

The shape of the building and its geographic orientation plays an important role in terms of heating, cooling and lighting in a building. Appropriate orientation and layout of the building and its surroundings can reduce current trends in the use of air conditioning. Planting trees around buildings and green roofs lead to substantial reduction of consumption – especially of electricity for air conditioning. The building proportions (length, height, width), glazing rate and building orientation should always be well analysed in construction plans in terms of their future energy demands.

Appropriate and recommended measures contributing to reduction of CO_2 emissions in the land use planning can be designed as follows:

- To create an offer of development areas mainly in strategic directions of development and in scope and quality able to compete with the offer of development areas outside the administrative boundaries of the City
- The functional structure of development areas must be balanced and contribute to reduction of mobility – within the residential areas, there should be a sufficient quantity of areas for public and commercial amenities
- To improve conditions for a high-quality residential environment of the City, able to compete with the area outside the administrative boundaries of the City of Liberec – reduction of the environmental burden, protection of landscape and natural values, sufficient offer of areas for recreation, sport and leisure
- To support the low-energy and passive construction perspective when designing the land use

For the designed solutions of brownfields and development areas, also collaboration with students, developers and investors, organization of design competitions, etc. proved to be successful.

Land use planning has a significant impact on energy consumption in both the transport and construction sectors. Strategic decisions concerning City development, such as preventing their expansion, affect energy consumption within urban areas and reduce the energy intensity of transport. Compact urban environments can enable cost-effective and more energy efficient public transport. Creating balanced housing, services and job opportunities (mixed use) in urban planning have a clear impact on patterns of citizen´s mobility and their energy consumption.

6. CLIMATE CHANGE ADAPTATION

While the purpose of mitigation measures is to reduce greenhouse gas emissions and thereby prevent climate change, the purpose of adaptation measures it to reduce the adverse impacts of ongoing climate change such as more frequent occurrence of extreme heat or frost, strong wind, storms, torrential rain, floods, droughts, etc.

6.1 Adaptation strategies in the EU and Czech Republic

6.1.1 EU adaptation strategy

In April 2013, the EU Commission adopted the Climate Adaptation Strategy. The aim of the Strategy is to make Europe more climate resilient by adopting a coherent approach and ensuring better coordination, improving readiness and ability of all levels of governance to respond to the impacts of climate change. EU Adaptation Strategy focuses on three key objectives:

- Support of actions of Member States: the Commission appeals to all Member States to adopt the comprehensive adaptation strategies and provides funding to help them build adaptation capacities and take necessary action. It also supports urban adaptation through the Covenant of Mayors for Climate and Energy.
- Climate protection actions at EU level through further adaptation support in key vulnerable industries such as agriculture, fishery, cohesion policy, ensuring greater resilience of European infrastructure and promoting the use of insurance against natural and human-made disasters.
- Improved awareness at decision-making through addressing knowledge gaps in adapting and further development of European Climate Adaptation Platform (Climate-ADAPT) as “one-stop shop” for adaptation-relevant information in Europe.

6.1.2 Adaptation strategy in the Czech Republic

Based on Czech Government Resolution No. 861/2015, the **National Action Plan on Adaptation to Climate Change** was prepared in 2015 as the Implementation Document of the Strategy on Adaptation to Climate Change in the Czech Republic.

6.1.2.1 Main climatic risks

The document defines the following main climate change related risks:

- Long-lasting drought
- Floods and flash floods
- Increase in temperatures
- Extreme meteorological phenomena
    - Heavy precipitation
    - Extremely high temperatures
    - Extreme wind
- Wildfires

Long-lasting drought

From a climatological point of view, drought is a randomly recurrent phenomenon related to the water scarcity in the landscape. As a temporary anomaly, it can occur in all climatic zones and this distinguishes it from permanent aridity. It is characterized by a slow rise and development with persistence during different long season, or years. There are three types of drought:

- Meteorological
- Soil (sometimes, in terms of impacts referred to as agricultural drought)
- Hydrological (related to surface water and groundwater) the consequence of which are economic, social and environmental impacts.

The major problem with the occurrence of long-lasting drought is the lack of water in sources, which meet water demand of inhabitants, critical infrastructure elements and ecosystems. In the final consequence, the lack of water may endanger health and lives of the inhabitants, reduce economic production, increase the risk of occurrence and spread of wildfires and cause damage to forest stands and crops. With regard to a probable rise in temperatures, we can expect an increasing frequency of occurrence and prolongation of drought seasons.

Floods and flash floods

Floods are a natural phenomenon, which cannot be completely avoided, similarly as other natural hazards. In the Czech Republic, natural floods of several types occur:

- Winter and spring floods, caused by melting of snow cover, mostly in combination with rainfall. These floods occur most frequently in mountain and submountain watercourses and move further to lowland stretches of large rivers.
- Summer floods, caused by long-lasting regional rainfall with rainfall lasting even several days and reaching relatively large areas. They usually occur on all watercourses in the affected area, usually with significant consequences on middle and lower stretches of watercourses.
- Winter ice floods, caused by narrowing the flow profile even at relatively smaller flows. They occur in the watercourse stretches prone to ice congestions in ice floe passage and crams in ice slush passage.
- Summer flash floods, caused by short-lasting rainfalls of high intensity, affecting usually small territories. They can occur everywhere on small watercourses, with catastrophic consequences especially on inclined fan-shaped river basins.

Floods have the greatest adverse impacts on heavily urbanized areas (whether in terms of possible impacts on human health or on economic activity and cultural heritage), further on water management, agriculture (flash floods and soil erosions have particularly adverse impact), transport, industry and energy, and temporarily also on tourism. Floods require continuous development and strengthening of integrated rescue system.

Increase in temperatures

According to studies, the period of 2002 – 2011 was the warmest one ever recorded in Europe. The average Earth surface temperature in Europe is by 1.3 °C higher than the pre-industrial average. Scenarios until 2099 (compared to baseline period of 1961 – 1990) assume a gradual increase in average temperatures in the Czech Republic. In the first period of 2010 – 2039, the air temperature is likely to increase by about 1 °C. In the period of 2040 – 2069, warming is expected to be higher, in spring and summer it can range from 2.3 °C to 3.2 °C, in autumn from 1.7 °C to 2.1 °C and in winter from 1.5 °C to 2.0 °C. In the last period of 2070 – 2099, the warming in summer will be in average 4 °C and in winter 2.8 °C.

In terms of season, the highest increase in air temperature is expected in spring and summer months, the temperature increase in autumn and winter is assumed lower. The highest temperatures will continue to be in the area of Southern and Central Moravia, the Ostrava Basin and in Polabí; the increase without major differences will be in the whole Czech Republic. Gradually, there will be an increase of summer days (from 45 to 91) and tropical days (from 8 to 31), tropical nights, currently very exceptional, will be more frequent, a significant decrease will occur in the number of frosty days (from 112 to 69) and ice days (from 30 to 8) and arctic days will practically cease to exist. The occurrence of these days with extreme values in the Czech Republic will naturally depend on the locality.

Gradual and continuous increase in temperatures will have the greatest impacts on agriculture and forestry sectors (both positive and negative), water management (especially agriculture-related), biodiversity, tourism, and health and hygiene.

Extreme meteorological phenomena

Heavy Precipitation

Heavy precipitation events are characterized by very strong intensity of rainfall or snowfall. Under unfavourable conditions, the rainfall can lead to a rapid runoff, especially on hard, low-permeable or saturated surface, and to inundation of lower situated locations, buildings, or to increase in water level in watercourses, and to floods. Heavy rainfall together with storm activity is a relatively frequent phenomenon, but in most cases, they have only a short time of duration (up to 30 minutes). Besides torrential rainfall, storms are usually accompanied by gusty wind, electrical discharges, or hail. Heavy rainfall can also cause other adverse phenomena, especially soil erosion and slope movements, which may subsequently cause disruption of transport infrastructure, clogged sewage, reduction of flow capacity of riverbeds and retention area of water recipients.

Extreme snowfall can cause an extraordinary situation in view of a strong intensity of snowfall or with regard to creation of enormously high snow cover. An intensive snowfall, frequently accompanied by wind, causes acute problems in the form of reduced visibility, road impracticability, creation of snowdrifts, etc. The creation of a high snow cover is associated with avalanche risk, damage to building structures, disruption of infrastructure (e.g. energy industry, transport), damages to forest cover and special agricultural crops (e.g. fruit orchards, hop gardens, vineyards), reduced food availability for wildlife, etc.

This category of risks includes also glazed frost and rime. Glazed frost comes to existence by freezing small drops of freezing fog or rain at their contact with the Earth´s surface, with surfaces of objects at a temperature below freezing point. Black ice raises from freezing a wet surface when the temperature drops bellow freezing point. A strong rime as well as high snow cover can cause extreme mechanical stress, which can endanger human health and life, damage of buildings, disruption of critical infrastructure elements, especially in energy industry, transport, and damage of forest cover and special agricultural crops.

Extremely high temperatures

Thermal stress can lead to subjective difficulties and objective health disorders in varying range and intensity, to increased energy demands for cooling, to negative impact on economic performance and to decreased quality of life. The consequences of extremely high temperatures include above all with the thermal stress associated increased mortality and sickness rate of the population, especially in cities.

Extremely high temperatures are exacerbated by direct sunlight resulting in greatly heated surfaces, particularly artificial ones, which causes higher air temperatures in their neighbourhood than in open countryside.

Extreme wind

In the Czech Republic, dangerous wind speeds occur during the winter half of a year in the procedure of deep depression towards east, in the summer half of a year in an intensive storm activity. Extreme wind with serious consequences usually affects only a certain part of the territory. The wind consequences consist above all in impacts on transport, energy industry, roads and settlements and on forest cover, which can be totally damaged or destroyed. There are dangerous falls of wind-loosened objects. The energy infrastructure is directly endangered causing consequent domino effect. Adverse impacts are manifested both directly by the kinetic energy of the wind and indirectly by the decrease of visibility due to the turbidity of the atmosphere by wind-driven particles as well as the danger of road impassability due to their sedimentation, or by creation of snowdrifts.

Wildfires

Wildfires, i.e. mainly fires of forests, grassland, farmland and peat bogs, constitute a present problem. In the context of climate change, we expect a higher frequency of dry and hot seasons, and therefore we must anticipate the increasing frequency and seriousness of wildfires. A higher probability of their outbreak occurs with lower humidity of organic matter (grassland, forest cover, forest floor, etc.), drought, lower humidity of the environment (air, soil), higher air temperature and higher length and intensity of sunshine. Vegetation fires can be caused by an abiotic natural agent (e.g. lightning), but the most common cause of fires in the natural environment is making naked flame, grass burning, and smoking in the wild. Fires can also raise from agricultural machinery, or transport (railways). Strongly complicating factors, especially for forest fires, include particularly rapid spread of fire on vast areas, long distance of water availability for fire intervention, poor access to fire due to terrain configuration and missing access roads, and the necessity of deployment of a high number of persons and fire fighting techniques.

Besides the threat to property, health and life of the population, wildfires have a considerably devastating impact on the environment. The grave ones can include fires of border forests with spreading over the state border and fires of particularly valuable biotopes jeopardizing ecological stability or directly immediate existence of the biotopes. In case of fires in protected areas, the problem is the environmental damage and the risk of their damage during the fire intervention.

Vast area fires cause significant air contamination. Particularly meteorological situation (temperature, relative air humidity, wind, altitude, etc.) influence the overall adverse impacts of fires.

6.1.2.2 Specific objectives of Strategy on Adaptation to Climate Change in the Czech Republic

The following Table gives the overview of specific objectives defined in the National Action Plan on Adaptation to Climate Change. Objectives highlighted in colour can be relevant to the City of Liberec.

Tab. 66 Specific objectives of the Strategy on Adaptation to Climate Change in the Czech Republic

Number	Specific objective
SC1	Supporting natural adaptability of forests and enhancing their resilience to impacts of climate change
SC2	Protection and restoration of natural water regime in forests
SC3	Improving land adaptation with respect to climate change
SC4	Ensuring and preserving genetic sources in agriculture
SC5	Stopping soil degradation due to excessive erosion, depletion of nutrients, loss of organic matter and hardening
SC6	Reducing arise and impacts of agricultural drought
SC7	Strengthening stability and biodiversity of agricultural ecosystems
SC8	Ensuring sustainability and production function of agricultural farming in the country to reduce the adverse impacts of climate change
SC9	Improving risk management in agriculture
SC10	Improving management of rainwater by using it in urbanized areas
SC11	Improving the natural retention capacity of watercourses and (water)meadows
SC12	Efficient protection and use of water sources
SC13	Mitigation of flood consequences in urbanized areas
SC14	Strengthening environmental stability and reducing risks related to temperature and air quality in urbanized landscapes
SC15	Adaptation of buildings to climate change
SC16	Supporting settlement adaptability by reducing urbanized area footprint
SC17	Improving environmentally-stabilizing roles and permeability of landscape
SC18	Conceptual extension of nature protection by climate change prospects
SC19	Limiting spreads of invasive species
SC20	Ensuring research, prevention, health care and elimination infectious and non-infectious diseases
SC21	Managing and developing friendly and sustainable tourism with respect to climate change
SC22	Strengthening a knowledge base of mutual relations and effects of climate change on tourism
SC23	Ensuring flexibility and reliability of the transport sector with respect to the effects of climate change, ensuring the traffic after extreme weather conditions
SC24	Ensuring the safety of industrial facilities in relation to expected effects of climate change
SC25	Ensuring strategic reserves of the Czech Republic
SC26	Ensuring the possibility of off-grid operation
SC27	Ensuring a high resistance of the Czech transmission grid, diversifying transport routes and source territories
SC28	Renewable energy sources resisting the effects of climate change
SC29	Protection of population, early warning system for extraordinary events
SC30	Developing and strengthening the integrated rescue system
SC31	Improving the critical infrastructure protection
SC32	Improving environmental safety

Number	Specific objective
SC33	Developing safety research and development
SC34	Educating, training, awareness raising in relation to climate change

Data source: National Action Plan on Adaptation to Climate Change

6.2 Adaptation Strategy – Liberec

Liberec does not have a separate Strategy on Adaptation to Climate Change. However, some climatic risks are mentioned and some adaptation actions designed in other strategic documents.

The Adaptation Strategy should be prepared at the time of the city´s joining the Covenant. Adhering to SECAP Guidelines, the following items should be prepared:

- Risk analysis – within 2 years of joining
- Adaptation actions – within 4 years of joining.

The following strategic documents of the City relate to adaptations to climate change:

Tab. 67 Documents related to the assessment of risks and vulnerability associated with climate change

Name	Author/s	Year
Territorial Landscape Study Commissioning	ÚAP and GIS Department of the Statutory City of Liberec	2019
Update of the Development Strategy 2014-2020 of the Statutory City of Liberec	Department of Strategic Development and Subsidies of the Statutory City of Liberec	2014
Flood Plan of the Statutory City of Liberec	Ing. Jan Papež, Ing. Lumír Pála, Hydrosoft Veleslavín, s.r.o.	2014
Waste Management Plan of the City of Liberec	ISES, s.r.o.	2016

Data source: Municipal Authority of Liberec

6.3 Risk and vulnerability climatic analysis (RVA)

Since the City of Liberec has not yet developed the Strategy on Adaptation to Climate Change, a risk assessment has been carried out in collaboration with the staff of the Municipal Authority of Liberec. Following three Tables show the assessment summary:

Tab. 68 Climatic risks relevant particularly for the Statutory City of Liberec

Climatic risk type	Current risk level	Expected change of frequency	Expected change in frequency	Timeframe	Risk related indicators
Extreme heat	Medium	Increase	Increase	Medium-term	• Number of days/nights with extreme temperature (compared to ref. annual/seasonal temperatures at day/night times) • % change in average annual/monthly temperature • % share of sensitive population groups (e.g. elderly (65+)/young (25-) people, lonely pensioner households, low-income/unemployed households) – compared to national average in year X in country X
Extreme cold	Low	Reduction	Reduction	Medium-term	• Number of days/nights with extreme temperature (compared to ref. annual/seasonal temperature at day/night times
Extreme precipitation	High	Increase	Increase	Current	• Number of days/nights with extreme precipitation(compared to ref. annual/seasonal precipitation at day/night times for each season
Floods	Medium	Increase	Increase	Long-term	• Number of flash floods
Droughts	Medium	Increase	Increase	Long-term	• Number of consecutive days/nights without rainfall
Storms	High	Increase	Increase	Current	• Number of storms, storm type
Landslides	Medium	Increase	Increase	Long-term	• Number of landslides/slides of rock massifs • Number of areas at risk on the territory
Forest fires	Low	Increase	Increase	Long-term	
Other **Extreme wind**	Medium	No change	No change		
Black ice and snow	High	Increase	Increase		• Number of days reported as black icy

Data Source: Municipal Authority of Liberec

Tab. 69 Vulnerability of the Statutory City of Liberec

Vulnerability type	Vulnerability-related indicators
Socio-economic	Temperature rise – deterioration of conditions in social, health, school facilities, increased cooling demand (agreement with heat supplier – cold supplies) Number of days of public service interruption (i.e. energy/water supply, health service/civil protection/rescue service/waste collection
Physical & environmental	Rainwater runoff – damage on buildings. Change in amount of precipitation, floods and damage to infrastructure

Data Source: Municipal Authority of Liberec

Tab. 70 Expected impacts on the Statutory City of Liberec

Impacted policy sector/s	Expected impact/s	Probability of occurrence	Expected impact level	Timeframe	Impact-related indicators
Buildings	Increased demand for cooling and thermal insulation, esp. schools, social services, health care	Probable	Medium	Medium-term	• Increased energy consumption, increased City budget expenditures
Transport	Damage of transport infrastructure	Possible	Low	Medium-term	• km of damaged roads / networks
Energy	Damage of transmission networks, heat supply, electricity and gas supply	Probable	Low	Long-term	• number of days with public service interruptions (e.g. energy/water supply, waste collection)) • number or % of transport/energy/water/waste/ICT infrastructures damaged by extreme weather conditions/phenomena
Water	Increased lack of water	Probable	Low	Medium-term	
Land use planning	Heat island effect, floods with imperfect rainwater drainage	Possible	Not available	Long-term	
Environment & Biodiversity	Forest monocultures – endangered by bark beetle, dam – cyanobacteria, knotweed invasion	Not available	Not available	Not available	

Data Source: Municipal Authority of Liberec

The biggest climate risks endangering the City of Liberec include:

- Floods of the Lužická Nisa river and its tributaries – flood endangers all types of buildings (residential buildings, services, industry including critical infrastructure – DH plant, TERMIZO, railway…). There are also various sources of possible pollution in flood zones. Heat supply led through the Lužická Nisa riverbed is also endangered.
- Strong storms with flash rainfalls when there is a danger of flash floods and flooding of the whole centre.
- Black ice and snow, disrupting traffic and endangering electrical networks.

6.4 SECAP Adaptation Actions

The City Adaptation Strategy should establish specific adaptation actions and details on their implementation. Some examples of suitable actions for the greatest risks for the City of Liberec are mentioned below. Some actions can contribute to reducing more types of risks.

Tab. 71 Suitable actions for reducing the greatest climatic risks for the Statutory City of Liberec

Risk	Action
Extreme precipitations	• Preserving flood zones • Building dry polders • Revitalizing and building side arms of water courses, pools and wetlands • Capturing rainwater and its subsequent use for urban greenery irrigation • Developing and strengthening of the integrated rescue system
Storms	• Increasing the share of permeable areas in the City • Capturing rainwater and its subsequent use for urban greenery irrigation • Capturing rainwater and its use as non-potable water • Infiltration contour furrows, rain gardens • Developing and strengthening of the integrated rescue system
Black ice and snow	• Early Warning System • Wind barriers • Road maintenance plans • Increasing critical infrastructure protection • Developing and strengthening of the integrated rescue system
Drought	• Capturing rainwater and its subsequent use for urban greenery irrigation • Capturing rainwater and its subsequent use as non-potable water • Revitalizing municipal park
Extreme heat	• Green roof (new buildings with flat roofs) • Fountain in the City • Early Warning System • Landscape planning – building orientation, respecting the terrain morphology … • Building regulations for building insulation and shading using greenery, building passive cooling • Revitalizing municipal park

Within the property of the city, these measures were designed and supplemented by cost analysis.

Tab. 72 Indicative unit cost of individual adaptation measures

Measure type	Price range	Unit
Sun protection (outdoor shielding)	3,000,–,12,000	Kč / m^2 okna
Rainwater utilisation for watering	1,200,–,2,200	Kč / m^2 střechy

Rainwater use for flushing	2,200,–,4,600	Kč / m^2 osobu
Green roofs	1,000,–,3,000	Kč / m^2 střechy
Rain gardens	2,500,–,5,000	Kč / m^2 zahrádky
Sinking tunnels	20,000,–,80,000	Kč / 100 m^2 odvodňované plochy

Notes on unit costs:

- Costs are considered without major building modifications, usually as part of a comprehensive renovation of the building
- By persons is meant the users of the object (employees, pupils, teachers, or alternatively the indicator of water management terminology "equivalent inhabitant" can be used).
- In the case of a combination of green roofs and using rainwater for grouting, the unit price is higher.

Tab. 73 Indicative estimate of cost of adaptation measures within the property of the city 2015 – 2030 (in CZK thousand)

Measure type	Estimated cost of implementation of the measure [thous. CZK]
Sun shielding	6,000
Rainwater management	4,000
Green roofs	3,000
Rain gardens	2,000
Sinking tunnels	12,000
Total cost of all measures	**29,000**

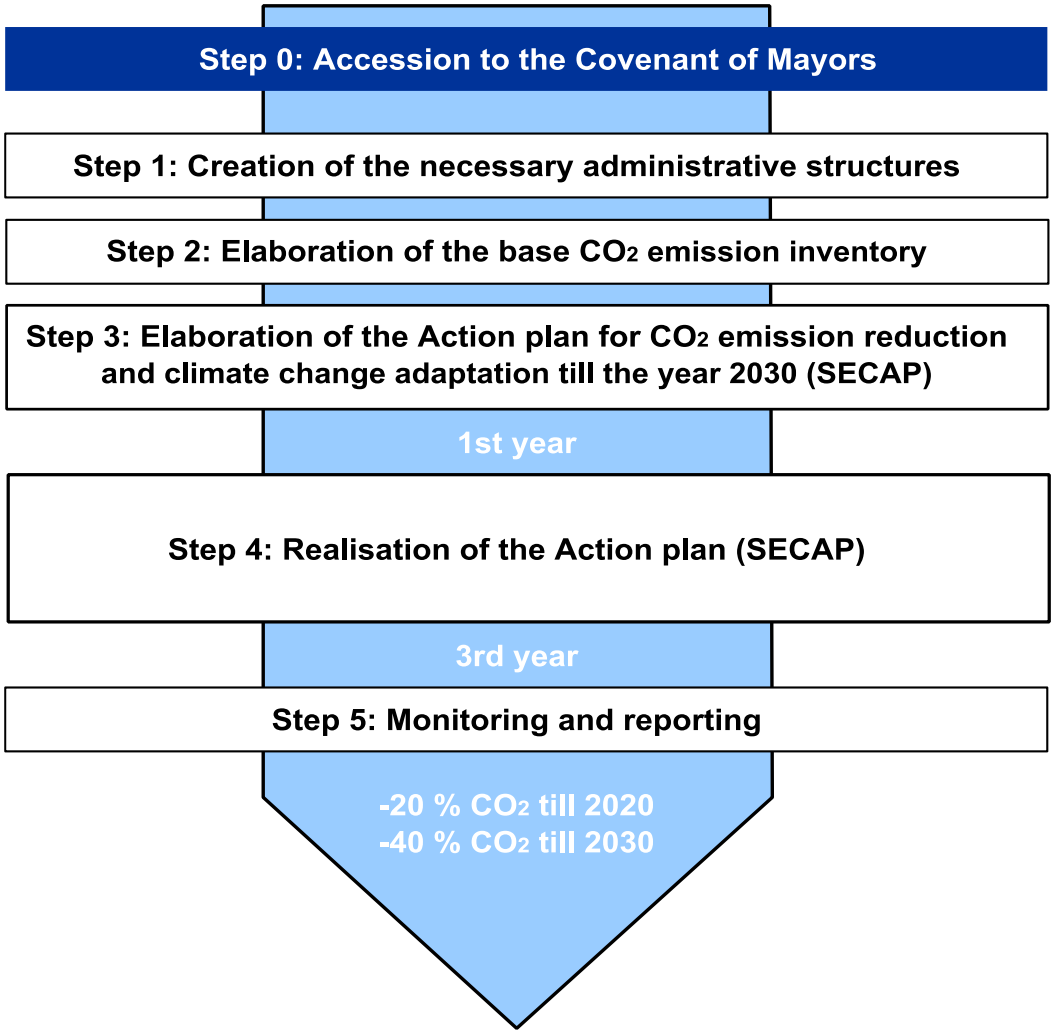
For the city of Liberec, there is a significant risk of intense rainfalls, which is why water and water retention measures are proposed.

7. ACTION PLAN IMPLEMENTATION

7.1 Creation of the Necessary Administrative Structures

The following Picture shows the recommended procedure for SECAP development:

Fig. 16 Procedure recommended if joining the Covenant of Mayors



Source: Action plan guidance elements (redrawn)

The preparation of the City Policy and Action Plan is lengthy and needs systematic planning and managing. Collaboration and coordination between City Departments is essential. Emission Reduction Plan can be successful only if all these departments take it for their own, involving it as part of their daily routine and do not perceive it as an issue not falling under their field of activity.

A clear organizational structure and determination of responsibilities are prerequisite for successful and sustainable plan implementation. Poor coordination of strategic materials and policies, activities of individual departments and external institutions are a frequent problem, which local governments experienced when implementing e.g. energy management, or in energy and transport planning.

That´s why the requirement for mainstreaming or, if needed, adjusting the organizational structure of the city, and allocation of sufficient number of staff for the Action Plan preparation and its implementation, including monitoring and evaluating, became a formal commitment for those

joining the Covenant. The Covenant signatories create an individual apparatus with sufficient powers, funding and human resources to manage duties associated with the Covenant commitments. How to adjust the City administrative structure?

At the beginning of the whole process of joining and Action Plan developing, a **Covenant Coordinator** should be nominated. He/she should have a full political support, time and budget for handling the task. In big cities, a special separate unit dedicated just to these matters should be available for the coordinator, employing several workers, one of whom can focus on data collection and CO_2 emission inventory.

As an example, the City can establish two groups:

- Steering Committee made up of politicians and managers – for setting strategic directions and providing the necessary political support.
- One or several working groups consisting of energy planning manager, key staff from individual and collaborating departments, agencies, etc. These people will develop the Action Plan and prepare the follow-up activities. They will ensure the participation of stakeholders, organize and ensure monitoring, prepare reports, etc. These working groups can be open also to other personalities coming from outside the city.

Both the Steering Committee and working groups need clear management irrespective of the fact they are supposed to be able to work together. The objectives and roles must be clearly defined. Reports, administrative work, schedule – these are issues necessary to master the SECAP creation and especially the implementation.

Sustainable energy management must be integrated into other activities and initiatives of other relevant departments. It also must become part of general planning of the municipality/City development. The responsibility for individual areas should be allocated, set and shared as clear as possible – good organisation of the process with task leaders is essential. A special communication campaign can be useful to convince the office staff from different departments.

Areas of activities that cannot be underestimated include both technical skills and training in specific fields (such as energy efficiency, renewable energy sources, efficient transport,…) and management skills, project management, data processing (lack of knowledge in this field can lead to serious consequences), financial management, investment project preparation, communication…

7.2 Examples of possible ways of SECAP management in EU

Vienna

Among Benchmarks of Excellence, we can mention Vienna and its Climate Protection Programme (KliP). The KliP Programme started as early as in 2000 and the City joined the Covenant of Mayors later (in 2012). All organizational structures however were set. In Vienna, they realistically evaluated achievable actions first, than set the objective (1990 – 2020 emission reduction by 20% per capita). KliP, which is simultaneously the Sustainable Energy Action Plan adhering the EU methodology, contains five areas of activities:

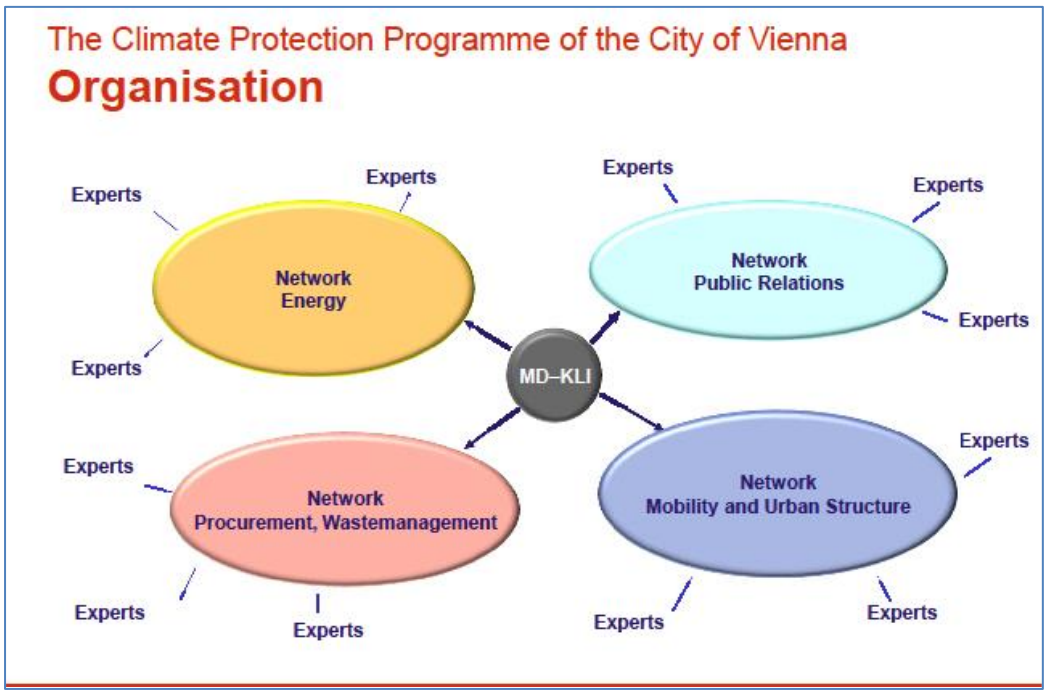
1. Energy production
2. Energy use and savings
3. Mobility and infrastructure
4. Public procurement, waste treatment, agriculture, forestry
5. Marketing

The Fig. 17 shows the KliP implementation structure. The KliP office (MD-KLI) has five employees with the support of different City Departments and institutions and external experts. For this purpose, they created four working groups:

- Energy (energy production and savings)
- Mobility and infrastructure
- Public procurement, waste treatment (other – agriculture, forestry)
- Marketing (cooperation with the public)

Each working group includes experts from the City and municipal institutions (e.g. from the municipal DH plant, technical services, social housing, etc.). Their expertize serves as a basis for designing and implementing new actions.

Fig. 17 Organization chart – KliP Vienna



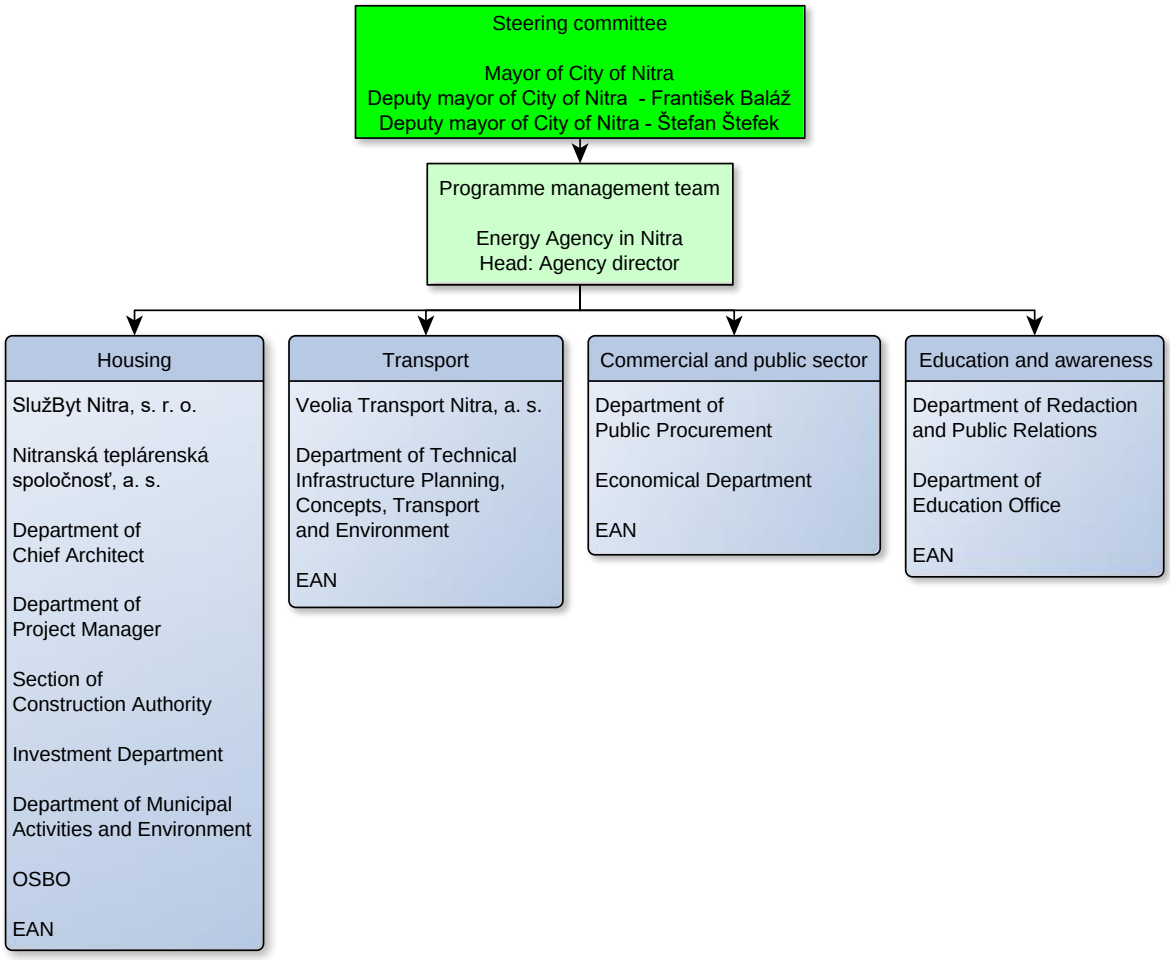
Nitra

The chart of the Slovak City of Nitra is relatively simple. Nitra signed the Covenant of Mayors as the first Slovak City in 2008. The organization chart created by the City is relatively simple. It has three layers:

1. The Steering Committee in which Mayor, Deputy Mayor, etc. are in session
2. Programme Management – responsible for the Action Plan coordination and implementation. The responsible institution is the Energy Agency in Nitra (EAN).
3. Four working groups, with representatives of City Departments/institutions and stakeholders. The working groups were categorized as follows:
    - Housing
    - Transport
    - Commercial and public sectors
    - Training and awareness raising

Both Vienna and Nitra have thus created special organizations to implement SECAP. In Vienna, it is the KliP office, in Nitra the Energy Agency.

Fig. 18 Organization chart – SECAP Nitra



Source: Own elaboration of EAN, 2010

(Redrawn)

In particular, Nitra was inspired by the chart in the SECAP Manual designed by the Covenant of Mayors Secretariat, http://www.paktstarostuaprimatoru.eu/IMG/pdf/seap_guidelines_en-2.pdf

The basis of each organization chart consists of:

- The Steering Committee in which e.g. politicians and other City leaders are in session
- Programme management, or SECAP office, responsible for the SECAP implementation
- Several working groups providing their expertise to the SECAP implementation.

7.3 Designed SECAP management structure for Liberec

7.3.1 Creating the necessary administrative structures

Involving stakeholders and citizens

- Authority
  - Municipal Authority Departments
- Key City institutions:
  - The Transport Company of Liberec and Jablonec nad Nisou (Dopravní podnik měst Liberce a Jablonce nad Nisou)
  - Technical Services of the City of Liberec
- Stakeholders in the city:
  - The Regional Office of the Liberec Region
  - MVV Energie CZ a. s. (the owner of the DH plant Liberec, Termizo Waste-to-energy Plant and the Municipal DH system)
  - The Technical University in Liberec (TUL)
- The Public (workshops, website)

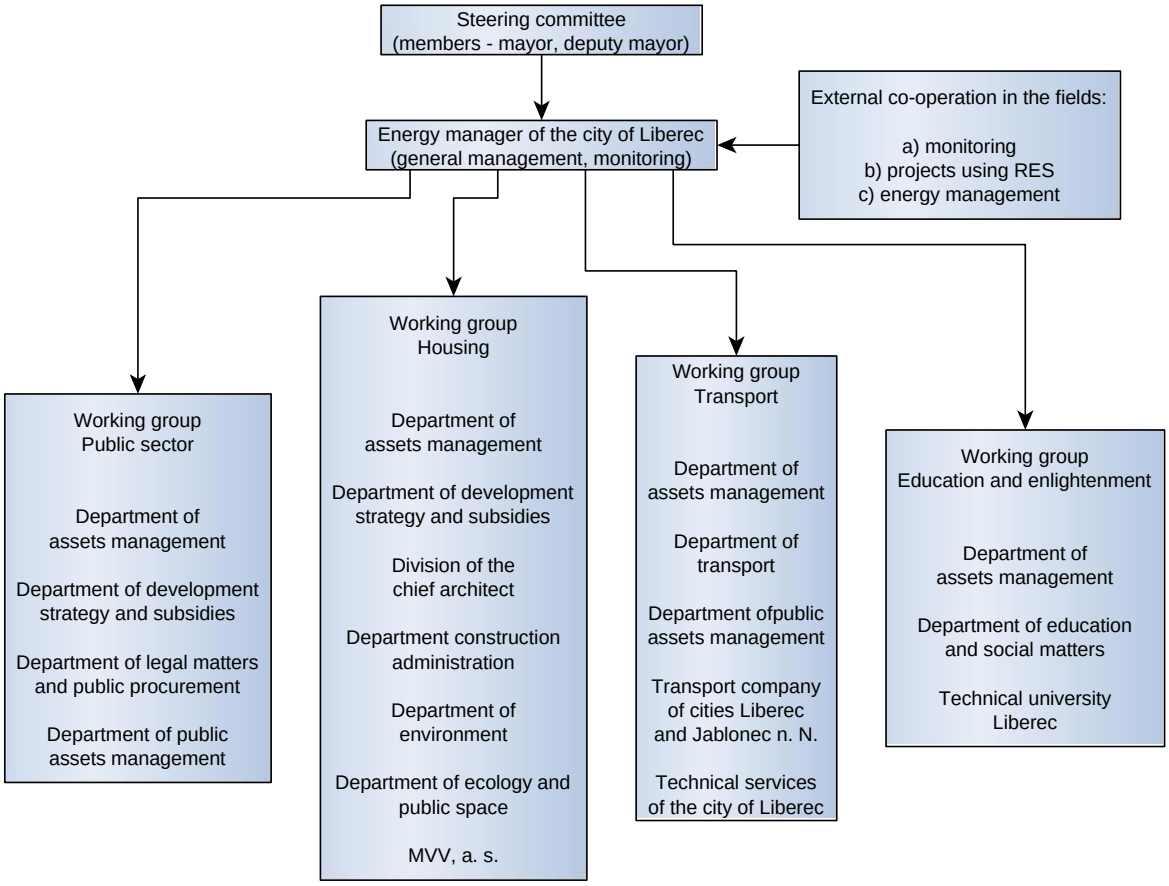
7.3.2 Designed SECAP management structure in Liberec

First, the City of Liberec should establish a separate job – **Energy Manager of the City of Liberec**. In terms of organization, this job should fall under the Department of Assets Management, the Department of Building and Facility Management. During the SECAP implementation, the Steering Committee, composed of City leaders, should provide support to this Department.

According to the activities designed, we can consider creation of four working groups:

- Public sector
- Housing
- Transport
- Training and awareness raising

Fig. 19 Organization chart of SECAP securing (Departments and institutions involved)



We identified three activities, for which it would be advisable to support the City by external collaboration, as the current Municipal Authority staff capacity could be insufficient. It concerns mainly:

1. Monitoring the SECAP implementation (every two years after SECAP submission),
2. Implementation of major projects in the field of energy industry (e.g. RES projects)
3. Introduction of energy management in municipal buildings (both the assets managed by the Municipal Authority and institutions established by the MA).

7.3.3 Involvement of City Departments

The Table below shows the departments and their proposed involvement in the SECAP implementation.

Tab. 74 Activities of individual departments and municipal institutions in relation to SECAP

Department	Activity	Role in SECAP
Department of the Environment	Department of the Environment to the Liberec Municipal Authority performs the state administration in delegated powers in the field of environmental and monument care in the scope assigned to municipal authorities, authorized municipal authorities and municipal authorities with extended competence pursuant to individual constituent laws. In its independent competence, it imposes fines and correction measures pursuant to Act 128/2000 Coll., On Municipalities, as amended.	The Department arranges benefits of subsidy applications for solid fuel boiler replacement in households and other buildings for SECAP monitoring. Supervises the compliance with emission limit values from combustion sources.
Department of Strategic Development and Subsidies	The department monitors possibilities of drawing energy resources in favour of the Statutory City of Liberec (SCL). It provides SCL institutions with advice on EU funds. It implements the Integrated Development Plan for Liberec - Jablonec nad Nisou.	The Department collaborates on coordination of SECAP with other strategic documents of the city. It continuously monitors EU funding opportunities available for SECAP actions/measures.
Department of Transport	The Department of Transport carries out activities related to the administrative work entrusted by the state to the Municipal Authority of Liberec for the district of extended competence of the Statutory City of Liberec. It performs activities related to registration or permission of activities arising particularly from the provision of Act 13/1997 Coll., On Road Traffic, Act 361/2000 Coll., Road Traffic Act and Act 56/2001 Coll., On Conditions for operating vehicles on roads. In its activity, it collaborates with road owners or road administrators and the Police of the Czech Republic.	The Department is a partner for transport related measures under SECAP.
Law and Public Procurement Department	Law and Public Procurement Department provides comprehensive legal service, and performs legal acts associated with the activities of the Statutory City of Liberec and coordinates procedure of individual departments in public procurement.	The Department coordinates preparation of public procurement related to SECAP implementation.
Department of Assets Management	It completely prepares and implements (or coordinates) investment-requiring maintenance, inspections, reparations, refurbishment and reconstruction in buildings in the property of SCL serving for social, health or housing purposes of the City of Liberec. Operationally and continuously provides the maintenance of buildings serving for social, health or housing purposes of the City of Liberec and their facilities in accordance with valid regulations, including flexible arranging emergency repairs as part of continuous incident reporting and emergency service. Provides administration and coordinates maintenance, prepares documentation for project preparation for property of contributory organizations established by SCL for the purpose of providing social and health services; comprehensively prepares,	This Department is the most suitable for establishing Energy Manager job. The Department is a partner for SECAP implementation and determines investment priorities in the field of energy savings in buildings administered by the Municipal Authority, also considering their possible benefits in reducing energy consumption, costs and CO_2. It will ensure monitoring of this investment benefits. The Department is responsible for combined natural gas and electric energy purchase for all municipal buildings as well as for heat purchase. Data that are available for this purpose are default data for SECAP monitoring. Energy and natural gas purchase has also a significant impact on the City

Department	Activity	Role in SECAP
	implements or coordinates refurbishment and repairs of investment character in buildings serving these contributory organizations. Completely administers all Municipal Authority of Liberec (MAL) buildings (except for buildings serving MAL), ensures their operability – media supply, maintenance, repairs, investments and development. Ensures wide-range inspections (electronic security systems - ESS, electronic fire systems – EFS, electricity, gas, diesel generator, air conditioning, cooling, lifts, etc.). Completely provides administration, maintenance and investment activity associated with all the real estates and related property owned by the Statutory City of Liberec, the guarantor of which is the Department of Education and Culture. Provides pre-project and construction project preparation, construction realization, building acceptance from contractors and final inspection for occupancy certificate awarding. Prepares public procurement documentation and participates in tendering for specified construction.	economy. By means of updated data, benefits of SECAP energy efficiency measures implemented in the City, property can be monitored in terms of energy and fuel consumption and costs. We suggest interconnecting activities in the field of combined purchase with energy management activities (when purchasing energy, to set conditions for energy suppliers to inform on energy consumption of individual buildings). In addition, the operators will introduce and require registering energy consumption once a year within the Purchase Portal. Energy management introduction is essential for SECAP monitoring.
Department of Public Assets Management	The Department activity includes the administration and maintenance of roads, public lighting, bridge structures, traffic signs, municipal cemeteries, the Vestec Recreational and Sports Centre and actions of investment character to the listed property owned by the Statutory City of Liberec.	The Department is a partner for SECAP implementation in fields and measures related to transport and public lighting by means of the Technical Services of the City of Liberec and the ELTODO-CITELUM company. It submits proposals of investment actions for the transport sector and public lighting for budgetary outlook and determines investment priorities in these areas. It is responsible for SECAP measure implementation in transport and public lighting.
Chief Architect Department	It issues partial statements to land use proceedings in terms of a land use proceeding participant pursuant to § 85 subsection 1 paragraph b) of the Building Act. Based on documentation of self-governing Departments, it provides statements and represents the Statutory City of Liberec in administrative proceedings, concludes contracts for consent to construction or measure implementation in cases where the competence is not delegated to other departments.	The Department is responsible for land use planning. The land use planning includes among others so called areas to be built and reserved areas (areas with the potential for new construction). It also determines where new industrial areas can be. Currently, the land use planning does not include the condition that the building operator must not disconnect the building from district heating system. This condition is not included even in the city´s internal guidelines. This trend threatens the stability and efficiency of DH system and heat supply.
Department of Education and Social Affairs	It performs the Department of Education and Social Affairs administrative work. Provides all administration of the Education Support and Development Fund including	The Department collaborates with the Department of Assets Management in determining investment priorities in school and social service buildings. It will also collaborate in providing

Department	Activity	Role in SECAP
	board of directors. Prepares and concludes contracts with subsidy beneficiaries from the Education Support and Development Fund.	documentation for energy management implementation. The Department provides promotional and educational activities for the public.
Department Building Office	It conducts construction proceedings for the Liberec, Jeřmanice, Šimonovice, Dlouhý Most and Stráž nad Nisou municipalities.	The Department supervises complying with the building standards in terms of energy performance.
Environment and Public Space Department	It provides comprehensive administrative work relating to investments to development and restoration of public greenery and playgrounds on land owned by the Statutory City, comprehensive administration of small watercourses, and landfills, rock massifs owned by the Statutory City.	The Department will collaborate in particular in designing adaptation actions to climate change.
Department of Informatics and Process Control	The Department of Informatics and Process Control sees to functioning and development of the information system of the Municipal Authority of Liberec. It also maps process procedures in performing MAL administrative activities.	The Department will collaborate on energy saving data administration and monitoring in municipal buildings or subordinate institutions.
Transport Company of the Cities of Liberec and Jablonec nad Nisou	It operates public transport in Liberec and Jablonec nad Nisou (bus and tramlines).	Determines investment priorities in public transport. Prepares potential subsidy applications for the area of public transport.
Technical Management od the City of Liberec	It sees to construction and maintenance of City roads, ensures road practicability in the city, maintains the City greenery and ensures City cleaning.	Monitors benefits of SECAP measures implemented in City roads.

7.4 SECAP Communication Strategy

7.4.1 Summary of current situation

What have you done in the field of communication? How successful has it been? What have you achieved in communication? What tools do you use and what with what results?

Tab. 75 Spheres of communication (related to SECAP)

Sphere	Materials/activity	Year of publication/distribution	Target audience
Energy planning, energy supply, energy savings, etc.	Municipal Energy Strategy of the City of Liberec (CL MES)	2003	Residents of the City of Liberec (CL)
	CL MES update 1	2010	Municipal Authority
	CL MES update 2	2016, not approved by the MA yet	Municipal Authority
	Development Strategy of the Statutory City of Liberec for 2014 – 2020 – Update Strategic goals D7 and D8	2014	CL residents, MAL Departments, CL local government
Transport – sustainability, reduction of emissions, reduction of energy consumption, traffic load, etc.	Statutory City of Liberec Development Strategy 2014 – 2020 – Update Strategic goals D1 to D6	2014	CL residents, MAL Departments, CL local government
	Development of strategic analysis for the development area „Technical Infrastructure, Transport Accessibility“ and Availability“ (documentation for the Strategy update)	2012	MAL, City Development Department
Climate change adaptation	Commissioning of the Territorial Landscape Study for the municipality with extended competence Liberec	2017	MML, Land Use Planning Department

Tab. 76 Used communication tools

Document/Activity	Tool
Municipal Energy Strategy of the City of Liberec (CL MES)	Publishing on the City website
CL MES Update 1	Sending the document to stakeholders
CL MES Update 2	Sending the document to stakeholders
Statutory City of Liberec Development Strategy 2014 – 2020 – Update Strategic goals D7 and D8	Publishing on the City website
Statutory City of Liberec Development Strategy 2014 – 2020 – Update Strategic goals D1 to D6	Publishing on the City website
Development of strategic analysis for the development area „Technical Infrastructure, Transport Accessibility“ and Availability“ (documentation for the Strategy update)	Sending the document to stakeholders
Commissioning of the Territorial Landscape Study for the municipality with extended competence Liberec	Sending the document to the stakeholder group – city Departments, local government representatives, SECAP author/s, representatives of selected concerned entities operating within the territory

7.4.2 SECAP - project goals

The purpose of the communication strategy is to support the achievement of project goals – the transformation. It is useful to summarize here your particular project goals.

The aim of the project is to achieve a substantial CO_2 reduction in the City in the selected sectors, which the City can influence by its activity. Achieving this goal means to enforce activities resulting in CO_2 reduction in sectors concerned.

Tab. 77 SECAP sectors concerned and activities to reduce CO_2 emissions

Sector	Measures to reduce emissions
Municipal buildings, facilities/equipment	Heat savings for space heating – all measures including RES use Hot water savings – all measures including RES use Obvious electricity savings Energy management
Tertiary sector (except for the municipal property) – buildings, facilities/equipment	
Residential buildings	
Public lighting	Electricity savings in light sources Consumption control
Urban road transport: municipal fleet (Municipal Authority´s vehicles, waste collection, police…)	Reduction of specific vehicle consumption – use of vehicles with higher EURO Reduction of vehicle kilometres travelled Support of cycling Support of pedestrian traffic Parking and navigation systems Greening of public transport Greening of municipal fleet and municipal institutions´ fleet
Urban road transport: public transport	
Urban road transport: passenger and company transport	
Urban rail transport	

7.4.3 Communication Goals and Target Groups

What do you want to achieve in the field of internal and external communication? How will these goals contribute to achieving the project objectives mentioned above?

The aim of communication is to launch/deepen activities resulting in CO_2 reduction. The communication is both internal – within the city, and external – towards the region and target groups outside the City structures.

7.4.3.1 Internal Communication

a) <u>SECAP defence and approval</u>

The Municipal Authority must approve SECAP before submitting it to the Covenant of Mayors Office. Prior to the approval of the Municipal Authority, the Municipal Council will discuss it, prior to its discussion in the Council, it should be agreed and accepted by the Municipal Departments – they will be in charge of its implementation. The Departments should be aware of their involvement and tasks in measure implementation under SECAP.

Tab. 78 Project team communication at the SECAP submission

Field of SECAP	Target group inside the City	Communication tools
Discussion of SECAP „mitigation" action design: Energy savings in the municipal property (City of Liberec) Energy savings in the municipal housing stock Energy savings in public lighting Energy savings in transport Use of RES in municipal buildings	– MAL – Department of Assets Management - Mr. Schejbal) – schools, kindergartens, energy management, swimming pool – MAL – Department of Public Assets Management - public lighting, actions to improve safety, P + R and B + R parking facilities, public transport preference, low-emission zones, telematics, car sharing – MAL – Department of Social Affairs – nursing homes, municipal housing stock, special purpose houses – MAL – Secretary´s Office Department, Department of building operation and administration – URAN, purchase of green vehicles for SCL, eco-driving – MAL, Department of Strategic Development and Subsidies – hub, support of cycling – MML – Chief Architect Department – measures in Land Planning for new construction – MAL – Personnel Department – eco-driving training for drivers – Transport Company of the City of Liberec, Regional Hospital of Liberec, Liberec Region, ZOO (meetings took place at SECAP action designing)	Written communication – sending documents Meetings „at the round table" with the participation of all actors Potential bilateral meetings with team members
Discussion of SECAP „adaptation" actions:	– MAL – Environment and Public Space Department – MAL – Chief Architect Department – actions in land use planning for new construction – MAL – Department of the Environment – Nature and Landscape Protection Agency	Written communication – sending documents Meetings „at the round table" with the participation of all actors Potential bilateral meetings with team members
Presentation of draft SECAP	– Municipal Authority – MAL Departments – SECAP author/s	SECAP Workshop organisation prior to its submitting to the Municipal Authority for approval Explanation of actions, etc. during the workshop
SECAP acceptance – approval	– Municipal Council – Municipal Authority	Presentation – examples, proposals
SECAP „mitigation" and „adaptation" action implementation	– Programme Management – MAL a SCL	

SECAP management

There is no established SECAP management structure (as per CoM– adaptation of administrative structures). The City of Liberec will create a Programme Management responsible for the SECAP implementation.

Proposal: The Programme Management needs a support in the **Steering Committee** made up of City leaders. These are activities related to the implementation of actions classified in SECAP as “mitigation” and “adaptation” ones. (Almost all actions are also embedded in the Development Strategy of the Statutory City of Liberec 2014 – 2020, partial activities in the Municipal Energy Strategy, and in other documents of the city).

Proposal: Working groups to support the SECAP implementation – according to the activities designed, the City can create five working groups (they are also listed in the draft implementation structure):

1. Public sector
2. Housing
3. Transport
4. Training and awareness raising
5. Climate change adaptation

Internal communication tools of working groups

- Meetings
- Internal newsletter, intranet
- Personal communication, etc.

b) Programme Management communication (persons responsible for the SECAP management):

The SECAP Programme Management – after signing the Covenant, once in two years, the City will be responsible for the implemented action monitoring and evaluating according to the set of indicators, which include also CO_2 emissions as one of benefit indicators. The results will serve for reporting on results achieved to DG TREN and the Covenant Office. It is important to ensure – from the very beginning of the system implementation – monitoring, verification and evaluation.

Continuous emission monitoring and inventory update is significant to motivate also all stakeholders who contribute to achieving the CO_2 reduction target – it enables them to observe the results of their efforts. The Programme Management communicates both inside and outside the City to collect data and evaluate results and benefits of implemented actions.

Tab. 79 SECAP implementation monitoring – ensuring information and data

TASK of the Management	Communication target group	Communication tools
Proposal to ensure continuous fuel and energy monitoring Responsible persons Budget	Department Manager Municipal Authority	Written communication Responsible persons' activities
Data collection for a compilation of SECAP interim monitoring inventories, collection of fuel and energy billed consumption Auxiliary data collection to calculate the consumption in the City in selected sectors Electricity production data in the City of Liberec – a database	RWE GasNet, s.r.o. ČEZ Distribuce, a. s. Teplárna Liberec, a. s. ČHMÚ All municipal buildings and facilities/equipment (ERÚ (Energy Regulatory Office) + own survey + Atlas equipment using renewable energy sources (www.calla.cz/atlas),	Creating an agreement to the transmitted data structure with data providers. Data collection for the municipal assets; the way of data collection will be decided by the Programme. Management; developing methodological instructions for building operators?
Data collection to calculate fuel and energy consumption in transport – road, public transport	The City and its departments and institutions	Working group meetings. Methodological instructions for the departments?
Collection of data necessary for monitoring results of actions implemented under SECAP, and benefit calculation	The City and its departments and institutions SCL Building Authority – housing stock insulation data (reporting to the Czech Statistical Office-ČSÚ)	Oral discussion Written – mail communication
Design of new projects	The City and its departments and institutions	Written – electronic communication Oral discussion Web application for new action designs for private persons
Preparation of projects and looking for appropriate subsidy titles for new action implementation and securing the operation of already implemented systems or system actions	Departments responsible for the budget and subsidy titles Municipal Authority	Written – electronic communication Oral discussion
Elaboration of monitoring CO_2 emission inventory	SECAP Programme Management, or external assistance	Written – electronic communication, Database documentation Oral discussion
Reporting	DG TREN and the Covenant Office	Written form – filling in web templates, report on monitoring balance and action results

7.4.3.2 External communication

To achieve the project goals, it is essential to raise awareness on

- The relation between climate change and fuel and energy consumption in stationary and mobile combustion sources, in waste disposal, etc.

- Climate change impacts,
- Actions taken by the city, and
- Actions that the citizens can take to reduce CO_2 emissions and to implement designed actions related to their target group.

Who can help us best achieve our project goals? Those who are to implement mitigation and adaptation actions are decisive. These target groups include:

- Municipal building operators (??? – are just City Departments enough?)
- City Departments,
- Public lightning operators,
- Mobile sources operators,
- Public transport operators,
- Residential building owners,
- Vehicle owners,
- Source operators in the city.

These are the groups to address. For each group we plan to communicate with, the Programme Management will work out the following items:

- What do we want to change for this group?
- What do we want the group would know/perceive?
- What do we know about the best ways to address them?
- What is currently their approach to CO_2 reduction: what do they know about it and what is their behaviour in terms of CO_2 reduction?
- What way do they prefer to get information? In what way do they get information most often?
- What prevent them from noting/perceiving/accepting information we deliver?
- What do we want them to do?

Key messages

In general, key messages are sentences, information, emotions used to adapt general communication targets for individual groups with which we communicate. They constitute the basic way to achieve consistency in communication (they enable to communicate the same information or emotions on a long-term basis – and repetition is the mother of wisdom).

In case of SECAP, the aim is to communicate the importance of the actions designed, general SECAP objectives – the importance of reducing greenhouse gas emissions, implemented action benefits, risks of their non-implementation.

Nevertheless – politicians should say what kind of contexts and approaches, etc.

External communication tools

We do not select the communication tools before knowing the target groups and key messages for them. We take into consideration the ways the given group communicates most often and we can adapt ourselves to it.

- media: TV, radio, internet servers,

- expert articles,
- comments,
- letters of readers,
- the Internet,
- company´s websites,
- Facebook, Twitter, etc.,
- Websites of friendly/partner companies,
- advertising,
- printed matter,
- leaflets,
- booklets,
- posters, etc.,
- public events,
- talks, lectures, conferences,
- phone calls,
- auspices of a well-known/distinguished personality,
- cultural events, open days, etc.

Tab. 80 Analysis of target group communication

Target group	Existing approach and awareness	Issue we want the group to know
Municipal Authority and Departments	We don´t know how they are informed, how they are authorized in terms of building supply, repair implementation, investment..	Building needs Possibilities to be economical in buildings MES importance (??) Adaptation actions
Municipal building operators	They are not always informed about their fuel and energy consumption and costs They know the selected problems with their building operation They report their repair and investment demands to MAL They involve pupils/students/staff/seniors/users to activities	Fuel and energy consumption and costs Savings opportunities in their buildings Costs of achieving these savings or RES use Way of data collection and their reporting Benefits of actions to reduce costs, to improve comfort in using building
Mobile source operators	Public Public transport drivers	Savings opportunities in transport. Emissions reduction, actions in transport, opportunities, how to implement.
Public transport operator	??	Adaptation actions
Residential building owners	??	Savings opportunities in their buildings Costs of achieving these savings or RES use Benefits – payback, impacts, benefits Adaptation actions
Vehicle owners	??	Savings opportunities in transport Emission reduction and actions in transport
Operators of sources in the City	The awareness is certainly good, especially in case of sources above 0.3 MW_t	Where to get information if needed?
Public	How public gets information currently?	Where to get information on energy performance, subsidies, climate change adaptation, RES use, …

Tab. 81 Proposal of SECAP external communication

Target group	The most frequent way of getting information	How to address them
Municipal building operators	Energy audits Energy Performance Certificates Boiler inspections according to Decree 194/2013	MAL – messages, instructions, Discussion workshop with explanation of city´s goals and objectives, etc.
Municipal mobile source operators	Media Internet Leaflets	Internal training
Public transport operator	Internal printed material	Internal training
Residential building owners Vehicle owners Public	Media Internet Leaflets Facebook, Twitter Posters Talks, lectures	City websites
Municipal source operators		Information on potential source measures Links to appropriate websites (e.g. TZB-info)
Pupils/students	Internet Facebook, Twitter	e-learning popularization programmes and games involving guards into monitoring

7.5 Overview of resources for SECAP measures funding

The Action Plan cannot be implemented successfully without funding resources. Improving energy efficiency, reducing CO_2 emissions and adapting to climate change has a strong link, particularly when striving to achieve the ambitious commitments of the Covenant of Mayors, with the need of considerable investments to the City property. It is therefore essential to know the appropriate resources for energy efficiency project funding.

Investments in energy efficiency projects go through an investment budget and thus must stack up to many other investment project competitions within the whole scope of activities of the city. The energy efficiency and climate protection investments, as ones of the few investment projects, have the potential for returning the invested resources to the municipal budget (by reducing energy payments) and reducing thus the required operating resources. Since the budget resources are limited, other possible funding resources should be continuously sought.

In Liberec, individual municipal departments must include the resources necessary for project implementation under the Covenant in annual budgets. Regarding the commitment funding in a long-term perspective, a long-term agreement of political parties is recommended to avoid problems after the new Municipal Authority Management election.

In fact, cities often decide to finance first energy efficiency projects with a short payback period. This procedure, however, does not allow capturing the largest part of energy savings, achievable by a complex building refurbishment, especially by thermal insulation, windows replacement, etc. Such measures are economical due to their long lifetime even at the payback of for example 15 years.

As potential resources for funding measures under the Action Plan, we can list:

- The City budget, the responsible Departments are as follows:
- External funding sources, including:
  - Operational Programmes (OPE, IROP, OPEIC, OPT) in 2014+
  - Other EU mechanisms (JESSICA, ELENA, JASPERS, IEE)
  - Other international funding (i.e. Norway Grants or Swiss Funds)
  - National Programmes (e.g. Green Savings, State Housing Development Fund)
  - EU funding through private financial institutions
  - Energy Performance Contracting

Financial schemes recommended by the Covenant Office are available here: http://www.paktstarostuaprimatoru.eu/support/funding-instruments_cs.html.

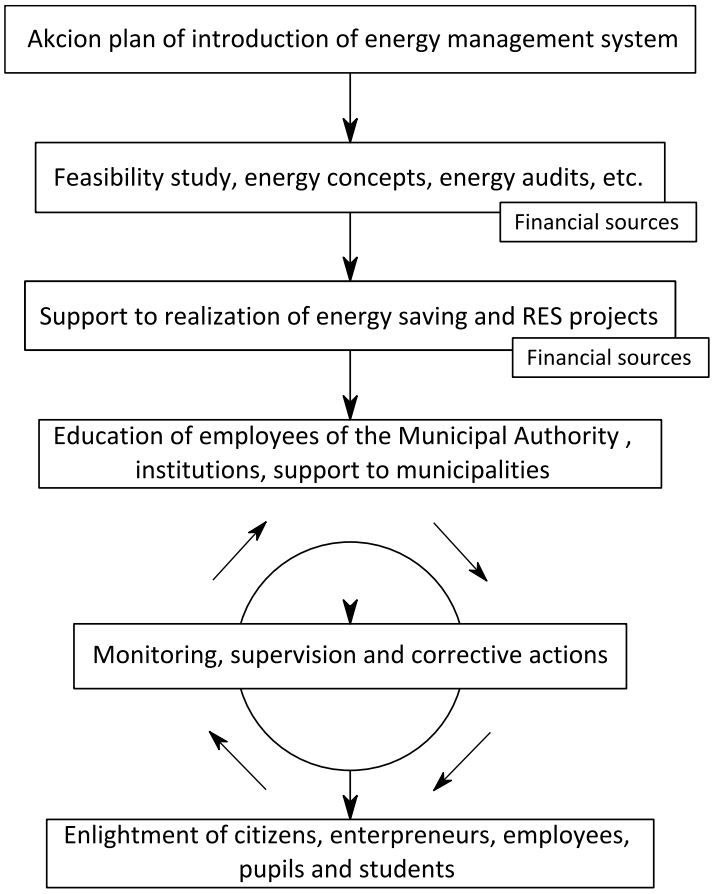
8. ACTION PLAN MONITORING AND EVALUATION

The Baseline CO_2 Emission Inventory (BEI) quantifies the amount of CO_2 emitted by fuel and energy consumption in the City in the baseline/reference year 2000.

Baseline Emission Inventory (BEI) is a tool that shows the City what the emissions were at the outset. The task of the City is to monitor how emissions develop compared to the 2030 target. Continuous emission monitoring and inventory update is important also to motivate all stakeholders who contribute to achieving CO_2 reduction – allowing them to observe the results of their effort[1].

8.1 Procedure of monitoring Action Plan implementation

After signing the Covenant, every two years, the City will be obliged to among others monitor the implemented measures and evaluate them according to the set of indicators, which include also CO_2 emissions as one of benefit indicators. The results will serve for DG TREN and the Covenant Office reporting on results achieved. It is important to determine – from the very beginning of the system implementation – monitoring, verification and evaluation.



(Redrawn)

8.2 Dates of Action Plan evaluations

The Action Plan should be evaluated on a regular basis every two years. Nevertheless, continuously it is necessary:

- To evaluate and monitor consumption in municipal buildings and facilities/equipment. The condition is to complete the existing building and facility/equipment database, to establish a database connection with all supply points where possible.
- To monitor implemented projects, their benefits and costs (see project monitoring by the Department of Implementation of European Funds) by all Departments in question.
- To monitor data indicated in the specification of the inventory description.
- To monitor additional data not yet reported – according to indicators specified for individual measures.

The method of data collection and procession should enable the calculation of CO_2 emissions and respect the Action Plan structure.

8.3 Monitoring and evaluation indicators

Selected evaluation indicators should meet the criteria:

Relevance + availability + reliability + quantification

The design of appropriate monitoring indicators is part of the Action Plan preparation, each SECAP measure/action preparation and the way of its evaluation. Indicators are selected especially at the level of results and impacts and for meeting the reporting requirements of the Covenant of Mayors Office.

At the level of **inputs**, we can monitor the following items:

- Fuel and energy consumption data of individual sources from REZZO 1 and 2
- Natural gas and electricity supply by sector, building, facility
- Heat supply by sector, building, facility
- Electricity production from RES, waste, etc. according to the description of CO_2 inventory creation

At the level of **outputs**:

- Number of projects implemented to reduce CO_2 emissions
- Number of implemented awareness campaigns
- Number of insulated buildings, flats, m^2
- Achieved thermal insulation parameters, benefits of measures/actions expressed in technical units
- Achieved parameters of specific heat consumption for space heating
- Energy savings by fuel and energy type
- Number of RES projects
- m^2 of installed solar collectors
- kW capacity of installed heat pumps
- kW_p of installed PV panels
- Number of buildings with stricter requirements for building thermal protection and energy efficiency in total – number of low-energy buildings, passive buildings
- Number of buildings with implemented use of non-combustible technologies of renewable sources

We can monitor the results of measures/actions e.g. as follows:

- Increase in power and emissions from new sources (both CO_2 emissions and air pollutants)

- Emission reduction for retrofitted sources
- Fuel and energy reduction by insulation project implementation
- Number of workshop participants, website visitors
- Renewable electricity production
- Electricity production from heat sources

We recommend to verify the measures/actions results (e.g. using the methodology adhering to the International Performance Measurement and Verification Protocol which was disseminated in the Czech Republic within the PERMANENT Project - see www.permanent-project.eu). Savings verification adhering to the IPMVP is used also for EPC projects.

At the level of measure/action **benefits/impacts,** the indicators are monitored by means of which the meeting of the target in individual sectors listed in BEI will be demonstrated.

- Emission reduction by source category
- CO_2 reduction in heat production
- CO_2 reduction through municipal building insulation
- Emission reduction through further residential and family building retrofit
- CO_2 reduction through renewable energy production
- etc.

Action Plan monitoring will allow to evaluate achieving the target – every two years, CO_2 Emission Inventories will be developed and achieving the target will be evaluated.

9. BIBLIOGRAPHY

[1] Bartoš, L., Richtr, A., Martolos, J., Hála, M. (2012). TP 225 Prognóza intenzit automobilové dopravy, II. edition. Plzeň: Edip, 28 s. ISBN 978-80-87394-07-6.

[2] SEAP (2010). How to develop a sustainable energy action plan (SEAP) - Guidebook. Luxembourg: Publications Office of the European Union, 120 s.

[3] EMEP/EEA air pollutant emission inventory guidebook 2016 [online]. Available at WWW: http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

[4] Nationwide transport census 1995, 2000, 2005, 2010, and 2016

[5] PÍŠA, V. et al. (2001). Zjištění aktuální dynamické skladby vozového parku a jeho emisních parametrů. ATEM. Praha. 85 s.

[6] PÍŠA, V. et al. (2006). Zjištění aktuální dynamické skladby vozového parku na silniční síti v ČR a jeho emisních parametrů v roce 2005. ATEM. Praha. 169 s.

[7] PÍŠA, V. et al. (2010). Zjištění aktuální dynamické skladby vozového parku na silniční síti v ČR a jeho emisních parametrů v roce 2010. ATEM. Praha. 135 s.

[8] Tables of Dynamic Fleet Structure based on Nationwide Transport Census 2016. ATEM. Praha.

[9] KAREL, J. et al. (2016) Metodika pro určení dynamické skladby vozového parku na komunikacích v České republice v roce 2016. ATEM. Praha. 160 s.

[10] ICCT (2014). EU CO_2 emission standards for passenger cars and light commercial vehicles. International Council on Clean Transportation. Berlin.

[11] ICCT (2016). CO_2 emissions from new passenger cars in the EU: Car manufacturers' performance in 2015. International Council on Clean Transportation. Berlin.

[12] EC (2014). The Commission presented a Strategy to Reduce CO_2 Emissions from Trucks and Buses. European Commission. Brussels

[13] EMEP/EEA air pollutant emission inventory guidebook 2016 [online]. 2016. Luxembourg: European Environment Agency, 2016 [cit. 2017-10-27]. ISBN 1977-8449. Dostupné z: https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

[14] Höglund, P. G. – Niittymäki, J. (1999): Estimating Vehicle Emissions and Air Pollution related to Driving Patterns and Traffic Calming. Conference "Urban Transport Systems". Lund. Sweden. 11 p

[15] Trieber, M. et al. (2008): How Much does Traffic Congestion Increase Fuel Consumption and Emissions? Applying a Fuel Consumption Model to the NGSIM Trajectory Data. Transportation Research Board 87th Annual Meeting. Washington. USA. 17 p.

10. ATTACHMENTS

ATTACHMENT A SUSTAINABLE ENERGY AND CLIMATE ENERGY PLAN (2030) – STATUTORY CITY OF LIBEREC – BASE EMISSION INVENTORY (IN CZECH)

Attachment A Sustainable Energy and Climate Energy Plan (2030) – Statutory City of Liberec – Base Emission Inventory (in Czech)