NET ZERO CITIES

EU MISSION PLATFORM | CLIMATE NEUTRAL AND SMART CITIES

Climate City Contract

2030 Climate Neutrality Action Plan

2030 Climate Neutrality Action Plan

City of Lappeenranta

LAPPEENRANTA

THE CLIMATE CAPITAL OF FINLAND

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Summary

Textual element
This action plan details the strategies and actions needed for the reaching climate-neutrality by 2030. The action plan is a living, continuously updating document. Part A presents the current state of climate actions, including the emission inventory for the year 2020. Part B includes the Impact Pathway framework used for creating the pathway to carbon neutrality. The individual actions and indicators are presented in B-2 and B-3. Part C includes the necessary organisational and governance innovations, and social innovations.

List of figures

The list of figures **identifies the titles and locations** (page numbers) of **all visual elements:** figures, drawings, photos, maps, etc. used in the Action Plan.

List of tables

The list of tables **identifies the titles and locations** (page numbers) of **all tables** used in the Action Plan.

Abbreviations and acronyms

The list of abbreviations and acronyms **identifies the abbreviations** (a shortened form of a word used in place of the full word) **and acronyms** (a word formed from the first letters of each of the words in a phrase of name) used in the Action Plan.

Abbreviations and acronyms	Definition
AP	Action plan
IP	Investment plan
DH	District heating
SECAP	Sustainable energy and climate action plan
SYKE	Finnish Environment Institute
kt	1000 tons
CO2e	Carbon dioxide equivalent
IPPU	Industrial processes and product use
AFOLU	Agriculture, forests and other land use

1 Introduction

Introduction - textual element

The city of Lappeenranta is one of the municipalities of the Finnish HINKU network and is committed to aiming for at least an 80 per cent emission reduction by 2030. In the Lappeenranta 2037 city strategy, the city has defined carbon neutrality as its goal by 2030. The carbon-neutral target applies to the entire city area and all sectors. The action plan takes into account mainly scope 1 emissions. Scope 2 emissions that are taken into account are emissions related to electricity production outside of the city area. Scope 3 emissions considered are the emissions related to waste incineration outside of the city area.

The city's SECAP was completed in 2021. The city's updated climate program for 2021-2030 was approved on 14 December 2020. However, the measures identified in the climate program are not enough to achieve carbon neutrality by 2030. The size of the emissions reduction gap was determined using climate neutrality scenario tool provided by the Finnish environmental institute. The city has defined additional measures to achieve carbon neutrality that are based on the prepared sector-specific scenario tool. The content of additional measures, side benefits and the level of necessary investments were defined in cooperation with residents, experts and companies in workshops in spring 2023 and autumn 2023 and as expert work in autumn 2023.

The definition of the emission reduction gap is based on the city's 2020 emission calculation. Lappeenranta aims ambitiously to cut emissions in all sectors. Only those emissions that are impossible or difficult to cut are compensated with certified emission reductions outside the area or additional carbon sinks in the city area. However, compensations and additional carbon sinks will not exceed 20% of Lappeenranta's 2007 greenhouse gas emissions.

The share of Lappeenranta's city organization and city companies in the area's total emissions is relatively small. To achieve the goal of carbon neutrality, other regional actors, residents and companies must also be involved in emission reduction measures. The most challenging emission reduction sector for Lappeenranta is transport and mobility. In 2020, approx. 40 per cent of emissions came from traffic. In the transport sector, the city sets an example and moves to carbon-neutral modes of public transport, transport services, and logistics. With the help of service procurement, the city can have a broader influence on the emissions of transport services. Important in the transport sector, e.g. stakeholders were identified as operators, companies providing transport services, residents of the area and housing associations.

In the energy sector, the city aims to reduce emissions to nearly zero by 2030. The key to this is making the heating of buildings carbon-neutral and increasing the production of renewable electricity and the share of renewable electricity consumption. To enable a renewable energy system, paying attention to energy efficiency and the intelligent control and flexibility of energy use is essential. District heating companies in the region, companies developing renewable energy production, significant individual electricity users and residents of the region have been identified as crucial stakeholders

2 Work Process

Work Process

1. Build a strong mandate

The city of Lappeenranta is strongly committed to achieving carbon neutrality by 2030. The city has been a pioneer in climate action for several years. The first climate program of the city was approved as early as 2009, and the 30 % emission reduction target of this initial climate program was achieved ahead of schedule in 2015. The city joined the HINKU network in 2014, and at the same time, the emission reduction target was set at 80 % reduction by 2030.

The city's new climate program was approved in 2021, with the goal of achieving carbon neutrality by 2030. The City Strategy 2037, also approved in 2021, emphasizes sustainable urban development and carbon neutrality as one of its strategic objectives and CO2 emissions are one of the main indicators.

LPR 2037 – SUSTAINABLE SUCCESS STORIES

Lappeenranta – Sustainable city: Lappeenranta will be carbon neutral by 2030.
Clean water and air, zero waste.

In 2022, the city of Lappeenranta was approved as one of the one hundred cities in the EU's Climate-Neutral and Smart Cities by 2030 network.

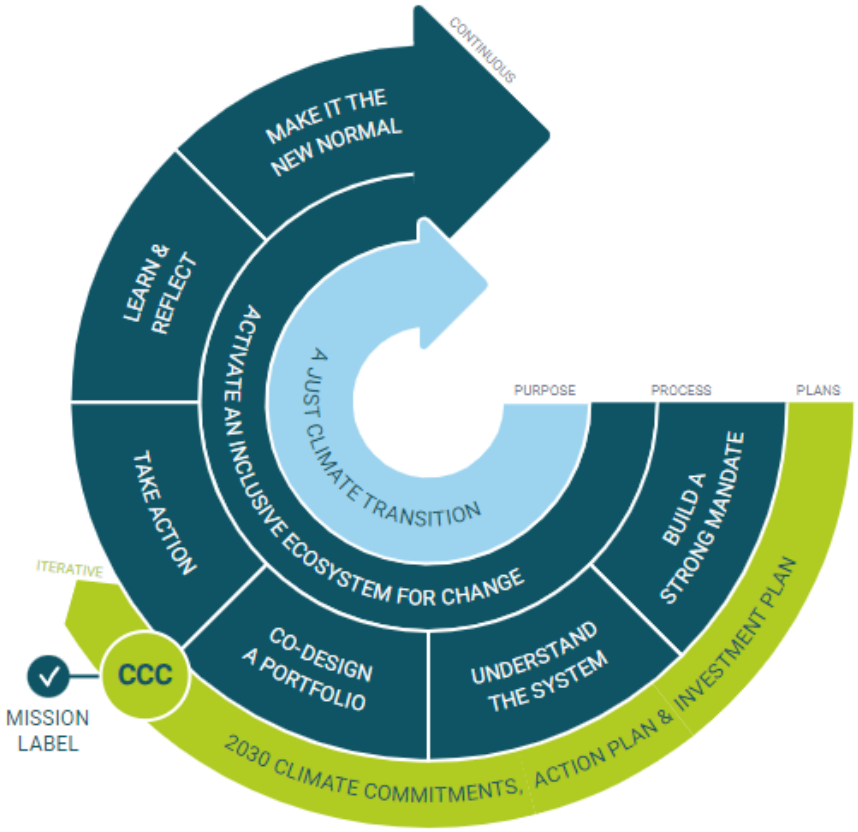

Figure 1. NetZeroCities transition map.

The climate efforts in Lappeenranta are guided by the city group's common *Greenreality working committee*. The working committee has members from departments and also from the city owned companies. However, the influence of the Lappeenranta city group on the emissions across the entire area is limited. Therefore, in addition to the Greenreality working committee, a wider transition team is being established to monitor and guide the city's climate efforts. The team will include representatives from local businesses, the regional council, LUT University, LAB University of Applied Sciences, as well as various organizations and associations. The transition team will meet at least twice a year.

The NetZeroCities mission team is the core team of city employees participating in the work needed for the CCC. The structure and members of the mission team can change as needed. For the successful planning and implementation of the AP and IP, the team needs wide expertise from various sectors, including financing, energy efficiency, renewable energy, sustainable transportation and nature based solutions.

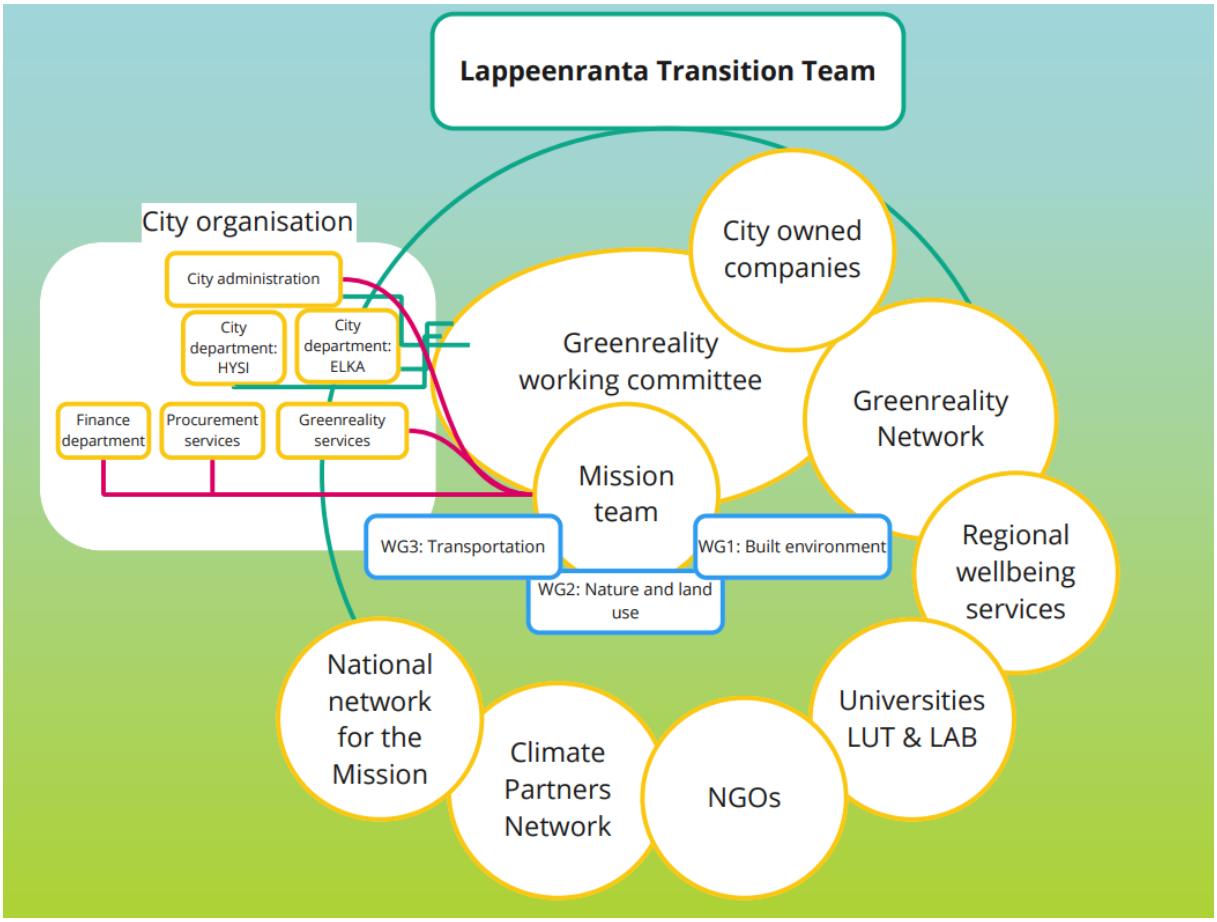

Figure 2. Lappeenranta Transition team

The fig. 2 presents the structure of the transition team in Lappeenranta. The NetZeroCities mission team is the core team of city employees participating in the work needed for the CCC. The structure and members of the mission team can change as needed. For the successful planning and implementation of the AP and IP, the team needs wide expertise from various sectors, including financing, energy efficiency, renewable energy, sustainable transportation and nature based solutions. The mission team works continuously and actively.

For the efficient implementation of AP and IP, there will be themed working groups. The working groups will include members from the city departments, companies and NGOs. The first three working groups are: Working group 1: Built Environment, Working group 2: nature and land use and Working group 3: Transportation. The working groups have scheduled meetings several times a year.

The Greenreality working committee follows and guides the CCC work inside the city organisation, including the city owned companies. The committee has meetings once a month.

2. Understand the system

City of Lappeenranta has been doing emission inventories since 2015 and there has been quite clear view of the greenhouse gas emissions from the different sectors. The figure 3 presents the GHG emission development based on previous emission inventory calculations.

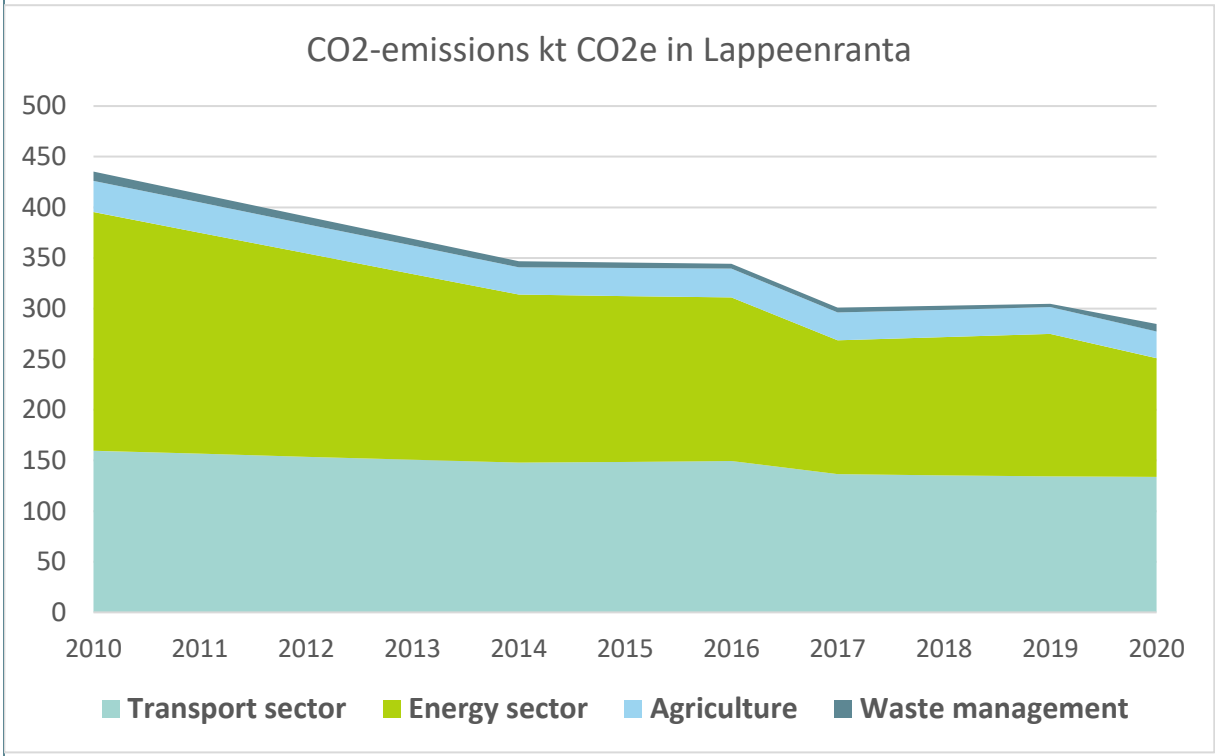

Figure 3. Greenhouse gas emissions 2010-2020.

However, the land use and forests have been excluded in the previous emission inventories. For the NetZeroCities emission inventory we'll use the emission inventory provided by the Finnish Environment Institute (SYKE). Link for the additional information: https://www.hiilineutraalisuomi.fi/en-US/Emissions_and_indicators/Municipalities_and_regions_usagebased_greenhouse_gas_emissions
The emission inventory provided by the SYKE has been modified to include also the land use and forest sectors. The data for emission inventory of the forests was gained from IBC Carbon project coordinated by Finnish Environmental Institute (SYKE). Land cover data is from the period 2015-2020 and is based on registry data or remote sensing. Forest productivity is modelled using process-based forest growth model PREBAS, developed in Helsinki University. More spesific methodology has been described in the Annex *1 : Emission inventory methodology*.

Emission inventory is based on the 2020 data and the year 2020 will be used as a base year for calculating the emission gap. The emission gap refers to the gap in GHG emissions between the carbon neutrality and the emission trajectory with current policies.

The biggest GHG emission source sectors were *Transportation, Buildings* and *Agriculture, forests and land use.*

The emission gap has been calculated with a climate neutrality scenario tool provided by the Finnish Environment Institute. Link: https://skenaario.hiilineutraalisuomi.fi/

The GHG emissions were 461 ktCO2e in the 2020 emission inventory. In the 2030 baseline scenario the GHG emissions are 342 ktCO2 in 2030, representing only 24 % decline in the emissions. Additional actions and compensations need to cover the emission gap of that 341 kt CO2e.

Figure 4. Emission inventory 2020 and base scenario for the 2030.

3. Co-design a portfolio

After completing the emission inventory and calculation of the emission gap, we started the process to define the actions needed to fill in the gap to carbon neutrality. The work started by identifying the relevant stakeholders for each system. The stakeholders were invited to the workshops and take part in the planning of the action and investment plans. The work was done as a participatory process including several themed workshops. In the workshops, there were participants from various city departments, businesses, the university, and also city residents.

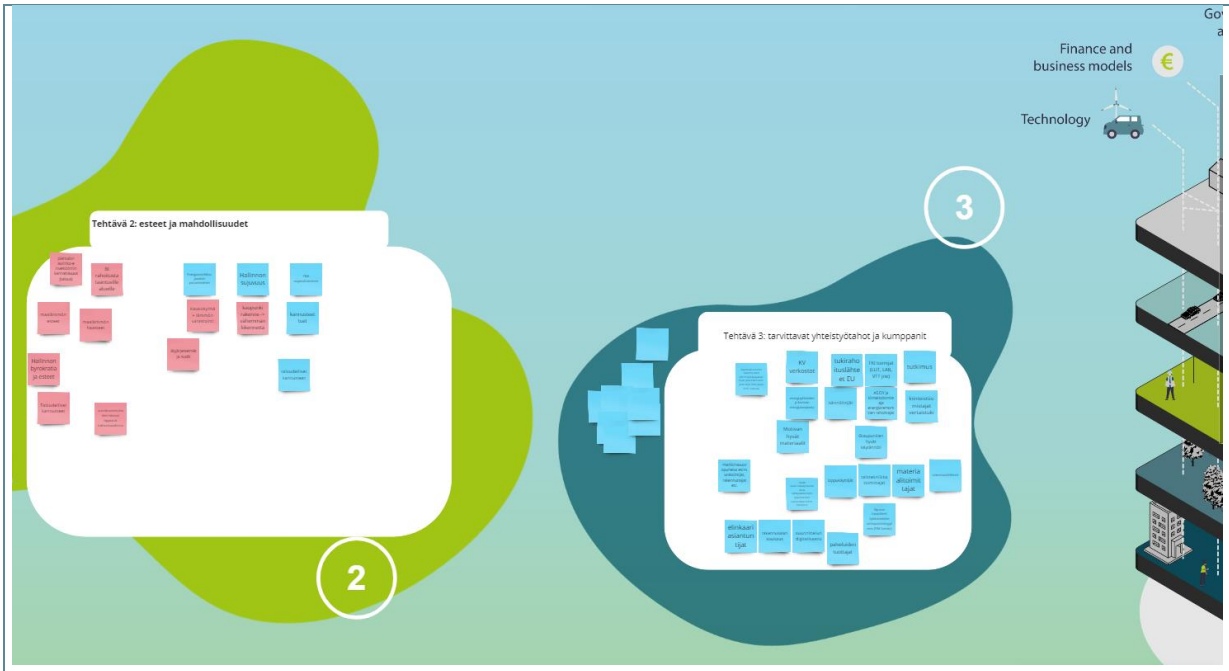

Figure 5. Part of the Miro-board from the Built Environment workshop.

Additionally citizen participation has been done in the events organised by the city, ie in the Greenreality Carnival 2023.

Figure 6. Greenreality Carnival 2023.

The main tasks in the workshops included the planning of the new possible emission reduction actions, mapping of the relevant stakeholders, understanding the barriers and recognising the co-benefits and possible negative effects.

Based on the workshop results and expert assessments, a new carbon-neutral Lappeenranta scenario was created. The 2030 carbon neutrality scenario, 2030 WAM1, shows a pathway to decrease GHG emissions by 87 % by 2030. The remaining emissions will need to be offset either through additional measures or by purchasing emission offsets.

The carbon neutrality investment plan was created using both top-down and bottom-up approaches. In the bottom-up approach the implementation costs were estimated for each action in the action portfolio. The estimated costs included both the capital expenditure and operational costs (or cost reductions).
On the top-down approach the required investment level to reach emission reduction goals were estimated for each sector.

4. Take action

Climate change is progressing rapidly, and measures to prevent climate change are urgent. For this reason, the action program must be flexible and constantly moving forward. The most urgent actions need to be implemented quickly and additional actions planned.

The action plan and investment plan are both constantly developing plans. However, there will be formal updates done for both plans at least every second year. First update is planned for the year 2025.

Development and implementation of the actions are both constant processes. The action plan and will be integrated to the online monitoring site: https://kestavyysvahti.lappeenranta.fi/. Each action has a responsible department and a contact person(s).

The monitoring site is being updated to include also co-benefits of the actions and adding a possibility to include third party actors (outside of the city group).

The AP and IP development and implementation work is coordinated by the Mission team. The mission team reports the progress and current situation to the Greenreality working committee. The committee has members from the city departments and form the city owned companies. The committee has a meeting every month and it´ll monitor and guide the work related to CCC.

The changes and updates to the AP and IP will be presented to the Transition team. Transition team will meet twice a year. After the transition team, the updates and progress reports will be presented to the city board (twice or more per year).

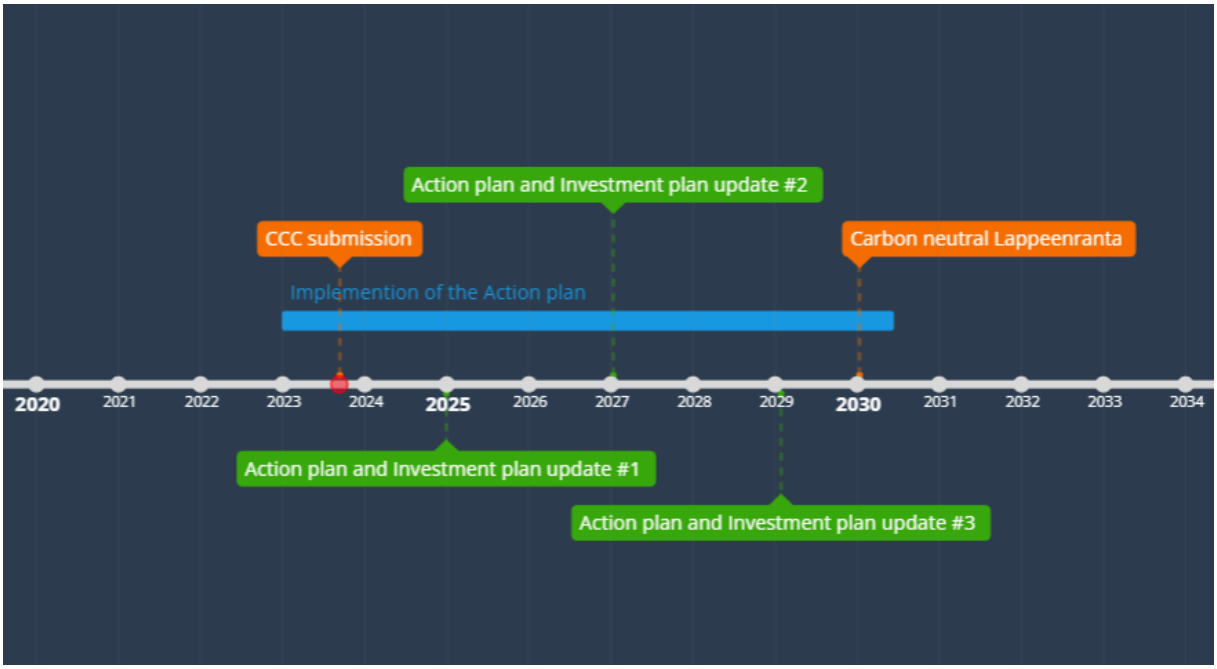

Figure 7. Timeline for the CCC process.

3 Part A – Current State of Climate Action

Part A "Current State of Climate Action" describes the point of departure of the city towards climate neutrality, including commitments and strategies of key local businesses, and informs the subsequent modules and the outlined pathways to accelerated climate action.

3.1 Module A-1 Greenhouse Gas Emissions Baseline Inventory

Module A-1 "Greenhouse Gas Emissions Baseline Inventory" should detail and describe the city's latest GHG inventory to establish the emission baseline and to establish the emissions gap to 2030 climate neutrality according to the inventory specifications defined in the Cities Mission's *Info Kit for Cities* and the process outlined in the Action Plan Guidance.

A-1.1: Final energy use by source sectors				
Base year				
Unit	GWh/year			
	Scope 1	Scope 2	Scope 3	Total
Buildings				
Electricity (GWh) Heating: electricity Heating: geothermal Heating: district heating Heating: heating oil Heating: wood fuel Heating: other	 541.2 43.9 132.4 33.2	425.3 81.4 10.8		
Transport (GWh) Railway: diesel Railway: electricity Marine Road transport: local Road transport: drive through	 9.1 16.3 513.8 30.5	 11.9		
Waste				
(Fuel type/ energy used)				
Industrial Process and Product Use (IPPU)	-	-	-	
(Fuel type/ energy used)				
Agricultural, Forestry and Land Use (AFOLU) Agriculture (GWh)	Energy use in the agriculture is included in the Buildings and Transportation categories			
(Fuel type/ energy used)				

A-1.2: Emission factors applied

Electricity emission factors

The emission factors are calculated both on annual and monthly levels, the latter of which is applied to calculating the emissions of heating electricity. The emission factor is, on average, larger during the heating season than during other times, which means that heating electricity has larger specific emissions than other use of electricity.

The monthly factor is calculated by allocating the annual GHG emissions of Finnish electricity production to different months in accordance with different production methods, and by dividing the monthly emission result with the electricity consumption of each month. The monthly data are taken from the statistics of Finnish Energy.

The emission factor other electricity use than heating (consumption electricity) is calculated by deducting the emissions of heating electricity, calculated with the monthly factors, from the total emissions of electricity and, similarly, the consumption of heating electricity from the total electricity consumption.

Emission factors of fuels

The CO2 emission factors of fuels are taken from the annually updated Fuel Classification maintained by Statistics Finland. Bio-based fuels have zero carbon dioxide emissions. The factors of methane and nitrous oxide are obtained from IPCC's Emission Factor Database.

The methane and nitrous oxide emission factors of fuels are taken from IPCC's Emission Factor Database. They are separate for energy industries, manufacturing industries and other sectors, which includes housing and services. The 2006 IPCC Default is the selected emission factor option.

The carbon dioxide equivalence factors are calculated by using IPCC's Global Warming Potential (GWP) values of 2007, which are also used for national greenhouse gas inventory calculation. In a hundred-year period, the heating effect of methane is 25 times that of carbon dioxide (GWP100 = 25), and for nitrous oxide it is 298 times as large (GWP100 = 298). The GWP values of F-gases vary between 124–22,800, depending on the compound.

Links to data sources:
https://www.stat.fi/media/uploads/tup/khkinv/khkaasut_polttoaineluokitus_2022.xlsx

https://www.ipcc-nggip.iges.or.jp/EFDB/main.php

A-1.3: Activity by source sectors			
Base year 2020			
	Scope 1	Scope 2	Scope 3
Buildings (floor area 1000 x m2)			
Residential buildings Service buildings and offices Industrial and storage buildings	4069 1461 1297		
Transport; mileage Mkm/a			
Personal vehicles Vans Buses Heavy transport	432 63 5 41		
Waste, tons/a			
Paper and carton Metal Plastic Glass Organic waste Other Soils	2710 800 460 340 13500 262420 631 0 6690		
Industrial Process and Product Use (IPPU)			
(Activity)			
Agricultural, Forestry and Land Use (AFOLU), Area; ha			
Land area; fields Land area: forests Land area: protected areas	20 631 113 800 1 996		

A-1.4: GHG emissions by source sectors				
Base year				
Unit	Kt CO2equivalent/year			
	Scope 1	Scope 2	Scope 3	Total
Buildings	86.4	40.4		126,7
Transport	136.4	0.9		137.3
Waste	3.6		28.2	31.8
Industrial Process and Product Use (IPPU)	6.5			6.5
Agricultural Forestry and Land Use (AFOLU)	147.6			147.6
Other	11.1			11.1
Total	391.5	41.3	28.2	461.1

A-1.5: Graphics and charts

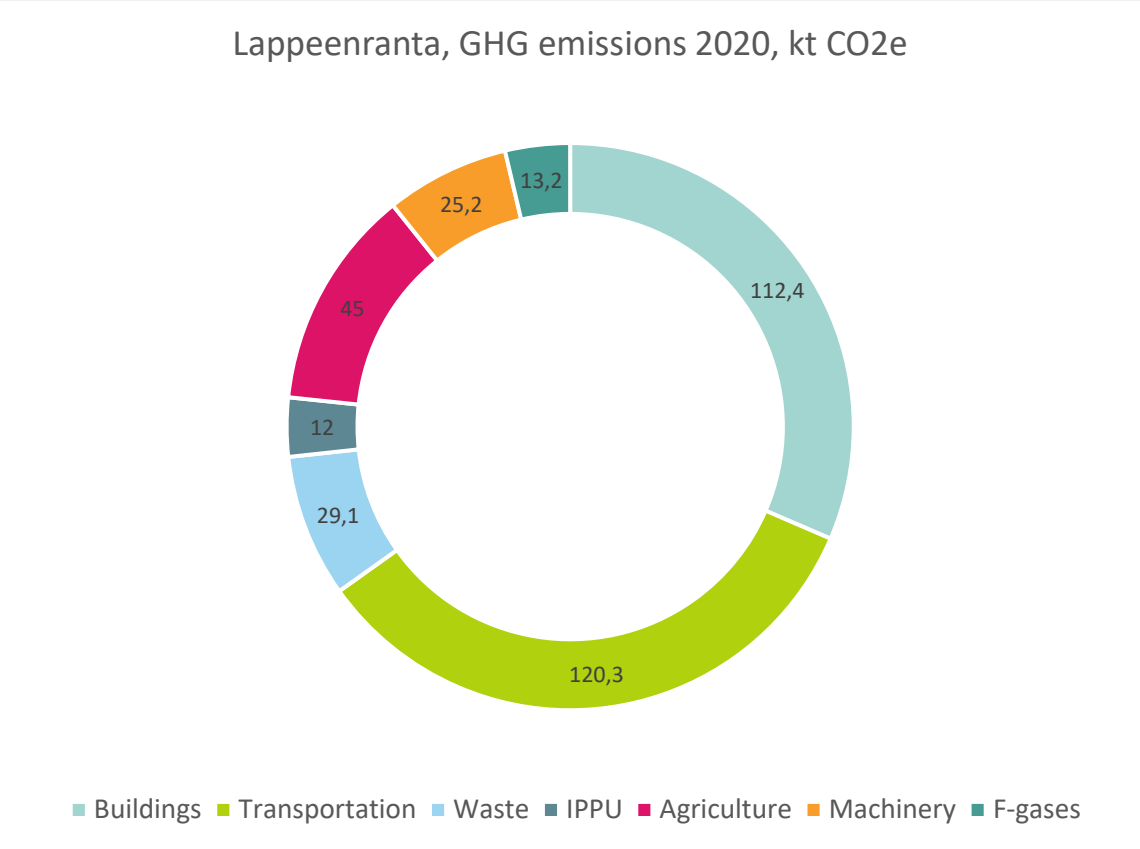

Figure 8. Greenhouse gas emissions by sector, 2020

Emission source	emissions: kt CO2e	share
Electricity use	32,8	7,1 %
Heating: electricity	7,6	1,7 %
Heating: district heating	46,6	10,1 %
Heating: fuel oil	11,6	2,5 %
Heating: other	12,1	2,6 %
Industry	6,5	1,4 %
Machinery	28,0	6,1 %
Transport: railways	3,4	0,7 %
Transport: roads	123,3	26,7 %
Transport: marine	4,2	0,9 %
Agriculture	43,1	9,3 %
Forestry	97,7	21,2 %
Waste	31,8	6,9 %
F-gases	12,3	2,7 %
Total	461,1	100,0 %

Table 1. 2020 emissions divided by source

A-1.6: Description and assessment of GHG baseline inventory
Emission inventory is based on the 2020 data and the year 2020 will be used as a base year for calculating the emission gap. For the NetZeroCities emission inventory we'll use the emission inventory provided by the Finnish Environment Institute (SYKE). The emission inventory provided by the SYKE has been modified to include also the land use and forest sectors. The data for emission inventory of the forests was gained from IBC Carbon project coordinated by Finnish Environmental Institute (SYKE). Land cover data is from the period 2015-2020 and is based on registry data or remote sensing. Forest productivity is modelled using process-based forest growth model PREBAS, developed in Helsinki University. More spesific methodology has been described in the Annex 1 : Emission inventory methodology. The biggest GHG emission source sectors were Transportation, Buildings and Agriculture, forests and land use. The GHG emissions were 450 ktCO2e in the 2020 emission inventory. Local renewable energy production (wind power) was used to mitigate part of the scope 2 emissions (-10 ktCO2e) from electricity use. Calculation was done by using national grid electricity emission factor. In the 2030 baseline scenario the GHG emissions are 342 ktCO2 in 2030, representing only 24 % decline in the emissions.

3.2 Module A-2 Current Policies and Strategies Assessment

Module A-2 "Current Policies and Strategies" should list relevant policies, strategies, initiatives or regulation from local, regional and national level, relevant to the city's climate neutrality transition.

A-2.1: List of relevant policies, strategies & regulations					
Type	Level	Name & Title	Description	Relevance	Need for action
(regulation/ policy/ strategy/ action plan	(local, regional, national, EU)	(Name of policy/ strategy/ plans)	(Description of policy/ strategy/ plans)	(Describe relevance/ impact on climate neutrality ambition)	(list any suggested action in relation – to be further picked in Module C-1)
Action Plan	local	Climate Program 2021-2030	The climate program 2021-2030 includes emissions inventories and an action portfolio for the climate neutrality.	The goal of the climate program is to implement the carbon neutrality goal of the city of Lappeenranta by 2030.	…
Action plan	local	Sustainable mobility plan	The sustainable mobility program of the city of Lappeenranta (2021–2033) is a comprehensive promotion program for implementing a sustainable transport system in the future.		
Strategy	local	City Strategy 2037		One of the main goals in the strategy is that city moves towards carbon neutrality and aims for 60 % CO2 emission reduction by 2025.	
Strategy	national	Carbon neutral Finland 2035 – national climate and energy strategy	The National Climate and Energy Strategy outlines measures by which Finland will meet the EU's climate commitments for	Targets set in the Climate Change Act: reduction of the greenhouse gas emissions by 60 per cent by 2030 and being carbon	

			2030 and achieve the targets set in the Climate Change Act	neutrality by 2035	
Action plan	national	Roadmap to fossil-free transport: Government resolution on reducing domestic transport's greenhouse gas emissions	In line with the Government Programme, the Ministry of Transport and Communications has prepared a Roadmap for fossil-free transport to reduce greenhouse gas emissions from transport.	According to the Government Programme, Finland will be carbon neutral by 2035. The targets for reducing emissions from transport must be in line with this goal. By 2030, Finland will reduce emissions from domestic transport by at least 50 per cent compared to the 2005 level.	
Strategy and action plan	regional	South Karelia's regional development strategy 2022-2025	The strategy outlines the development goals based on the province's opportunities, needs, culture and other special features, and reconciles the region's state of will, regional development and the EU's cohesion policy.	Environmentally responsible South Karelia is one of the four spearheads of the strategy. The strategy lists several climate and renewable energy related development goals.	
Action plan	local	Circular economy roadmap		Goals/listed actons	
Policy	local	Decision to procure only carbon neutral vehicles			
Policy	national	KETS		Energy efficiency targets for public buildings	

Action plan	national	KAISU - Medium-Term Climate Change Policy Plan Towards a carbon-neutral society in 2035	The creation of a Medium-Term Climate Change Policy Plan is provided for in the Climate Change Act.It is based on the tightened emissions reduction obligation proposed by the European Commission for 2030	The Medium-Term Climate Change Policy Plan investigates the measures needed to close the gap and how the emissions of the effort sharing sector can be reduced to make carbon-neutrality achievable.	
Action plan	national	MISU - Climate Change Plan for the Land Use Sector	Ministry of Agriculture and Forestry has prepared a comprehensive Climate Change Plan for the Land Use Sector, which will be one of the key elements of the planning system under the revised Climate Change Act.	The purpose of the plan is to promote the reduction of emissions from land use, forestry and agriculture, strengthening of removals by carbon sinks and adaptation to climate change. The plan sets down the measures targeted to land use changes, carbon dioxide emissions from agricultural lands and long-lived wood products, and several cross-cutting measures.	

A-2.3: Emissions gap										
2020 Emission inventory	Baseline emissions (percentage)		Residual emissions / offsetting[1]		Baseline emissions reduction target[2]		Emissions reductions in existing strategies[3]		Emissions gap (to be addressed by action plan)[4]	
	(absolute)	(%)	(absolute)	(%)	(absolute)	(%)	(absolute)	(%)	(absolute)	(%)
Buildings	110.8	24.6	5.9	6.9	86.9	78.4	56.0	50.5	48.9	18.7
Transport	130.9	29.0	51.0	60.0	79.9	61.0	35.2	26.9	44.7	17.1
Waste	31.8	7.1	6.4	7.5	25.4	80	11.2	35.1	14.3	5.5
Industrial Process and Product Use (IPPU)	6.5	1.4	1.3	1.5	5.2	80	0	0	5.2	2.0
AFOLU	140.8	9.6	-25.8	-30.4	166.6	118	0	0	140.8	53.8
Machinery	28.0	6.2	15.3	18.0	12.7	45.4	4.8	17.0	8.0	3.0
F-gases	12.3	2.7	5.1	6.0	7.2	58.3	7.2	58	0.0	0.0
Total	**450.7**	**100**	**85.0**	**100**	**365.7**	**81.1**	**114.2**	**24.8**	**261.9**	**100**
Total, incl. negative emissions from AFOLU	**450.7**	**100**	**59.2**	**100**	**391.5**	**86.9**	**114.2**	**24.8**	**287.7**	

[1] Residual emissions consist of those emissions which can't be reduced through climate action and are being offset. Residual emission may amount to a maximum of 20 % as stated by the Mission Info Kit.
[2] Baseline reduction target = Baseline emissions – residual emissions.
[3] Emission reductions planned for in existing action planning and strategies should be quantified per sector.
[4] Emissions gap = Baseline emission reduction target – Emissions reduction in existing strategies.

3.3 Module A-3 Systemic Barriers and Opportunities to 2030 Climate Neutrality

Module A-3 "Systemic Barriers to 2030 Climate Neutrality" should document the results of the stakeholder, systems and ecosystem mapping and identification of systemic barriers and opportunities.

A-3.1: Systems & stakeholder mapping				
(Fill out according to AP Guidance) – e.g.				
System description	Stakeholders involved	Network	Influence/power	Interest
Transportation system, including public transportation, passenger vehicles and logistics	1) Private car owners	Citizens	Low power	High, reduced/increased costs
	2) Cycling association	NGO/citizens	Low power/influence	High on some areas
	4) Logistic and transportation companies	Enterprises	Medium power	High
	5) Housing associations	NGO/citizens	High power in implementing	Low to medium
	6) Greenreality Network	NGO/enterprises	Low power, medium influence	medium
	7) Taxi companies	Enterprises	Low power, medium influence	Medium to high
	8) Local businesses	Enterprises	Low power, low influence	medium to high interest
	9) Regional waste management company	Public service	High power, high influence	High interest
	10) media	Enterprises	High influence medium power	Low interest
	11) Estate managers	Public services	Medium power	Low to medium
	12) Municipality: procurement dep.	Public services	High power	Medium
	13) Municipality: city planning dep.	Public services	Low power	High interest
	14) Municipality: city development dep.	Public services	Low power, medium int.	Medium to high interest
	15) Municipality: public transportation		High power, high influence	
Energy system, including district heating and	1) Lappeenrannan Energia Oy	Enterprises/Public service	High power and influence	High Interest

energy use on buildings	2) Private home owners	Citizens	Low power and influence	High interest
	3) Housing associations	NGOs/citizens	Medium power	Medium to high interest
	4) real estate companies	Enterprises	Medium power and influence	medium to high interest
	5) Service providers	Enterprises	Low power and influence	High interest
	6) Local businesses who own or rent real estate	Enterprises	Low power and influence	Medium interest
	7) Lappeenrannan toimitilat Oy	Public service/company	High power and influence	Medium to high interest
	8) Lappeenrannan Asuntopalvelu Oy	Public company	Low power, medium influence	Medium to high interest
Nature based solutions, including forests, agriculture, urban greening	1) Land owners : forests	Citizens, enterprises, NGOs	Low to medium power and influence	High Interest
	2) land owners : farmers	Citizens, enterprises	Low power, medium influence	High interest
	3) Citizens	Citizens	Low power, low influence	medium to high interest
	4) SLL	NGO	Low power and influence	High interest
	5) Virkistysaluesäätiö	NGO	Low power and influence	High interest
	6) Businesses on tourism sector	Enterprises	Low power and influence	Medium to high interest
	7) Municipality	Public service	varies from low to high	High interest

A-3.2: Description of systemic barriers – textual elements

The city has encountered many barriers on it's path towards climate neutrality.
Summary of the identified barriers and plan how to lower or break the barriers:

- Silos inside the city organisation. The cross-cutting Greenreality Working Committee enables participation and involment of all city departments and companies owned by the city
- Lack of resources. Lack of dedicated resources can hinder the climate work. New Greenreality Services department can provide information and assistance for other departments and city companies. Greenreality Services department also assists on finding funding or in other capacity needs. The assistance is not limited to city organisation or city companies. The Greenreality Services can help also other organisations and companies, ie. on renewable energy, energy efficiency actions or enabling new pilot projects.
- Lack of information. The climate impact of many actions has been unknown. Currently information gaps are biggest on transportation, and AFOLU sectors
- Multi-level governance coordination. Locally there has been successes on implementing new structures for Multi-level coordination. City is also active on national networks.
- Capacity to act. The city has very limited possibilities for making major changes for private transportation and logistics. Collaboration with service providers, regional healthcare services and large companies is needed for a wider impact

A-3.3: Description or visualisation of participatory model for the city climate neutrality – textual and visual elements

The city of Lappeenranta has a multi-level participatory model for the climate neutrality actions.
First we have the Greenreality Working Group. The working group has a representation from city departments and city owned companies. The committee is very valuable for spreading the information and enabling to involve all city departments and companies owned by the city.

To include other companies and organisations, the city coordinates the Greenreality Network.
Link: https://www.greenreality.fi/en/greenreality-network
Greenreality Network is a network of the Energy and Environment sector's companies operating in South Karelia, Finland. It creates growth and new business opportunities for its members as well as the entire area.The network includes companies of the energy and environment sector, municipalities of the area as well as research and educational institutions. It is coordinated by the city of Lappeenranta.

City also coordinates the Climate Partners network.
https://www.greenreality.fi/en/yritykset-ja-yhteisot/greenreality-kumppanit/tutustu-greenreality-kumppaneihin
For the members, the network offers free assistance in assessing the initial situation of the company, for example, related to energy usage, waste, and transportation.

Climate-neutrality transition team includes members from the Greenreality Working Committee, Greenreality Network, NGOs, Universities and other organisations. The transition team is open for all residents, companies, and organisations.

Youth participation:
City coordinates the youth climate group, where youth can participate in planning the action.
Together with LUT University, city has developed UNIORI (junior university) model that enables information sharing and youth participation of all kids and students in Lappeenranta. The model is included in the curriculum of schools and reaches around 3000 students annually.
Link: https://www.uniori.fi/in-english/
City of Lappeenranta also has youth council, consisting of 31 elected 13-18 year old members, with the focus to make voice of youth heard in the decision making of the city.

City has been participating on Climate festivals that have been organised on the schools around South Karelia. The Climate Festivals is a half-day event including several themed workshops.

The city of Lappeenranta facilitates energy counselling for the residents of South-Karelia. This action is carried out as part of the work of Greenreality services and is funded by Finnish Energy Agency. The counselling is free of charge and thus enhances the accessibility of information for those who lack prerequisites for acquiring necessary information on their own.

For low barrier participation city has several participatory actions (questionnaires, polls, action planning) on different events. The organised events include ie. Greenreality carnival, Climate Café's, Zero emission traffic events etc.

The Action plan and investment plans were initially developed in workshops. The workshops were open for all. To enable wider participation, it was possible to attend also online. The workshop materials are also online on Miro-board. The participation and feedback has been open also after the workshops. For lowering the participation barrier, it was possible to participate also in English. Possibility to participate also in English will lower the barriers for non-native speakers.

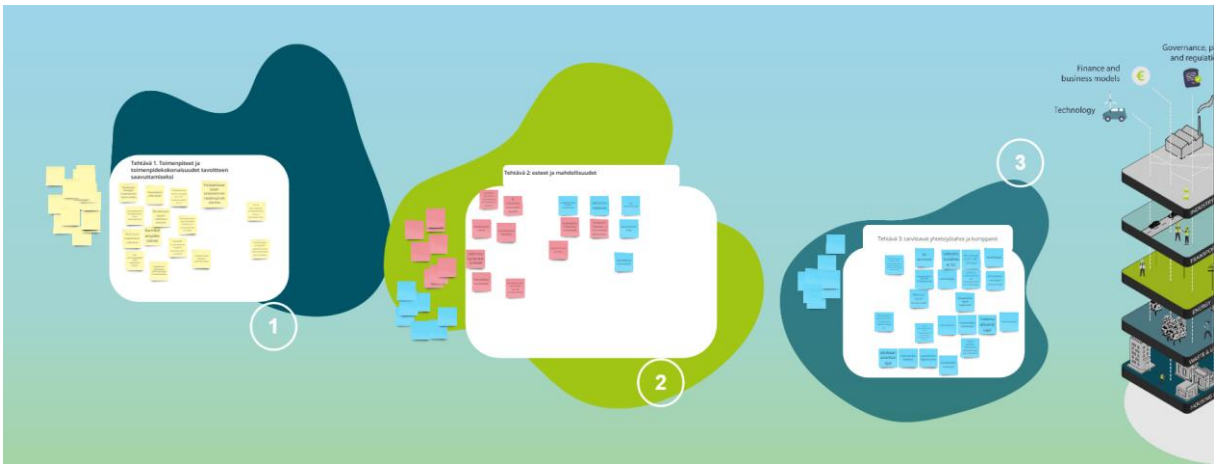

Figure 9. The Miro board from the Built Environment workshop.

4 Part B – Pathways towards Climate Neutrality by 2030

Part B represents the core of the Action Plan, shaped by local authorities, local businesses, and stakeholders, comprising of the most essential elements: scenarios, strategic objectives, impacts, action portfolios and indicators for monitoring, evaluation and learning.

4.1 Module B-1 Climate Neutrality Scenarios and Impact Pathways

The impact pathways have been created in a participatory process with stakeholders in themed workshops for Transportation, Nature based solutions and Built environment. Impact pathway for the Energy systems was created together with Lappeenrannan Energia Oy and Mission team.

The more detailed Impact pathways are created for all the fields of actions separately, starting with the most urgent and important sectors. The more detailed Impact pathway framework and analysis for the Mobility and transportation was created together with LUT University, stakeholders, and residents in 2023. (The summary tables of the framework are included as an attachment to AP). The work to create more detailed and in-depth version of the Impact pathway for the Built Environment is going on in the autumn 2023. The Impact Pathways for the AFOLU/nature-based solutions depend strongly of upcoming national and EU policies. The more detailed framework will be done after these policy decisions.

The more in-depth Impact pathways for the waste and recycle economy will be done in 2024 together with stakeholders and ASKI-project, which focuses on creating and implementing recycling solutions together with residents.

B-1.1: Impact Pathways					
Fields of action	Systemic levers	Early changes (1-2 years)	Late outcomes (3-4 years)	Direct impacts (Emission reductions	Indirect impacts (co-benefits)
Energy systems	Governance & Policy	City sets up collaboration with relevant stakeholders	Co-projects and pilot actions.		Additional investments, employment, economic wellbeing
		Guidelines for the land leasing for the renewable energy plants	Transparent processes implemented and guidelines are well defined. => Clear processes and stable investment environment attract additional investments		
		City recognises the development			

		needs and applies for funding through international funding possibilities			
	Technology & infrastructure	Plans for the carbon neutral heat production	Implementing the action plan. Investments for the DH plants, DH grid and storages.	Emission reduction > 20 000 tons of CO2e	Reduction of incineration leads to cleaner air. Increased demand for sustainable wood biomass can increase employment
		Plan for the increased solar and wind power deployment. Zoning and planning for the potential sites.	Construction of the industrial scale solar and wind parks	Emission reductions : 20 000 - 40 000 tons of CO2e, depending of the scale and national emission factor for the grid electricity	Increased employment : direct, 300 - 600 jobs.
	Democracy & participation	City coordinates multi-actor network focusing on sustainable energy use on buildings	New piloted technologies have been adopted also by other actors.		
		Citizen participation on utility scale solar and wind park planning			
	Finance and Funding	Mapping and testing of new ways to finance renewable energy deployment, ie. power purchase agreements.	Innovative financing reduces the need for additional private capital	Increased amount of installed solar power, emission reductions included on "Technology and infrastructure"	

Mobility & transport *The more detailed version of the Mobility & Transportation Impact Pathway framework has been included as an attachment.	Governance & Policy	Collaboration model and agreement with other regional actors. Mobility Working Group meets regularly,	Wider collaboration. Working group actively advances new ways for sustainable transportation.		Increased democracy and participation
		Guidelines for producing the services	New modified processes implemented for producing the services		
		Sustainable urban mobility plan, SUMP	Updated version of the plan		
		Guidelines for HPC charging station deployment on public spaces			
		Guidelines for enabling EV charging on city owned buildings, parking halls, and apartment buildings.			
	Technology and Infrastructure	Information gathering, understanding the system. Scenarios for the low emission transportation			
		Implementation plan for carbon-neutral public transportation service. Procurement of carbon-neutral school ride service.	Procurement of electric city bus service Procurement of electric regional bus service		
		EV charging infrastructure installations on municipality owned buildings and parking spaces, first phase : 50-100 charging points	EV charging infrastructure installations on municipality owned buildings and parking spaces, second phase : 150-300 charging points	100 t CO2e	better air quality, noise reduction

		Public HPC EV charging station to Pormestarinkatu	Additional HPC charging stations. Charging station(s) for the heavy transportation		
		Low emission school ride service	Zero emission school rides		Improved air quality ,noise reduction
			Public transportation : Electric city bus service	100 t CO2e	Improved air quality, noise reduction
		Information gathering, emission inventory for machines	Zero emission road maintenance vehicles, first phase	missing information	Improved air quality, noise reduction, service quality (?)
	Social Innovation	Shared electric vehicles, city hall	Shared electric vehicles, Lappeenrannan Asuntopalvelut, other housing companies		Reduced costs
		City bike system, additional bikes and better coverage			increased social equality
		New methods for enabling modal change : subsidised bicycles for employees and raised embursement for trips done by bike.	Increased share of commuting done by bicycles		Health benefits
Waste & circular economy	Governance & Policy	Collaboration with other municipalities to create new targets and guidelines regarding the regional waste management	New, more ambitious strategy for the waste management and recycling		
		New participatory models in place			
	Technical Innovation & Infrastructure	Plan for the new waste separation line	New waste separation line	5000 tCO2e	Air quality (scope3) Employment

		Survey for the biogas demand needs (2023)	Investment for biogas production increase		reduced use of materials affordable fuel for transportation
			Investment for biogas liquefication system		reduced use of materials
	Social Innovation	New innovative ways to motivate residents for better recycling effort.	New models for more efficient waste recycling and collection		reduced use of materials reduced costs for residents
	Finance and funding	mapping of funding possibilities for innovative projects	Development projects enable more ambitious actions		
			Green bonds for investment projects		Lower capital cost enables bigger investments
Green infrastructure & nature based solutions	Governance and policy	New action and conservation plan for the forests owned by the municipality			
	Democracy and participation	New Working Group for the nature based solutions	Multiple land owners working together to increase biodiversity and carbon sinks		increased democracy and participation
Built environment	Technology and Infrastructure	Examination of the potential ways to increase energy efficiency and heat demand elasticity. Plan for the implementation.	Virtual power plants for buildings owned by the city.		reduced costs
			New data platform for the building data		
		Pilot for the smart controlling of the heating and	The piloted actions are implemented also in the	Heat demand reduction of at least 5 % in most	Reduced energy costs.

		enabling the heat demand response in apartment buildings	buildings owned by the stakeholders	apartment buildings. No direct emission reduction ; part of the systemic change	Reduced use or primary energy
	Democracy and participation	Collaboration on energy audits	Joint procurements		Increased investments for EE

4.2 Module B-2 Climate Neutrality Portfolio Design

Module B-2 "Climate Neutrality Portfolio Design" should contain a project description for **each intervention planned**, including interventions by local businesses and industry, according to the template B-2.1, including actions those interventions targeted at enhancing carbon sinks to address residual emissions. Narrative analysis and comments can be provided in B-2.2. A summary of how residual emissions are addressed, should be provided in B-2.3.

B-2.1: Description of action portfolios - textual or visual		
Fields of action	Portfolio description	
	List of actions	Descriptions
1. Energy systems	1.1. Phasing out peat in the biomass power plants	The peat fuel usage on the biomass power plant will end by 2026. The biomass power plant provides about 85 % of the heat for the district heating networks in Lappeenranta.
	1.2. Phasing out fossil fuels on heating plants	Lappeenranta has several smaller heating plants connected to either main DH grid or separate local DH grids. Main fuel on these plants has been natural gas. The use of natural gas and fuel oil will be either replaced with renewable fuels or electricity. Two separate DH grids will be connected to the main DH network.
	1.3. District heating network efficiency improvements	Lowering of the DH network temperature reduces heat losses. Detection and prevention of the leaks will reduce
	1.4. Seasonal heat storage	To enable the efficient utilization of new heat sources, a large district heating storage facility is being constructed
	1.5. Utility scale solar and wind power	Several utility scale solar projects are on the planning phase and expected total of the utility scale solar is approx. from 600 MWp to 1000 MWp by 2030.
Mobility & transport	2.1. Carbon neutral public transportation	Public transportation services provided by the city will be carbon neutral by 2030. This includes local buses, regional buses and school rides.
	2.2. Carbon neutral transportation services and logistics	Transport and traffic related services of the city of Lappeenranta are carried out in a carbon-neutral manner

	2.3 Accelerating the adoption of clean vehicles on private sector.	Multiple actions are needed for accelerating the adoption of EVs and other clean vehicles, ie EV charging infrastructure deployment
Waste & circular economy	3.1. Waste recycling rate increase 3.2. Biogas production increase	The amount of waste sent for incineration is being reduced by improving source separation and constructing a new waste sorting line where organic waste and metals are separated from dry waste. Regional waste management company does an investment to increase biogas production and delivery capacity of the biogas to the stations.
Green infrastructure & nature based solutions	4.1. Increase of the strictly protected land area 4.2. Restoration of forests and fields on organic soils. Raising the water level and restoring former peat production sites. 4.3. Lengthening the growth cycle of forests	One target of the EU Biodiversity strategy is to increase the amount of strictly protected land areas up to 10 % of the area. The Finnish Nature Panel has recommended that 10 % of the land areas is protected in every region. Protecting 10 % of Lappeenranta's land areas mean 140 km2. Organic forests act as a substantial methane source, estimated to represent net emissions of about 110 kt CO2e/a. Carbon storages of the forests are increased by lengthening the growth cycle of the forests and thus reducing timber removal. Continuous growth is applied where suitable.
Built environment	5.1. Energy efficiency renovations 5.2 Replacing heating oil with renewable energy on the buildings	Energy-efficient renovations are necessary for a large portion of Lappeenranta's properties. Renovations include additional insulation, energy efficient windows and doors and also deep renovations. The use of the natural gas and fuel oil will end in all municipally owned buildings by 2030. City will collaborate with companies and housing associations to end the oil use on privately owned buildings. City will launch Information campaigns and provide energy advisor services to accelerate the oil phase out in the private homes.

B-2.2: Individual action outlines		
Action outline	Action name	1.1 Replacing peat as a fuel in a biomass power plant
	Action type	Technical Intervention
	Action description	Kaukaan Voima biomass power plant will phase out the use of peat fuel by 2030. Peat will be replaced by increased use of wood based biomass, renewable electricity, heat pumps and industrial excess heat. Short duration heat storage enables more flexible use of electricity and biomass. The used biomass is mainly residues (bark and sawdust) from the forest industry
Reference to impact pathway	Field of action	Energy systems
	Systemic lever	Technology and infrastructure
	Outcome (according to module B-1.1)	The use of energy peat as a fuel ends and is replaced by biomass, other renewable energy, utilization of excess heat sources and increased energy efficiency.
Implementation	Responsible bodies/person for implementation	Lappeenrannan Energia Oy, Lappeenrannan Lämpövoima Oy, Kaukaan Voima Oy, Pohjolan Voima Oy
	Action scale & addressed entities	District heating production for the main district heating network
	Involved stakeholders	District heat customers, peat producers, industrial partners, City of Lappeenranta
	Comments on implementation	The planned peat phase out is by 2026.
Impact & cost	Generated renewable energy (if applicable)	8 % of the total energy production. Up to 70 GWh.
	Removed/substituted energy, volume or fuel type	109 GWh, peat, share of the district heating 70 GWh
	GHG emissions reduction estimate (total) per emission source sector	25 000 tCO2e/a
	Total costs and costs by CO2e unit	**Investments:** Geothermal heat pumps and/or utilisation of the excess heat sources, 8 000 000 eur by 2030. Estimated emission reduction of 25 000 tons of CO2e. Estimated investment costs by CO2e unit: 35 eur/ tCO2e. (costs include also the action 1.4. Seasonal heat storage)
External costs and benefits	Nature and biodiversity	Effects on peat lands (+++) Effects on biodiversity (+/-) Effects on forests (-)
	Socioeconomic effects & well-being	Improved air quality Affordable heating

B-2.2: Individual action outlines		
Action outline	Action name	1.2 Replacing natural gas and oil with renewables on local district heating heat plants
	Action type	Increased use of the renewable energy
	Action description	The use of fossil fuels ends in the local district heating plants.
Reference to impact pathway	Field of action	Energy systems
	Systemic lever	Technology and infrastructure
	Outcome (according to module B-1.1)	Local heat plants using natural gas or oil have been modified to use only renewable fuels or replaced by other heating modes 2030.
Implementation	Responsible bodies/person for implementation	Lappeenrannan Energia Oy, Lämpövoima Oy, Imatran Lämpö Oy, Lappeenrannan Energiaverkot Oy
	Action scale & addressed entities	District heating network
	Involved stakeholders	Elstor Oy, CT Industrial Oy, Imatran Lämpö Oy
	Comments on implementation	Implementation on going in 2023. Investments will be completed by end of 2024
Impact & cost	Generated renewable energy (if applicable)	
	Removed/substituted energy, volume or fuel type	Natural gas + heating oil
	GHG emissions reduction estimate (total) per emission source sector	7 500 t CO2e/a
	Total costs and costs by CO2e unit	Investment costs: • Connecting separate DH grid in Rauha to Imatra's main DH grid: 1,3 M€ • Connecting the separate DH grid in Mustola to Lappeenranta's main DH grid: 0,9 M€ • Converting heat plant in Ihalainen to use wood pellets: 5,0 M€ • Converting heat plants in Selkäharju to use electric boiler + heat storage: 0,8 M€ Investment costs by CO2e unit: 71 eur/ tCO2e
External costs and benefits	Nature and biodiversity	Wood pellets are manufactured sustainably according to RED II
	Socioeconomic effects & wellbeing	

B-2.2: Individual action outlines		
Action outline	Action name	1.3. District heating network efficiency improvements
	Action type	Technical intervention
	Action description	Reduction of the heat losses in the district heating network by optimizing the temperature.
Reference to impact pathway	Field of action	Energy systems
	Systemic lever	Technology and Infrastructure
	Outcome (according to module B-1.1)	More efficient heat production and distribution.
Implementation	Responsible bodies/person for implementation	Lappeenrannan Energia Oy, Lämpövoima Oy, Lappeenrannan Energiaverkot Oy
	Action scale & addressed entities	City wide district heating network
	Involved stakeholders	District heating customers, companies/service providers
	Comments on implementation	Further DH grid temperature reduction requires investments on the demand side. (Energy efficiency in the buildings)
Impact & cost	Generated renewable energy (if applicable)	
	Removed/substituted energy, volume or fuel type	1,3 % reduction of the losses, 1000 MWh/year
	GHG emissions reduction estimate (total) per emission source sector	Direct GHG reductions are included in the action 1.1. Network efficiency improvements assist in phasing out the peat usage on biomass power plant
	Total costs and costs by CO2e unit	
External costs and benefits	Nature and biodiversity	Positive impact: efficiency improvements reduce the use of energy and reduce the demand for wood fuels. Enables more sustainable biomass feed in the power plant.
	Socioeconomic effects & wellbeing	Air quality improvement Cost of energy

B-2.2: Individual action outlines		
Action outline	Action name	1.4. Seasonal heat storage
	Action type	Technical intervention
	Action description	To enable the efficient utilization of new heat sources, a large district heating storage facility is being constructed
Reference to impact pathway	Field of action	Energy systems
	Systemic lever	Technology and Infrastructure
	Outcome (according to module B-1.1)	Large (150 000 – 250 000 m3) heat storage. Reduced use of primary energy
Implementation	Responsible bodies/person for implementation	Lappeenrannan Energia Oy, Lämpövoima Oy, Lappeenrannan Energiaverkot Oy
	Action scale & addressed entities	City wide district heating network
	Involved stakeholders	Companies/service providers. Companies providing excess heat. Citizens living in the area.
	Comments on implementation	The heat storage implementation method is still under review. The reviewed options for the seasonal heat storage are cave storage and pit storage.
Impact & cost	Generated renewable energy (if applicable)	
	Removed/substituted energy, volume or fuel type	The storage enables the efficient use of alternative heat sources, ie .geothermal and excess heat usage. Yearly utilization of the storage 10 000 – 15 000 MWh.
	GHG emissions reduction estimate (total) per emission source sector	Direct GHG reductions are included in the action 1.1. The use of alternative heat sources and seasonal heat storage assist in phasing out the peat usage on biomass power plant
	Total costs and costs by CO2e unit	4 000 000 – 6 000 000 eur. Costs by MWh: 40 eur/MWh
External costs and benefits	Nature and biodiversity	Positive impact: reduces the use of energy and reduce the demand for wood fuels. Enables more sustainable biomass feed in the power plant.
	Socioeconomic effects & wellbeing	Air quality improvement (+) Cost of energy (+) Employment (-/+)

B-2.2: Individual action outlines		
Action outline	Action name	1.5 Utility scale solar and wind power
	Action type	Technical intervention
	Action description	New industrial-scale solar power plants are being built in the Lappeenranta city area, and possibly also wind power..
Reference to impact pathway	Field of action	Energy systems
	Systemic lever	Technology and Infrastructure
	Outcome (according to module B-1.1)	Solar power production increases by 600 MWp – 1000 MWp. Renewable electricity production increases by 600 GWh - 1 000 GWh.
Implementation	Responsible bodies/person for implementation	City of Lappeenranta
	Action scale & addressed entities	Land area needed for the power plants is 850 – 2000 ha.
	Involved stakeholders	Private land owners, citizens, companies developing the solar power projects.
	Comments on implementation	The mapping for the most promising areas has been completed. Zoning, impact assesment and permitting processes are on going in 2023.
Impact & cost	Generated renewable energy (if applicable)	600 GWh – 1 000 GWh
	Removed/substituted energy, volume or fuel type	The increased renewable electricity generation replaces fossil fuel generation.
	GHG emissions reduction estimate (total) per emission source sector	24 000 – 25 000 tCO2e when calculated using the national grid electricity emission factor of 40 gCO2e/kWh.
	Total costs and costs by CO2e unit	400 M€ - 650 M€.
External costs and benefits	Nature and biodiversity	Reduces the use of fossil fuels nationally (+) Large project areas can lead to negative impacts on biodiversity, especially if plants are built on forest areas. (--)
	Socioeconomic effects & wellbeing	Cost of energy (+) Employment (+++)

B-2.2: Individual action outlines		
(fill out one sheet per intervention/project)		
Action outline	Action name	2.1 Carbon neutral public transportation
	Action type	Technical Intervention
	Action description	Public transportation services provided by the city will be carbon neutral by 2030. This includes local buses, regional buses and school rides.
Reference to impact pathway	Field of action	Mobility
	Systemic lever	Technology and Infrastructure
	Outcome (according to module B-1.1)	20-30 diesel buses replaced by electric buses. Rest of the diesel buses are either using biogas or other renewable fuels.
Implementation	Responsible bodies/person for implementation	City of Lappeenranta: roads and environment department.
	Action scale & addressed entities	The area covered by the public transportation services
	Involved stakeholders	Service providers, citizens
	Comments on implementation	new procurement for the local city bus service in 2026: 100 % electric Procurement for the school rides, starts in 2024: 90 % renewable diesel. New procurement for the regional public transportation service in 2025-2026: Partly electric. By 2030 either electric or 100 % renewable fuel.
Impact & cost	Generated renewable energy (if applicable)	
	Removed/substituted energy, volume or fuel type	Fuel consumption not monitored for the previous years. Public transporation: yearly kilometers -city buses 1 400 000 km -regional buses 970 000 km -school rides 800 000 km
	GHG emissions reduction estimate (total) per emission source sector	Fuel consumption and emissions are not monitored for the previous years. Estimate for the emission reduction is 1 900 tCO2e per year.
	Total costs and costs by CO2e unit	Investment cost: Electric buses: 13 000 000 – 19 000 000 eur Charging infrastructure: 3 000 000 eur Estimated operating cost savings cover the investment costs in a long run. The cost for the public transportation service with electric buses is estimated to be at the same level than with diesel buses
External costs and benefits	Nature and biodiversity	Reduced amount of fine particles (+)
	Socioeconomic effects & wellbeing	Reduced noise (+) Affordable transportation service (+)

B-2.2: Individual action outlines		
(fill out one sheet per intervention/project)		
Action outline	Action name	2.2 Carbon neutral transportation and logistics
	Action type	Technical Intervention/Governance
	Action description	Transport and traffic related services of the city of Lappeenranta are carried out in a carbon-neutral manner, including, among other things, commuting during the workday, street maintenance, and food transportation
Reference to impact pathway	Field of action	Mobility
	Systemic lever	Technology and Infrastructure
	Outcome (according to module B-1.1)	Procurement of carbon neutral vehicles and transportation services
Implementation	Responsible bodies/person for implementation	City of Lappeenranta: Greenreality services, roads and environment department.
	Action scale & addressed entities	City departments
	Involved stakeholders	Service providers, citizens
	Comments on implementation	Most of the passenger vehicles and vans purchased by the city are zero emission vehicles. In the near future same has to be applied also to transportation services
Impact & cost	Generated renewable energy (if applicable)	-
	Removed/substituted energy, volume or fuel type	Fossils fuels, 1 200 MWh/a
	GHG emissions reduction estimate (total) per emission source sector	300 tCO2e/a
	Total costs and costs by CO2e unit	Increased cost for the provided services: 100 000 eur per year Additional purchase and leasing costs for vehicles and machines: 60 000 eur per year Costs by CO2e unit: 530 eur/tCO2e
External costs and benefits	Nature and biodiversity	Reduced amount of fine particles (+)
	Socioeconomic effects & wellbeing	Reduced noise (+)

B-2.2: Individual action outlines		
(fill out one sheet per intervention/project)		
Action outline	Action name	2.3 Accelerating the adoption of clean vehicles on the private sector
	Action type	Technical Intervention/Governance
	Action description	Multiple actions are needed for accelerating the adoption of EVs and other clean vehicles. Actions included: -enabling HPC stations on city owned land -installing charging points to municipality owned buildings and street sides -promoting the charging infrastructure installations to apartment buildings -promotion of biogas use on transportation sector
Reference to impact pathway	Field of action	Mobility
	Systemic lever	Technology and Infrastructure/Governance
	Outcome (according to module B-1.1)	80 additional public quick charging points and 5000 additional slow charging points by 2030 The number of rechargable vehicles increases by 12 000 by 2030
Implementation	Responsible bodies/person for implementation	City of Lappeenranta, Lappeenrannan toimitilat Oy, Lappeenrannan Asuntopalvelu Oy
	Action scale & addressed entities	Buildings owned by the city and by city owned companies. Streets and parking spaces owned by the city
	Involved stakeholders	Service providers, transportation and logistic companies, citizens and employees
	Comments on implementation	First phase of the charging point installations to municipality owned buildings started in 2022. Decision to offer city owned parking lots for HPC stations was done in 2023. Most of the investments will be done by private sector and citizens
Impact & cost	Generated renewable energy (if applicable)	-
	Removed/substituted energy, volume or fuel type	replaced fossil fuels: 140 000 MWh
	GHG emissions reduction estimate (total) per emission source sector	38 000 tCO2e
	Total costs and costs by CO2e unit	Charging infrastructure: Quick charging: 8 000 000 eur Public slow chargers: 2 000 000 eur Private slow chargers: 10 000 000 eur EVs: additional purchase cost: 60 – 90 M€ by 2030 Ethanol and CNG conversions: 2.5 M€ Costs by CO2e unit: 350 eur/tCO2e
External costs and benefits	Nature and biodiversity	The reduction of fine particles (+) The reduced use of primary energy (++)
	Socioeconomic effects & wellbeing	Socioeconomic effects (+/-) Additional purchase cost of EVs can increase social injustice (-) Installing chargers to municipality owned buildings can enable the EV ownership for tenants living in apartment buildings (+)

B-2.2: Individual action outlines		
Action outline	Action name	3.1. Waste recycling rate increase
	Action type	Technical Intervention
	Action description	Roughly a quarter of the waste incinerated for energy consists of organic waste. The amount of waste sent for incineration is being reduced by improving source separation and constructing a new waste sorting line where organic waste and metals are separated from dry waste. The goal is to reduce the amount of waste sent for incineration by approximately 20% by 2030
Reference to impact pathway	Field of action	Waste
	Systemic lever	Technology and Infrastructure Governance Social Innovation
	Outcome (according to module B-1.1)	The amount of waste going to inceneration decreases by 20 %. The amount of organic waste feed going to biogas plant increases by 2500 tons per year The amount of metal recycling increases by 200 tons.
Implementation	Responsible bodies/person for implementation	Regional waste management company, municipalities, ASKI-project
	Action scale & addressed entities	Regional.
	Involved stakeholders	Citizens, Housing co-operatives, businesses at service sector
	Comments on implementation	
Impact & cost	Generated renewable energy (if applicable)	Increased biogas production: included in the action 3.2.
	Removed/substituted energy, volume or fuel type	
	GHG emissions reduction estimate (total) per emission source sector	Reduction of the emissions coming from waste inceneration: 10 000 tCO2e/year
	Total costs and costs by CO2e unit	New waste separation line: 3 – 3.5 M€ Waste recycling improvements: 0.1 M€ per year Savings: 0.5 M€ per year Costs by CO2e unit: from -8 eur/tCO2e to -3 eur/tCO2e
External costs and benefits	Nature and biodiversity	Reduced use of raw materials (+)
	Socioeconomic effects & wellbeing	Economic effects: Affordable services (+)

B-2.2: Individual action outlines		
Action outline	Action name	3.2. Biogas production increase
	Action type	Technical Intervention
	Action description	Regional waste management company makes investments to increase biogas production and delivery capacity of the biogas to the stations.
Reference to impact pathway	Field of action	Waste
	Systemic lever	Technology and infrastructure
	Outcome (according to module B-1.1)	Biogas production increase by 5 000 MWh
Implementation	Responsible bodies/person for implementation	Etelä-Karjalan jätehuolto Oy
	Action scale & addressed entities	Internal action for the waste management company. BiG biokaasu.
	Involved stakeholders	Companies working on the transportation and logistic sectors
	Comments on implementation	Biogas production increase needs additional organic waste feeds. New waste separation line enables additional organic waste feed for the biogas production.
Impact & cost	Generated renewable energy (if applicable)	5 000 MWh
	Removed/substituted energy, volume or fuel type	Replaces fossil fuels in transportation, estimated reduction 5 000 MWh
	GHG emissions reduction estimate (total) per emission source sector	1 370 tCO2e/year.
	Total costs and costs by CO2e unit	Estimated investment costs: 1 000 000 eur Estimated costs by CO2e unit: 50 eur/tCO2e
External costs and benefits	Nature and biodiversity	Reduction in fossil fuel use (++)
	Socioeconomic effects & wellbeing	effects on employment (+)

B-2.2: Individual action outlines		
(fill out one sheet per intervention/project)		
Action outline	Action name	4.1 Increase of the strictly protected land area
	Action type	Nature based solution
	Action description	One target of the EU Biodiversity strategy is to increase the amount of strictly protected land areas upto 10 % of the area. The Finnish Nature Panel has recommended that 10 % of the land areas is protected in every region. Protecting 10 % of Lappeenranta's land areas mean 140 km2.
Reference to impact pathway	Field of action	AFOLU
	Systemic lever	Governance and policy
	Outcome (according to module B-1.1)	69 kt CO2e/a less carbon removed from the tree stock.
Implementation	Responsible bodies/person for implementation	City of Lappeenranta, land owners, nature protection organisations and experts
	Action scale & addressed entities	140 km2 protected land area, land owners
	Involved stakeholders	Land owners, local communities, residents, local authorities, forest industry
	Comments on implementation	
Impact & cost	Generated renewable energy (if applicable)	-
	Removed/substituted energy, volume or fuel type	-
	GHG emissions reduction estimate (total) per emission source sector	69 kt AFOLU
	Total costs and costs by CO2e unit	
External costs and benefits	Nature and biodiversity	Enhances biodiversity of protected biotypes.
	Socioeconomic effects & wellbeing	Nature increases the potential for travel sector and the wellbeing of residents.

B-2.2: Individual action outlines		
(fill out one sheet per intervention/project)		
Action outline	Action name	4.2. Restoration of forests and fields on organic soils. Raising the water level and restoring former peat production sites.
	Action type	Nature based solution
	Action description	Organic forests act as a substantial methane source, estimated to represent net emissions of about 110 kt CO2e/a.
Reference to impact pathway	Field of action	AFOLU
	Systemic lever	Governance and policy
	Outcome (according to module B-1.1)	Restored peat extraction site area: 200 ha Restoration of the organic soil forests: 5 km2 Enhancing the carbon sequestration of organic soil forests; 20 km2 Restoration of the organic soil croplands, 6 km2
Implementation	Responsible bodies/person for implementation	City of Lappeenranta Big forest owners: Lappeenrannan seurakuntayhtymä, forest companies
	Action scale & addressed entities	
	Involved stakeholders	Forest Centre, Forest management associations, Private forest owners
	Comments on implementation	
Impact & cost	Generated renewable energy (if applicable)	-
	Removed/substituted energy, volume or fuel type	-
	GHG emissions reduction estimate (total) per emission source sector	33 kt CO2e
	Total costs and costs by CO2e unit	-
External costs and benefits	Nature and biodiversity	Has positive effects on biodiversity and water protection.
	Socioeconomic effects & wellbeing	

B-2.2: Individual action outlines		
(fill out one sheet per intervention/project)		
Action outline	Action name	4.3. Lengthening the growth cycle of forests
	Action type	Nature based solution
	Action description	Carbon storages of the forests are increased by lengthening the growth cycle of the forests and thus reducing timber removal. Continuous growth is applied where suitable.
Reference to impact pathway	Field of action	AFOLU
	Systemic lever	Governance & policy Finance and finding
	Outcome (according to module B-1.1)	Carbon storage increased in 87500 ha of forests in Lappeenranta city area.
Implementation	Responsible bodies/person for implementation	City of Lappeenranta, Forest authorities, Forest Centre, national authorities
	Action scale & addressed entities	Forest owners, Forest industry
	Involved stakeholders	Forest owners, citizens
	Comments on implementation	Incentives are needed for extending the rotation period of forests and pricing large timber. National and EU policies will form the framework for the incentives.
Impact & cost	Generated renewable energy (if applicable)	-
	Removed/substituted energy, volume or fuel type	-
	GHG emissions reduction estimate (total) per emission source sector	30 kt
	Total costs and costs by CO2e unit	Depends of the incentive system. Estimated costs 10 – 50 eur tCO2e
External costs and benefits	Nature and biodiversity	Positive effects on biodiversity. (++)
	Socioeconomic effects & wellbeing	effects on forest owners income (+/-) effects on employment (-) effects on recreational use (+)

B-2.2: Individual action outlines		
(fill out one sheet per intervention/project)		
Action outline	Action name	5.1. Energy efficiency renovations
	Action type	Technical intervention
	Action description	Energy-efficient renovations are necessary for a large portion of Lappeenranta's properties. Renovations include additional insulation, energy efficient windows and doors and also deep renovations.
Reference to impact pathway	Field of action	Energy, electricity
	Systemic lever	technology and infrastructure
	Outcome (according to module B-1.1)	Energy efficiency renovations have been completed for an additional 15 % of the building stock. Reduced energy demand by 5 %.
Implementation	Responsible bodies/person for implementation	City of Lappeenranta, Buildings working group, Asuntopalvelut Oy, building owners
	Action scale & addressed entities	15 % of the building stock
	Involved stakeholders	Citizens, service providers
	Comments on implementation	Implementation is going on and continues beyond year 2030.
Impact & cost	Generated renewable energy (if applicable)	Installed PV as a part of EE renovation, 25 MWp=> 2 000 MWh
	Removed/substituted energy, volume or fuel type	Reduced demand for the electricity, 7 000 MWh Reduced demand for the district heating 15 000 MWh
	GHG emissions reduction estimate (total) per emission source sector	Electricity use: 500 tCO2e/year Costs by CO2e unit: reduced OPEX costs cover the investment costs.
	Total costs and costs by CO2e unit	6 800 000 per year, 40 000 000 by 2030.
External costs and benefits	Nature and biodiversity	Reduced use of fossil fuels (+) Reduced use of primary energy (++)
	Socioeconomic effects & wellbeing	Affordable housing (+) Employment (+)

B-2.2: Individual action outlines		
Action outline	Action name	5.2 Replacing heating oil with renewable energy on the buildings
	Action type	Technical Intervention
	Action description	The use of natural gas and fuel oil will cease in all municipality-owned buildings by 2030. The city collaborates with businesses and housing cooperatives to phase out oil usage in privately-owned buildings. The city initiates awareness campaigns and offers energy advisory services to accelerate phasing out the oil usage in private homes.
Reference to impact pathway	Field of action	Energy systems
	Systemic lever	Technology and infrastructure
	Outcome (according to module B-1.1)	Most of the oil and natural gas heating systems will be replaced with systems using renewable energy.
Implementation	Responsible bodies/person for implementation	Energy counselling service, Building sector working group, Lappeenrannan toimitilat Oy
	Action scale & addressed entities	Buildings heated by oil or natural gas: 61 apartment buildings 3000+ private homes 300+ other buildings
	Involved stakeholders	Service providers, tenants living in apartment buildings, private home owners
	Comments on implementation	Implementation on going in 2023. The use of oil and natural gas in municipally owned buildings has almost ended by 2023.
Impact & cost	Generated renewable energy (if applicable)	Heat pumps and wood fuels, 21 500 MWh
	Removed/substituted energy, volume or fuel type	Natural gas + heating oil, 43 000 MWh
	GHG emissions reduction estimate (total) per emission source sector	Apartment buildings and houses: 7 300 tCO2e Municipal and service buildings: 4 000 tCO2e
	Total costs and costs by CO2e unit	Investment cost estimate: 31 M€ Investment costs by CO2 unit: 140 eur/tCO2e Reduction in OPEX 3 500 000 Total costs with a 20 year calculation period: -10 eur/tCO2e
External costs and benefits	Nature and biodiversity	reduced use of fossil fuels and primary energy (++)
	Socioeconomic effects & wellbeing	Air quality (++) Wellbeing: reduced energy costs (+)

B-2.3: Summary strategy for residual emissions

In the Action Plan, the residual emissions are calculated to be 85 000 tons of CO2e in 2030, representing 18.9 % share of the baseline emissions. AFOLU sector has been an emission source in Lappeenranta. With additional actions, it is expected that AFOLU sector will be a carbon sink of 25 800 tons of CO2e by 2030. When considering also the carbon sinks from the AFOLU sector, the residual emissions would be 59 200 tons of CO2e.

The Action plan is continuously updating plan. New actions for the further emission reductions will be added and the target is to find additional interventions to cover part or all of these residual emissions.

All remaining residual emissions will be compensated with verified carbon credits or by purchasing EU ETS carbon allowances.

Lappeenrannan Energia Oy is committed to provide carbon neutral district heating by 2026. The residual emissions for the district heating has been estimated to be 3000 – 4000 tons of CO2e. These emissions will be compensated by verified carbon credits or EU ETS allowances, starting in 2027.

Financing the compensations

To cover the compensation costs, city can direct revenue from solar farm property taxes and yearly land rents. Emission reductions and carbon sink growth are expected to continue after year 2030, reducing the amount of residual emissions. By 2035 residual emissions should be eliminated and there would not be need for additional compensations.

4.3 Module B-3 Indicators for Monitoring, Evaluation and Learning

Module B-3 “Indicators for Monitoring, Evaluation and Learning” should contain a selection of indicators taken from the Comprehensive Indicator Sets developed by NZC. The following should be provided: An overview table listing the indicators selected per outcome and impact including targets and evaluation points (B-3.1); and a metadata table for each indicator selected, as specified in the Comprehensive Indicator Sets (B-3.2).

B-3.1: Impact Pathways							
Outcomes/ impacts addressed	Action/ project	**Indicator No.** (unique identified)	Indicator name		Target values		
					2025	2027	2030
(list early changes/ late outcomes and impacts to be evaluated by indicator)	(list action/ pilot project if applicable)	(indicate unique identifier)	(Insert indicator name)		(list one value per indicator)	(list one value per indicator)	(list one value per indicator)
…	…	…	…		…	…	…

B-3.2: Indicator Metadata	
Indicator Name	Amount of EVs
Indicator Unit	number of vehicles
Definition	Number of EVs registered in Lappeenranta
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Mobility
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Mobility & transport: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Traficom
Expected availability	Available public data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Municipal buildings energy consumption
Indicator Unit	kWh/m2
Definition	Energy consumed in municipal buildings both as electricity and as heat
Calculation	Ratio of energy consumption and floor area
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Buildings
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Energy systems: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Statfi
Expected availability	Available public data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Air quality; fine particles
Indicator Unit	µg/m3
Definition	Amount of fine particles PM10 and PM2,5 in the air
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	
Does the indicator measure indirect impacts (i.e. co- benefits)?	Yes
If yes, which co-benefit does it measure?	Air quality; fine particles
Can the indicator be used for monitoring impact pathways?	No
If yes, which NZC impact pathway is it relevant for?	
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Lappeenranta Region Environmental Services
Expected availability	Available public data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Clean environment and renewable energy employment
Indicator Unit	Number of persons
Definition	Number of persons working In the field of environment and renewable energy
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	
Does the indicator measure indirect impacts (i.e. co- benefits)?	Yes
If yes, which co-benefit does it measure?	Economy – employment
Can the indicator be used for monitoring impact pathways?	No
If yes, which NZC impact pathway is it relevant for?	
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Statfi
Expected availability	Not publicly available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Household energy costs; district heating
Indicator Unit	€/kWh
Definition	Costs of energy for the consumers
Calculation	Consumers district heating costs in relation to the produced heat
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	
Does the indicator measure indirect impacts (i.e. co- benefits)?	Yes
If yes, which co-benefit does it measure?	Economy – energy costs
Can the indicator be used for monitoring impact pathways?	No
If yes, which NZC impact pathway is it relevant for?	
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Lappeenrannan energia Oy, Lappeenrannan lämpövoima oy
Expected availability	Not publicly available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Urban green spaces
Indicator Unit	ha
Definition	Total area of green spaces in Lappeenranta city area
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	
Does the indicator measure indirect impacts (i.e. co- benefits)?	Yes
If yes, which co-benefit does it measure?	Biodiversity
Can the indicator be used for monitoring impact pathways?	No
If yes, which NZC impact pathway is it relevant for?	
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Lappeenranta City Forest Services
Expected availability	Not publicly available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Citizen involvement in co-creation/co-design of climate actions
Indicator Unit	number of citizens
Definition	
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	No
If yes, which NZC impact pathway is it relevant for?	
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Greenreality Services
Expected availability	Not publicly available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Modal share of walking and cycling
Indicator Unit	% of mobility
Definition	The percentage share of walking and cycling in travel behaviour
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Mobility & transport: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Greenreality Services
Expected availability	Not publicly available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Recycling rate of municipal waste
Indicator Unit	% recycled of municipal waste
Definition	
Calculation	Ratio of recycled and total municipal waste
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	
Does the indicator measure indirect impacts (i.e. co- benefits)?	Yes
If yes, which co-benefit does it measure?	Circular economy
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Waste: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	EKJH
Expected availability	Available public data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Urbanized land area
Indicator Unit	m2/capita/year
Definition	Amount of new urbanized land area per capita in Lappeenranta
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	No
If yes, which NZC impact pathway is it relevant for?	
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Statfi
Expected availability	Available public data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
(for each indicator selected – take from Comprehensive Indicator Sets)	
Indicator Name	Carbon sinks in municipality owned forests
Indicator Unit	tC and tCO2e
Definition	GHG emissions and changes in the carbon stocks of City owned forests
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	Yes
If yes, which emission source sectors does it impact?	AFOLU
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Green infrastructure and nature-based solutions
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Statfi
Expected availability	Available public data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Number of EV charging points
Indicator Unit	Number of QC points Number of public charging points
Definition	
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Mobility
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Mobility & transport: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Traficom
Expected availability	Available public data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Amount of peat used in a biomass power plant
Indicator Unit	MWh of peat
Definition	Total amount of peat consumed in energy production.
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Buildings
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Energy Systems: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Kaukaan Voima
Expected availability	Available data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Reduction in GHG emissions
Indicator Unit	tCO2e
Definition	Direct reduction of GHG emissions
Calculation	According to the emission factor of the fuel
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	Yes
If yes, which emission source sectors does it impact?	Buildings
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Energy Systems: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Kaukaan Voima
Expected availability	Available data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
(for each indicator selected – take from Comprehensive Indicator Sets)	
Indicator Name	Amount of natural gas and oil consumed at local district heating plants
Indicator Unit	MWh of natural gas and oil
Definition	Total amount of natural gas and oil consumed in local district heating plants
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Energy Systems: Technology & Infrastructure
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Energy Systems: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Lappeenrannan Energia Oy
Expected availability	Available data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Reduction in GHG emissions
Indicator Unit	tCO2e
Definition	Direct reduction of GHG emissions
Calculation	Difference between reduction in consumption of fossil fuels and the emissions from replacing energy sources,
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	Yes
If yes, which emission source sectors does it impact?	Buildings
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Energy Systems: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Lappeenrannan Energia
Expected availability	Available data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Reduction in energy losses
Indicator Unit	MWh of heat
Definition	Reduction of energy losses within the district heating system
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Buildings
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Energy Systems: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Lappeenrannan Energia OY
Expected availability	Requires calculations to produce data
Suggested collection interval	Before and after actions/investments
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Number of properties that have switched away from oil heating
Indicator Unit	Number of properties
Definition	Number of properties that have switched away from oil heating
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Buildings
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	No
If yes, which NZC impact pathway is it relevant for?	Energy Systems: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	StatFi
Expected availability	Regional data publicly available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
(for each indicator selected – take from Comprehensive Indicator Sets)	
Indicator Name	Installed solar and wind power capacity
Indicator Unit	MW
Definition	Installed solar and wind power capacity
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Buildings
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Energy Systems: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Energy companies
Expected availability	Data publicly available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Buses in public transportation services that use carbon neutral energy
Indicator Unit	% of buses
Definition	Ratio of electric and biofuel buses to buses using fossil fuels
Calculation	Ratio of electric and biofuel buses to buses using fossil fuels
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Transportation
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Mobility & transport: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Transportation service providers
Expected availability	Data available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
(for each indicator selected – take from Comprehensive Indicator Sets)	
Indicator Name	City vehicles that use carbon neutral energy
Indicator Unit	% of vehicles
Definition	Ratio of electric and biofuel vehicles to vehicles using fossil fuels
Calculation	Ratio of electric and biofuel vehicles to vehicles using fossil fuels
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Mobility
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Mobility & transport: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Lappeenranta City
Expected availability	Data available within Lappeenranta City
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Number of EV charging points
Indicator Unit	Number of QC points Number of public charging points
Definition	
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Mobility
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Mobility & transport: Technology & Infrastructure
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Traficom
Expected availability	Available public data
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Amount of biowaste to incineration
Indicator Unit	Tons of biowaste
Definition	Quantities of biowaste sent to incineration
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	Waste
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Waste and circular economy
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	EKJH
Expected availability	Data available
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Strictly protected land area
Indicator Unit	ha
Definition	Land area protected according to EU biodiversity strategy
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	AFOLU
Does the indicator measure indirect impacts (i.e. co- benefits)?	Yes
If yes, which co-benefit does it measure?	Biodiversity
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Green infrastructure and nature-based solutions
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Natural Resources Institute Finland
Expected availability	Data available
Suggested collection interval	Once every three years
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Restored peat extraction sites
Indicator Unit	ha
Definition	Area of former peat production sites restored
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	AFOLU
Does the indicator measure indirect impacts (i.e. co- benefits)?	Yes
If yes, which co-benefit does it measure?	Biodiversity
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Green infrastructure and nature-based solutions
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Expert organizations
Expected availability	Data available
Suggested collection interval	Once every three years
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
(for each indicator selected – take from Comprehensive Indicator Sets)	
Indicator Name	Restored organic soil forests
Indicator Unit	ha
Definition	Area of drained organic soil forests restored
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	AFOLU
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Green infrastructure and nature-based solutions
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Expert organizations
Expected availability	Data available
Suggested collection interval	Once every three years
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Restored croplands of organic soil
Indicator Unit	ha
Definition	Area of croplands with organic soil restored
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	AFOLU
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	Yes
If yes, which NZC impact pathway is it relevant for?	Green infrastructure and nature-based solutions
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Expert organizations
Expected availability	Data available
Suggested collection interval	Once every three years
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

B-3.2: Indicator Metadata	
Indicator Name	Average age of forest harvesting
Indicator Unit	years
Definition	Years since previous clearcutting
Calculation	
Indicator Context	
Does the indicator measure direct impacts (i.e. reduction in greenhouse gas emissions?)	No
If yes, which emission source sectors does it impact?	AFOLU
Does the indicator measure indirect impacts (i.e. co- benefits)?	No
If yes, which co-benefit does it measure?	
Can the indicator be used for monitoring impact pathways?	No
If yes, which NZC impact pathway is it relevant for?	Green infrastructure and nature-based solutions
Is the indicator captured by the existing CDP/ SCIS/ Covenant of Mayors platforms?	
Data requirements	
Expected data source	Expert organizations
Expected availability	
Suggested collection interval	Annually
References	
Deliverables describing the indicator	
Other indicator systems using this indicator	

5 Part C – Enabling Climate Neutrality by 2030

Part C "Enabling Climate Neutrality by 2030" aims to outline any enabling interventions, i.e. with regard to organizational setting or collaborative governance models, or related to social innovations – designed to support and enable the climate action portfolios described in Module B-2 as well as aiming to achieve co-benefits outlined in the impact pathway (Module B-1).

5.1 Module C-1 Organisational and Governance Innovation Interventions

Module C-1 "Organisational and Governance Innovation Interventions" consists of a summary table, listing organizational and governance interventions and describing their impact (C-1.1) and a section for more detailed descriptions and comments (C-1.2).

C.1.1: Enabling organisational and governance interventions					
Intervention name	Description	Responsible entity/ dept./ person	Involved stakeholder	Enabling impact	Co-benefits
(indicate name of intervention)	(describe the substance of the intervention)	(indicate responsible)	(list all stakeholder involved and affected)	(describe how intervention enables climate neutrality)	(indicate how intervention helps achieve impact listed in Module B-1)
Mission Team	Establishing mission team, including members from multiple departments and from the city administration	Environment director	Greenreality services, road & environment, city administration, procurement services, Finance department	Enables effective work between different city departments	Essential for advancing the climate actions on all sectors
Working Group 1	Working group for the built environment	Greenreality Services	Asuntopalvelut, Lappeenrannan toimitilat Oy, LOAS, service providers, Lappeenrannan Energia Oy	Enables cross-organisational collaboration	Advances EE actions
Working Group 2	Working group for the sustainable transportation	Greenrereality services	Streets and environment, regional council, Cycling association, residents, emplyees, service providers, enterprises, public transportation	Information sharing and collaboration can accelerate the change towards more sustainable transportation system	Essential for successfull implementation of zero emission transportation and logistic services

Working group 3	Working group for nature based solutions	Greenreality services	Streets & environment dep., NGOs, regional council, regional environmental office, residents	gathering information and feedback is needed for creating the plans. Collaboration and information sharing is very valuable	
Greenreality Services	Greenreality services is an cross-departmental unit focusing on climate, renewable energy and nature solutions	Greenreality services	city departments, NGOs, city owned companies, local companies, university, citizens	The Greenreality services unit is essential for developing new projects and pilots, but also for coordinating the work between the departments and also between city and private companies.	Knowledge sharing, providing assistance to other departments, introducing new practices and funding opportunities
Greenreality Working Committee	The committee covers all city departments and city owned companies	City management, Greenreality Services	City departments, city owned companies	Enables effective work between different city departments and city owned companies	More efficient information and knowledge sharing. More agile governance.
Greenreality Network	Network of the energy and environment sector's companies.	City development	Local and regional companies. Universities, other municipalities	Enables efficient collaboration between companies and with the city of Lappeenranta.	
Transition team	Cross-sectoral team monitoring and guiding the CCC	City management, Greenreality services	local and regional companies, university, NGOs	Essential for including the actors outside of the city in the CCC process	Knowledge sharing, collaboration, gathering information

C-1.2: Description of organisation and governance interventions – textual and visual elements

5.2 Module C-2 Social and Other Innovation Interventions

Module C-2 "Social and Other Innovation Interventions" consists of a summary table, listing organizational and collaborative governance interventions and describing their impact (C-2.1) and a section for more detailed descriptions and comments (C-2.2).

C.2.1: Enabling social innovation interventions					
Intervention name	Description	Responsible entity/ dept./ person	Involved stakeholder	Enabling impact	Co-benefits
(indicate name of intervention)	(describe the substance of the intervention)	(indicate responsible)	(list all stakeholder involved and affected)	(describe how intervention enables climate neutrality)	(indicate how intervention helps achieve impact listed in Module B-1)
UNIORI	sustainability focused education package and model for the schools	HYSI, LUMO, LUT	Greenreality services, children and students	The model is a big opportunity to share information to all children and students and at the same time include children and youth in participatory processes	New possibilities to reach all the students, increased youth participation
Youth climate group	Group for youth interested of climate actions	Greenreality services, dept. for youth counselling	Residents, age 12-20.		
Climate festivals	Sustainability focused set of workshop at schools	Regional council, Greenreality services	Students, NGOs, Etelä-Karjalan jätehuolto, ENNE	Dissemination, information sharing	
Pyöräilyryhmä	Working group for cycling	Streets and environment	Greenreality services, cycling association, regional council, residents	Essential collaboration to advance cycling infrastrucure development.	
Housing association forum	A forum for advancing group procurements for housing associations	Greenreality services, energy counselling	Housing associations, home owners, Greenreality services	Advancing investments in energy efficiency	
Borrowing thermal camera	There are thermal cameras available to be	Greenreality services, Energy Counselling	Home owners	Advancing investments in energy efficiency	

	borrowed for residents to identify cold spots from their buildings.				

C-2.2: Description of social innovation interventions – textual and visual elements

5.3 Module C-3 Financing of Action Portfolio

Module C-3 “Financing of Action Portfolio” should contain the list of action portfolios and interventions outlined in Modules B-2, and those from C-1 and C-2 with cost implication to provide a summary list of interventions that need to be unpacked in the Investment Plan.

C-3.1: Summary of interventions with cost implication (to be unpacked in Investment Plan)					
Action/ intervention name	Responsible entity and person	Start/end date	Field of action	Impact	Total cost estimated
(list action portfolios and interventions from Modules B-2, C-1 and C-2, which have a cost implication)	(indicate responsible entity and person)	(indicate start and end date of the activity)	(indicate the field of action the interventions belongs to)	(indicate impact - i.e. the GHG reduction/ co-benefit)	(indicate the total costs in €, estimated for the intervention)
1.1.	Lappeenrannan Energia, Jarkko Kovanen	2024-2026	Energy systems	25 000 tCO2e	8 000 000
1.2.	Lappeenrannn Energia, Jarkko Kovanen	2023-2025	Energy systems	7 500 t CO2e	8 000 000
1.4.	Lappeenrannan Energia, Arto Nikkanen	2024-2027	Energy systems		4 000 000 – 6 000 000
1.5.	GR Services, private companies	2024-2030	Energy systems	25 000 tCO2e	650 M€
2.1.	Streets and environment, Terhi Koski	2023-2030	Transportation	1 900 tCO2e	-
2.2.	Streets&Env, GR services	2023-2030	Transportation	300 tCO2e	100 000 per year
2.3.	GR services	2023-2030	Transportatoin	38 000 tCO2e	100 M€
3.1.	EKJH, ASKI-hanke	2024-2030	Waste	10 000 tCOe2	4 000 000
3.2.	EKJH	2025-2028	Waste, transportation	1370 tCO2e	1 000 000
5.1.	Greenreality Services	2023-2030	Buildings	500 tCO2e	6 800 000
5.2.	Greenreality Services	2023-2030	Buildings	11 300 tCO2e	31 M€

6 Outlook and next steps

This section should draw any necessary conclusions on the Action Plan above and highlight next steps and plans for further refining the Action Plan as part of the Climate City Contract.

Plans for next CCC and Action Plan iteration – textual elements
The action plan and investment plan are both constantly developing plans. However, there will be formal updates done for both plans at least every second year. First update is planned for the year 2025. Development and implementation of the actions are both constant processes. The action plan and will be integrated to the online monitoring site: https://kestavyysvahti.lappeenranta.fi/ Each action has a responsible department and a contact person(s). The monitoring site is being updated to include also co-benefits of the actions and adding a possibility to include third party actors (outside of the city group). The AP and IP development and implementation work is coordinated by the Mission team. The mission team reports the progress and current situation to the Greenreality working committee. The committee has members from the city departments and form the city owned companies. The committee has a meeting every month and it´ll monitor and guide the work related to CCC. The changes and updates to the AP and IP will be presented to the Transition team. Transition team will meet twice a year. After the transition team, the updates and progress reports will be presented to the city board (twice or more per year). The next transition team meeting will be on February 2024. The Impact pathway frameworks will be reviewed and progressed to add coverage of actions and details. For the next emission inventory there will be more detailed and robust calculations for the Nature based solutions. The next comprehensive update for the Action Plan will be done in 2025.

7 Annexes

Annex 1. Emission Inventory and methodology

Annex 2. Examples of the participatory processes

Annex 3. Impact Pathway Framework for the Transportation and Mobility

Emission inventory methodology, part 1: Alas model, excluding forests

ALas model's calculation principles

The Finnish Environment Institute (SYKE) calculates the annual greenhouse gas emissions of Finnish municipalities by using the ALas model (Alueellinen Laskenta, regional calculation). ALas 1.4 – covers 309 municipalities and the years 2005–2021. The model is updated as necessary, and the most recent results are published annually. The carbon dioxide, methane and nitrous oxide emissions, as well as F-gases, are calculated and the results are presented as carbon dioxide equivalents. With regard to carbon dioxide, bio-based fuels have zero emissions in the calculations. The energy consumption of various operations is

also calculated, in addition to the emissions.

The calculation method of the ALas model is usage-based. The region's production-based emissions act as the starting point, but some operations that generate emissions are calculated based on consumption, regardless of their geographical area of origin. In broad terms, the calculation is similar to the basic level of GHG Protocol's GPC standard, with agriculture, F-gases and grid losses included, but without the local air service included in the standard.

Table 1 presents the ALas 1.4 model's emission sectors and their calculation principles. Hinku calculation (of the Towards Carbon Neutral Municipalities project) is the default calculation approach for monitoring municipal emissions. The Hinku calculation rules imply that the following aspects are excluded from municipal emissions:

- fuel usage of industrial plants that are part of the EU Emissions Trading System (ETS),
- all industrial electricity consumption,
- emissions from industrial waste treatment,
- drive-through traffic of trucks, vans and buses.

Additionally, emission compensations are calculated for the municipality for any wind power produced in the region, based on the annual electricity emission factor.

In the ALas model, all results are also produced without the Hinku calculation rules. Furthermore, the emissions are allocated in the emission trading and effort sharing sectors.

Corrections with heating degree days are not used to even out the differences between different years or municipalities. The benefit allocation method is used to calculate the emissions of combined heat and power plants.

ALas 1.4 does not include the following sectors:

- Air traffic
- Foreign boat traffic
- Ice breakers
- Industrial processes
- LULUCF.

Table 1. ALas 1.4 model's emission sectors and calculation principles.

Emission sector	Calculation principle	Hinku calculation	Notes
District heating – ETS	Consumption	Yes	Municipal production + purchase - sales. Subsectors: residential, services, industry, agriculture.
District heating – non-ETS	Consumption	Yes	
Oil heating	Territorial	Yes	Subsectors: residential, services, agriculture.
Electric heating	Consumption	Yes	Finnish average electricity, monthly emission factor. Subsectors: residential, services, agriculture.
Ground source heat pumps	Consumption	Yes	
Wood heating	Territorial	Yes	Separate heating. Subsectors: residential, services, agriculture.
Other heating	Territorial	Yes	Gas, heavy fuel oil, peat, coal; separate heating. Subsectors: residential, services, agriculture.
Consumption electricity	Consumption	Yes	Finnish average electricity. Subsectors: residential, services, industry, agriculture.
Consumption electricity – industry	Consumption	No	
Cars	Consumption	Yes	Annual mileage of vehicles registered in the municipality, regardless of municipal borders. Subsectors: roads and streets.
Motorcycles and mopeds	Consumption	Yes	
Busses – drive-through	Territorial	No	Mileage of vehicles registered in other municipalities, in the area under study. Subsectors: roads and streets.
Vans – drive-through	Territorial	No	
Trucks – drive-through	Territorial	No	
Busses	Territorial	Yes	Territorial emissions with drive-through traffic subtracted = "Own road traffic" Subsectors: roads and streets.
Vans	Territorial	Yes	
Trucks	Territorial	Yes	
Rail traffic	Territorial	Yes	Metros, trams, commuter and passenger trains; electricity and diesel. Freight trains; electricity and diesel.
Water traffic	Territorial	Yes	Boats, passenger and cruise ships, cargo ships, fishing vessels, work boats and ferries.
Industry – ETS	Territorial	No	Industry fuel use. Electricity generation and district heat sold outside are excluded.
Industry – non-ETS	Territorial	Yes	
Machinery	Territorial	Yes	Construction, mining and industrial, road and street, agricultural and forestry and other machinery.
F-gases	Territorial	Yes	Commercial refrigeration, air-conditioning of buildings and vehicles, other sources
Agriculture	Territorial	Yes	Enteric fermentation, manure management and cultivation; inorganic and organic fertilizers, soil emissions, other.
Waste treatment	Consumption	Yes	Amount of waste generated in the municipality, regardless of the treatment site. Subsectors: Landfills, wastewater treatment, composting and anaerobic digestion; industrial and municipal waste.
Industrial waste	Consumption	No	
Compensations	Territorial	Yes	Wind power produced in the region; calculated by the annual emission factor for average Finnish electricity.

Updates to ALas 1.4

Global warming potential (GWP) multipliers of greenhouse gases were updated to the values given in the IPCC's fifth assessment report.

Allocation of industrial emissions was changed so that also methane and nitrous oxide emissions caused by the ETS industry are left out from the Hinku emissions. Previously they were included in Hinku emissions as methane and nitrous oxide emissions are not regulated under ETS but instead they belong to the effort sharing sector.

In wastewater treatment the emissions calculation was separated to centralized and decentralized treatment as they have different emission factors. Emissions were allocated to municipalities based on the inhabitants in urban areas and dispersed settlement areas.

In the calculation of road transport emissions, the emission coefficients were specified.

Updates to ALas 1.3

The biggest change in ALas 1.3 is related to the reporting of industrial emissions. In the previous calculations separate heating emissions of industrial buildings are reported within heating method specific emissions. However, in ALas 1.3 these emissions are included in industrial emissions. As a result, heating method specific emissions are decreased while industrial emissions are higher than before.

The change might have an effect on emissions calculated with Hinku calculation principles. This is because the emissions of separate heating methods are included in Hinku emissions while industrial emissions under emissions trading system are excluded from Hinku emissions. The same principle applies for the emissions under effort sharing sector, but it does not have such effect on Hinku emissions as industrial emissions under effort sharing sector have been included to Hinku emissions also in the previous results.

Another change was made on the allocation of emissions to emissions trading system and effort sharing sector. That is, carbon dioxide emissions of electricity and district heat generation, and industrial fuel usage are included in the emissions trading system, whereas methane and nitrous oxide emissions belong to effort sharing sector.

Updates to ALas 1.2

The calculation of district heating emissions is changed so that the amount of residual emissions distributed across municipalities is lower. This affects especially the emissions in small municipalities.

The calculation principles of wind power compensation are changed. In ALas 1.2 municipal wind power outputs are calculated by multiplying annual wind power output in Finland by the share of municipality's wind power capacity of total capacity in Finland.

Corrections to heating degree days are made, that affect the emissions and energy usage of building-specific separate heating systems. Time series of agricultural emissions in 2005–2018 were corrected for five municipalities due to inaccuracies in the original datasets.

In Hinku calculation, territorial road traffic emissions are used for Åland due to missing data to calculate drive-through traffic.

Updates to ALas 1.1

The updates of the ALas 1.1 that have the most significant effect on the results compared to the previous calculation (ALas 1.0 / February 2020) were made for agriculture, industry and water transport. Agricultural emissions were recalculated for the whole reference period 2005–2018, whereas previously the results where combined from different sources.

The emission calculation for industry was adjusted in ALas 1.1 so that not all emissions from the separate heating of industrial buildings are deducted from the total emissions of the effort-sharing sector, but now also from the emissions trading sector. This gives a more realistic picture of the non-heating emissions of the industry, and for several municipalities, emissions from small-scale industries included in the Hinku calculation are now better reflected. Emissions from the industry under Emissions Trading System, on the other hand, are slightly lower than in ALas 1.0.

In the calculation of waterborne traffic, the municipal allocation of emissions from boats, ferries and cargo ships was fine-tuned. The initial data for boats registered in Åland were supplemented. The calculation of ferries was comprehensively renewed on the basis of better data sources. The basic data on emissions from connecting vessels and road ferries in mainland Finland are the fuel consumption of the operators by route, and in the case of Åland, fuel consumption is estimated on the basis of ferry activity data.

The calculation of emissions from cargo ships was refined so that the size of ships now also affects the municipal allocation of emissions, instead of the number of port calls alone. Emissions decreased, especially in municipalities with small-scale, albeit busy, freight traffic. Correspondingly, ALas 1.1 allocates more emissions to larger-scale freight traffic than before.

In addition to the more significant methodological updates, small changes were made to the emission calculation of the electricity consumption and electric heating, affecting the previous years' results. Also, the consumption of heating electricity in greenhouse-intensive municipalities was estimated lower than before. Emissions from district heating decreased somewhat between 2005 and 2015 due to a revision of the calculation of the residual emissions. In the case of individual municipalities, plant-specific data adjustments were made for both district heating and industry.

The sector-specific calculation principles are presented in more detail below.

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District heating

The main data source of the district heat emission calculation is the annual district heat statistics published by Finnish Energy, which are supplemented with information from the Association of Finnish Municipalities' publication "Tietoa pienistä lämpölaitoksista" (Information on small-scale heat plants). After this, the possible residual emissions are allocated between the municipalities so that the total district heat emissions equal the district heat emissions presented in table 3.4.3 of the Statistics Finland's Energy -chart service.

The emission factors of carbon dioxide in Statistics Finland's fuel classification and methane and nitrous oxide in IPCC's Emission Factor Database (EFDB) are used for the calculation. The municipality-specific estimated district heat consumption, modelled on the basis of the region's building stock and heating demand, is also utilised for the calculations. The emissions from municipal waste incineration are allocated to the municipality where the heat that is produced from the waste is consumed. Hazardous waste is counted to have zero emissions.

The district heating statistics are used to calculate the district heat emissions for each heat producer, as well as the purchased and sold emissions, using the benefit allocation method. The net emissions are summed up for each municipality. Additionally, the emissions included in emissions trading are estimated by comparing the plants in the district heat statistics with the data from the emissions trading registry, and the production-based emissions are calculated separately.

The district heating statistics cover about 170 municipalities. The reports of small-scale heat plants by the Association of Finnish Municipalities add about 50 municipalities to the calculations. To prevent any overlap, only the municipalities in the report by the Association of Finnish Municipalities that are not included in the district heating statistics are included in the calculations. Any gaps of the time series are filled in with the previous year's results and the municipality's modelled consumption. The end results are the known emissions and energy consumption of district heating in around 220 municipalities.

According to building stock data, almost all Finnish municipalities have buildings with district heating. The combined emissions of the district heating statistics and small-scale heat plants are also smaller than the total Finnish district heat emissions calculated by Statistics Finland. The difference between emissions is divided between the municipalities where the known consumption is lower than the modelled consumption. The residual emissions are about 6–14 % of the total emissions of district heating, and the residual consumption is about 8 % of the total consumption.

Data sources:

- District heating statistics (Finnish Energy)
- Information on small-scale heat plants (The Association of Finnish Municipalities)
- Electronic service system of environmental protection control YLVA (Ministry of the Environment)
- Finnish air pollutant data system IPTJ (SYKE)
- Plant-specific verified emissions of emissions trading (Energy Authority)
- Energy 2022 chart service, table 4.1 (Statistics Finland)
- Energy 2022 chart service, table 3.4.3 (Statistics Finland)
- Fuel classification (Statistics Finland)
- Emission Factor Database EFDB (IPCC)
- Heating degree days (Finnish Meteorological Institute)
- Corrected building stock data (Statistics Finland)
- RHR – building and apartment data in the Population Information System (Digital and Population Data Services Agency)

Oil, wood and other separate heating

The principle of the municipality-specific oil heating calculation is to divide the amount of heating oil that is annually consumed in Finland between the municipalities based on certain allocation principles. Table 7.3 in the Statistics Finland's Energy 2022 chart service presents the light fuel oil consumption in single-family houses, linked and terraced houses, residential apartment buildings, recreational homes, service buildings, industrial buildings and agricultural buildings. These annual consumptions are distributed between the municipalities based on their oil-heated floor square meters, taking into account regional differences in heating demand. Heating demand has no effect on water heating. It is estimated that about 20 percent of heating energy is used for heating water.

With regard to residential buildings, gross floor area data corrected municipality-specifically by Statistics Finland's, are used for the calculations. The floor areas of other building types are calculated by using the building and apartment registry (RHR) in the Population Information System, adjusted with the average national correction factors calculated from the materials of Statistics Finland, excluding agricultural buildings, the floor areas of which are taken directly from the RHR.

The municipal allocation process of wood heating is equal to the allocation process of oil heating. Quantity information of small-scale wood usage presented in table 7.3 of Statistics Finland is used, divided between the wood-heated buildings in municipalities based on the corrected building data and heating demand.

Other separate heating include natural gas, heavy fuel oil, peat and coal, the consumption and emissions of which have been calculated for municipalities by applying the same method as with the oil and wood heating calculations. Agricultural diffuse consumption and emissions from the Finnish air pollutant data system IPTJ are added to other separate heating used in agriculture. These mainly cover the usage of grain dryers.

The greenhouse gas emissions of the oil, wood and other heating fuel consumption are calculated with the emission factors presented in the fuel classification of Statistics Finland and by IPCC. A zero-emission bio-share of 0–4 percent is calculated for heating oil in 2009–2015, and only the methane and nitrous oxide emissions are taken into account with regard to wood.

The calculation does not include buildings with an unknown purpose of use and buildings that have "other" or "unknown" as their heating fuel. However, their share of the total separate heating is very small.

Data sources:

- Energy 2022 chart service, table 7.3 (Statistics Finland)
- Corrected building stock data (Statistics Finland)
- RHR – building and apartment data in the Population Information System (Digital and Population Data Services Agency)
- Heating degree days (Finnish Meteorological Institute)
- Fuel classification (Statistics Finland)
- Emission Factor Database EFDB (IPCC)

Electric heating and ground source heat pumps

The municipality-specific annual consumption of heating electricity and ground source heat pumps is

calculated based on building type -specific typical heat consumption from POLIREM model, weighted with heating demand and the corrected building stock data. Consumption according to POLIREM is also estimated for other uses of electricity, i.e. consumption electricity. The model's typical consumption calculated for building volume is changed to correspond to the floor area-specific consumption with the help of the average room heights of different buildings.

The statistical electricity consumption of housing in a municipality is calculated for a residential building's heating electricity, ground source heat pumps' electricity demand (COP=3) and other electricity use in relation to the consumptions calculated with the help of POLIREM.

In the service and industrial sectors, the shares of electric heating, ground source heat pumps and other electricity of the sector's total electricity consumption are estimated in a similar manner to residential buildings. However, if the consumption of heating electricity is larger when using this method than when calculated directly with POLIREM's factors, the latter values are used. Then, other electricity consumption is the value that remains after heating electricity is deducted from the total statistical consumption. This ensures that the emissions of heating electricity will not become excessive, if the municipality has buildings that consume a great deal of electricity, but not a corresponding amount of floor area with electrical heating.

The POLIREM model does not have information on agricultural buildings. It is estimated that

their typical heat consumption is 70–80 kWh/m2. The typical consumption is weighted with the heating demand of the municipalities, and the consumption of electric heating and ground source heat pumps are calculated based on the gross floor areas in the building and apartment registry (RHR).

The annual consumption of municipality-specific heating electricity is distributed over the months based on the monthly variation of local heating needs, and the emissions are calculated by using the monthly emissions factors of electricity. It is estimated that 20 percent of heating energy is used on heating household water, and the varying heating demand does not affect this.

The electricity consumption of heat pumps other than the ground source heat pumps is included in other

electricity usage (Consumption electricity).

Data sources:

- POLIREM – Policy scenario model for building sector energy consumption and greenhouse gas emissions (TTY/SYKE)
- Municipality-specific electricity use (Finnish Energy)
- Corrected building stock data (Statistics Finland)
- RHR – building and apartment data in the Population Information System (Digital and Population Data Services Agency)
- Heating degree days (Finnish Meteorological Institute)

Consumption electricity

Consumption electricity includes the use of all electricity except electric heating, the electricity consumption of the ground source heat pumps and rail transport. In addition to the electricity consumption of machines, equipment, air conditioning and lighting, consumption electricity also includes the electricity consumption of charging electric cars and other heat pumps.

The share of consumption electricity of the total energy consumption of housing is estimated based on the typical consumption values for residential houses presented in the POLIREM model. The municipality-specific usage of consumption electricity in agriculture and industry is calculated by deducting heating electricity and the electricity used by ground source heat pumps from the sector-specific total electricity consumption. Additionally, the electricity used by rail transit (passenger and local traffic) is deducted from the service sector's other electricity usage.

Housing and agriculture have been counted together in the statistic of municipality-specific electricity consumption by Finnish Energy. First, the agricultural electricity consumption is separated from this value on a national level. Natural Resources Institute Finland (Luke)'s data on agricultural electricity consumption in 2010, 2013 and 2016 are supplemented with data on the development of agricultural buildings' floor area in the missing years.

The national annual total electricity consumption of agriculture is divided between the municipalities based on the municipality-specific total floor areas of agricultural buildings and, with a lower weighted value, based on the share of agricultural buildings with electric heating as well as local heating demand. The electricity consumption of greenhouses is taken into account separately in few municipalities.

The emissions of consumption electricity are calculated by using the national annual emission factors of electricity, taking into account the higher emissions of heating electricity compared to other electricity usage.

Data sources:

- Municipality-specific electricity use (Finnish Energy)
- POLIREM – Policy scenario model for building sector energy consumption and greenhouse gas emissions (TTY/SYKE)
- Energy source-specific agricultural and horticultural energy consumption (Luke)
- Corrected building stock data (Statistics Finland)
- RHR – building and apartment register in the Population Information System (Digital and Population Data Services Agency)
- Heating degree days (Finnish Meteorological Institute)

Wind power

In accordance with the Hinku calculation rules, emission compensations are calculated for a municipality for wind power generated in its region. These compensations are calculated as their own emission category as negative greenhouse gas emissions. They can be considered to primarily compensate the municipality's emissions of electricity usage and, if they are compensated in full, other emissions. Utilising wind power compensation means that the national emission factor of electricity is increased correspondingly, when wind power's effect of decreasing the emissions of grid electricity has already been allocated to certain municipalities as emission compensations.

The project listing of Finnish Wind Power Association has the data on municipal capacity. The wind power production is calculated by multiplying annual wind power output in Finland by the share of municipality's wind power capacity of total capacity in Finland. The annual grid loss calculated by the Finnish average, presented in table 3.2 of the Statistics Finland's Energy chart service, is then deducted from this value. This results in an estimate of the wind electricity produced in the municipality that has ended up for consumption, which is then multiplied by the national electricity emission factor.

The amount of compensation is dependent on the installed capacity and windiness, but also, notably, on the emissions of electricity generation in Finland. When the annual emission factor of national electricity generation decreases (when calculated without wind power), the emission compensations received by the municipality for generating wind power will also decrease.

Data sources:

- Wind power plants built in Finland 1991–2021, project listing (Finnish Wind Power Association)
- Capacity factors of wind power production in Finland (VTT)
- Energy 2022 chart service, table 3.2 (Statistics Finland)

Industry

The greenhouse gas emissions of industry include the emissions generated due to the fuel use of industrial plants. They do not include electricity and district heat production and the heating of industrial buildings. The emissions are divided into emissions trading and effort sharing sectors.

Industrial emission data (carbon dioxide, methane, nitrous oxide) have been gathered from the Finnish air pollutant data system (IPTJ) where they are divided between industry and energy production by using a classification method used in international reporting of air pollutant emissions (NFR).

With regard to the emissions trading sector (ETS), electricity production's emissions, as separately estimated with the benefit allocation method, as well as municipality-specific, production-based emissions of district heating are deducted from the IPTJ-based total emissions of the sites included in both industrial and energy production, based on their NFR classification. The result of this is an estimate of the ETS emissions of industrial heating and steam production, which is then further scaled so that the total emissions of the energy sector are equal to the Finnish greenhouse gas inventory. Industrial emissions that are part of emissions trading are not included in Hinku calculation.

With regard to plants involved in emissions trading, the IPTJ data has been corrected so that the emissions of plants, which have belonged to the ETS only in part of 2005–2021, are calculated as ETS emissions during the whole period of 2005–2021. This prevents any unmerited benefits or detriments to the municipality caused by changes in the emissions trading register.

Industrial emissions excluded from emissions trading system include the heat and steam emissions

of industrial plants belonging in the effort sharing sector, as calculated based on the IPTJ, as well as industrial diffuse emissions.

The diffuse emissions in IPTJ are based on the difference between the national fuel balance and the consumption of known locations. The emissions have been divided among the municipalities in relation to the surface areas of their industrial buildings that do not use district heat.

The lack of emissions of industry in the effort-sharing sector in some years does not (necessarily) mean that the municipality has no industry and industrial emissions, but instead this can be due to the calculations' technical factors or it could be related to the adequacy of initial data.

The best possible data sources have been used for industrial municipal calculations, but, simultaneously, the calculations include many assumptions that compromise their accuracy. All emission and energy consumption estimates are computational, both in the emissions trading and effort sharing sectors, and cannot be directly linked to any individual company.

Data sources:

- Finnish air pollutant data system IPTJ (SYKE)
- Electronic service system of environmental protection control YLVA (Ministry of the Environment)
- Energy 2022 chart service, table 3.4.3 (Statistics Finland)
- Corrected building stock data (Statistics Finland)
- RHR – building and apartment data in the Population Information System (Digital and Population Data Services Agency)

Machinery

Emissions of work machinery are calculated by dividing the national results of the TYKO model between the municipalities by using different allocation principles that depend on the machinery class. TYKO is a Finnish emission calculation model of machinery developed at VTT Technical Research Centre of Finland. It is used to produce the official annual emission quantities for the statistics of EU, UN and Finland. The allocation principles are taken from the Finnish Regional Emission Scenario model FRES by SYKE.

TYKO features a total of 51 machinery types, including off-road vehicles. In FRES, machinery types are divided into 13 main types: cranes, forklift trucks and industrial tractors, road graders, wheel loaders and dumper trucks, excavators, agricultural machinery, other maintenance machinery, forestry machinery, snow mobiles and ATVs, gardening machinery, diesel generators, diesel compressors and chain saws. Various allocation models, i.e. "proxies", are used to divide the emission results of these main

categories between municipalities.

In total, nine different proxies have been developed to describe the conditions associated with the use of machinery in the municipalities. These are based on land use (industrial areas, fields, forests, residential areas, mines, green areas), road and street sections and their traffic numbers, as well as population data. Depending on the machinery category, one proxy or a combination of several can be used to allocate the emissions to municipalities. For example, all forestry machinery are allocated in accordance with the Forestry proxy, which means that the emissions are divided between municipalities in accordance with the categories Clc3111–3133 of CORINE Land Cover (forests, excluding national parks, and nature conservation areas), but, in comparison, 25% of excavators' emissions are allocated to industry, 25% to roads and 50% to building (population data).

The results of the 13 main types will then be further combined municipality-specifically into nine different categories; agricultural machinery, forestry machinery, construction machinery, landscaping machinery, industrial machinery, mining machinery, machinery of residential homes, road machinery, roads and road machinery, and streets. This is the most detailed level on which producing results is possible. When reporting municipal emissions, the number of categories has been cut to five: construction machinery,

mining and industrial machinery, road machinery, agriculture and forestry machinery and other machinery.

Data sources:

- Emissions calculation model of machinery in Finland TYKO (VTT)
- Finnish Regional Emission Scenario model FRES (SYKE)

F-gases

The basis for municipality-specific emissions of fluorinated greenhouse gases in 2005–2021 are the emissions of the Finnish greenhouse gas inventory reported to the EU and UNFCCC in spring 2022. For the municipality-specific calculations, the emissions of the entire country have been divided using sector-specific, applicable data or, if there is none, population figures.

In municipality-specific calculations, F-gas emissions have been divided into four different sectors – commercial refrigeration, buildings' ventilation devices (including heat pumps), the air conditioning devices of vehicles and other sources of F-gases. The emission calculations of the GHG inventory are made on the level of more than 20 different sectors, and the emissions are reported by using the classification defined in IPCC's guidelines (Common Reporting Format, CRF). Other sources of F-gases contain other refrigeration units and air conditioning devices (household and industrial refrigeration units and refrigerated transport), cellular plastics, aerosols, electricity distribution equipment, semiconductor industry, fire extinguishing

equipment and a group of other, smaller emission sources.

Dividing the F-gas emissions of commercial refrigeration between different municipalities is based on the number of various grocery stores and professional kitchens in the municipality. The emissions of building's air conditioning devices have been allocated municipality-specifically based on population. With regard to air conditioning devices in vehicles, the municipal traffic emission calculations based on the ALas model have been utilised. It is assumed that the F-gas emissions of road traffic are distributed to the municipalities in accordance with their road traffic mileage. The F-gas emissions of rail transit have been allocated municipality-specifically, based on the electricity consumption of passenger and local traffic. The F-gas emissions of machinery have been allocated to municipalities the same way as their carbon dioxide emissions. The emissions of underground railway and trams have been allocated to municipalities where these transport forms are available. The emissions from other sources of F-gases, excluding the semiconductor industry, have been allocated to municipalities based on their population numbers. The emissions of semiconductor industry have been allocated to municipalities based on the production plants' locations.

Data sources:

- Finnish greenhouse gas inventory (Statistics Finland/SYKE)
- Municipal numbers of grocery stores, listed by store types (Liiteri/SYKE)
- The numbers of professional kitchens in regions (Horeca register/Taloustutkimus)
- Population information (Statistics Finland)
- Rail transit performances in 2021, station locations of the metro line (Helsinki City Transport HKL)
- Finnish Regional Emission Scenario model FRES (SYKE)

Road traffic

VTT Technical Research Centre of Finland maintains LIISA, the calculation system of exhaust gases and energy consumption of Finnish road traffic. The LIISA model is part of the LIPASTO calculation system for all modes of transport. It is used to calculate the Finnish official annual emissions for the statistics of EU and UN.

VTT produces territorial road traffic emission data. In this calculation method, all driving mileage within the municipalities' borders, and the corresponding emissions, are allocated to that municipality. Road traffic emissions are calculated separately for cars, vans, buses and trucks, as well as for motorcycles, mopeds and moped cars. Car, van, bus and truck emissions are separated into street and road emissions. Due to the territorial-based allocation in LIISA, the emissions of road traffic are high in municipalities that have a great deal of traffic from vehicles registered to other areas (drive-through traffic). The territorial allocation principle of emissions has been found to be problematic, which is why two alternative ways of municipal allocation of road traffic emissions have been developed: usage-based calculation and calculation that takes drive-through traffic into account.

In Hinku calculation, the emissions of cars, motorcycles, mopeds and moped cars are calculated based on their usage. Region-based emissions are calculated for vans, buses and trucks, but drive-through traffic is excluded ("region's own road transportation").

In the usage-based calculation method, all emissions caused by the driving mileage of vehicle stock registered in a certain municipality are allocated to it, regardless of where the driving actually takes place. The calculation is based on Traficom's vehicle register information about the vehicle's first registration date and the odometer reading registered during the vehicle's latest inspection. An average annual driving mileage of each vehicle has been calculated based on this information and, based on this, the average annual, municipality-based driving mileage of each vehicle registered in the municipality is calculated. When calculating the average driving mileage, vehicles that do not have an odometer reading are excluded. These include new cars that have not yet gone through an annual inspection and old cars that do not have a reading for some other reason.

Annual, municipality-specific total driving mileage is calculated by multiplying the municipality-specific average driving mileage with the number of vehicles registered in the municipality (including vehicles that do not have an odometer reading). The total driving mileage is allocated to municipalities' streets and roads based on LIISAs road and street driving shares. The computational street and road driving mileage are transformed into emissions utilising the vehicle-specific emission factors in Traficom's vehicle register. Based

on this information, the average gCO2/km emission factor of the vehicle stock is calculated for each municipality. The lacking gCO2/km data have been imputed from vehicle information saved in the vehicle register, categorised by the vehicle's year of initial registration, engine displacement and driving power.

The vehicle register does not include emission factor data for buses, trucks, motorcycles, mopeds or moped cars. Buses have been divided into five classes: small and large diesel engine buses, large buses that use natural gas, large buses that use bio-fuel and large buses that run on electricity. The usual average emission factors typical to vehicles from a certain year, as determined in LIPASTO unit emissions database, have been used for these vehicles. Similarly, annual average emission factors have been used for vans, motorcycles, mopeds and moped cars. Municipality-specific emissions are calculated by multiplying the municipal driving mileage with a municipality-specific emission factor. Finally, the levels of municipal emissions are adjusted municipality-specifically so that the computational emissions of vehicle classes in the entire country are equal to the emissions in LIPASTO calculated as Finland's carbon dioxide equivalents.

A calculation that takes drive-through traffic into account means the allocation aims to estimate the amount of emissions caused by vehicles registered in other municipalities. In other words, drive-through traffic includes the driving which may end in the inspected region, start there or pass over the borders of the inspected municipality. Both the region- and usage-based calculation methods are utilised for drive-through traffic calculations. If the region-based driving mileage is larger than the computational annual driving mileage of the municipality's registered vehicle stock (surplus), the vehicles registered to other municipalities must drive in the region of the inspected municipality as much as the difference indicates. Equally, if the region-based driving mileage is smaller than the computational annual driving mileage of the municipality's registered vehicle stock (deficit), the vehicles of the inspected municipality must drive in other municipalities as much as the difference indicates. The deficit sum is deducted from the surplus sum of driving mileage, so that the total driving mileage is equal to LIPASTO's Finnish total driving mileage. The remaining drive-through mileage is allocated to municipalities based on their street and road driving mileage. The emissions caused by the driving allocated to the municipality (region's own road traffic) are calculated based on the

average emission factor of the vehicles in the inspected vehicle class that are registered in

the municipality in question. The emissions of drive-through traffic are calculated by applying

the whole country's average emission factor.

Territorial emissions are used for Åland's municipalities in Hinku calculation.

Data sources:

- LIISA, road traffic exhaust emissions calculation model (VTT Technical Research Centre of Finland)
- LIPASTO, the calculation system of exhaust gases and energy consumption of Finnish traffic (VTT Technical Research Centre of Finland)
- Vehicle register (Traficom)

Rail traffic

The emissions of rail transit are calculated separately for electricity and diesel used for passenger traffic and freight transport, as well as for electricity used for local traffic (including metros and trams). The national energy consumption data of rail transit that is allocated to municipalities are taken from VTT's LIPASTO calculation system, the Finnish greenhouse gas inventory and, with regard to metros and trams, from Helsinki City Transport (HKL). The emissions are calculated by applying the national annual electricity emission factor. The diesel emission factor (tCO2e / GWh), on the other hand, is calculated based on data from LIPASTO and the Finnish greenhouse gas emission inventory.

When allocating the emissions of passenger traffic to municipalities, passenger kilometers need to be calculated for different railway sections (= number of trips x length of the section). The proportion of passenger kilometers in the rail section to the similarly calculated performance of the whole country is further weighted with the population numbers along the track (municipalities with a train station/stop in 2021). The result is a municipality-specific "passenger kilometer share" of the railway section, weighted with population numbers, which is calculated in total, and also separately for electrified and unelectrified railway sections.

The annual electricity consumption of passenger traffic in Finland is allocated to the municipalities based on electrified railway sections' passenger kilometre shares, and the consumption of diesel based on the unelectrified

sections. The diesel consumption of shunting and depot operations is allocated to municipalities in relation to the passenger kilometres of municipalities that have depots.

The rail sections' net tonne-kilometres (= transported freight x length of the section) are calculated for freight transport, and these are then divided evenly between the section's departure and arrival municipalities. The municipal net tonne-kilometres are calculated from the whole country's net tonne-kilometres as a whole and separately for electrified and unelectrified rail sections. The specific net tonne-kilometres of railway sections have been compiled from three years (2005, 2012, 2017), and the gap years have been interpolated

linearly. The railway sections of freight transport that are no longer in use have been taken into account.

The annual electricity consumption of freight transport in Finland is allocated to municipalities by multiplying the electricity consumption with each municipality's annual net tonne-kilometre share of its electrified rail sections.

The consumption of diesel is divided between the unelectrified railway network (49%) and the electrified railway network (51%) based on its net tonne-kilometre shares, diesel's total consumption and the average typical consumption of diesel locomotives. The consumption shares of diesel are distributed to municipalities based on the net tonne-kilometres of their electrified and unelectrified railway network. The diesel consumption of shunting and depot operations is allocated to municipalities in relation to the net tonne-kilometres of municipalities that have depots.

The energy consumption and emissions of electrical and diesel locomotive operations are allocated to municipalities based on their freight transport. With regard to electrical locomotives, the allocation principles of freight transport's electricity consumption are applied. The consumption of diesel locomotives is allocated based on the municipality-specific net tonne-kilometres of the entire rail network.

The electricity consumption of local traffic is divided between the municipalities with local rail network according to their population figures. The metro and tram power consumption data of Helsinki and Espoo are based on a report by HKL.

Data sources:

- LIPASTO/RAILI emission etc. data (VTT)
- Greenhouse gas inventory (Statistics Finland)
- Passenger and freight transport on railways (data and annual reports by Finnish Transport Infrastructure Agency)
- Railway network data (Finnish Transport Infrastructure Agency)
- Maps and schedules of long-haul and local transport (VR)
- Power consumption of metro and tram transport (HKL)
- Municipal population data (Statistics Finland)

Water traffic

In the water traffic calculations, the domestic water traffic emissions in the greenhouse gas inventory of Finland are allocated to municipalities. Allocation principles based on available materials have been developed for seven different categories of water traffic – recreational boats, passenger ships, cargo ships, cruise ships, fishing vessels, work boats, and ferries. The emissions of ice breakers are not included in municipal water traffic emission calculations. The fairly low emissions of cruise ships have been combined with passenger ships in the reports.

The emissions of recreational boats are allocated based on Traficom's and Åland's vessel registers. The category of recreational boats includes outboard motorboats, sterndrive motor boats, inboard motor boats, inflatable boats, hydrocopters, jet skis, motor sailboats and sail boats. The allocation basis is the municipality's total amount of recreational boats and for Åland's vessel register, the municipalities' population data.

With regard to passenger ships, the source material used are port calls (Portnet/MEERI) and the annual reports of domestic water traffic's passenger transport. The water body -specific share of each year's passenger traffic is calculated based on the passenger kilometres of domestic passenger traffic. The water body shares are allocated to municipalities with ports that were visited by vessels.

The allocation basis for cargo ships is the statistics data of port calls of domestic cargo transport and the tonne-mileages in inland and coastal areas.

The emissions of cruise ships are allocated to municipalities that have business locations of companies involved in coastal and/or inland passenger water traffic. This information is taken from Statistics Finland's regional business statistics. Coastal water passenger traffic has been weighted with the annual total revenue.

When allocating the emissions of fishing vessels (note, vessels of sea fishing), the regional business statistics are also utilised. The share of municipality-specific business locations of sea fishing are weighted with the combined total engine powers of fishing boats, as determined in the statistics maintained by the regional Centres for Economic Development, Transport and the Environment (ELY centres).

Ferries are distributed to municipalities on the basis of fuel consumption on connecting ferry and road ferry routes. Consumption data for mainland Finland have been obtained from the ELY Centre for Southwest Finland and consumption data for Åland have been estimated on the basis of road ferry activity and fleet data.

The work boats' emissions are allocated to municipalities based on their water surface areas and population figures.

Data sources:

- Finnish greenhouse gas inventory, water traffic emissions (Statistics Finland)
- Vessel register (Traficom)
- Port visits (MEERI calculation system; VTT)
- Domestic water traffic statistic (Finnish Transport Agency)
- Domestic water traffic statistics (Traficom/Statistics Finland)
- Regional business statistics (Statistics Finland)
- Registered fishing vessels in the sea area (LUKE)
- Municipal surface area data (National Land Survey)
- Population data (Statistics Finland)
- Åland Road Ferry Statistics (ÅSUB Statistics and Research Åland)
- Consumption data for connecting vessels and road ferries (Southwest Finland ELY Centre)

Agriculture

The greenhouse gas emissions of agriculture include the methane and nitrous oxide emissions of livestock, manure and cultivation of agricultural lands as well as the carbon dioxide emissions of liming and urea fertilization. The carbon dioxide emissions generated by the decomposition of peatlands are allocated to land use, land use change and forestry sector (LULUCF) and they are not included in the Alas calculation.

The calculation principles are the same as in the greenhouse gas inventory of Finland. The emissions of animals' enteric fermentation and manure management are based on municipality-specific animal numbers. The calculations include cattle, horses, sheep, goats, swine, poultry, reindeer and fur animals.

The emissions from cultivation are generated by the application of inorganic fertilizers, manure, urea and sewage sludge, nitrogen released from organic soil, plant residue decomposing on the fields, manure and urine from grazing, field burning of plant residues, liming and nitrogen leaching.

The emissions from cultivation are calculated based on the municipal, crop-specific cultivated surface areas, municipal soil data, regional yield data (by ELY centre) as well as the national data on the use of lime, mineral nitrogen fertilizers and sewage sludge.

Data sources:

- Municipal, crop-specific cultivated surface areas (Natural Resources Institute Finland; Luke)
- Regional yield data for different crops (Luke)
- Forage grass areas by region (Luke)
- Agricultural use of municipal sewage sludge (Luke)
- Soil class information database (Luke)
- Finnish normative manure system (Luke and Finnish Environment Institute SYKE)
- Municipal data on the number of animals by Luke, Finnish Fur Breeders' Association (FIFUR) and Reindeer Herders' Association
- Finnish greenhouse gas inventory report (Statistics Finland)

Waste management

The landfill emissions include the methane emissions of municipal waste, construction and demolition waste, municipal sludge, and industrial waste and sludge taken to a landfill. These emissions are generated when the biodegradable parts of waste decompose in oxygen-free conditions into methane over years. The FOD method (First Order Decay), in accordance with the IPCC's calculation guidelines, is used in the calculations. This method assumes that the amount of generated methane depends on the amount of coal left in the waste, if conditions remain stable. The recovered quantity of landfill gas is deducted from the emissions and, additionally, the oxidising share of the landfill's surface layers is taken into account.

The quantity of landfill emissions is also dependent on the annual amounts of waste deposited in the landfill, the composition of waste and their decomposition properties and the recovery of landfill gas. The default values in the greenhouse gas inventory of Finland are applied as the calculation parameters. The waste quantity and gas recovery data are municipality- and landfill-specific.

Municipal waste landfill utilization rates are based on cooperation areas of regional and municipal waste management companies and other reviewed cooperation. The landfill waste quantities within these cooperation areas are distributed to the municipalities in relation to their population. In history data, the waste quantities of the years preceding the cooperation (for which landfill-specific data are not available) are also allocated based on the municipal population figures. Otherwise, history data, of which landfill-specific information is not available, are scaled by applying the same waste quantity ratios as in the national inventory. Other waste fractions (sludge, construction waste and industrial waste) are either allocated based on the cooperation areas and population figures of municipalities or estimated as local.

In a few cases, a different method of allocation is applied; for example, forest industries' landfills are often located in other municipalities than where the actual plant is. In such cases, the waste emissions are allocated to the municipality where the waste has been generated, in accordance with the principles of usage-based calculations. Industrial waste emissions are not included in the Hinku calculation.

The HSY data of the Ämmänsuo landfill emissions have been used with regard to Helsinki, Espoo, Vantaa, Kauniainen and Kirkkonummi. All landfill emissions in the Helsinki Metropolitan Area are allocated to municipal waste.

The greenhouse gas emissions from wastewater treatment, composting and anaerobic digestion are

calculated by distributing the emission data of the national greenhouse gas inventory to municipalities. The allocation basis is population data for community waste and the floor surface area of industrial buildings for industrial waste.

Data sources:

- Finnish greenhouse gas inventory (Statistics Finland/SYKE)
- Landfill-specific waste quantity data, methane recovery (YLVA, SYKE's inventory surveys)
- IPCC 2006 Guidelines for National Greenhouse Gas Inventories
- Municipality-specific landfill usage (Suomen Kiertovoima Ry KIVO/other reviews)
- Population information (Statistics Finland)

- RHR – building and apartment data in the Population Information System (Digital and Population Data Services Agency)
- Helsinki Region Environmental Services Authority HSY

Electricity emission factors

When calculating the greenhouse gas emissions of municipalities, an average emission factor of electricity consumption in Finland is applied to all municipalities. This factor is calculated by dividing the emissions of Finnish electricity production, calculated with the benefit allocation method, by the total consumption of electricity.

The emission factor of consumption is different than the electricity production's factor, as the amount of electricity consumed in Finland every year is different from the annually generated amount of electricity. The difference is due to distribution losses and net import. Because consumption in Finland exceeds the production, the emission factor of total consumption is smaller than the emission factor of production. Imported electricity is assumed emissions-free.

The emission factors are calculated both on annual and monthly levels, the latter of which is applied to calculating the emissions of heating electricity. The emission factor is, on average, larger during the heating season than during other times, which means that heating electricity has larger specific emissions than other use of electricity.

The monthly factor is calculated by allocating the annual GHG emissions of Finnish electricity production to different months in accordance with different production methods, and by dividing the monthly emission result with the electricity consumption of each month. The monthly data are taken from the statistics of Finnish Energy.

The emission factor other electricity use than heating (consumption electricity) is calculated by deducting the emissions of heating electricity, calculated with the monthly factors, from the total emissions of electricity and, similarly, the consumption of heating electricity from the total electricity consumption.

The monthly and annual factors are also calculated without wind power production. These higher factors, in which wind power's effect of decreasing the electricity emissions has been neutralised, are used in the Hinku calculation, in connection to the wind power compensation.

Data sources:

- Energy 2022 chart service, tables 3.1, 3.2 and 3.4.3 (Statistics Finland)
- Monthly statistic of electricity (Finnish Energy)
- Fuel classification (Statistics Finland)
- Emission Factor Database EFDB (IPCC)

Emission factors of fuels

The CO2 emission factors of fuels are taken from the annually updated Fuel Classification maintained by Statistics Finland. Bio-based fuels have zero carbon dioxide emissions. The factors of methane and nitrous oxide are obtained from IPCC's Emission Factor Database.

Until 2013, fuel classifications are available as Excel files. Before this, the same factors as in 2013 were applied, excluding light fuel, for which zero-emission bio-shares were calculated in 2009–2012. The factors of earlier years than 2013 of engine petrol and diesel have also been calculated based on the figures of 2013, while taking into account the change of the bio-composition share. For traffic, however, the emission factors of VTT's LIPASTO system are used in the emission calculation of the ALas model.

The methane and nitrous oxide emission factors of fuels are taken from IPCC's Emission Factor Database. They are separate for energy industries, manufacturing industries and other sectors, which includes housing and services. The 2006 IPCC Default is the selected emission factor option.

The carbon dioxide equivalence factors are calculated by using IPCC's Global Warming Potential (GWP) values of 2007, which are also used for national greenhouse gas inventory calculation. In a hundred-year period, the heating effect of methane is 25 times that of carbon dioxide (GWP100 = 25), and for nitrous oxide it is 298 times as large (GWP100 = 298). The GWP values of F-gases vary between 124–22,800, depending on the compound.

Data sources:

- Fuel classification (Statistics Finland)
- Emission Factor Database EFDB (IPCC)

Emission inventory methodology, part 2: Forests

The data for emission inventory of forestry was gained from IBC Carbon project coordinated by Finnish Environmental Institute (SYKE).
Land cover data is from the period 2015-2020 and is based on registry data or remote sensing. Forest productivity is modelled using process-based forest growth model PREBAS, developed in Helsinki University. Initial state of the forest model is derived from the multi-source national forest inventory (MS-NFI; version 2015) and harvesting intensities are modelled based on the Finnish national statistics according to National Resources Institute Finland (LUKE).
Results of the project are shared as raster data with 250m-by-250m resolution. Emission intensities are reported as gCO2e/m2 based on the 100 year GWP as reported in the IPCC 5th assessment report.
CO2 emissions from decomposition on mineral soils are estimated with the soil carbon model YASSO07. On drained peatlands, in addition to CO2 emissions due to peat and litter decomposition, the soil emissions include the CH4 and N2O emissions. Net emissions due to CO2, CH4 and N2O from drained peatland are calculated using separate coefficients for nutrient rich and nutrient poor sites.
Emission calculations are based on averages for the years 2017-2025, assuming the timber harvesting rates remain at the same level as in previous five years. Negative values correspond to sinks and positive values correspond to emissions.

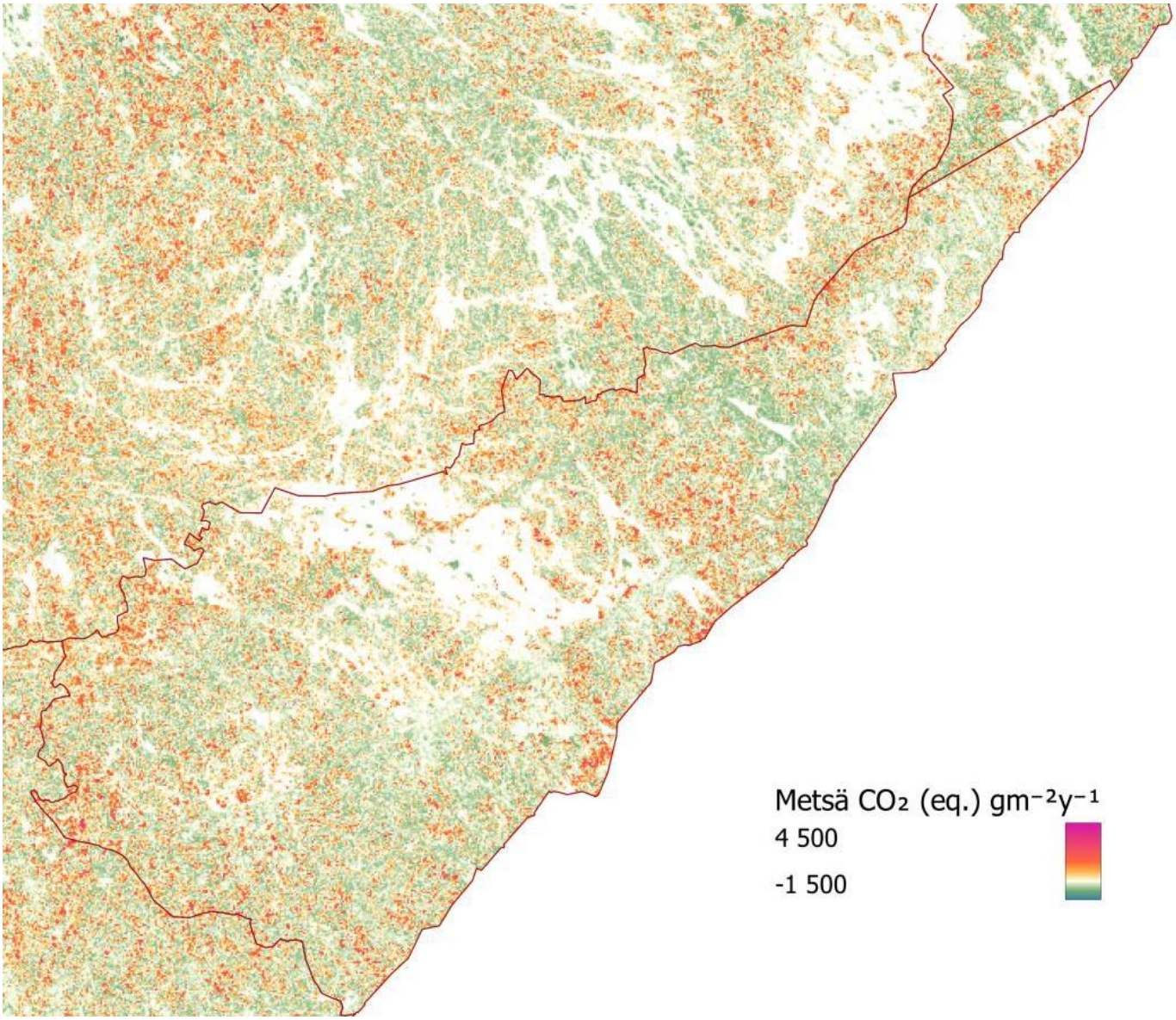


Figure: Greenhouse gas net emission intensities in South Karelia. Raster data with a 250m-by-250m resolution.
Zenodo: doi : 10.5281/zenodo.7827577

Emission Inventory 2020						
City of Lappeenranta						
		Calculations are based On Alas 1.4 model, developed by the				
		Finnish Environment Institute				
taso_1	taso_2	taso_3	taso_4	taso_5	ktCO2e	Energy Consumption (GWh)
Energia	Kulutussähkö	Kulutussähkö	Kulutussähkö	Asuminen	10,969	146,882
Energia	Kulutussähkö	Kulutussähkö	Kulutussähkö	Asuminen	0,35	0
Energia	Kulutussähkö	Kulutussähkö	Kulutussähkö	Maatalous	0,644	8,617
Energia	Kulutussähkö	Kulutussähkö	Kulutussähkö	Maatalous	0,02	0
Energia	Kulutussähkö	Kulutussähkö	Kulutussähkö	Palvelut	20,151	269,833
Energia	Kulutussähkö	Kulutussähkö	Kulutussähkö	Palvelut	0,643	0
Energia	Rakennusten lämmitys	Sähkölämmitys	Sähkölämmitys	Asuminen	5,572	68,092
Energia	Rakennusten lämmitys	Sähkölämmitys	Sähkölämmitys	Asuminen	0,167	0
Energia	Rakennusten lämmitys	Sähkölämmitys	Maalämpö	Asuminen	0,63	7,7
Energia	Rakennusten lämmitys	Sähkölämmitys	Maalämpö	Asuminen	0,019	0
Energia	Rakennusten lämmitys	Sähkölämmitys	Sähkölämmitys	Palvelut	0,938	11,457
Energia	Rakennusten lämmitys	Sähkölämmitys	Sähkölämmitys	Palvelut	0,028	0
Energia	Rakennusten lämmitys	Sähkölämmitys	Maalämpö	Palvelut	0,097	1,191
Energia	Rakennusten lämmitys	Sähkölämmitys	Maalämpö	Palvelut	0,003	0
Energia	Rakennusten lämmitys	Sähkölämmitys	Sähkölämmitys	Maatalous	0,153	1,865
Energia	Rakennusten lämmitys	Sähkölämmitys	Sähkölämmitys	Maatalous	0,004	0

Energia	Rakennusten lämmitys	Sähkölämmitys	Maalämpö	Maatalous	0	0
Energia	Rakennusten lämmitys	Sähkölämmitys	Maalämpö	Maatalous	0	0
Energia	Rakennusten lämmitys	Kaukolämpö	Kaukolämpö	Asuminen	22,07211	267,1568
Energia	Rakennusten lämmitys	Kaukolämpö	Kaukolämpö	Palvelut	12,47751	151,0255
Energia	Rakennusten lämmitys	Kaukolämpö	Kaukolämpö	Teollisuus	3,618129	43,79317
Energia	Rakennusten lämmitys	Kaukolämpö	Kaukolämpö	Maatalous	0,008765	0,106089
Energia	Rakennusten lämmitys	Kaukolämpö	Kaukolämpö	Asuminen	4,88457	45,7667
Energia	Rakennusten lämmitys	Kaukolämpö	Kaukolämpö	Palvelut	2,761279	25,87221
Energia	Rakennusten lämmitys	Kaukolämpö	Kaukolämpö	Teollisuus	0,800694	7,502219
Energia	Rakennusten lämmitys	Kaukolämpö	Kaukolämpö	Maatalous	0,00194	0,018174
Energia	Rakennusten lämmitys	Öljylämmitys	Öljylämmitys	Asuminen	7,364971	27,8196
Energia	Rakennusten lämmitys	Öljylämmitys	Öljylämmitys	Maatalous	0,20838	0,789214
Energia	Rakennusten lämmitys	Öljylämmitys	Öljylämmitys	Palvelut	4,046443	15,28457
Energia	Rakennusten lämmitys	Muu lämmitys	Puulämmitys	Asuminen	4,012932	117,8333
Energia	Rakennusten lämmitys	Muu lämmitys	Puulämmitys	Maatalous	0,073384	10,7287
Energia	Rakennusten lämmitys	Muu lämmitys	Puulämmitys	Palvelut	0,131416	3,858812
Energia	Rakennusten lämmitys	Muu lämmitys	Muu lämmitys	Asuminen	2,733883	13,48803
Energia	Rakennusten lämmitys	Muu lämmitys	Muu lämmitys	Maatalous	2,413064	8,952714
Energia	Rakennusten lämmitys	Muu lämmitys	Muu lämmitys	Palvelut	2,766277	10,76898
Energia	Teollisuus ja työkoneet	Teollisuus	Teollisuus	Teollisuuden polttoaineet	6,496	98,375

Energia	Työkoneet	Työkoneet	Työkoneet	Muut työkoneet	1,182424	4,727383
Energia	Työkoneet	Työkoneet	Työkoneet	Maa- ja metsätalouskoneet	6,802577	25,33123
Energia	Työkoneet	Työkoneet	Työkoneet	Rakennustyökoneet	6,826181	25,76639
Energia	Työkoneet	Työkoneet	Työkoneet	Kaivos- ja teollisuustyökoneet	6,27217	23,67876
Energia	Työkoneet	Työkoneet	Työkoneet	Tietyökoneet	6,924309	26,1358
Energia	Liikenne	Raideliikenne	Henkilöliikenne	Diesel	0,008	0,029
Energia	Liikenne	Raideliikenne	Henkilöliikenne	Sähkö	0,344	4,552
Energia	Liikenne	Raideliikenne	Lähiliikenne	Lähijunat	0	0
Energia	Liikenne	Raideliikenne	Lähiliikenne	Lähijunat	0	0
Energia	Liikenne	Raideliikenne	Lähiliikenne	Metrot ja raitiovaunut	0	0
Energia	Liikenne	Raideliikenne	Lähiliikenne	Metrot ja raitiovaunut	0	0
Energia	Liikenne	Raideliikenne	Tavaraliikenne	Diesel	2,455	9,117
Energia	Liikenne	Raideliikenne	Tavaraliikenne	Sähkö	0,553	7,313
Energia	Liikenne	Raideliikenne	Henkilöliikenne	Sähkö	0,012	0
Energia	Liikenne	Raideliikenne	Tavaraliikenne	Sähkö	0,019	0
Energia	Liikenne	Vesiliikenne	Huviveneet	Huviveneet	2,274	9,321
Energia	Liikenne	Vesiliikenne	Laivat	Matkustajaliikenne	0,163	0,206
Energia	Liikenne	Vesiliikenne	Laivat	Tavaraliikenne	0,75	2,759
Energia	Liikenne	Vesiliikenne	Työveneet	Kalastusalukset	0	0
Energia	Liikenne	Vesiliikenne	Työveneet	Lautat ja lossit	0,046	0,174
Energia	Liikenne	Vesiliikenne	Työveneet	Työveneet ja alukset	1,016	3,828
AFOLU	Maatalous	Maatalous	Kotieläimet	Eläinten ruuansulatus	13,00526	

AFOLU	Maatalous	Maatalous	Peltoviljely	Epäorgaaniset lannoitteet	5,272874	
AFOLU	Maatalous	Maatalous	Kotieläimet	Lannankäsittely	4,010467	
AFOLU	Maatalous	Maatalous	Peltoviljely	Maaperä	10,6376	
AFOLU	Maatalous	Maatalous	Peltoviljely	Muut viljelysmaiden päästöt	7,756562	
AFOLU	Maatalous	Maatalous	Peltoviljely	Orgaaniset lannoitteet	1,815014	
Jätteiden käsittely	Jätteiden käsittely	Jätteiden käsittely	Jätevesien puhdistus	Yhdyskuntajäte	2,249	
Jätteiden käsittely	Jätteiden käsittely	Jätteiden käsittely	Mädätys	Yhdyskuntajäte	0,105	
Jätteiden käsittely	Jätteiden käsittely	Jätteiden käsittely	Kompostointi	Yhdyskuntajäte	1,21	
Jätteiden käsittely	Jätteiden käsittely	Jätteiden käsittely	Kaatopaikat	Yhdyskuntajäte	28,245	
Teollisuusprosessit	F-kaasut	F-kaasut	Kaupan ja ammattikeittiöiden kylmälaitteet	Kaupan ja ammattikeittiöiden kylmälaitteet	7,579079	
Teollisuusprosessit	F-kaasut	F-kaasut	Rakennusten ilmastointilaitteet	Rakennusten ilmastointilaitteet	1,575437	
Teollisuusprosessit	F-kaasut	F-kaasut	Ajoneuvojen ilmastointilaitteet	Ajoneuvojen ilmastointilaitteet	1,689833	
Teollisuusprosessit	F-kaasut	F-kaasut	Muut F-kaasujen lähteet	Muut F-kaasujen lähteet	1,484635	
Kompensaatiot	Kompensaatiot	Tuulivoima	Tuulivoima	Tuulivoima	-10,4	64,358
Kompensaatiot	Kompensaatiot	Aurinkovoima	Aurinkovoima	Aurinkovoima	0	
AFOLU	Maatalous	Maatalous	Kotieläimet	Laidunnus	0,601655	
Energia	Liikenne	Tieliikenne	Kadut	Henkilöautot	27,44251	101,4195
Energia	Liikenne	Tieliikenne	Kadut	Linja-autot	0,419741	3,423326
Energia	Liikenne	Tieliikenne	Kadut	Kuorma-autot	6,404445	25,08379

Energia	Liikenne	Tieliikenne	Kadut	Pakettiautot	3,028553	12,38373
Energia	Liikenne	Tieliikenne	Moottoripyörät ja mopot	Moottoripyörät ja mopot	1,224267	5,12005
Energia	Liikenne	Tieliikenne	Tiet	Henkilöautot	42,18707	188,5561
Energia	Liikenne	Tieliikenne	Tiet	Linja-autot	0,353611	2,629414
Energia	Liikenne	Tieliikenne	Tiet	Kuorma-autot	36,68939	152,372
Energia	Liikenne	Tieliikenne	Tiet	Pakettiautot	5,520218	22,82227
AFOLU	Forests			Mineral soil	-12,99	
AFOLU	Forests			Organic soil	110,7	
TOTAL					**450,7246**	**2085,884**

Annual Greenreality carneval

Greenreality-carneval is an annual environment and climate action themed event , organized by the city of Lappeenranta. Event is for all citizens, but the main target groups are the children and students.

The Greenreality Carnival is being organized for the fifth time in 2023. The total attendance in previous years has been estimated at approximately 2,000-4,000 visitors. The event has also been attended by around 400 elementary school students from the city, along with their teachers.

In previous years, the Greenreality Carnival has generated significant interest, and it has seen a substantial participation from businesses, environmental organizations, as well as cultural and leisure sector actors.

Etelä-Karjalan energianeuvonta (ENNE)

South Karelia Energy Advice (ENNE) is a part of the Lappeenranta Greenreality Services. Energy advice is available to residents, housing companies, businesses, and communities throughout the South Karelia region. Energy advice provides guidance to the residents and housing companies in the region on energy-efficient living, transportation, and heating choices.

For municipalities and the SME sector, the main focus of the advice is on energy efficiency agreements, inspection activities, and energy support opportunities. Energy advice also lends two thermal cameras for identifying heat leaks. Additionally, energy advice can be booked for appearances at events and gatherings.

Buildings Working Group

Under the Greenreality Network, there is a ***Buildings Working Group*** where companies gather at least four times a year. In the working group, an annual action plan is updated, which guides the invitation of speakers to meetings and aims to combine site visits related to the meeting topic.

Key principles of the operation:
The goal is to influence the discussion and practical actions related to environmental and climate responsibility in construction, affecting the entire South Karelia region.
The aim is to facilitate and initiate projects and investments in which companies from the Property Group have the opportunity to participate.
The objective is to stimulate discussion and influence especially on construction projects that are still in the planning stage.

Forum for the housing associations

During the forum's member meetings, various expert presentations are given based on the needs and interests of the members. The goal is to increase members' knowledge and expertise in a cost-effective manner while enhancing the overall quality of living in the condominium. In the long term, the forum aims to foster collaboration among condominiums, such as jointly procuring purchases or renovations to achieve cost savings. The Condominium Forum meets every one to two months, with an exception for a summer break.

Junior University

Uniori, also known as Lappeenranta Junior University, is a nationally and internationally unique educational program that enhances students' interest in science, research, and university studies in accordance with the principles of sustainable development.

Uniori is a continuum of general education from early childhood education to high school. Uniori guides students equally to pursue university studies and strengthens their problem-solving skills and hope. Thanks to UNIORI activities, all students in the city of Lappeenranta go through a study package related to the environment, sustainable development, and climate change.

In Uniori activities, the existing curriculum guidelines are followed, and there is close educational cooperation between the City of Lappeenranta and LUT University. The objectives and content of Lappeenranta Junior University activities are based on the Lappeenranta city's strategy extending to 2037 and the strategic focus areas of LUT University.

Participatury actions for the city planning

Example 1

Lappeenranta organized a large kickoff seminar related to the Horizon Comprehensive Plan, which focuses on green themes. The seminar took place at the Nuijamies cinema, which had been repurposed for cultural use by local activists. Residents had the opportunity to listen to expert presentations on nature and the environment, explore the activities of local associations, and participate in workshops related to the objectives of the comprehensive plan.

Image: A large number of people participated in the kickoff seminar for the Horizon Comprehensive Plan focusing on green themes

Example 2

In Lappeenranta, plans are underway for what would be the largest solar power project in Europe. The solar power project has been in preparation in collaboration with the project initiator, and from the early stages of planning, several open public events and online surveys have been organized. These events have representatives from urban planning and the solar power project, providing answers to landowners' and the public's questions. Residents have had the opportunity to express their opinions through a separately arranged online survey.

Example 3

Climate and environmental issues have been prominent in the environmental and urban art projects carried out by the city of Lappeenranta. Lappeenranta's urban planning department participated in the project "Kamalan hienoa! – Kestävät teot näkyväksi ympäristötaiteen keinoin," which was funded by the Ministry of the Environment. This project made visible the diverse sustainable development work done by the city in the urban environment through environmental and urban art.

As an example of one completed initiative, the city organized an art competition inspired by participatory budgeting, where residents had the opportunity to propose an environmental art piece and receive €2,000 for its realization. Sustainable development has also been strongly reflected in the works of LAB University of Applied Sciences students hired by the urban planning department, who have made the importance of the environment visible to residents and visitors to the city.

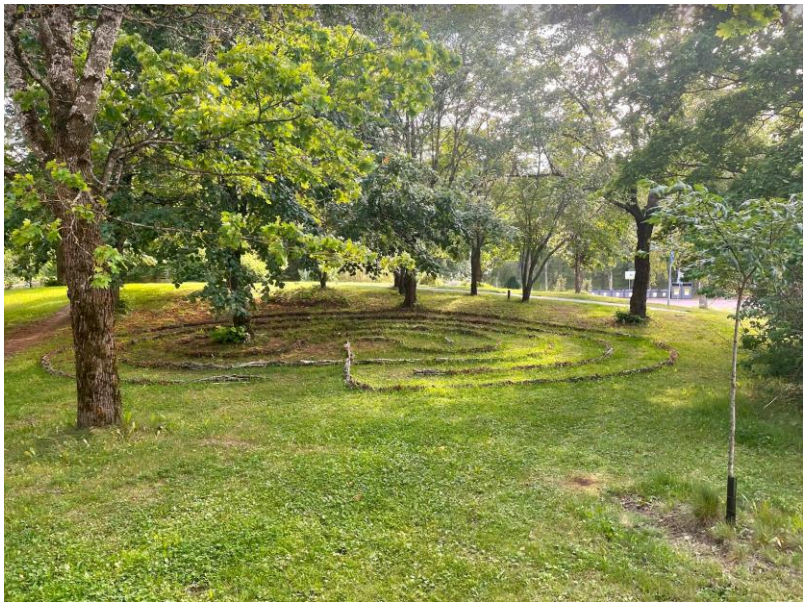


Image: Ella Kettunen won the art competition inspired by participatory budgeting with her proposal and had the opportunity to realize her proposal in a park located in Lappeenranta. The implementation of the artwork utilized materials generated during tree maintenance.

Example 4

Lappeenranta's urban planning department has hired young people aged 15-18 for summer jobs over several summers. These young individuals have created content for the urban planning department's social media channels, sharing information about current climate-related projects in our city and their own perspectives on topics that are important to them. The content produced by these young people has helped strengthen their participation and communicate content of interest to young people, produced by young people themselves.

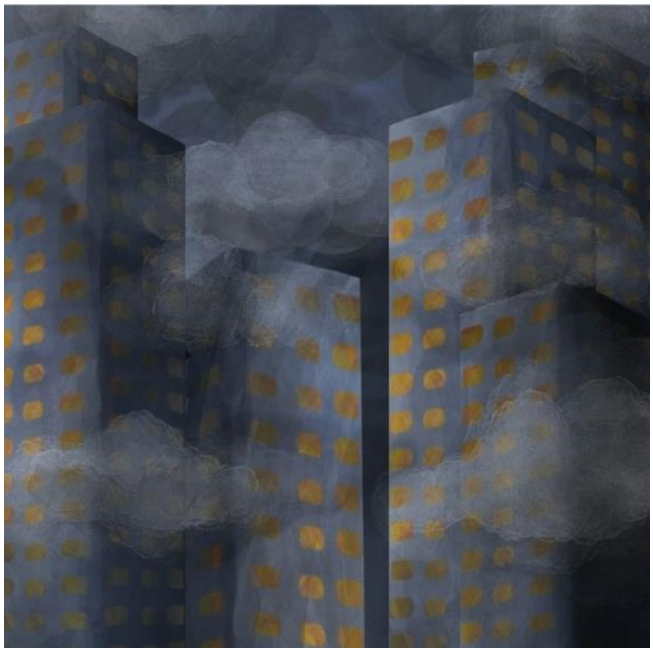


Image: Young people have helped produce content on social media that interests them. The image shows an observational drawing created by a young person during their summer job, depicting a city covered in pollution.

Example 5

The city of Lappeenranta is involved in the project "Developing Climate and Energy Impact Assessment in Lappeenranta Urban Planning - Towards a Sustainable City." The aim of this project is to experiment with and develop tools and methods for assessing climate and energy impacts in the evaluation of urban planning projects. The goal is also to enhance the practices and expertise in impact assessment at both the master planning and detailed planning levels. Workshops will be organized during the project to facilitate collaboration between urban planners from other cities and the city's own network of experts.

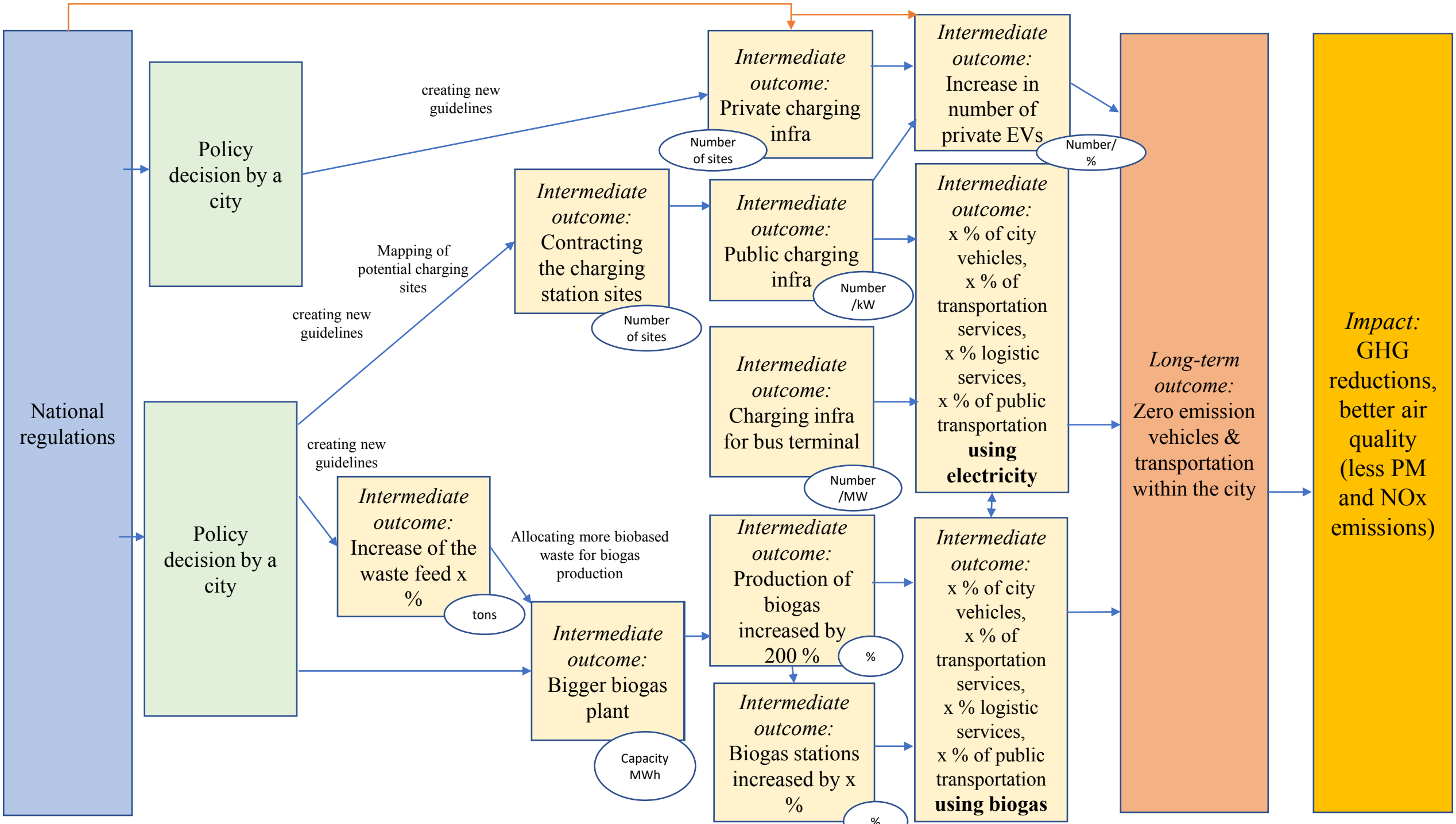
Example 6

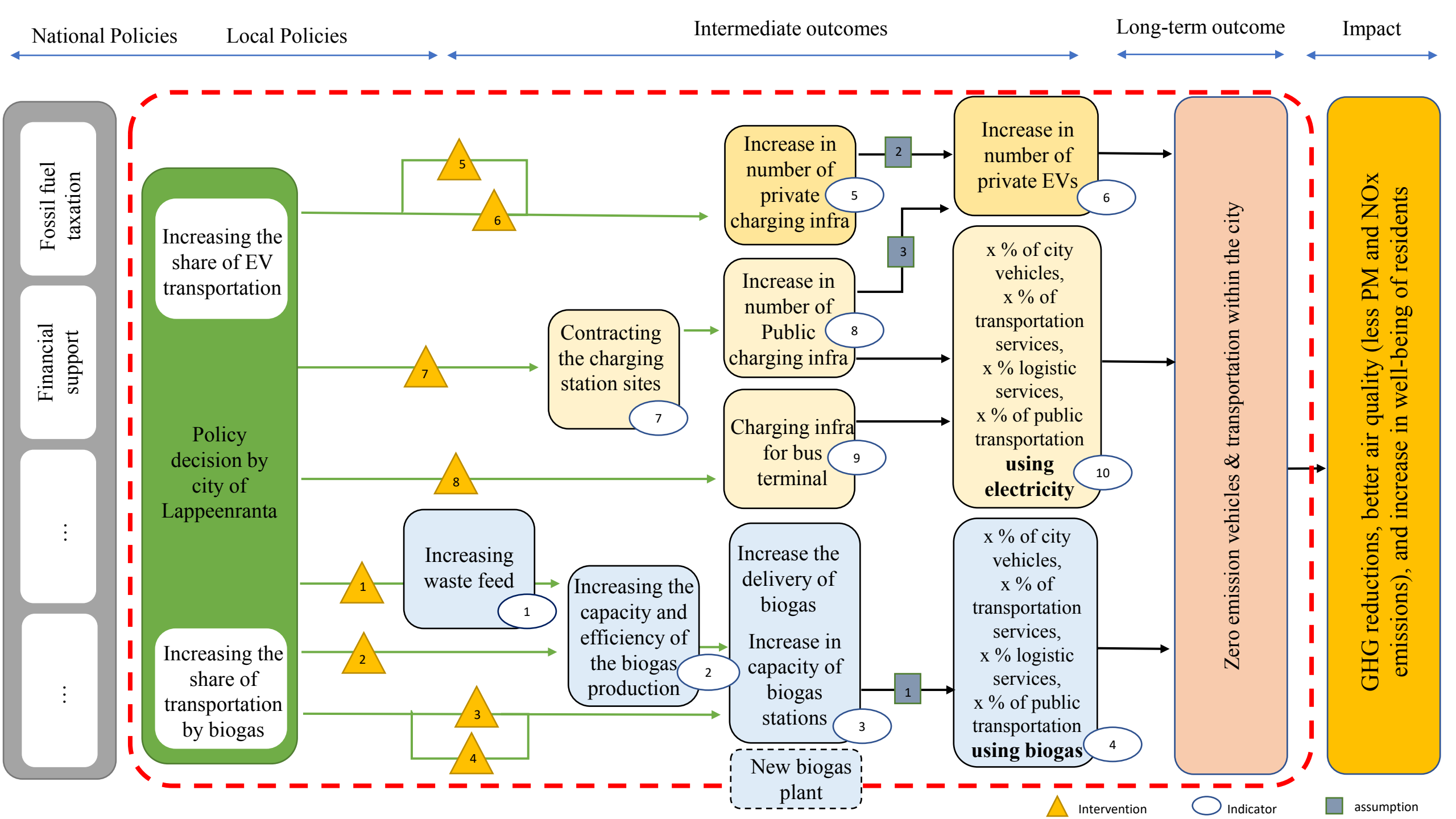
The city of Lappeenranta is involved in collaboration with LUT University in the Lappeenranta Junior University, or UNIORI program. Urban planning has participated in organizing a workshop for eighth-graders, where students have the opportunity to explore the fundamentals of clean energy, sustainable housing, and their own carbon footprint, as well as future solutions. In the workshop, students have had the chance to work together with experts in the field on perspectives related to their own residential areas.

A short recording from the urban planning workshop is featured in this English-language video introducing the UNIORI program.. https://youtu.be/rBm6xwh7TJ8?t=233

Example 7

The city of Lappeenranta participated in the international NordicPATH research project, which aimed to identify ways in which residents could engage in improving air quality. As part of the project, various approaches were tested to enhance residents' participation and involve them in collecting important data for the research. Examples of such initiatives included various online surveys and experiments where representatives from the local cycling club attached air quality monitoring devices to their bikes, allowing them to track particulate matter levels along the routes they used. Additionally, participating residents had the opportunity to install a separate sensor in their yards, which provided information on various factors affecting air quality.


National regulations
Policy decision by a city
creating new guidelines
Intermediate outcome: Private charging infra
Number of sites
Intermediate outcome: Increase in number of private EVs
Number/ %
Mapping of potential charging sites
creating new guidelines
Intermediate outcome: Contracting the charging station sites
Number of sites
Intermediate outcome: Public charging infra
Number /kW
Intermediate outcome: Charging infra for bus terminal
Number /MW
Intermediate outcome: x % of city vehicles, x % of transportation services, x % logistic services, x % of public transportation using electricity
Policy decision by a city
creating new guidelines
Intermediate outcome: Increase of the waste feed x %
tons
Allocating more biobased waste for biogas production
Intermediate outcome: Bigger biogas plant
Capacity MWh
Intermediate outcome: Production of biogas increased by 200 %
%
Intermediate outcome: Biogas stations increased by x %
%
Intermediate outcome: x % of city vehicles, x % of transportation services, x % logistic services, x % of public transportation using biogas
Long-term outcome: Zero emission vehicles & transportation within the city
Impact: GHG reductions, better air quality (less PM and NOx emissions)


National Policies
Local Policies
Intermediate outcomes
Long-term outcome
Impact
Fossil fuel taxation
Financial support
…
…
Policy decision by city of Lappeenranta
Increasing the share of EV transportation
Increasing the share of transportation by biogas
Increasing waste feed
Contracting the charging station sites
Increasing the capacity and efficiency of the biogas production
New biogas plant
Increase in number of private charging infra
Increase in number of Public charging infra
Charging infra for bus terminal
Increase the delivery of biogas
Increase in capacity of biogas stations
Increase in number of private EVs
x % of city vehicles, x % of transportation services, x % logistic services, x % of public transportation using electricity
x % of city vehicles, x % of transportation services, x % logistic services, x % of public transportation using biogas
Zero emission vehicles & transportation within the city
GHG reductions, better air quality (less PM and NOx emissions), and increase in well-being of residents
1
2
3
4
5
6
7
8
9
10
Intervention
Indicator
assumption

	1	2	3	4	5	6	7	8	9	10
Indicator 	Mass/tons	Capacity/ MWh per day	Capacity/ MWh per day	Percentage/ %	Number of sites	Number or Percentage/ %	Number of sites	Number or Capacity/ MWh per day	Number or Capacity / MWh per day	Number or Percentage/ %
Intervention 	Investing in new technologies and communicatio n with local farmers	Investment in new technologies	Investment for filling tank and compressors	Investment for biogas transportation	Increasing parking price to be invested in charging infrastruct ure	Implementation of parking space requirement in new buildings	Mapping of the new charging sites. (Criteria: equity)	Investment for the new charging infrastructure in the current bus terminals		
Assumption 	There is already demand for extra biogas production	Lack of private charging stations is a barrier for shift to EVs	Lack of public charging stations is a barrier for shift to EVs							

NET ZERO CITIES

EU MISSION PLATFORM | CLIMATE NEUTRAL AND SMART CITIES

Climate City Contract

2030 Climate Neutrality Commitments

Climate Neutrality Commitments

City of Lappeenranta

LAPPEENRANTA

THE CLIMATE CAPITAL OF FINLAND

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Disclaimer

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Table of contents

1 Introduction

As part of the Horizon Europe programme, the EU has launched a Mission *"100 Climate-Neutral and Smart Cities by 2030"*. The objectives of the mission are to achieve 100 climate-neutral and smart European cities by 2030 and to ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow suit by 2050. The City of Lappeenranta has been selected as one of these 100 Climate-Neutral and Smart Cities. The choice by the European Commission strengthens Lappeenranta's position as one of the pioneering European climate cities.

Cities play a key role in achieving climate neutrality by 2050, the goal of the European Green Deal. They take up only 4% of the EU's land area, but they are home to 75% of EU citizens. Furthermore, cities consume over 65% of the world's energy and account for more than 70% of global CO2 emissions.

Since climate mitigation is heavily dependent on urban action, EU has decided to support cities in accelerating their green and digital transformation. In particular, European cities can substantially contribute to the Green Deal target of reducing emissions by 55% by 2030 and, in more practical terms, to offer cleaner air, safer transport and less congestion and noise to their citizens.

The city of Lappeenranta has joined to the EU mission, because it supports the city climate actions. City has already committed to be climate neutral by 2030. Opportunity to join the EU mission gives more tools to reach the goal in the future. In the city strategy to year 2037 city has committed to be carbon neutral by 2030. The strategy is named as - Sustainable Succes Stories -. It means that city aims for sustainability and the city provides success stories for all kind of different stakeholders. In the climate work city has a long tradition. The work has started more than 20 years ago.

The best achievements in climate work have been in the energy sector. The city has changed its energy production totally in the last 15 years. First from natural gas to sustainable bioenergy in 2010, then changing its city's own electricity provider to climate neutral EKO energy. Later the smaller energy production unts have been switched from fossil to renewable energy. Energy efficiency in buildings has been a long-term target for the city owned buildings.

City has been awarded by WWF as a Climate Capital of Finland. The city has also received recognitions from Natural Protection Agency of Finland, Finnish Association of Municipalities and Finnis Environmental Institute of its work in Climate Actions.
In 2020 the City of Lappeenranta won the highest nomination of the cities by EU commission receiving the EU Green Leaf title. After that city has been selected to the EU City Mission in 2022.

City has committed to the climate neutrality target in 2030 when joining the national HINKU network (carbon neutral municipalities) in 2014. City is also a member in the Finnish Sustainable Municipalities (FISU). Internationally city has joined Covenant of Mayors and the ICLEI networks. City is also an active member in the EU Green Leaf network. In 2022 City joined the Glasgow Declaration for Tourism. It is a global climate program for the sustainable tourism. The Declaration strengthens the actors in the climate work in the city. In the latest city strategy, one of the main goals is the carbon neutrality for the city by 2030.

The city actions in the climate policy have provided energy security for the citizens and a solid action towards sustainable energy production and energy infra to the future. There has been a lot of actions for the carbon neutrality targets such as mobility, waste management, energy efficiency of the buildings and the diverse energy actions. Luckily, we have been able to connect to the best energy university in Finland – LUT University. It provides us a continuous flow of new solutions to the area.

2 Goal: Climate neutrality by 2030

The city of Lappeenranta has been ambitious for the climate actions during last 10 year when the city committed to the climate actions by joining several networks and accelerating the climate work.

The emission reduction target is a minimum of 80% and the emission compensations and additional carbon sinks are a maximum of 20% of the emissions.

City Council has decided that city is aiming for the climate neutrality by 2030 10.12.2020 and climate positive by 2035. Target is for the whole geographical area of the city, including all the sectors excluding scope 3 and emission trading private companies.

The climate program consists of several main topic such as communication, energy system, land use, transport and mobility, sinks and compensations, public green procurements, sustainable consumption, waste handling and circular economy, buildings, climate risks and adaptation. The program can be found in finish from https://kestavyysvahti.lappeenranta.fi/ilmasto.

The co-benefits are improvements on public health, new jobs and business opportunities, increase in nature-based solutions and increase of biodiversity at the area.

Lappeenranta has a lot of climate and circular economy related regional, national and European projects that can distribute new ideas to all cities in Europe. City has also a contract with state (Ministry of Economic Affairs ad Employment of Finland) about regional development. The topic of the contract is Green Electrification. In the contract Lappeenranta is developing together with Imatra municipality and Universities new greener solutions to the world. The topics are renewable electricity production, hydrogen economy, small and modular nuclear reactors.

The main challenge for the city climate neutrality is in the mobility sector. As a small and partly rural city the distances are long to the jobs and services. Because the population is small the effective public transport is difficult to organise. Also the transformation to electric vehicles is slow. In the sustainable mobility program there are targets to increase public transport as well as to increase a use of cycling and electric charging stations.

3 Key priorities and strategic interventions

The climate program has ten different topics for the different actions. In the Mission program the main priorities for the city climate program are:

Climate neutral **energy system** for municipality, citizens and companies. Every sector run by the city in the energy system will be climate neutral by 2030. This includes district heating, city premises, city owned companies and subsidiaries.

Climate neutral mobility and transport. Actions will be made towards climate neutral and low emission mobility and transport including biogas production. Target is difficult because of the city structure and the vast green areas. Actions are electrification of the traffic and transport, biogas production, renewable fuels.

Building sector climate neutrality and energy efficiency for all sectors in the city area. Energy efficiency actions, climate neutral energy and planning towards hydrogen economy in building sector are the targets. The energy efficiency of new city owned buildings is higher than currently valid energy efficiency requirements. To enable systemic change in the energy use and consumption, city focuses on smart monitoring and smart use of the energy.

Climate handprint actions of the city include renewable energy production for industrial size solar powerplants, hydrogen economy development and other environmental and energy sector actions that are leading towards the sustainable future. Greenreality Network is one of the key stakeholder groups.

4 Principles and process

Achieving carbon neutrality by 2030 requires significant changes in the energy system, movement, land use and consumption choices of residents. To steer the climate program city has established a transition team, which includes the city's various industries, group companies and the most important stakeholders, such as key companies and communities, universities and residents of the area.

Lappeenranta's action plan has been prepared in cooperation with stakeholders, and the transition team monitors the implementation of the action program and investment plan and guides their development as we advance. The action and investment plans are constantly updated programs, and the transition team monitors the implementation every six months. The climate city contract as a whole is updated every two years.

The action plan development began by reviewing the city's current climate programs, goals and policies/practices. Based on this report and the latest emissions calculation, the city has determined the level of additional measures needed. New significant additional measures were mapped out in spring 2023 in four thematic workshops cooperating with stakeholders and residents. The themes discussed were transport, construction, nature-based solutions and sustainable tourism. A portfolio of the most important and urgent actions to be implemented by 2030 was drawn up with the help of the measures defined in the workshops and the Finnish Environment Institute's scenario tool.

City stakeholders such as citizens, companies and institutions can join this program and announce their contributions as well as wishes for the city to help the each individual organization to achieve targets.

City of Lappeenranta has separate boards for citizen participation, elderly and disabled groups as well as youth parliament. A separate group for young to participate in climate work was founded in 2020.

To increase the participation the city has opened a website of the Mission and produced a video that describes for the citizens the aims and benefits of the EU Mission of Climate Neutral and Smart Cities.

Additional examples of the citizen and stakeholder participation has been included as an attachment to the Acion plan.

Link to the website : EU Cities Mission - Greenreality and EU Cities Mission - Greenreality

Link to the video : (228) Lappeenranta – NetZeroCities - YouTube

5 Signatories

Include a list of stakeholders who have committed to help your city achieve its goal to reach climate neutrality by 2030. Detailed commitments and agreements between individuals or groups of stakeholders should be appended to this Commitments document. This list will likely increase over time.

Name of the institution	Sector/Area	Legal form	Name of the responsible person	Position of the responsible person
Lappeenrannan Energia Oy	Energy and water services.	Limited Company / City owned	Arto Nikkanen	Managing Director
Lappeenrannan Asuntopalvelut Oy	City owned residential buildings	Limited Company / City Owned	Martti Mäkelä	Managing Director
Lappeenranta Free Zone Oy	Port of Lappeenranta	Limited Company / City Owned	Mikko Hietamies	Managing Director
Etelä-Karjalan Jätehuolto Oy	Waste management services	Limited Company / Public owned	Mika Suomalainen	Managing Director
Lappeenrannan Lahden teknillinen yliopisto LUT	University	Public organization	Juha-Matti Saksa	Rector
LAB Ammattikorkeakoulu	University of applied sciences	Public organization	Turo Kilpeläinen	President and CEO
Etelä-Karjalan hyvinvointialue	Healthcare and wellfa	Public organization	Sally Leskinen	Chief executive officer
Etelä – Karjalan Osuuskauppa	Services, groceries, hotels, restaurants, car dealer	Cooperative	Juha Riikonen	Managing Director