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Deliverable 1.1 - Tool Design Schematic for financial aspects' integration

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1 Key words and concepts

Concept	Description
Activity data	Generally, emissions calculation is based on activity data and emissions intensity data. The tool mostly uses this kind of break down to calculate emissions of a certain sector or action impacts. Activity could be for example: electricity consumption, fuel consumption, heat consumption or km driven with different types of vehicles depending on the emissions intensity data available
Baseline scenario	A baseline scenario means the chosen scenario to which the impact of actions is compared. In this case, how climate emissions would develop, if nothing further would be done to change the future course of emissions. Can include changes that the entity making the scenario cannot affect and/or climate actions that are already being implemented.
Climate action	An action planned to be implemented that is expected to result in positive climate-effects such as climate change mitigation and adaptation advancements.
Climate budget	A climate budget is a governance system that mainstreams climate commitments and considerations into decision-making on policies, actions, and budget through integrating climate targets from the city's Climate Action Plan (CAP) in the financial budget process and assigns responsibility for implementation, monitoring, evaluation and reporting across the city government.
Cost-effectiveness	Cost-effectiveness is used in economics to compare the costs and outcomes (effects) of different actions. It is commonly expressed as a ratio, where the numerator is the cost associated with achieving the effect, and the denominator is the effect of an action.
Cost-efficiency	Cost-efficiency refers to the least costly way of achieving the desired output, i.e. minimizing costs. For example, if two different actions reduce CO2 emissions by the same amount, the action doing it at the lowest costs is the most cost-efficient.
Cost-benefit	Cost-benefit analysis measures thew costs and benefits of an action. It compares the total expected costs of an action with the total expected benefits.
Discounting	Discounting is used to determine the present value of future cash flows. In order to make current and future cash payments comparable, the value of future payments must be converted to the present by applying a discount rate, i.e. discounted. The further into the future a payment is made, the less value it has in the present, even if there is no inflation.
Emission intensity/Emission factor	The amount of emissions, mostly climate emissions in this report, produced per an activity unit. For example, the unit of intensity/factor for energy consumption could be g CO_2e/kWh or for transport g CO2e/km driven.

GHG	Greenhouse gas
GPC Protocol	Greenhouse gas protocol for cities: a global accounting and reporting standard for cities by the GHG Protocol, an entity that establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions. Available at https://ghgprotocol.org/ghg-protocol-cities
MAC	Marginal Abatement Cost (MAC) illustrates the cost of reducing environmental negatives, such as greenhouse gas emissions. It usually measures the cost of an additional emission unit. The economic profitability of actions in relation to other actions is often illustrated on a marginal abatement cost curve (MACC), where the x-axis indicates the emission reduction potential of the actions (CO2e), while the y-axis shows the action's cost-effectiveness(€/CO2e). The curve shows the actions in the order of their cost-effectiveness, with the most cost-effective actions on the left-hand side of the curve.
NPV	Net present value (NPV) is the value of all future cash flows, including investment and operational costs, discounted to the present value. If the net present value of a project or investment is positive, it means that the investment is profitable.
Projection	Estimate of future time trend of some variable given all input data and the selected scenario.
Scenario	Scenario is a particular set of assumptions that are used to estimate future projections. Importantly, a scenario defines which actions are implemented and which are not. In the tool, the user can switch between scenarios to explore possible future situations. In this report they include baseline climate emissions and climate action emissions and financial impacts.
Timeline	A series of timepoints that are considered in the tool. The output of a variable timeline is based on historical data or future projections.
Tool target groups	In this deliverable target groups are defined as the utilisers of the data provided by the tool. Identification of target groups help the tool developers to understand the various needs for the tool, to make the tool provide accurate and relevant information and finally, to reach its objectives.
Tool user groups	In this deliverable the user groups are divided based on their interaction with the tool. The identification of user groups helps to understand the different user profiles and the data production and processes behind the tool's public interface. In addition to data consumers, user groups such as data providers, data collectors and data administrators are identified.

2 Introduction

2.1 Climate-4-CAST project

This deliverable is prepared as part of an Interreg BSR funded Climate-4-CAST project that supports cities achieving climate neutrality with a Climate Action Decision Support Tool to visualise and analyse climate action scenarios for better planning of public budgets and to monitor the results of the implementation of climate neutrality measures. A key objective for Climate-4-CAST project is to empower local public authorities who struggle to integrate climate concerns into urban governance processes with limited municipal funding.

As cities worldwide strive for climate neutrality, they encounter a host of challenges. High levels of uncertainty about emissions impacts, timing and cost of impacts, and potential of feedback effects are a barrier to climate action. There is also a mismatch in the languages between the decision makers and the climate experts and climate specialists need to translate their analyses in terms that municipal budget-makers understand. The decision-makers also need a reliable science-based foundation on which to base their financial allocations and to monitor results. To tackle these problems, Climate-4-CAST equips local public administrations with an open-source decision support tool to allow both a visualisation of individual measures' emissions impacts in different scenarios and a cost-benefit analysis of the measures' performance against city goals.

Through transnational co-development and piloting, the tool will be adapted to local contexts and needs while allowing better cross-border coordination, e.g., on data. The operationalisation will be proof-tested with key decision-makers to ensure usability as a governance instrument for climate budgeting. Thus, the project accelerates cities' climate actions and improves policy implementation for climate neutrality.

2.2 Scope and Aim of the deliverable

This Deliverable 1.1. (D1.1.) describes the tool design schematic for the Climate Action Decision Support Tool that is developed in Climate-4-CAST project. D1.1 is the first and most important basic cornerstone of the tool development process in Climate-4-CAST project, guiding the way to technical tool development and the operationalisation framework for tool implementation in the cities. Therefore, it is essential to all the further project activities and the final project output (Final tool code package and operationalisation guidelines). The deliverable is primarily of project-internal value, feeding into the more transnationally relevant deliverables and outputs in later project phases.

The deliverable comprises an overview of the key functionalities and features of the tool, data requirements and limitations as well as descriptions of key target and user groups and their informational needs. In addition, the deliverable outlines the key objectives for the tool, initial factors of usability and design and the scope of tool calculations and their possible limitations. In the end of the document next steps and further considerations for next project activities are outlined.

The key objective of the tool is to support cities achieving their climate neutrality goals. By providing Local Public Authorities improved, science-based and meaningful information about achievement of climate neutrality targets and the diverse impacts of specific climate actions the tool empowers and improves the city-level decision making.

The tool design schematic is based on two main features:

1. An overview of different climate actions and their individual climate and economic impacts. This feature helps cities analyse the effectiveness of climate measures, prioritise climate actions and understand in-depth the various impacts of climate actions.
2. Visualisation of city-level emissions projections. The feature helps cities to follow and project the achievement of their climate neutrality goals and emissions targets, and how individual climate actions contribute to the achievement of emissions targets.

2.3 Background for development

The Climate Action Decision Support Tool is being developed, based on the emissions scenario tool that is currently used in the City of Tampere and technically provided and developed by Kausal Ltd. The current tool used in city of Tampere contains all the data available of climate-related activity and fuels and energy production emission factor, while offering projections of city-level emissions under different scenarios and visualises emission and climate impacts of specific climate actions. However, the tool has several needs for further development to be more effective. Firstly, for making the tool useful for decision makers it should provide more understandable and meaningful information about the impacts of climate actions. In addition to visualising and assessing the climate impacts, there is a need to make scenarios of economic impacts and monetise impact values. This would make the impact assessment more useful for more users. See the tool used in Tampere: Carbon Neutral Tampere 2030 | Emissions scenarios of Tampere.

In the Climate-4-CAST project the emissions scenario tool will be improved, and new features will be developed. A key improvement will be an inclusion of economic impacts assessment of individual climate actions. In addition, improving the calculation models for assessing both the emissions and the economic impacts of individual climate actions is of importance in the tool development.

Technically the tool will be based on Kausal Paths solution, provided by Kausal Ltd and available as open-source code. Kausal Paths is an interactive scenario modelling tool for calculating and visualizing the development of a city's greenhouse gas emissions and other impacts. It allows cities to experiment with different combinations of emission reduction measures. Making the impacts of different decisions visible, Kausal Paths facilitates the process among experts and decision-makers helping them choose an optimal combination of measures for the climate plan. For more information see: Kausal | Kausal Paths

2.4 Approach: Establishing transnational cooperation and co-developing the tool

The Deliverable 1.1 is produced as part of Work Package 1 (Preparing solutions) and is a key output of Group of Activities (GoA) 1.1. – Establishing transnational cooperation and co-developing the tool, work. The deliverable and the tool design schematic have been prepared in close collaboration with Climate-4-CAST project partners (PPs) and associated organisations (AOs), and thus the activities have served as a crucial starting point for transnational cooperation within the project.

City of Tampere, as the GoA 1.1. lead, has been responsible of the deliverable's development and coordination. The deliverable has been prepared in close collaboration with Group of Activities 1.2., where the tool technical open-source code package is being produced. Thus, the partners from Kausal Ltd. have contributed to the writing of the deliverable, specifically the description of the key tool functionalities and features and the data requirements and limitations. The identification of tool objectives and the key target and user groups, also pave way for the tool operationalization framework, that is being developed in GoA 1.3. – Co-creating the operationalisation framework.

Project partners and associated organisations have been engaged in the development process of the tool design schematic in two Co-Design Workshops and via an online survey directed for pilot cities, through which the cities' needs and perspectives have been considered. Next the key activities contributing to the development of the tool design schematic are described.

2.4.1 1st Tool Co-Design Workshop

- Date and place: November 2023, during project kick-off meeting in Hamburg
- Organisers: City of Tampere and Kausal Ltd.
- Participants: All project partners.
- Scope and aim: Presenting project partners the current emissions scenario tool and climate budget work in the City of Tampere. Understanding the pilot city needs for the tool. Starting the transnational cooperation within the project.
- Key results: Creating understanding of the current tool used in Tampere and their climate budget process. Identification of a set of factors and features to be included in the Climate Action Decision Support tool design framework. Especially the key factors about economic and financial impacts were identified.

2.4.2 Internal tool development

- Time: 12/2023-2/2024
- Key actors: City of Tampere City and Kausal Ltd.

- Scope and aim: Inclusion of WS1 results and the identified city needs and perspectives in the tool design framework.
- Key actions: Bi-lateral meetings, WP1 Coordination meetings and online communication between project partners included in WP1.
- Results: Inclusion of the key economic impacts in the tool schematic (ROI, Cost-Effects, Cost-benefits). Identification of default Climate Actions to be included in the tool framework. Definition of the emissions calculation framework: GPC Protocol.

2.4.3 2nd Tool Co-design Online Workshop(s)

- Date and Place: March 5 & 8 2024, Online
- Organisers: City of Tampere, Kausal Ltd., Futurice Ltd. (external expert)
- Participants: All Project Partners (both days) and Associated Organisations (only on March 5)
- Scope and aim: Presentation of the Tool Design Schematic for participants to create common understanding of the tool and its functionalities (emission scenarios, climate actions, economic impacts), user specifications and data requirements and limitations. Understanding pilot city needs and priorities for the tool use, especially those relating to prioritization of individual climate actions. Deepening cooperation within the partnership. Start cooperation with AOs.
- Results: Improved understanding of the tool and its functionalities among project partners and associated organisations. Improved understanding of pilot cities' needs and priorities for the tool. Improved understanding of data requirements and limitations for the tool.

2.4.4 Survey for pilot cities

- Time: 3/2024
- Actors: City of Tampere.
- Scope and aim: An online survey was circulated among the pilot cities and project partners in March to collect insights for EU or local level policies behind the cities' climate work.
- Key results: Improved understanding about the pilot city priorities related to climate action and impact assessment. Mapping of key EU and local level regulation, policies and strategies guiding the climate work in the cities.

2.4.5 Preparation and finalisation of Tool Design Schematic in Deliverable 1.1

- Coordination: City of Tampere
- Key contributors: City of Tampere and Kausal Ltd.

- Comments and validation: Project Partners and Associated Organisations
- Process: The deliverable has been prepared along the workshops and internal development. First version was disseminated to project partners in mid-April and discusses during Aarhus Consortium Meeting (25.-26.4.2024) and finalised based on the received comments from project partners. Afterwards the deliverable will be disseminated for the Associated Organisations and published on the project websites.

3 Key challenges, objectives, and target audiences of the tool

3.1 Key challenges

As cities worldwide strive for climate neutrality, they encounter a host of challenges. In Climate-4-CAST project the project partners have identified four key challenges that are to be encountered with the solutions developed in the project.

The challenges identified are listed as follows:

1. High levels of uncertainty in assessing the impacts of climate measures in the cities.
2. Local public authorities lack knowledge, tools, data, and political backing to reach climate-neutrality goals.
3. Mismatch between climate specialists' technical analysis and the language of decision-makers.
4. Decision-makers need a reliable science-based foundation on which to base their decisions, financial allocations and to monitor results.

3.2 Key objectives

The ultimate objective of the Climate-4-CAST project and the Climate Action Decision Support Tool is to support cities achieving their climate neutrality goals. By providing Local Public Authorities improved and meaningful information about the achievement of climate neutrality targets and the diverse impacts of climate measures the tool empowers and improves decision making.

The key objectives of the tool are:

1. Support Climate Neutrality Goals of cities. The primary objective of the tool is to support cities in achieving their climate neutrality goal. The tool provides a framework for evaluating the variety of impacts of climate measures and visualises emissions projections for the future. With the information the tool guides cities in aligning their actions with their long-term climate goals and provides information how to achieve their climate neutrality goals efficiently.

2. Enhance decision-making. Well informed decision-making lies at the heart of effective climate action. The tool facilitates informed and science-based decision-making for climate actions by providing a user-friendly visual and analytical interface that assists local public authorities and decision-makers in evaluating climate measures under different scenarios.
3. Improved understanding of the various impacts of climate measures. In addition to climate impacts the tool offers information about the economic impacts of the climate actions, an important point of view for decision makers. The tool will focus on measuring impacts such as return on investment, cost-effectiveness, and cost-benefits. This helps cities to assess the effectiveness and economic implications of different climate actions and further, allows effective resourcing and prioritising of actions in the decision making. Analysis of cost-benefits allows also identify impacts wider to the society and/or residents.
4. Bridge the gap between climate specialists and decision makers. A key objective for developing the tool has been to make it provide information about emissions scenarios and the impacts of climate actions in a way that is understandable and meaningful for decision makers. Here the various visualisation techniques and the inclusion of economic impact assessment play a key role.
5. Enhance and ease the work of climate experts and city planners. The adaptability functionalities in the tool ease the work of climate experts to assess and compare climate actions and achievement of climate neutrality targets with up-to-date data and parameters.
6. Integration of the tool in city governance processes. In the end, Climate-4-CAST will provide an operationalisation framework that guides its integration into local climate and fiscal governance processes. This ensures that it becomes an integral part of decision making in the cities. The tool should help cities especially in their climate budgeting processes.
7. Open and available for all cities. The tool will be developed on an open-source code that is available for all cities as a code package with instructions.
8. Local context customisation. The tool and its features and calculation models are developed to be adaptable to local contexts.

3.3 Key target groups, their challenges, and informational needs

The Climate Action Decision Support Tool is a commendable initiative, and understanding the key target groups and their specific needs is crucial for its success. The target group identification focuses on addressing those actors who utilise the data and information provided by the tool. As the tool aims to support cities and the local public authorities in decision making, the most important target groups come from the city's own decision-making system, including the city administrators and planners, the city councils, committees, and elected representatives as well as municipally owned companies. In addition, important target groups are those who play a key role in implementing the climate actions in the city level. Here we can identify multiple of stakeholders varying from private companies to community organisations and residents as well as research and academia.

As cities differ in structure and in their climate neutrality strategies, there might be variation in the identification and prioritisation of the key target groups. Next the key target groups are described in more detail. Under each target group we describe their roles in the city-level climate work and their essential challenges, and informational needs for which the tool is expected to provide solutions. While reading through the possible target groups each city should reflect these to their own context: Who are the key target groups in their city? For whom and for which challenges do they wish to provide solutions with the tool specifically?

Target group 1: City Administrators and Planners

Role: City administrators and planners are responsible for day-to -day management of city operations, formulating of policies, regulations, and long-term strategies for political decision making, implementation of policies, management of city budgets and resources as well as coordination of city services. They play a key role in planning and implementing climate actions in the city level. The city administrators and planners work in the various departments of the cities.

Challenges

- Balancing short-term needs with long-term climate goals.
- Navigating political dynamics and stakeholder interests.
- Limited budgets and competing priorities.
- Focusing on sectoral goals instead of wider picture.

Informational needs

- Emissions Impact Assessment: Detailed assessments of climate measures' impact on the city's emissions, environment, infrastructure, and residents.
- Economic Impact Assessment: Information on the economic implications of various climate actions, including return on investment, cost-effectiveness, cost-benefits.
- Monitoring and Reporting: Tools to track progress on the achievement of climate neutrality targets and implemented actions and report to higher authorities.
- Resource Allocation: Insights into resource requirements for each measure.

Target group 2: City Councils, Boards, Committees and Elected Representatives

Role: They make final decisions on budget allocation, legislation, and policy adoption in the city level. They participate in debates, propose resolutions and vote on critical issues affecting the city. They utilise the tool as bases for their decision-making.

Challenges

- Short-term thinking: Short-term goals are overruling long-terms goals in the political decision making.
- Complexity of Climate Science: Understanding technical aspects of climate change, mitigation strategies, and adaptation measures. Communicating complex climate information to constituents. Bridging the gap between scientific evidence and practical decision-making.
- Resource allocation: Allocating limited resources (budget, personnel, time) to climate initiatives. Prioritizing climate actions alongside other pressing city matters.
- Diverse interests: Navigating conflicting viewpoints and finding common ground.
- Communication Challenges: Explaining climate concepts to constituents in a clear, relatable manner. Overcoming resistance or scepticism related to climate policies.

Informational needs

- Understanding climate measures: Clear information on proposed climate actions, their impact, and alignment with broader policy goals.
- Policy Implications: How climate actions align with their political agenda and constituents' interests.
- Trade-offs: Insights into trade-offs between environmental benefits and potential economic or social costs.
- Equality Considerations: Ensuring fairness in distribution of benefits and costs.

Target group 3: Municipal owned companies

Role: The municipal owned companies deliver essential services to the city, such as energy, water, waste management and public transportation, and thus play a critical role in implementing climate actions with their respective sectors and further achieving the cities' climate neutrality goals. Their actions and climate measures are likely to be incorporated and assessed in the tool.

Challenges

- Balancing Service Delivery and Sustainability: Meeting service demands while minimizing environmental impact. Ensuring reliable services without compromising climate goals.
- Legacy Infrastructure: Upgrading existing infrastructure (e.g., aging power plants, public transit systems) to be more sustainable. Overcoming inertia and resistance to change.
- Financial Constraints: Allocating funds for climate initiatives alongside routine operations. Demonstrating the long-term financial benefits of sustainability investments.

- Data Availability and Quality: Access to accurate data on energy consumption, emissions, and operational efficiency. Ensuring data transparency and reliability. Balancing business interests with openness.

Informational needs

- Sector-Specific Impact Assessment: Information on how specific climate actions affect their operations.
- Resource Implications: Insights into resource requirements (e.g., capital investment, operational costs) for implementing sustainable practices.
- Economic Impact Assessment: Assessing the costs and benefits of adopting climate-friendly technologies or practices. Quantifying the long-term financial gains from climate actions (return on investment).
- Integration and alignment with city goals and policies: Assessing how their activities align with the city's climate goals and policies.

Target group 4: Businesses and private sector

Role: Private businesses, spanning various sectors (energy providers, housing companies, construction firms), play a critical role in implementing city-level climate actions. They are key actors in transitioning toward climate neutrality by adopting sustainable practices, investing in green technologies, and influencing supply chains.

Challenges

- Balancing profit motives with sustainability goals.
- Encouraging private sector investment in climate-friendly projects.

Informational needs

- Business Opportunities: Identifying profitable ventures related to city level climate actions.
- Regulatory Compliance: Understanding how climate policies affect their operations.
- Innovation and Technology: Insights into emerging solutions.

Target group 5: Community Organizations and NGOs

Role: Community organizations and NGOs actively engage with local communities, advocating for climate action and resilience. They build awareness of climate action and bridge the gap between governments, researchers, and citizens.

Challenges

- Advocacy and Awareness: Communicating climate information effectively to the public.

- Resource Constraints: Limited funding and capacity for community-led initiatives.
- Inclusivity: Ensuring representation of diverse voices and marginalized communities.
- Policy Influence: Navigating political dynamics to influence policy decisions.

Informational needs

- Climate Literacy: Accessible information on climate science and city level climate work.
- Community Outreach and Engagement Strategies: Tools to educate residents about climate actions and their benefits. And tool for mobilizing local action.
- Policy Advocacy: Insights into effective advocacy strategies.
- Collaboration Platforms: Networks for sharing best practices and lessons learned.

Target group 6: City residents

Role: Residents are the heart of any city, directly impacted by climate changes and mitigation efforts. They make daily choices that collectively influence emissions and resilience.

Challenges

- Awareness Gap: Many residents lack awareness of climate issues and city level climate work and how it is affecting individuals.
- Behaviour Change:Encouraging sustainable practices (e.g., energy conservation, waste reduction).
- Equality: Ensuring that climate benefits reach all residents.

Informational needs

- Awareness of city-level climate work: Accessible information on the city level climate work, how resources are efficiently allocated and how climate actions may have impact on individuals.
- Local Initiatives: Awareness of community-led climate projects.
- Behavioural Tips: Improved understanding for reducing personal carbon footprint.

Target group 7: Research and Academia

Role: Researchers and academics contribute to climate knowledge, innovation, and policy. They inform decision-making, develop new technologies, and educate future leaders.

Challenges

- Interdisciplinary Collaboration: Bridging gaps between scientific disciplines.
- Public Engagement: Communicating complex climate findings to diverse audiences.
- Policy Relevance: Ensuring research aligns with real-world needs.

Informational needs

- Scientific evidence: Access to the latest climate science and adaptation strategies. Access to climate models, impact assessments, and best practices.
- Policy Impact: Insights into translating research into actionable policies.
- Collaboration Opportunities: Engaging in joint research and knowledge-sharing.
- Science Communication: Tools for effective public engagement.

4 Tool features and functionalities

The Climate Action Decision Support Tool is based on two main features:

1. An overview of different climate actions and their individual climate and economic impacts. This feature helps cities analyse the effectiveness of climate measures, prioritise climate actions and understand in-depth the various impacts of climate actions. The feature shows greenhouse gas emissions, energy consumption and costs and savings of climate actions.
2. A visualisation of city-level emissions projections and time trends by GPC sectors. This feature helps cities to track and project the achievement of their climate neutrality goals and emissions targets in different scenarios and course of action.

The tool focuses on providing visualization of timelines of the most important outcomes of interest such as time trends of city-level greenhouse gas emissions by GPC sectors, time trends of activity data (such as energy consumption or vehicle kilometrage) and time trends of economic costs and benefits of climate actions. All calculations and visualisations are updated instantaneously when any changes to input data is made.

The tool main features are interlinked. Emissions impact of a specific action is based on the projection of emission intensities. Also, the actions are included in chosen scenarios have their indicated impact on the indicated activity data and the results are shown in the city-level emissions projection. For example, an action that reduces energy consumption will refer to the emission factor of said energy form in the city-level emissions projections to determine the amount of emissions avoided. At the same time, the action will reduce the amount of energy consumed in the city-level emissions projection resulting in lower total emissions in the affected sector.

The GPC Protocol (the Greenhouse Gas Protocol for Local Communities) is used for calculating emissions inventories and future projections. This is the most common protocol, which is used by most of the cities who do greenhouse gas inventories. It has a standard structure for emission sectors, and most emissions are calculated by multiplying activities and related emission factors. In Annex 1 the division to sectors and sub-sectors is presented. For further details about the GPC protocol see: GHG Protocol for Cities.

4.1 Key feature 1: Climate actions and their impact assessment

Assessing and visualizing the impacts of climate actions is a core objective of the tool. The tool calculates two types of impacts: climate impacts and economic impacts. Of climate impacts the tool calculates emission reduction and energy savings. Of economic impacts the tool calculates: discounted costs and benefits, cost-effectiveness of emission reduction and return on investment. With the assessment of the various impacts, cities can analyse the effectiveness of different climate actions and when needed prioritize climate actions.

Climate actions are considered as actions that are expected to result in positive climate effect such as climate change mitigation and adaptation advancement. As the tool focuses on influencing city level decision making and financial planning the climate actions implemented directly by the city are of importance. Climate actions to which cities have indirect influence may also be assessed in the tool. An example of an indirect climate action could be energy counselling for private housing to make energy efficiency renovations in the privately owned buildings.

Climate actions implemented by the private sector without direct or indirect link to city level decisions or measures, could be included in the tool to show the importance of including and supporting the private sector in the city level climate work, but for the time being and in the scope of Climate-4-CAST project, the primary focus will be on the climate actions implemented by the cities.

4.1.1 Defining climate actions in the tool – starting from six default actions

Cities derive climate actions in the tool normally from their local climate action plans and strategies. These may be for example Sustainable Energy and Climate Action Plans (SECAP) or other climate neutrality plans. Each city defines their own set of climate actions to which they focus on. There is no limitation in the number of actions that can be included in the tool, but it is likely that not all climate actions included in the city level action plans can or will be included.

In the first phase, the tool will include six default climate actions that have been chosen to the tool based on their relevance for cities, data availability and previous experiences of impact assessment. As the knowledge of climate action specific impact assessment improves towards the piloting phase, cities may include more actions in the tool.

The six default actions suggested to be included in the first version of tool are:

1. Change streetlights to LED
2. Build renewable electricity production (PV)
3. Energy efficiency renovations in public buildings
4. Replace oil (or natural gas) heating with geothermal heating
5. Replace city fleet with electric vehicles
6. Electrify public transportation

During the co-development process project partners and pilot cities have identified multiple other climate actions that are relevant for the cities. A list of possible climate actions identified during the co-development process is provided in Annex 2.

In the 1st piloting phase, each city should identify the actions they wish to focus on to collect data and seek further knowledge of assessing their specific impacts. For pilot action plans an indicative list of prioritized actions is suggested to be made, so cities know where to start their data collection.

Questions to consider for cities:

1. Based on your city's objectives and needs, what kind of climate actions would you prefer to include in the tool?
2. Where do you derive the climate actions from?
3. List down the climate actions and prioritise them if needed.

4.1.2 Evaluation of Climate Impacts: calculation model, data requirements and possible challenges

The tool aims to analyse and visualise the emissions reductions and energy savings of each climate action. Actions may follow one of two technical implementations: simple actions, which consist of pre-calculated impacts to emission and/or activity factors, energy usage, and/or emissions, applied to the model baseline; or detailed actions, in which energy and/or emissions impacts are calculated by the tool, as a function of investment expenditure on altering stock composition, reducing emission and/or activity factors, etc. Detailed descriptions and examples are provided in the following subsections.

4.1.2.1 Simple Actions

Climate actions may be included in the tool via simple actions, in which pre-calculated time-series estimates of costs/benefits, reductions in emission and/or activity factors, energy usage, and/or emissions are applied to the model baseline. To implement a simple action, a city must enter (1) baseline estimates of the quantities which the action alters, and (2) estimates of the change to these quantities imposed by the action. For example, an action effecting the procurement of renewable grid electricity may require changes to two quantities: a decrease in the emission factor of electricity, and an increase in the unit cost of electricity. Baseline estimates of these quantities are entered on the "Baseline" tab of the data entry sheet, and the estimated changes in these quantities are entered on the "Simple Action" tab, associated with a new "Procure Renewable Electricity" action. An example of the data sheet to collect this information can be seen in Annex 4. Note that the tool recalculates derived quantities when the action is implemented: emissions, for example, are calculated by multiplying energy usage and emission factors, and are recalculated when emission factors change.

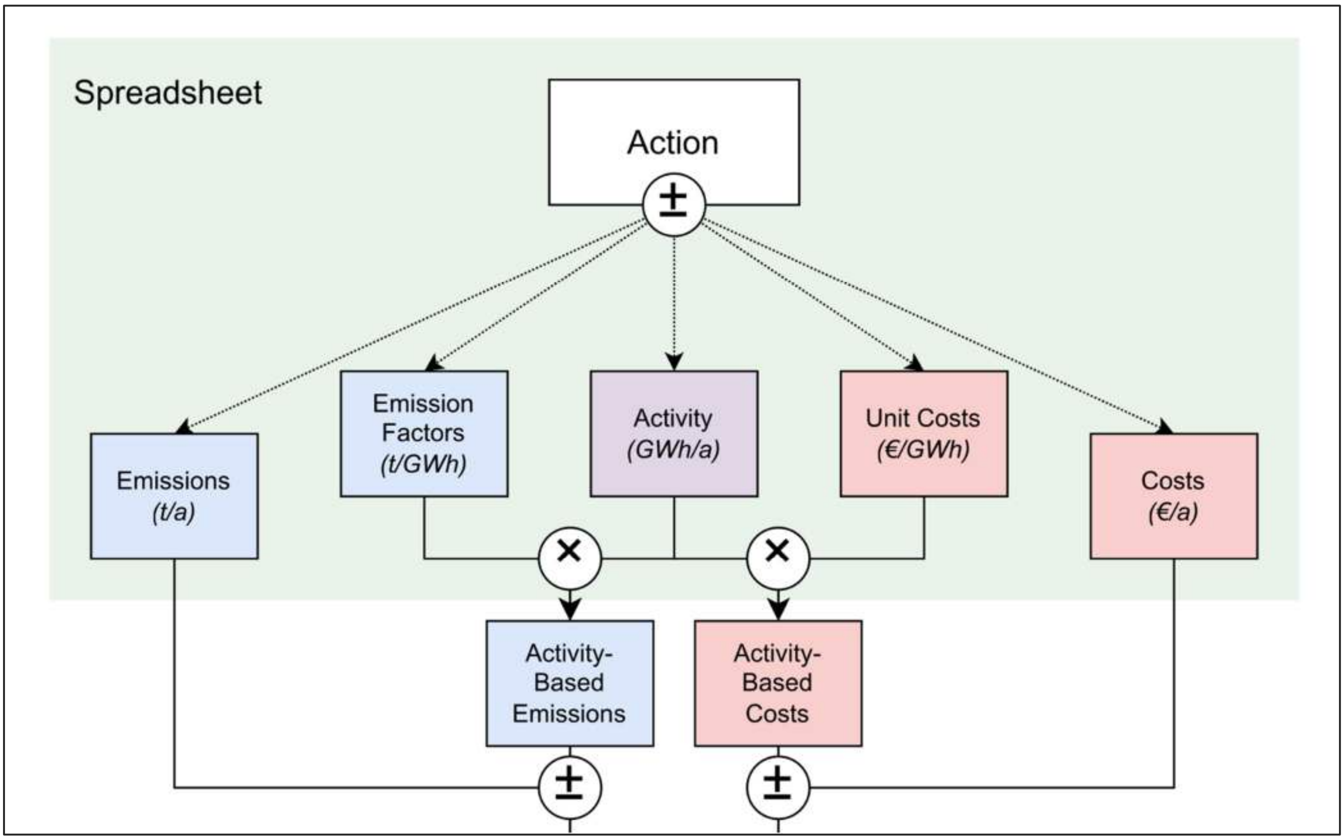

Figure 1: Schematic Diagram of Simple Actions.

Simple actions may be used when (1) input data are difficult to obtain, and a city wishes to visualize general estimates of action costs/benefits and energy/emissions reductions. This may be the case for indirect actions: for example, a subject-matter expert may use professional judgement to estimate a certain expenditure on educational materials, concerning the energy savings of building renovations, may result in a certain percentage decrease in residential energy consumption. These estimated impacts may be included in the tool using a simple action: time-series estimates of increased investment expenditure, and decreased energy consumption, may be entered, without the need to explicate the full causal chain between these associated quantities.

Alternatively, simple actions may be used when (2) the city uses an external model to calculate action impacts. Detailed, process-based models may be used to run complex simulations and derive detailed costs/benefits and energy/emissions reductions for certain actions. For example, a spatially explicit, agent-based model may be used to simulate the effects of implementing 15-minute neighbourhoods on urban transportation demand. Such models cannot reasonably be replicated within the tool, and instead, the simulated time-series impacts of these models may be included in the tool using a simple action.

4.1.2.2 Detailed Actions

Climate actions may also be included in the tool via detailed actions, in which each action's impacts are calculated by the tool itself. Where simple actions are flexible and unstructured, each simply applying time-series impacts to any baseline model quantity, detailed actions are structured, each requiring specific input data and following a particular causal diagram. Detailed actions, however, allow the city to set action targets, and to specify a maximum annual investment expenditure; this facilitates exploring the emissions, energy, and financial outcomes of different combinations of actions, action targets, and project funding.

Detailed actions follow templates, in which a common logic is applied. For example, of the default actions listed in Section 4.1.1, Actions 1, 3, 5, and 6 may be implemented using the template illustrated in Figure 2, in which an annual investment is used to change the composition of a stock or inventory of items. In Action 1 (Change Streetlights to LED), the city's stock of outdoor lighting may be inventoried in several categories (incandescent and LED lamps, for example), and investment expenditure used to replace incandescent lamps with LEDs. The action tracks the item stock (the number of lamps of each lamp type), and provided per-type energy usage, maintenance costs, etc., uses this changing stock to calculate changing emissions, energy usage, and costs/benefits.

Actions following this "stock replacement" template require specific input data. A city must provide:

1. An estimate of the baseline stock, categorized by relevant types: for example, the numbers of incandescent and LED lamps (Action 1), or ICE and electric buses (Action 6).
2. The maximum annual investment to be spent replacing items in this stock; this amount is spent in full until the target stock composition is achieved.

3. The target stock composition: for example, a city may aim to replace all incandescent outdoor lighting with LEDs, or to replace half its ICE transit fleet with electric vehicles.
4. The cost of a replacement, and the replacement scheme: for example, the price in EUR of replacing a single incandescent lamp with an LED lamp.
5. Finally, other baseline contextual data, including the energy usage of each item type, energy emission factors and unit costs, and maintenance costs for each item type.

Given these requirements, a city must assess the feasibility of estimating or collecting these detailed quantities. Where only more general estimates are available, a city may opt to use the simple, rather than the detailed, approach, to include these actions in the tool.

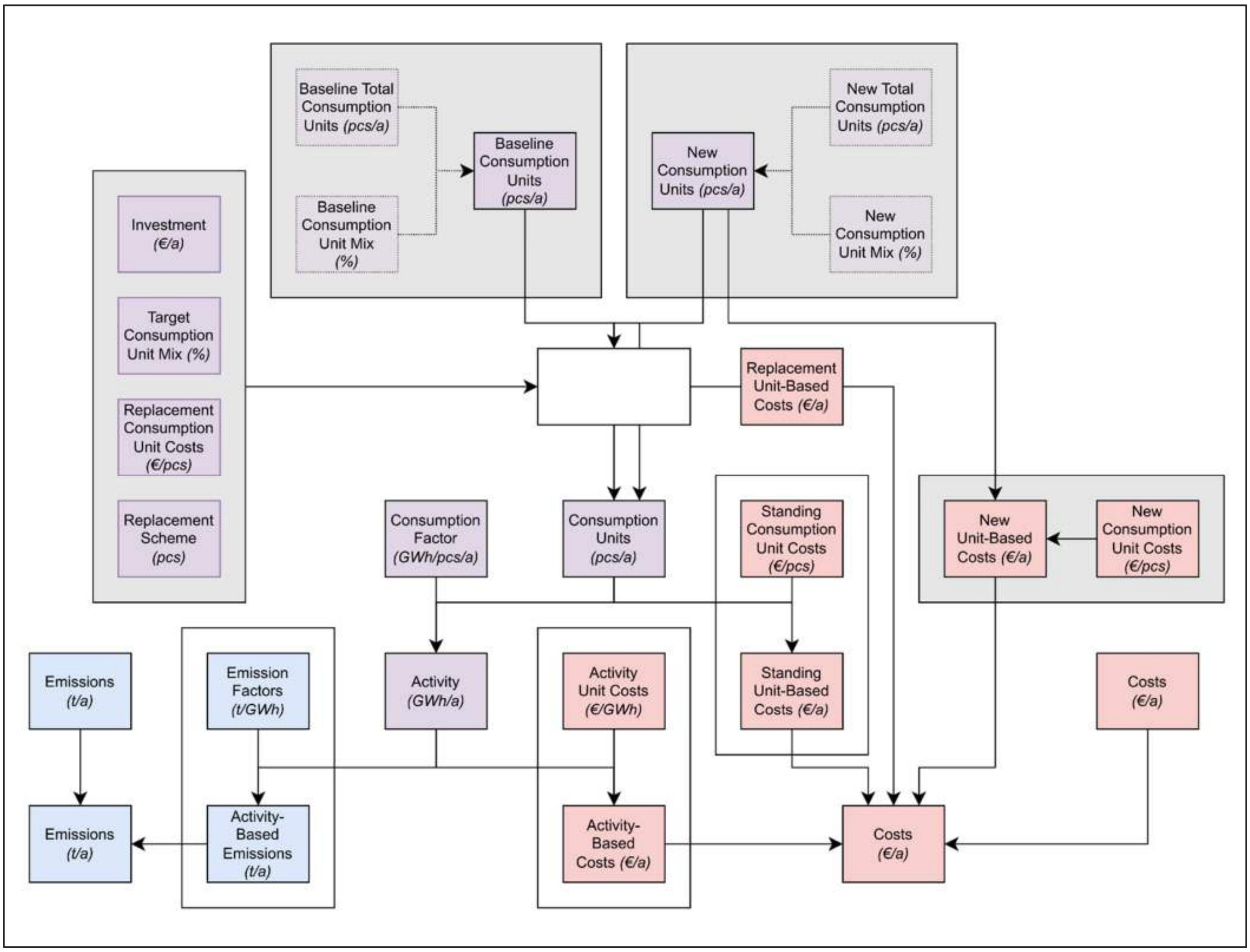

Figure 2: Schematic Diagram of Detailed Action

An example of estimating the individual impacts of Action 1, Changing streetlight to LED, is provided in a separate excel sheet in Annex 3. The example is a model used in Tampere and includes data from Tampere. Along the project similar calculation models may be provided for other climate actions and eventually incorporated in the tool framework.

4.1.2.3 Possible limitations in calculating impacts and needs for further improvement.

The tool is meant for managing all the data involved in calculating emissions projections and action impacts and easily making different projections and scenarios. The actual estimation of the impact of a certain action needs to be done first and is then inserted as input in the tool. The impact should be identified in relation to activity data of the baseline scenario, not emissions directly as described in 4.1.2. For example, investing in LED lights will have an impact on electricity consumption relative to the current situation. Just like all data, the impact is a time trend on a yearly basis and should be assigned to a year when the action takes place, or the impact is realized. The tool will then calculate the climate impact based on that year's electricity production emissions and reduce the amount of electricity saved from the overall electricity consumption projection if the action is included in chosen scenario.

The limitations to evaluating impacts in the tool are therefore same as in general evaluating the impact caused by an action on activity data. If it is not possible to identify for example how much the overall private car kilometrage is changed due to investing in a walking or cycling path, it is not possible to include it in the tool projections. Since the impact of some climate action is systemic and the emission calculation requires change in activity data, it can be near impossible to identify the impact of some actions. For example, the impact of investing in walking and cycling depends on how it affects the travel time of each of the people using that part of the route but is also impacted by the safety of the environment and suitable bicycle parking at destination. Thus, an individual action doesn't also have an individual impact. Also, transport habits change very gradually instead of an immediate change that can be identified easily.

The key challenges limiting the inclusion of climate actions in the tool, are thus data availability and lack of reliable science-based knowledge to assess the various impacts of individual climate measures. It is commonly identified that difficulties occur especially in the impacts assessment of emissions reduction of specific climate actions in the transportation sector. It is likely that difficulties might occur with other climate actions as well.

During the piloting phase of the project, the Climate-4-CAST partnership and pilot cities seek to find solutions to overcome some of these challenges and the tool is expected to be expanded with climate measure specific calculation nodes. As each pilot city has resources for data gathering and developing the analysis models of climate-measure-specific impact assessment, it is essential to exchange information between the pilot cities during the piloting phase.

4.1.3 Evaluation of Economic Impacts: calculation models, data collection and possible challenges

Evaluating the economic impacts is important for informed decision-making. Different approaches help understanding the monetary impacts of the actions. Depending on the used method and scope, the assessment can consider not only the direct effects but also the indirect effects as well as long-term impacts. Such evaluation helps in allocating the scarce financial resources effectively and make sustainable solutions also to the future.

4.1.3.1 Calculation and analysis models

Several different methods can be used to assess the economic impacts. The Climate Action Decision Support Tool (DST) developed in this project focuses especially on three of these:

1. Return on Investment (ROI): ROI measures the efficiency of an action by comparing the net benefits to the total costs of the action, and it can be expressed as:

    Return on Investment = (Total expected benefits of an action - Total expected costs of an action) / Total expected costs of an action x 100 (%).

2. Cost-Effectiveness Analysis (CEA): Cost-effectiveness is used to compare the costs and outcomes (effects) of different actions. It is commonly expressed as a ratio, where the numerator is the cost associated with achieving the effect, and the denominator is the effect of an action. In the context of climate actions, e.g., solar panel investment, the cost effectiveness can be expressed as:

    Cost-effectiveness = Cost of installing and maintaining solar panels / Amount of CO2 emissions reduced by the panels (€/CO2)

    The lower the ratio, the more cost-effective the action is, as it generates greater effects with less cost. Cost-effectiveness is important in making informed decisions about resource allocation in climate action planning. Annex 3 provides an example of cost-effectiveness analysis of LED streetlights change.

3. Cost-Benefit Analysis (CBA): Cost-benefit analysis measures the costs and benefits of an action. It compares the total expected costs of an action with the total expected benefits, and in the context, e.g., solar panel investment, the cost-benefit can be expressed as:

    Cost-benefit = (Savings on electricity bills + revenue from electricity sales) - (investment cost of panels + maintenance costs) (€).

    If the cost-benefit is positive, i.e., the benefits are greater than the costs, the project is a profitable investment. While cost-effectiveness analysis compares the cost of an action with the effect (emission reduction), cost-benefit analysis also monetises the effects, both emission reductions and other benefits (e.g., health benefits).

4.1.3.2 Data requirements and limitations

Assessing the economic impacts of climate action requires a robust and comprehensive set of data covering the different dimensions of both costs and potential benefits. The above-mentioned figure 2 gives a general overview of the components needed to calculate the costs of the actions and their emission reductions.

The starting point for the calculation is the baseline scenario, i.e., what the current situation is and how it will evolve in time, assuming no changes are made. The emissions and costs (and possible benefits) of the baseline scenario are compared with the situation in which the action is implemented, and the difference between these two scenarios is the impact of the measure, both in terms of costs and emissions.

The calculation is based on information on the current operational and maintenance costs as well as the investment, operational and maintenance costs of the new action to be implemented. Operating costs are a function of energy prices and energy consumption, which in turn affect the amount of emission reduction. Information on emission factors is needed to assess the emission reduction potential. The investment costs of the implemented action depend on the market situation and the scale of the investment required.

A particular challenge in assessing economic impacts relates to the highly uncertain future price forecast. In addition, calculations must consider the fact that the value of money changes over time: the same amount of money is worth more now than in the future. Therefore, the value of cash flows in future must be converted to the present by discounting using a discount rate.

The calculation of each cost component requires a different amount of information depending on the climate action and can be based on a variety of sources. Some of the information comes from the city, but others may be general information, for example from various national data sources. To calculate the monetary value of the various non-market benefits, information from the literature is likely to be needed and several assumptions will also have to be made when building the calculation model.

Data constraints often pose significant challenges. These can include incomplete data sets, lack of standardisation, delays in data availability and uncertainty in predicting future market conditions and policy changes. The data needed to assess the economic impacts of climate action are large and complex. The calculation always involves assumptions, and it must be balanced between the simplicity of the calculation model and a sufficiently accurate and credible calculation. Given the uncertainty and difficulty of predicting, for example, future price developments, an important feature of the tool is to allow for agile changes in initial values.

4.1.4 Visualisation of climate action data in the tool

In the tool view of climate actions, the users can choose one summary statistic and get a visualisation where all actions are summarised according to that statistic, allowing efficient comparison between the different climate actions. For example, in the marginal abatement cost (MAC) curve, each action is shown as a block where the hight is the cost-effectiveness of the action and the width is the impact of the action on the target year (See Figure 3). The administrator can choose which cost nodes and impact nodes are selected for a visualisation, so it is possible to build several different views, for example, cost-effectiveness can be show for the impact on energy reduction, or greenhouse gas reduction.

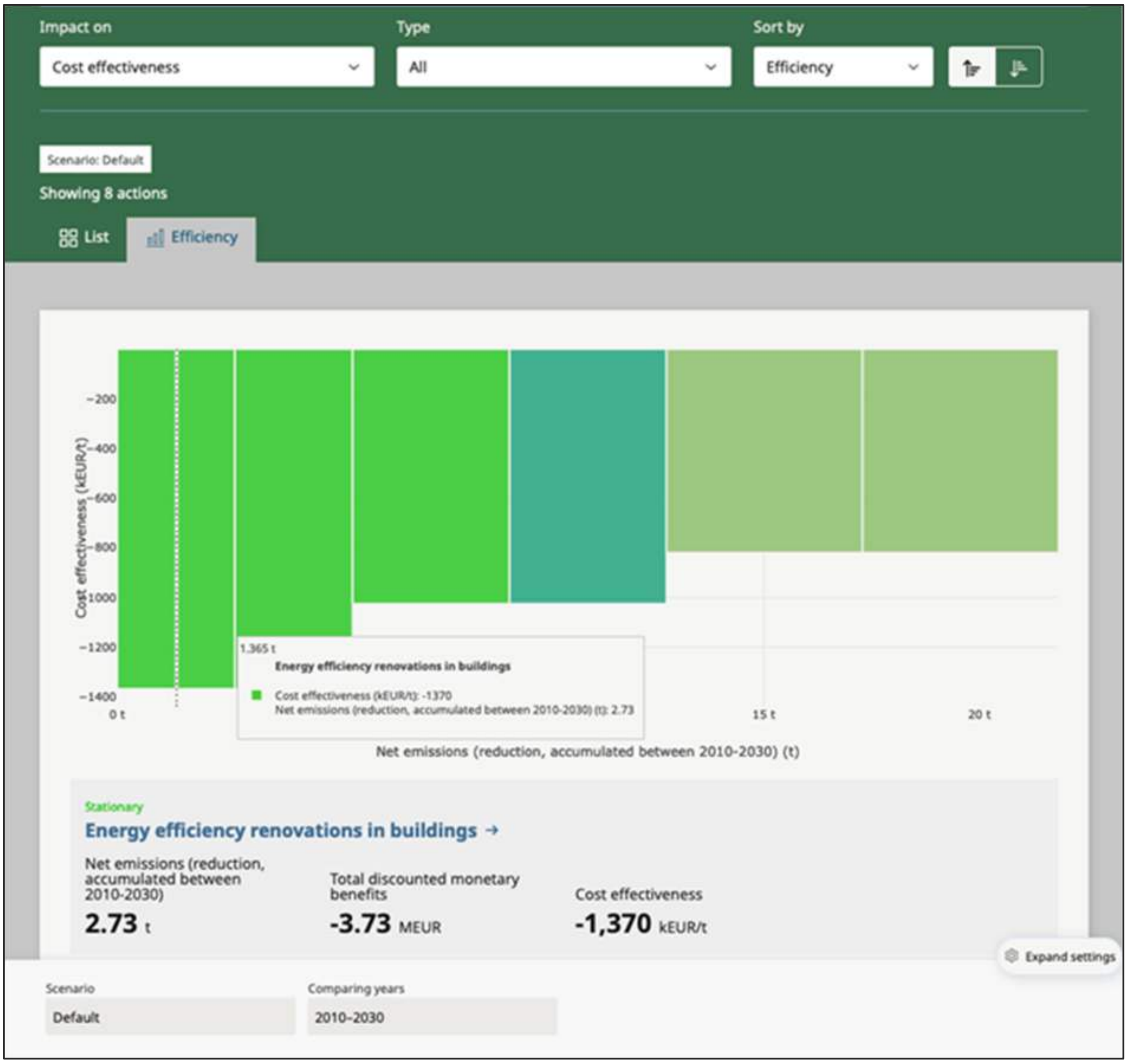

Figure 3: MAC curve with six actions and their capability of reducing greenhouse gas emissions.

In addition to cost-effectiveness analysis, the tool allows a comparison of the cost-benefit of actions. In such calculation, all impacts are considered in monetary terms, and, for example, emission reductions can be converted into monetary benefits. Figure 4 shows an example of a cost-benefit visualisation of different climate measures. Figure 5 visualises costs and benefits in more detail than the previous figure and shows more components, such as health impacts. The impact components can also be considered in terms of which group is affected (city organisation, citizens, or society). The coverage of the calculation components on the cost-benefit analysis depends on the input data available. Figure 6 visualises the ROI calculation for an example action in the tool.

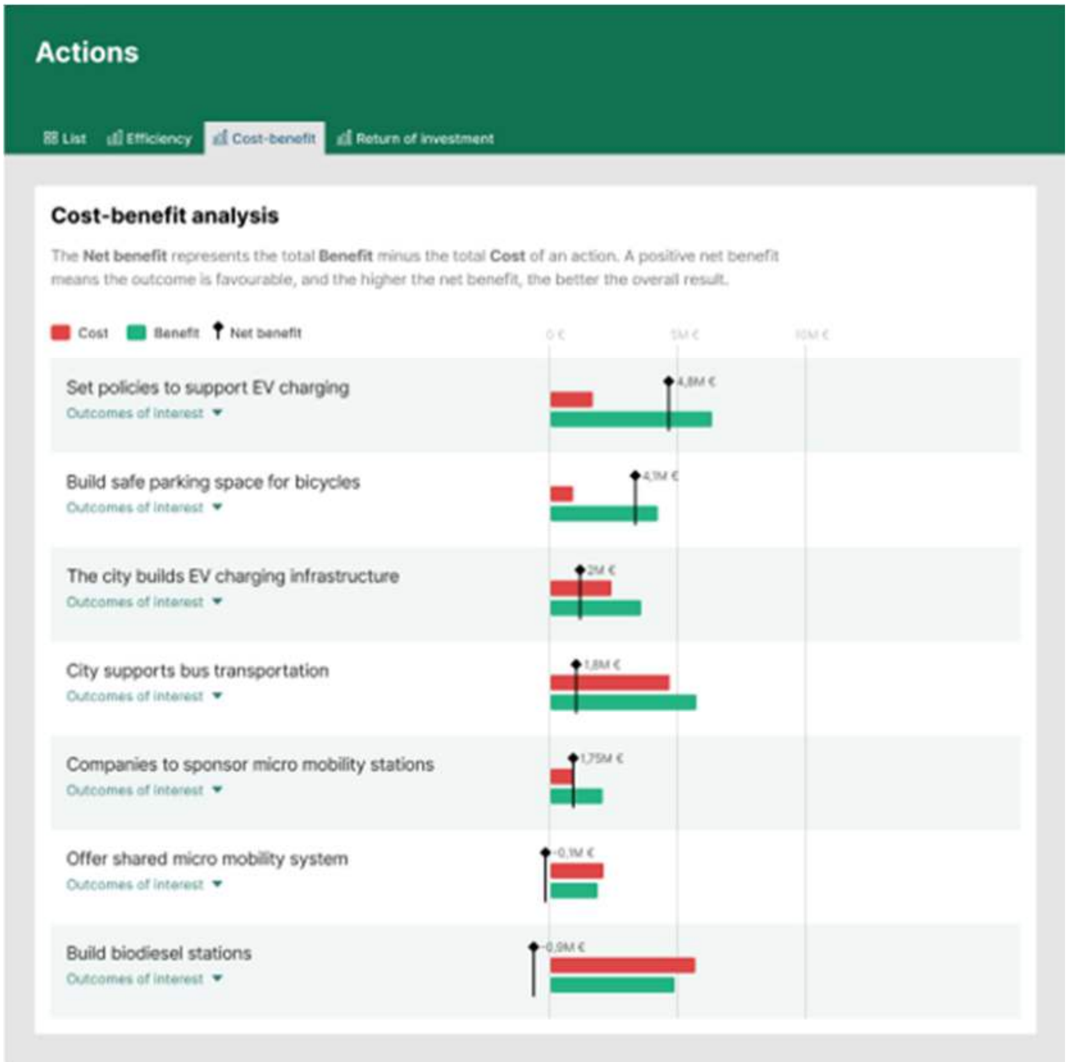

Figure 4: Example of cost-benefit visualization in the tool.

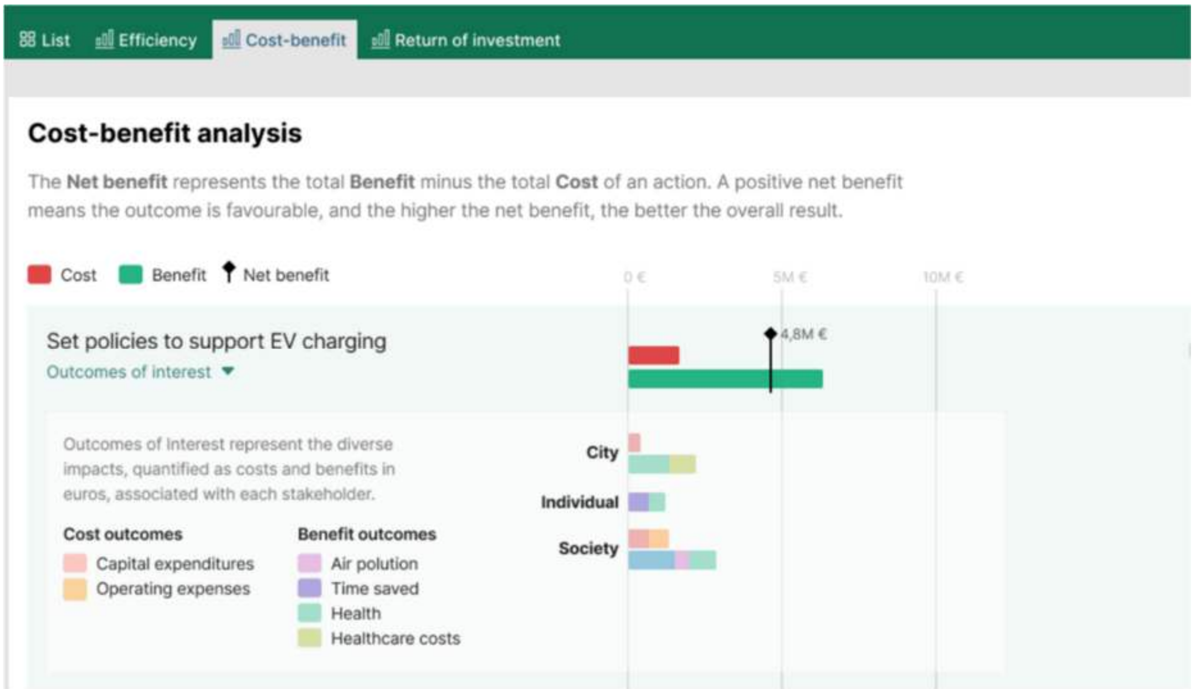

Figure 5: Breakdown of Cost-Benefit analysis of single climate action.

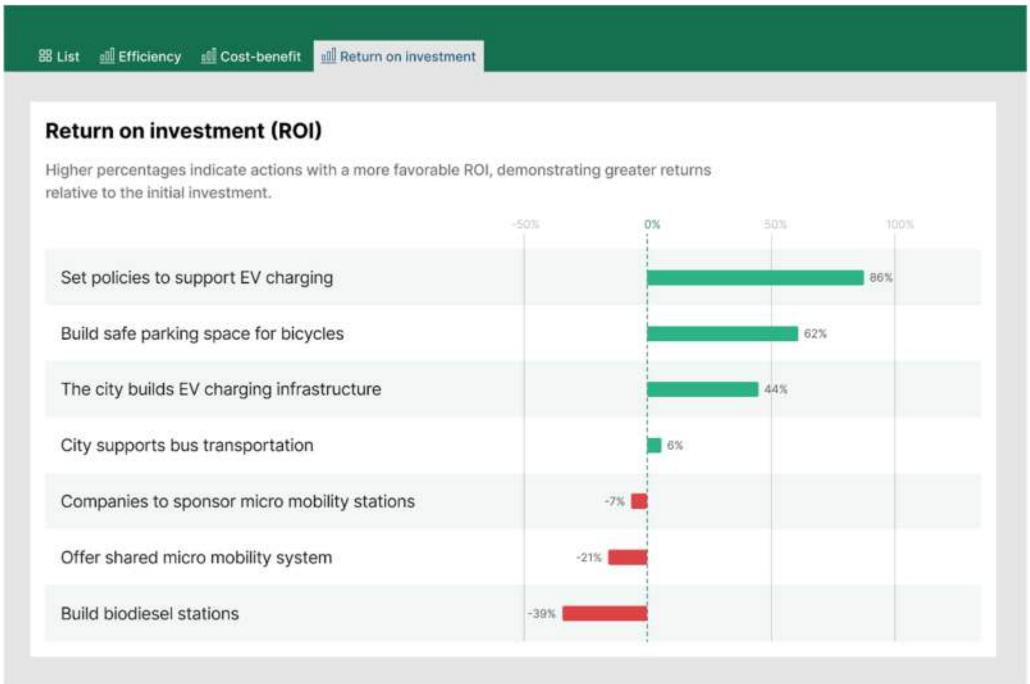

Figure 6: Visualisation of Return-on-Investment costs of Climate Actions.

4.2 Key feature 2: Visualisation of City-Level Emissions Projections

The second key feature of the Climate Action Decision Support Tool is to provide visualisations of projections of city-level emissions. This feature helps cities to track and project the achievement of their climate neutrality goals and emissions targets in different scenarios and course of actions. The emissions are divided to sectors and sub-sectors based on the GPC protocol (Annex 1).

4.2.1 Scenarios in the tool

The tool visualises different scenarios such as the target emissions scenario, baseline scenario and a tailored scenario. The visualisation of the scenarios helps to assess if the city is achieving its emissions targets.

Visualised emission scenarios:

1. Target emission scenario is build based on each city's climate neutrality targets and derived from the local plans and strategies.
2. Baseline scenario projects emissions if no further climate actions are implemented i.e., all the future actions are turned off in the tool.
3. Tailored scenario allows users to turn on and off various climate actions and see how the overall emission projection changes and whether targets are reached. This feature allows cities to estimate importance and volume of individual actions.

Each of the scenarios is based on the input data chosen by the city. The data is always in a yearly time trend form and mostly broken down to activity and emissions intensity data (e.g., Energy consumption and energy production emission factor). Examples of the kind of data used to create projections and calculate action impacts can be seen in Annex 4. The new features in the tool include more possibilities for using further data to analyse actions and calculate the emission factor or activity data as described in 4.1.2.1. This could be used for example to calculate the emission factor of a certain vehicle per km using fuel consumption per km and fuel emission factor. Since the activity and emission intensity data is input by the city, it is up to the administrators (normally climate experts) to decide what is included in the baseline scenario.

Target emission scenario and tailored scenarios are created by including the impact of climate action in the activity or emission intensity data. Figure 7 is an example of how the LED lighting investments are estimated to impact electricity consumption. The impact is determined either by data inserted by administrators or calculated in the action impact module developed in Climate-4-CAST. In this case, the city estimated that the LED investments will reduce electricity consumption by 1,05 GWh each year from 2021 to 2025 resulting in the action impact seen in the picture as area shaded with green. Together with the actions in the selected scenario, the selected scenario consumption is seen as a green line, whereas the baseline is seen in a black dashed line. Thus, the tool visualises the impact on electricity consumption.

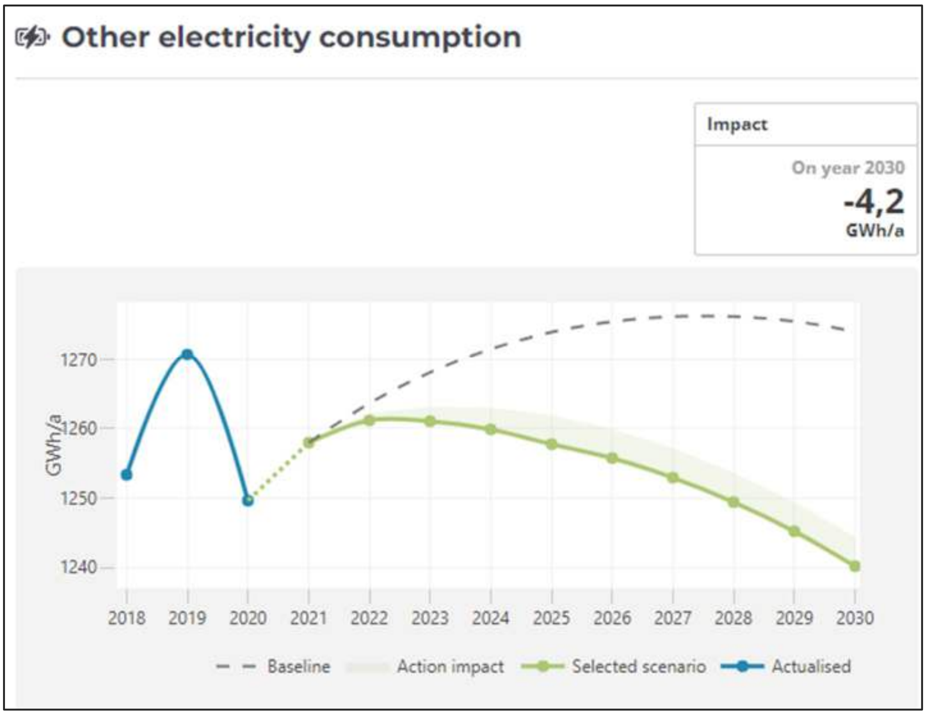

Figure 7: Action impact example – LED lighting investments in Tampere

The tool uses the electricity emissions factor to determine the emissions impact of the action on each given year and reveals the impact on the target year (can be adjusted by tool user) as well as total sum of avoided emissions from action implementation to target year. The results for the LED lights in the example above can be seen in Figure 8 below.

Figure 8: Emission impact of climate action presented in the tool, example from Tampere. Translation to Finnish text: Converting city street lighting to LED and incorporating smart control of lights by 2025.

The impact of a particular action can be different in different scenarios. In the LED lights example the result will change in case the scenario includes another action that impacts the emissions intensity of electricity production before or at the same time. Also, the impact is different in different years of the time trend if the emission intensity of electricity changes. A more detailed calculation model for this example of LED lights in city of Tampere can be found in Annex 3.

4.2.2 Tool view and adjustments for the emission projections

In the tool view users can drill down into the details of the sectors and subsectors to learn more about their details and formation. The users can also adjust the view by selecting another scenario or expanding or shortening the visible timeline. These adjustments affect all graphs in the tool.

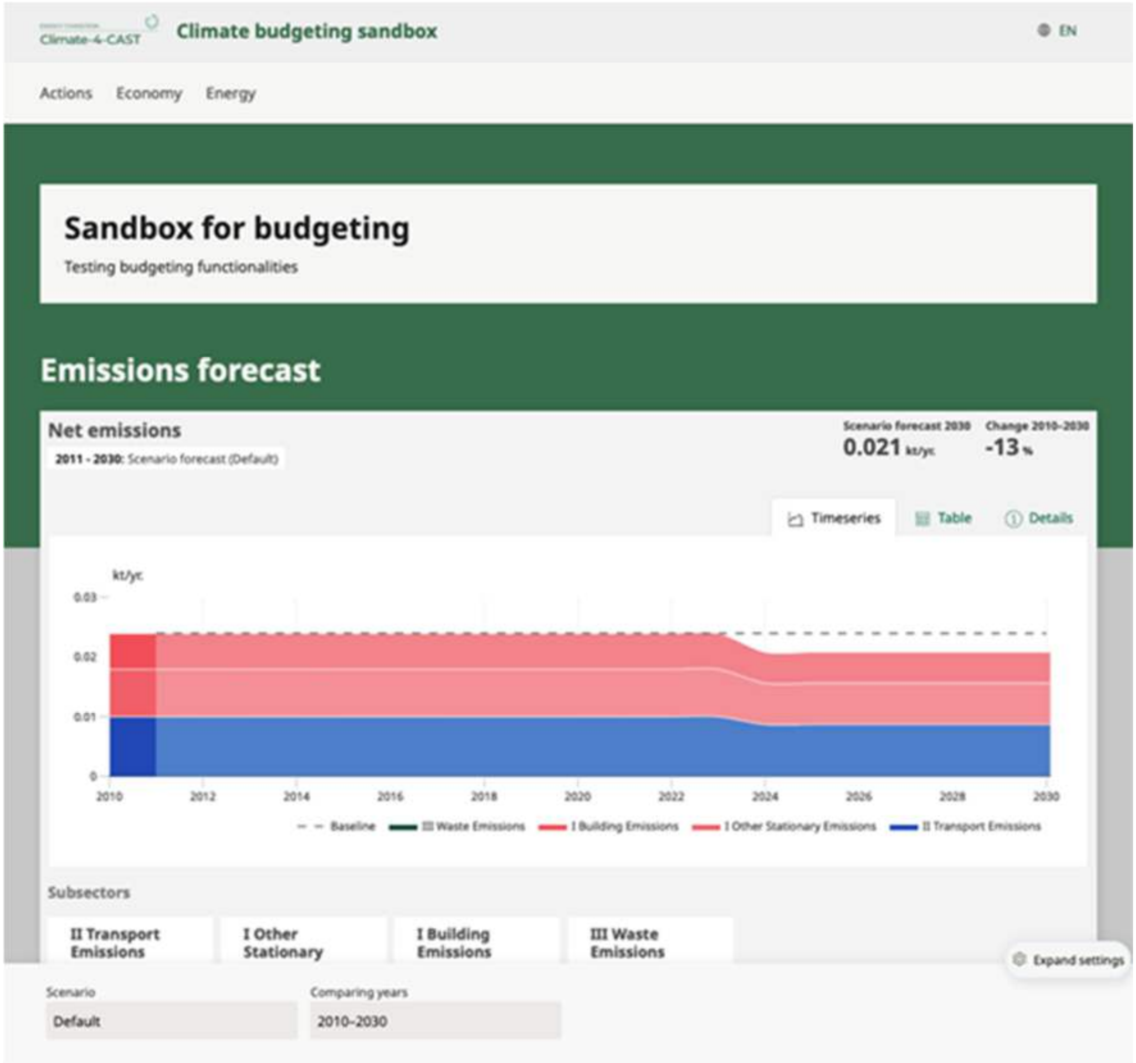

Figure 9. The main page of the tool showing the city-level greenhouse gas emissions as timelines.

4.2.3 Data requirements and limitations on the emissions inventory data

The emissions inventory data is collected based on the GPC protocol. The draft spread sheets about the needed data sources for data collection are described and provided in Annex 4. Based on the information exchange during the co-development process it is assumed that most cities are familiar with preparing city level emissions inventories and have already structures and processes for the data collection. There for the partners don't see that the cities face problems in providing data for the emissions inventories.

The challenge could be with projecting the data to the future. The tool requires a yearly time trend of each activity and emission intensity number used for calculating the emissions inventory. It could be that these projections don't exist and need to be created. Also, the projections need to be done for each sector in the GPC protocol and the availability of this kind of speculative information depends on the city and country. However, it is possible for the cities to start building projections for only the most crucial sectors and expand their inventories later.

Collecting the data needed for projections might take time and resources. For example, yearly trends on emission factors in Finland depend on the local power utility's (district heating provider) investments, the national electricity production mix and legislation on the traffic fuels and share of biofuels demanded. However, for the baseline scenario there is always an option of using historical data of actual emission factors used in the emissions inventories and simply continuing this trend. The city can also use people with expertise in the field to estimate if the trend will become faster of slower in the foreseeable future or estimate a percentage of reduction for the target year and simply use a linear progression. The projection does not have to be absolutely accurate in the first version. It can be updated and refined constantly as new information emerges.

4.3 Kausal Paths: The overall calculation framework of the tool

The overall calculation model of the tool consists of nodes that represent some real-life measurable quantities and edges, i.e., arrows that connect nodes that affect one another in a causal way. The structure is called a directed acyclic graph. Each node has a calculation function that takes in the output values from an upstream node and calculates its own output. That is again used downstream for calculating other nodes.

An example of a directed acyclic graph for one individual action, energy efficiency renovations in buildings, is shown in Figure 10, where an action is shown as a green node that influences both energy consumption and costs of implementing the action these primary effects have downstream effects on energy consumption, emissions, and net costs of the action. The real graph model consisting of multiple actions, is much larger than the one shown in Figure 10.

The graph is always computed for two different situations: the baseline scenario, and another scenario where the action is implemented. The difference between these two scenarios is the impact of the action.

Importantly, this approach makes it possible to calculate the interactions between actions in a realistic way. For example, the impact of building renovation action in an electric-heated building is larger if the electricity is produced with dirty methods, but the impact decreases if an action is added to clean electricity production.

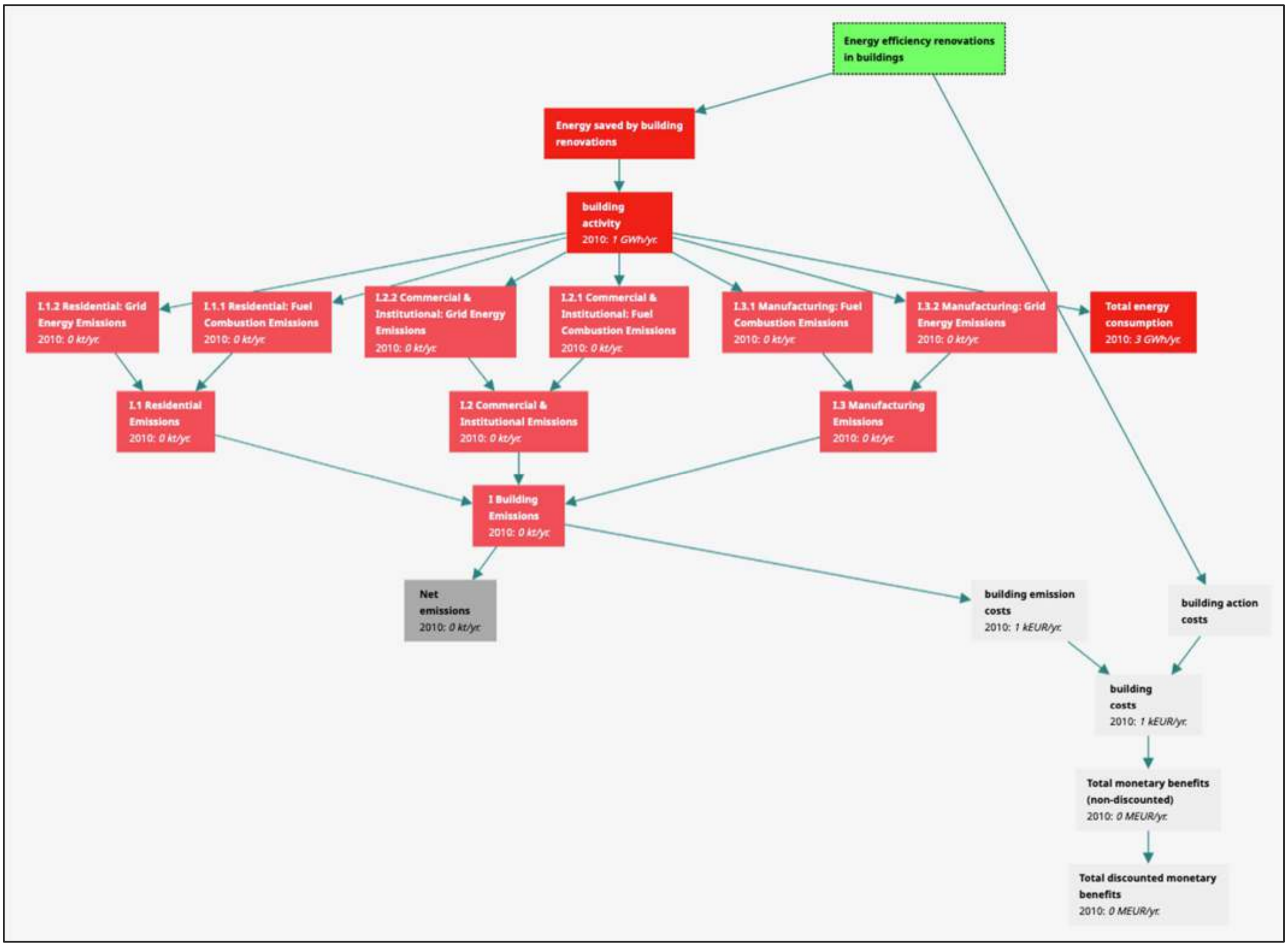

Figure 10. An example of the directed acyclic graph of the nodes and edges downstream of one climate action. The full model is much larger than what is shown here.

5 Technical implementation of the tool

The tool is designed for city-level use. Before usage, the city collects relevant data about energy consumption, vehicle mileage, and other activities, as well as emission factors. Then, the city also needs estimates about the immediate effects of the actions that are to be evaluated, for example effects on energy use intensity and renovation costs.

This dataset is uploaded to the tool, after which it will calculate the impacts based on what data was available for a particular city. The tool is open-source code and will be made available at Github. Two separate components are needed, frontend https://github.com/kausaltech/kausal-paths-ui and backend https://github.com/kausaltech/kausal-paths. The website shall contain information and instructions for installing the tool to an own computer. The uploading process will be improved and finalised during the project and more detailed information about the uploading process and utilisation of the open-source code package is provided in the final output deliverable, that will be published in the end of the project.

6 Identification of user groups for tool implementation

The identification of user groups helps to understand the technical needs and usage for the tool and how data is used and produced for the tool. Identification of the different users help to build up the leadership and management systems for the tool implementation.

The users have been divided in 6 groups based on their profiles:

1. Data consumers
2. Data providers
3. Data collectors and validators
4. Tool communicators and integrators
5. Tool managers and developers
6. Technical tool administrators and developers

Under each user group we seek to define further who the users typically are in the cities, what are their roles and responsibilities, how they access the tool and raise some technical and practical needs for the user groups. Depending on how the tool is implemented in the city governance systems, there might be variations in the detailed responsibilities of each user group, as well as how the responsibilities are divided or organised within the city system. Depending on the operational model used, there might also be variation in the prioritisation of user groups. Who the specific key users within the cities are, depend greatly on the operational details of specific city.

It is also very likely that some actors in the city might have multiple roles as users at the same time, varying from data consumers and communicators to data collectors and developers. As soon as cities start implementing the tool, it is suggested to identify and define the key actors and users of the tool within the city. Next the different user groups are further defined.

User group 1: Data consumers

Role and responsibilities: Data consumers primarily consume data generated by the tool. Their focus is on interpreting and deriving insights from the data. Data consumers rely on the tool's output to make informed decisions. They analyse climate predictions and projections and the impacts and effectiveness of the different climate measures. They use the tool's insights to shape policies, allocate resources, and plan climate actions and strategies. Data consumers communicate and integrate their findings in the city's governance and decision-making process.

Typical actors in the city: Data consumers are the key target groups of the tool varying from city officials, planners, and administrators from the different city departments to decision makers and political representatives in the city councils and committees, municipal and private businesses, researchers, and the community organisations and residents.

Access to tool: Data consumers access the tool's user-friendly interface. No need for user or access rights.

Technical and practical needs:

- Tool developers need to consider the diverse backgrounds of users from policy makers to community members.
- Provide them with well-organized and easy-to-understand reports, visualizations, and relevant metrics.
- Provide them with clear use instructions and well-functioning user interface, so they can interpret the tool and the results efficiently.

User group 2: Data providers

Roles and responsibilities: Data providers provide essential data to the tool so that the tool can generate results. They hold crucial data of emissions in the different emissions sectors as well as of specific climate actions and their impacts. They are also responsible of data accuracy and reliability of the data they provide.

Actors in the city: There are multiple data providers in the cities, varying from officials, planners and administrators from different city departments and agencies to municipal companies, private businesses or other actors who implement climate actions included in the tool. Researchers and scientists may also provide newest data and information about calculation models of emissions and impact assessments.

Access to tool: No need for user or access rights. Data is collected and provided first for data collectors.

Technical and practical needs and considerations:

- Need clear instructions of the process of data collection and the requirements from the different data providers (e.g., the needed data inputs, timetables, communication, and data-sharing procedures)
- Data providers need to be committed to the data collection required by the tool.
- In case of data shortage, need to consider alternative ways of collecting or estimating data.
- Functioning communication and collaboration between data providers and data administrators is crucial.
- Need to consider data privacy and security concerns as well as data-sharing agreements, when applicable.

User group 3: Data collectors and validators

Roles and responsibilities: Data collectors collect, generate and upload data for the tool's database from various sources in the city. Data collectors also do a final validation for the data sources and inputs and manage the data collection process in the city. In case of data shortage, they need to provide solutions for alternative data. Data collectors play a key role in data management and the overall functionality of the tool in the city organisation.

Actors in the city: Typically, the data collection is centralised in the city for a specific department, who is responsible of the overall management and development of the tool. Data collectors are usually climate or environmental specialists working in the city, who have specific expertise and knowledge to also assess the data accuracy.

Access to tool: Data collectors need access to the tool database and the admin interface.

Technical and practical needs and considerations:

- Clear guidelines on data collection methods and protocols.
- Good and functioning collaboration with data providers.
- Training and skills on data quality assurance and consistence.
- Enough resources and knowledge to collect and validate data.

User group 4: Tool communicators and integrators

Roles and responsibilities: Tool communicators and integrators work actively to communicate the results and information provided by the tool in the city governance system. They make sure that the information is utilised in the tool and that the tool is integrated in the city systems. They can also collect feedback from data consumers about the specific information needs for decision-making.

Typical actors in the city: Tool communicators and integrators are typically the same actors who manage and administrate the tool in the city.

Access to tool: Access mainly the tool's public interface.

Technical and practical needs:

- Good collaborative relations with the various departments and decision-making bodies in the city organisation.
- Understanding of city level decision-making and governance processes.
- Good communicative and negotiation skills to present the tool results for decision-makers in impactful way.

User group 5: Tool managers and developers

Roles and Responsibilities: Tool developers and managers create, manage, maintain, and enhance the tool framework in the city system. They ensure data integration, visualisation, and functionality together with the technical tool developers and follow that the tool is working as it should. They collect feedback for the tool and constantly enhance the tool with new knowledge and research.

Typical actors in the city: Typically, the tool management and development along with data collection is centralised in the city for a specific department. Tool managers and developers are usually climate and environmental specialists working in the city.

Access to tool: Access to admin interfaces and tool databases.

Technical and practical needs:

- Functioning collaboration with data collectors and technical tool developers.
- Resources to monitor and further develop the tool with newest knowledge.

User group 6: Technical tool administrators and developers

Roles and responsibilities: Technical tool administrators manage the technical aspects of the tool. They handle user access, permissions, and security. They do regular backups, system monitoring and troubleshooting. They make sure collected data is integrated in the tool and that there is seamless data flow and synchronisation between the databases and interfaces. Based on the open-source code, they create and manage the tool interfaces. They are involved in the development of the tool and when needed provide the technical solutions for the new addressed needs.

Typical actors: Depending on how the tool will be technically implemented in the city, the technical tool administrators can be staff from IT departments or other staff in the city, who have sufficient knowledge of managing and administrating. On some occasion, the technical management and support can be purchased from an external service provider.

Data access: Full access to both backend and frontend interfaces.

Technical and practical needs:

- Good IT skills to administrate the tool.
- Good and clear user instructions.

7 Next steps and lessons learned: towards tool implementation and operational models.

As stated in the beginning of this document, Deliverable 1.1 is the first and most important basic cornerstone of the tool development process in Climate-4-CAST project, guiding the way from technical tool development to the operationalisation framework for tool implementation in the pilot cities in the next phases of the project.

The deliverable is being prepared parallel with other Work Package 1 related Group of Activities (GoA) and their respective deliverables. Along the preparation there has been constant interaction between the different GoAs to make sure that the activities and key information is in line with each other. Next the key learnings for the next project activities are addressed.

7.1 Setting up the technical functions of the tool (GoA 1.2)

In GoA 1.2 project partners are preparing the technical implementation of the tool. Expanded capabilities and tool functionalities developed in Deliverable 1.1. are being implemented in an iterative process to produce a transferrable and scalable solution for the cities and their climate budgeting. GoA 1.2. builds on D1.1 to identify key operable points for tool functionality and code these functions into the tool code package. The identification of user groups and needs also steer the development of tool functionalities and the user instructions. A key deliverable for GoA 1.2 is Deliverable 1.2. – Code package and user instructions for the tool. The deliverable is being produced alongside Deliverable 1.1. and finalized to GitHub by the end of May 2024.

7.2 Co-creating the operationalization framework, preparation of local pilot action plans (GoA 1.3)

To improve the operationalization of the tool and its integration into local decision-making processes, in GoA 1.3. the project partners co-develop an innovative governance framework that aims to support local authorities in implementing the tool and to facilitate the local coordination processes. For Deliverable 1.3. each city prepares their own local pilot action plan, in which they describe how they wish to implement the tool in their governance processes. The Deliverable 1.1. and the tool design schematic serves thus as a crucial starting point for preparing the local action plans and start the piloting phase as part of WP2 activities. The information provided in the deliverable supports cities to understand the requirements, possibilities, and limitations of the tool implementation.

The key lessons learned and issues to consider for tool implementation and preparation of local pilot action plans:

1. Create understanding of the tool objectives, key target groups, functionalities, and features, and thus the possibilities of the tool implementation in your city. Based on this information start defining your city-specific objectives and goals. For whom specifically do you wish the tool to provide information? On what sectors and/or climate actions you might want to focus on first? Of which climate actions are you specifically interested to provide more detailed information?
2. Create understanding of the usability of the tool, and the key user groups to identify how the leadership and management system for the tool implementation in your local level pilot will be created. Who are the key users of the tool in your city? What is their role in the tool implementation?
3. Improve your understanding of the tool requirements, especially related to data collection, calculation models of climate and economic impacts and the technical needs for the tool. Start collecting the data and building up the data collection system.
4. Understand the possible limitations and challenges of the technical implementation of the tool and what needs to be further developed during piloting phase. Here especially the calculation models for climate action specific impact assessments are identified as key challenge and issue to be improved. Think also about the solutions how the challenges related to data or existing calculation models could be overcome.

7.3 Piloting and evaluating solutions, improving the tool functions (WP2)

The Work Package 2 starts directly after the activities in WP1 are finalized. The tool will be implemented and further developed in two pilot phases according to the cities' local pilot action plans. In between the piloting phases the tool will be co-evaluated and iterate. Towards the end of WP2 activities the tool will be finalized in the Final Output - The Final Tool Code Package and Operationalisation Guidelines. For the preparing the final output, Deliverable 1.1. will be updated continuously based on the lessons learned in the piloting phase.

On the technical side and for finalizing the tool design schematic the first pilot phase is of particular importance. In the first phase cities start collecting all the necessary data for the tool and decide on which climate actions they pursue to include in the tool. At the same time the calculation models and frameworks for assessing the impacts are being developed and it is presumed that cities will face common challenges. Here active exchange of information on the faced challenges and on the solutions to overcome the challenges is particularly important. It is also suggested that after the first experiences with tool implementation and piloting, more specific use cases could be identified and described to create a deeper understanding about utilisation of the tool.

Suggestions for project level actions to further improve the tool design schematic and to overcome the identified challenges:

1. Cities exchange information on the city level action plans and activities regularly during the piloting phase.
2. In the beginning of 1st piloting phase there is a need to map the prioritized climate actions of each pilot city, identify common interests and challenges in the impact assessment of specific climate actions and to come up with a plan how these challenges are going to be solved in collaboration.
3. Creating a common database for research papers and studies that provide scientific data for the different calculation models. Gradually build up a database for the calculation models of action specific assessments to be incorporated in the tool.
4. Identification and description of use cases, based on experiences gained from pilot cities and their tool implementation process.

8 Annexes

Annex 1: GPC sectors and sub-sectors

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
Stationary energy			
Residential buildings	a	a	a
Commercial buildings	a	a	a
Institutional buildings	a	a	a
Manufacturing industries and construction	a	a	a
Energy industries	a	a	a
Energy generation supplied to the grid	a		
Agriculture, forestry, and fishing activities	a	a	a
Non-specified sources	a	a	a
Fugitive emissions from coal	a		
Fugitive emissions from oil and natural gas systems	a		
Transportaton			
On-road	a	a	a
Railways	a	a	a
Waterborne navigation	a	a	a
Aviation	a	a	a
Off-road	a	a	
Waste			
Solid waste generated in the city	a		a
Solid waste generated outside the city	a		
Biological waste generated in the city	a		a
Biological waste generated outside the city	a		
Incinerated and burned waste generated in the city	a		a
Incinerated and burned waste generated outside city	a		
Wastewater generated in the city	a		a
Wastewater generated outside the city	a		
Industrial processes and product use (IPPU)			
Industrial processes	a		
Product use	a		
Agriculture, forestry, and fishing activities (AFOLU)			
Livestock	a		
Land	a		
Other agriculture	a		
Other scope 3			

a	= sources required for reporting
a	= sources required for BASIC reporting
a + a	= sources required for BASIC+ reporting
a	= additional scope 1 sources required for territorial reporting
	= other scope 3 sources
	= non-applicable emission sources

Annex 2: List of identified climate actions

A list of identified actions for Climate-4-CAST pilot cities:

Infrastructure and energy

- Change streetlights to LED
- Build renewable electricity production (PV)
- Cleaner electricity production (reducing emission factor)
- Cleaner district heating production
- Increase biogas production
- Increase wind power
- Procurement of fossil free / electric work machines
- Encourage electricity consumption savings
- Biogas production from citizen food waste

Buildings

- Energy efficiency renovations in public buildings
- Energy efficiency renovations in private buildings (energy counselling etc.)
- Replace oil (or natural gas) heating with geothermal with some renovation and operational costs.
- Develop beyond building code (affects new buildings only)
- Optimising heating & ventilation in city-owned buildings (affects energy use intensity)
- Encourage electricity consumption savings

Transportation

- Replace city fleet with electric vehicles (capex + fuel costs)
- Electrify public transportation
- Subsidise public transportation (subsidy cost + fuel costs to different stakeholders)
- Improve EV charging infrastructure (capex)
- Offer micro-mobility sharing system e.g.city bikes (capex, opex)
- Congestion charge (costs to different stakeholders)
- Improve walking and cycling network
- Car-sharing of municipal electric fleet.
- Subsidies in public transport
- Road-pricing and zero-emissions zones (high efficient measure)
- Lower speed limits
- Restrict parking in the city center
- Reduce parking spots + parking spot costs

Agriculture:

- Reduce livestock agriculture
- Increase plant based agriculture
- Afforestration and wetlands actions
- Biochar

Annex 3: Example of calculation model for streetlights

Annex 3 can be seen and downloaded here: https://cloud.hcu-hamburg.de/nextcloud/s/99aGqsjmxA26rzH

Annex 4: Data collection sheet

Annex 4 can be seen and downloaded here: https://cloud.hcu-hamburg.de/nextcloud/s/wgzNHYKCgNR9xfS