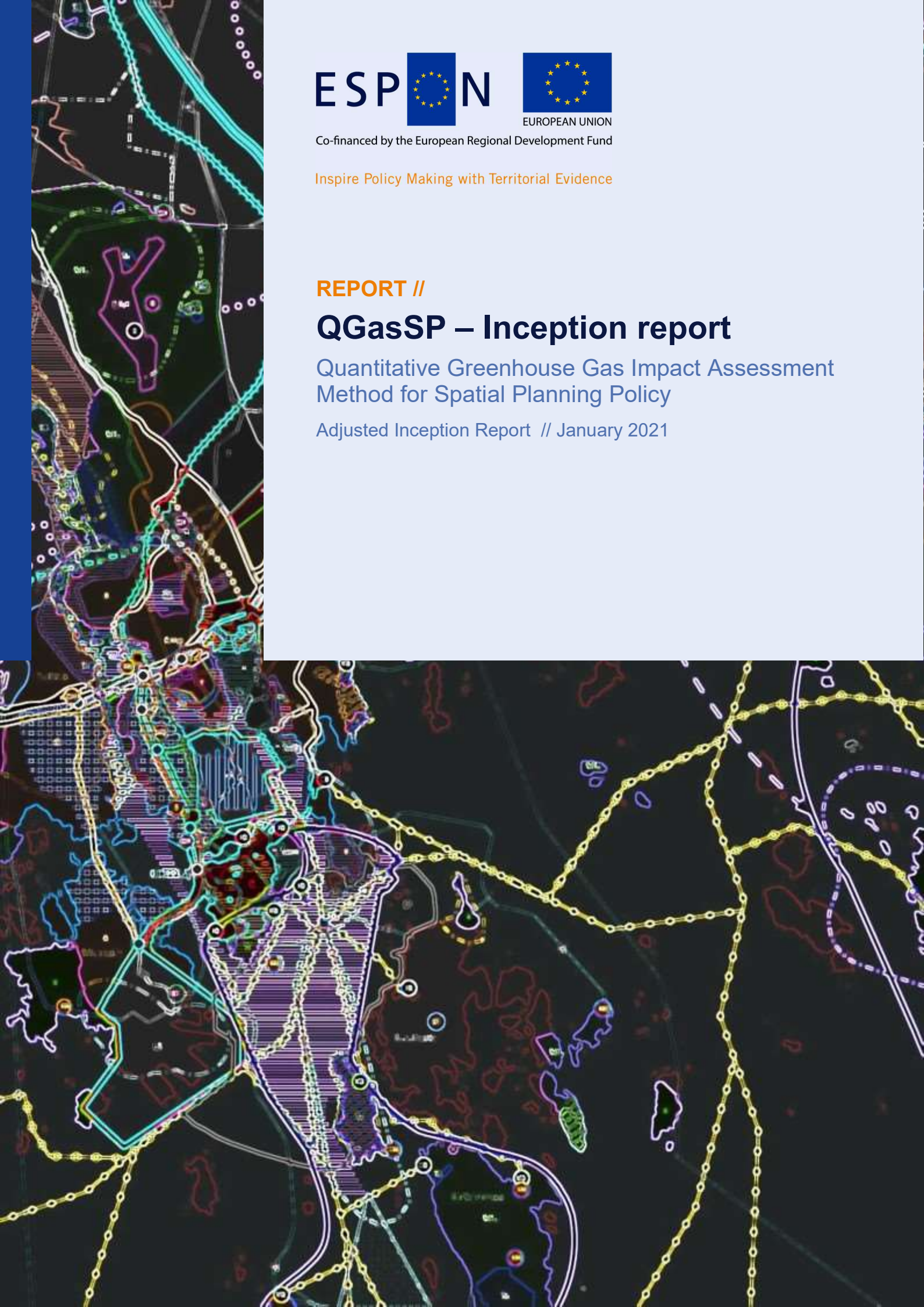


**REPORT //**

## **QGasSP – Inception report**

Quantitative Greenhouse Gas Impact Assessment  
Method for Spatial Planning Policy

Adjusted Inception Report // January 2021



This report is conducted within the framework of the ESPON 2020 Cooperation Programme, partly financed by the European Regional Development Fund.

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This delivery does not necessarily reflect the opinions of members of the ESPON 2020 Monitoring Committee.

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**REPORT //**

# **QGasSP – Inception report**

Quantitative Greenhouse Gas Impact  
Assessment Method for Spatial Planning  
Policy

Adjusted Inception Report // January 2021

**Disclaimer**

This document is an inception report.

The information contained herein is subject to change and does not commit the ESPON EGTC and the countries participating in the ESPON 2020 Cooperation Programme.

The final version of the report will be published as soon as approved.



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# Abbreviations

BEI	Baseline Emission Inventory
BER	Building Energy Rating Certificate, Ireland
BSI	British Standard Institution
CAFE	Corporate Average Fuel Economy
CIBSE	Chartered Institution of Building Services Engineers
CIFA	Community-wide Infrastructure Footprint Assessment
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2</sub> eqv	Carbon Dioxide equivalent
CoM	Covenant of Mayors
CORINE	Coordination of Information on the Environment Land Cover
CSO	Central Statistics Office
DEAP	Dwelling Energy Assessment Procedure, Ireland
EC	European Commission
EEA	European Economic Area
EF	Emission factor
EGD	European Green Deal
EGTC	European Grouping of Territorial Cooperation
EIA	Environmental Impact Assessment
EMRA	Eastern Midlands Regional Authority
EV	Electric Vehicle
GDA	Greater Dublin Area
GHG	Greenhouse Gasses
GPC	Global Protocol for Community-scale greenhouse gas emissions inventories
IE	Eastern and Midlands Regional Authority
IO	Economic Input-Output Matrix
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual property
KEKO	A Finnish tool for assessing the environmental sustainability in land-use planning
LCA	Life Cycle Assessment
LDP	Local Development Plan
LEAM	Land-Use Evolution and Impact Assessment Model
LULUCF	Land-use, Land-use Change and Forestry
MapElre	National Mapping of Greenhouse Gas and Non-greenhouse Gas Emissions Sources Project
NUTS	Nomenclature of Territorial Units for Statistics
OSI	Ordnance Survey Ireland
PAS	Publicly Available Specification
PM	Project Manager
POWSCAR	Place of Work, School or College Census of Anonymised Records, Anonymised census records
PV	Photovoltaic system
QGasSP	Quantitative Greenhouse Gas Impact Assessment Method for Spatial Planning Policy
QGIS	Quantum GIS (Open-source GIS programme)
RPO	Regional Policy Objective
RSES	Regional Spatial & Economic Strategy
SCATTER	Setting City Area Targets and Trajectories for Emissions Reduction
SEA	Strategic Environmental Assessment
SEI	Stockholm Environment Institute Tallinn centre
SEPA	Scottish Environmental Protection Agency
SPACE	Spatial Planning Assessment of Climate Emissions
SYKE	Finnish Environmental Institute
UI	User Interface
UNFCCC	United Nations Framework Convention on Climate Change
WFH	Work from Home



# 1 Introduction

## 1.1 Objectives of the assignment

The objective of the QGasSP project is to produce a methodology that will allow competent planning authorities at national, regional and local administrative levels to quantify the influence of spatial planning policies on greenhouse gas (GHG) emissions in a consistent manner. More specifically, the objective is to address the knowledge demands and technical requirements of the four stakeholders included within this Targeted Analysis Project, namely, the Eastern and Midlands Regional Authority (IE); Scottish Government – Planning & Architecture Division (UK); Department of Infrastructure, Northern Ireland (UK); and Regional Council of Kymenlaakso (FI).

The key research questions are as follows:

- How can consistent and comparable GHG baseline emissions data be collected at national, regional and local levels to assess the urban and land-use share of GHG emissions relevant for spatial planning policy and practice?
- How can the efficacy of spatial plans and possible alternatives be systematically modelled, via standardised quantitative methodologies and accounting protocols, to determine their overall impact on GHG emissions, and aid cross-country, inter-regional and inter-municipality comparisons?
- How can a better scientific understanding be developed of how national, regional and local planning authorities can prioritise relevant GHG mitigation strategies, including through enhancing the effectiveness of the SEA process, to rapidly build political will for climate action?

The inception report addresses these research questions and how they will be tackled by the service providers throughout the project.

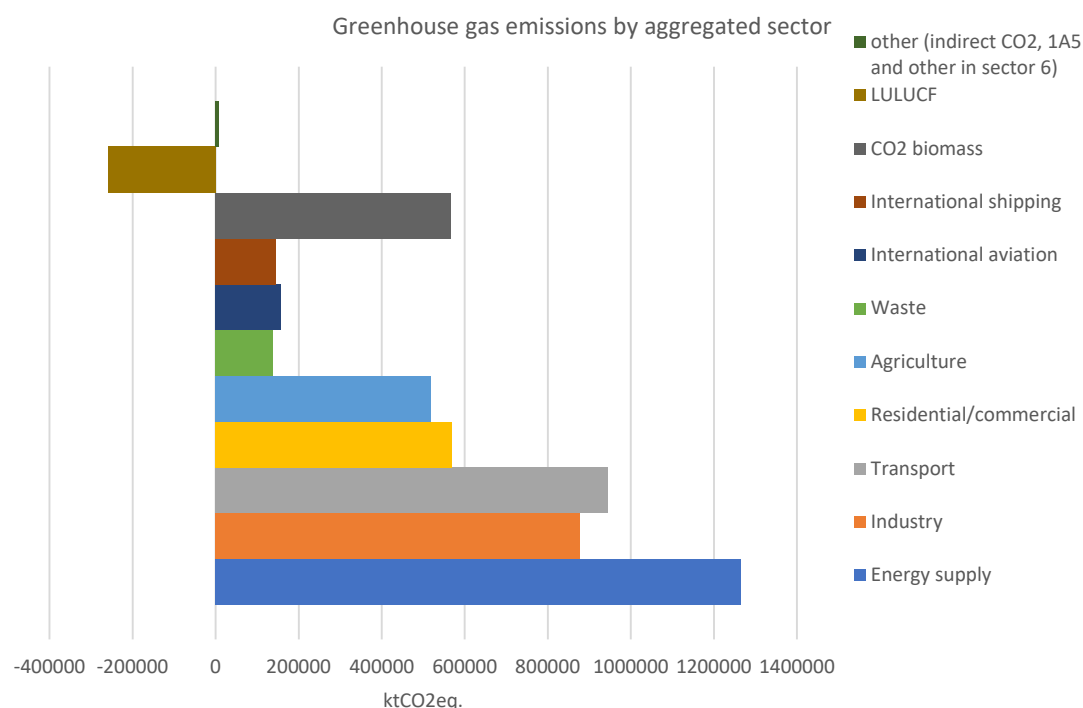
Pan-European applicability is a specific challenge for both the methodology and to integrate into the tool, this needs to be addressed in all work packages. GHG quantification in spatial planning is currently not harmonised by European or international standards: cities and countries have developed their own methods, which are being applied to monitor their own GHG emissions. There is a significant variation in the availability and structure of datasets across Europe, furthermore, the planning systems in each European country differ from one another. Newman and Thornley have described the differences in European planning systems through five categories or “five families”; Scandinavian family, British family, Germanic family, Napoleonic family and Eastern Europe (Newman & Thornley, 1996).

To overcome the lack of international harmonisation in GHG quantification in spatial planning, the service providers have chosen to focus on a limited set of direct emission sources that have a major impact on total CO<sub>2</sub> emissions and are directly dependent on spatial planning decisions. These sectors are:

- Building energy use: heat and electricity
- Transportation & Infrastructure
- Land use change and forestry (LULUCF).

The following chart shows GHGs emitted by different sectors in the 27 EU countries, this is based on the EU's GHG inventory submission to the UNFCCC (EEA, 2019).





**Chart 1: GHG emissions by aggregated sector, EU27**

The chosen GHG sectors will cover the majority of the GHG emission sources by directly targeting energy supply, transport, residential/commercial and LULUCF, and indirectly targeting the industry sector.

To future-proof the methodology and the tool, they cannot be limited only to quantify the impact of specific sectors with the method specified in the development phase. The service providers propose an open source tool with a modular structure, where the calculation modules can be further updated and developed even beyond the project timeline. Thus, both the method description and the tool will have placeholders for new calculation modules, which will extend the scope of GHG quantification. This approach is explained in more detail in chapter 4.2.

With regards to the challenge of integrating this methodology into different planning systems, the service providers consider the SEA process as a good way of integrating the methodology with various types of planning processes across Europe. SEA has the potential to develop into an important mechanism for GHG emissions mitigation. This is further described in chapter 3.3.

In order to prioritise GHG mitigation strategies among planners at national, regional and local levels, the service providers will propose a set of continuation projects as well as policy-making strategies that will identify the need to develop and harmonise regional and local databases.

## 1.2 Guiding policies of GHG quantification in spatial planning and impact assessment

The European Commission launched a new initiative “The European Green Deal” (EGD) on 11 December 2019 (COM(2019) 640 final). The Green Deal is a response to tackling climate and environmental-related challenges. The atmosphere is warming and the climate is changing with each passing year, one million of the eight million species on the planet are at risk of being lost. Forests and oceans are being polluted and destroyed, argues the European Commission. The European Commission (EC) stresses that EGD is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. Also, cities need to transform into climate neutral and socially innovative centers.

The EC’s proposed European Urban Initiative will provide assistance to cities to help them make best use of opportunities to develop sustainable urban development strategies and the EU Covenant of Mayors (CoM)

will continue to be a central force. The EC will work with the CoM to continue to provide assistance to cities and regions that want to commit to ambitious pledges on climate and energy policies. It will remain an essential platform to share good practices on how to implement change locally. As part of the EGD, the EC will adopt a new, more ambitious EU strategy on adaptation to climate change and cities and citizens are able to access data and to develop instruments to integrate climate change into their risk management practices. This project, Quantitative Greenhouse Gas Impact Assessment Method for Spatial Planning Policy (QGasSP), is addressing specifically these challenges, by collecting data and developing models to track the reduction of GHG emissions and associated impacts at different spatial scales.

Today SEA is recognised as the vehicle for the implementation of climate protection within spatial planning.

SEA is a systematic process for evaluating the likely environmental implications of a proposed policy, plan or programme and provides means for looking at cumulative effects and appropriately addressing them, at the earliest stage of decision making, along with economic and social considerations. It should be noted that public engagement into the stages of the SEA process is a key factor.

SEA and spatial planning processes are intertwined and complementing each other. Wende et al. stated in 2012 that “In Europe, land use, residential and commercial development and the development of the transportation infrastructure are as a rule controlled by means of spatial planning instruments, for which Strategic Environmental Assessments (SEA) must generally be carried out under the terms of a European Union Directive European Parliament and Council of the European Union, 2001” (Wende *et al.*, 2012).

### 1.3 Guiding policies at the National levels: Climate Mitigation and Targets in Each Region Studied

As a starting point, it is important to understand what each country/region developing the tool is trying to achieve at a national level in terms of ambitions, targets for GHG reductions and their drivers. In some jurisdictions there are more ambitious targets at National level when compared to EU wide targets, and again even higher targets at local municipality level.

In the **UK**, the UK Climate Change Act commits the UK to an ambitious target of reducing emissions by at least 100% by 2050 from 1990 baseline levels. This includes reducing emissions from the devolved administrations (Scotland, Wales and Northern Ireland). This was increased recently from an 80% target by 2050, and is one of the most ambitious national targets in Europe. Northern Ireland and Scotland, therefore, must at least achieve these targets.

In **Northern Ireland**, there is no separate climate change legislation, but greenhouse gas emissions from Northern Ireland contribute to the UK total under the Climate Change Act 2008, and it has a key role to play in meeting their obligations under the Paris Agreement. This consortium notes the findings of the Northern Ireland Committee on Climate Change report in 2019, which outlines the challenges these targets bring for Northern Ireland given its unique characteristics in comparison to the rest of the UK - such as the large proportion of GHGs from agriculture (30%), they are interconnected to the electricity system of the Republic of Ireland, they do not have an extensive gas grid (mostly oil heating) and degraded peatland adding to carbon sources. Latest GHG inventories (2017) show Northern Ireland have decreased emissions by 18% since the baseline year, which is the lowest % decrease of any UK country (England 45%, Wales 25% and Scotland 48%).

**Scotland** has gone one step further in terms of ambition, and have really become a leading country in terms of tackling climate change. The Scottish Government has set a target of net zero emissions by 2045, with defined interim targets of 56% by 2020, 75% by 2030, and 90% by 2040. The Planning (Scotland) Act 2019 introduces six outcomes that the National Planning Framework in Scotland will contribute towards, one of which is meeting targets relating to emissions reductions arising from the Climate Change (Scotland) Act 2009 (as updated). The 2019 Planning Act also introduces the requirement that the impact of lifecycle greenhouse gas emissions from national developments on achieving national greenhouse gas emissions reduction targets is assessed. It also embeds the principles of a ‘Just Transition’, which means reducing emissions in a way which tackles inequality and promotes fair work at the heart of Scotland’s approach to reaching net-zero. It will be interesting to see how spatial planning can help to contribute to national targets, while also trying to address these other economic aspects of the transition. The Scottish Environmental Protection Agency (SEPA) has produced a lot of guidance and advice for planning authorities in relation to development plans and their impact on the environment (e.g. waste and energy proposals), including GHG impact. One

of the existing tools investigated for this project, SPACE, was also developed in conjunction with the Scottish government for application in Scotland.

**Ireland** has set national targets under various EU directives that have been transposed as statutory instruments. These require that certain targets for energy efficiency, renewable energy and GHG reductions are achieved by 2030 and 2050. In Ireland, a Climate Action and Low Carbon (Amendment) Bill 2020 was published in October 2020. The Climate Action and Low Carbon Development (Amendment) Bill 2020 is an ambitious piece of legislation. It legally commits Ireland to move to a climate resilient and climate neutral economy by 2050. The Programme for Government commits to a 7% average yearly reduction in overall greenhouse gas emissions over the next decade, and to achieving net zero emissions by 2050. This Bill will drive implementation of a suite of policies to help Ireland to achieve this goal and the 2019 Climate Action Plan will be updated in early 2021. The 2019 Climate Action Plan – To Tackle Climate Breakdown, creates a pathway to 2030, which will be consistent with the EU's net zero target by 2050, and commits to reduce emissions by 80% (compared to 1990 levels) by 2050. In line with the Climate Action Plan is the Regional Spatial & Economic Strategy (RSES) for the Eastern & Midland Regional Assembly (EMRA). The strategy includes a number of climate Regional Policy Objectives (RPOs). One of the RPOs to be noted is RPO 3.6 which states that 'City and county development plans shall undergo assessment of their impact on carbon reduction targets and shall include measures to monitor and review progress towards carbon reduction targets.

**Finland** aims to become carbon neutral by 2035. A central pillar in climate action is the national climate legislation, which entered in force in 2015, introducing a legal commitment to cut down the national CO<sub>2</sub> emissions by 80% from the reference year 1990.

Achieving the target of a carbon neutrality by 2035 requires significant measures to reduce emissions in the energy and transport sectors, as well as emission reductions in the land use sector and strengthening carbon sinks and reservoirs. The current Government Programme contains a number of climate measures concerning agriculture, forestry and land use changes that will in future be incorporated into the climate plan for the land use sector. The preparation of the new energy and climate strategy, commenced by the ministry of Economic Affairs and Employment in April 2020, will take into account and coordinate the Government Programme's energy and climate policies, the long- and medium-term climate change policy plans referred to in the Climate Change Act, and the EU's energy and climate targets for 2030.

Besides the national climate commitments, also cities and regions have prepared their own actions plans and climate targets. The Towards Carbon Neutral Municipalities (Hinku) network brings together municipalities, businesses, citizens and experts to create and carry out solutions to reduce greenhouse gas emissions. The municipalities in the network are committed to an 80% reduction in greenhouse gas emissions from 2007 levels by 2030. There are over 70 Hinku municipalities and five Hinku regions in the network, all committed to the same emission reduction target. The network is coordinated by the Finnish Environment Institute (SYKE). The most ambitious climate target was recently introduced by the city of Lahti, aiming at carbon neutrality already by 2025.

In spatial planning, various tools and methodologies have been applied for GHG accounting. A new, non-commercial, open-source GHG quantifying tool developed by the Finnish Environment Institute was published in 2020.

## 2 Project organisation

### 2.1 Service providers

#### Partner 1: Tallinn University of Technology, Estonia (TalTech)

*Tallinn University of Technology* (TalTech) is the only technical university in Estonia, and one of the leading research universities of the country. *Academy of Architecture and Urban Studies* gives education and conducts research in the fields of architecture and urban planning. Academy has 140 students and 20 academic staff members. Academy is actively participating in international research projects, for example the *FinEst Twins* project, developing a Smart City Center of Excellence as a collaboration between Aalto University and TalTech, with a total funding of 32 million euros.

<https://www.ttu.ee/institutes/departments-of-civil-engineering-and-architecture/departments-14/academy-of-architecture-and-urban-studies/>

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#### Tasks:

- Lead on Task 5: User manual & Guidance;
- Lead on Task 6: Coordination, communication & Reporting;
- Traffic related GHG emissions methodology;
- Finnish case study pilot.

#### Partner 2: Stockholm Environment Institute Tallinn Centre (SEI Tallinn)

*Stockholm Environment Institute Tallinn Centre* (SEI Tallinn) is an international non-profit research and policy organization that tackles environment and development challenges. SEI Tallinn connects science and decision-making to develop solutions for a sustainable future for all. The work of SEI Tallinn spans climate, water, air and land-use issues, governance, the economy, gender and health. Stakeholder involvement is at the heart of our efforts to build capacity, strengthen institutions and equip partners for long-term change. SEI Tallinn is part of the Stockholm Environment Institute (SEI) global network of research centres.

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#### Tasks:

- Task 1: Methodological framework;
- Task 2: Baseline analysis;
- GHG emissions methodology related to land use and land use change;
- European policy analysis.

#### Partner 3: Codema - Dublin's Energy Agency

*Codema*, Dublin's Energy Agency, is a not-for-profit limited company, which is committed to leading Dublin's low-carbon transition towards 2030 and 2050. Codema acts as the energy adviser to the four local authorities in Dublin and their role is defined around the core function of supporting the local authorities in their own sustainable energy use. In doing so, they assist each council in leading and influencing this low-carbon transition by improving their energy efficiency, incorporating renewable energy technologies and reducing their greenhouse gas emissions. Codema's second role is engaging with EU and nationally-funded energy programmes to bring innovation to the Dublin Region. A third and increasingly important role is to increase energy and climate awareness among citizens and energy stakeholders in Dublin. Over the years, these three strands have become increasingly intertwined and integrated into a comprehensive, local and regional service for energy and climate change.

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#### Tasks:

- Lead on Task 4: Case Study pilots;
- Buildings related GHG emissions methodology;
- Data collection;
- Language check.

#### Partner 4: OIVAN (formerly: IWA)

*Oivan* is an IT-consultancy designing, developing and operating web services and mobile apps. In their projects, the company aims at the human-centric user experience by combining strong technical expertise with design thinking and practical experience. Oivan has offices in Finland, Thailand, Vietnam and Abu Dhabi and mostly works with leading companies in the areas of real estate, cleantech, fintech and blockchain.

In 2016-17 Oivan developed the newest version of the *Ecocity Evaluator* tool, a commercial SaaS service for urban planners for GHG accounting. The project successfully took the accumulated expertise of experienced consultants and turned it into a service that any urban planning professional can use independently.

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#### Tasks:

- Lead on Task 3: Model development;
- Service design,
- Programming of the free, open source calculation tool.

## 2.2 Tasks

Six interlinked tasks have been established for the implementation of the assignment. The tasks to be accomplished can be found below:

Task 1: Methodological framework

Task 2: Baseline analysis

Task 3: Model development

Task 4: Case study pilots

Task 5: User manual and guidance

Task 6: Coordination, communications and reporting

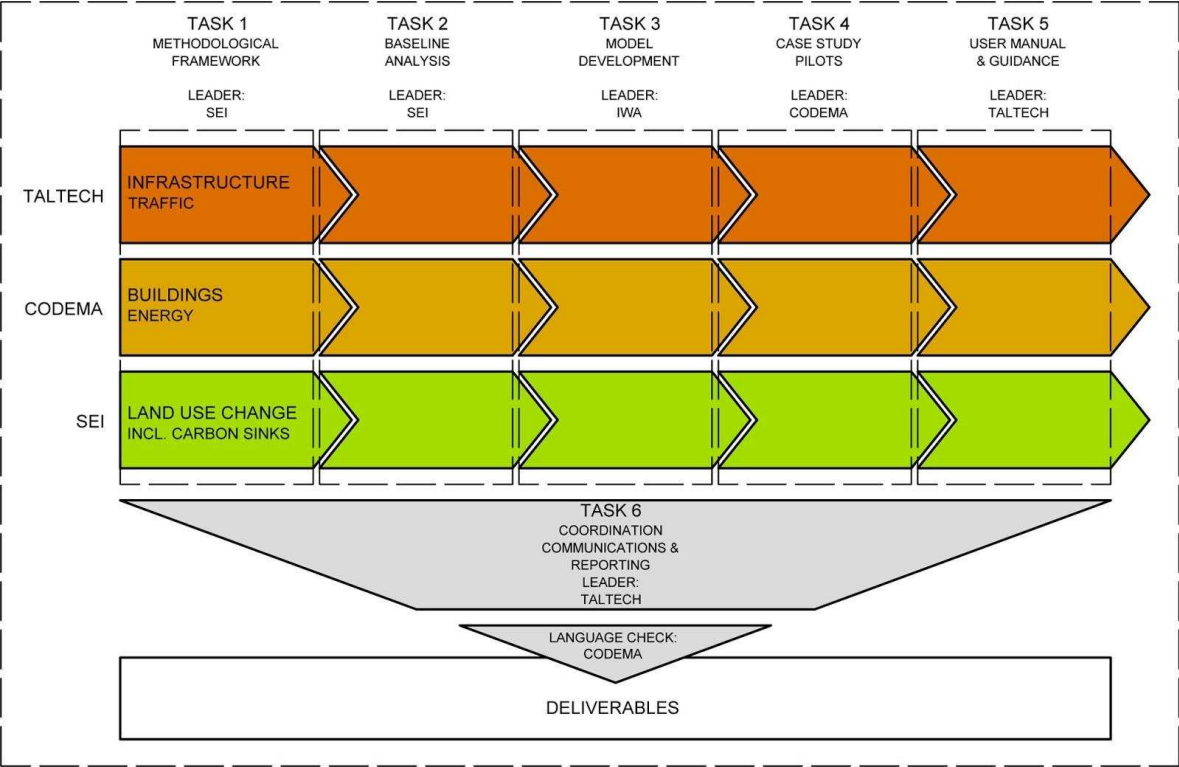


Figure 1: The relationship between the tasks as well as the responsible project partners

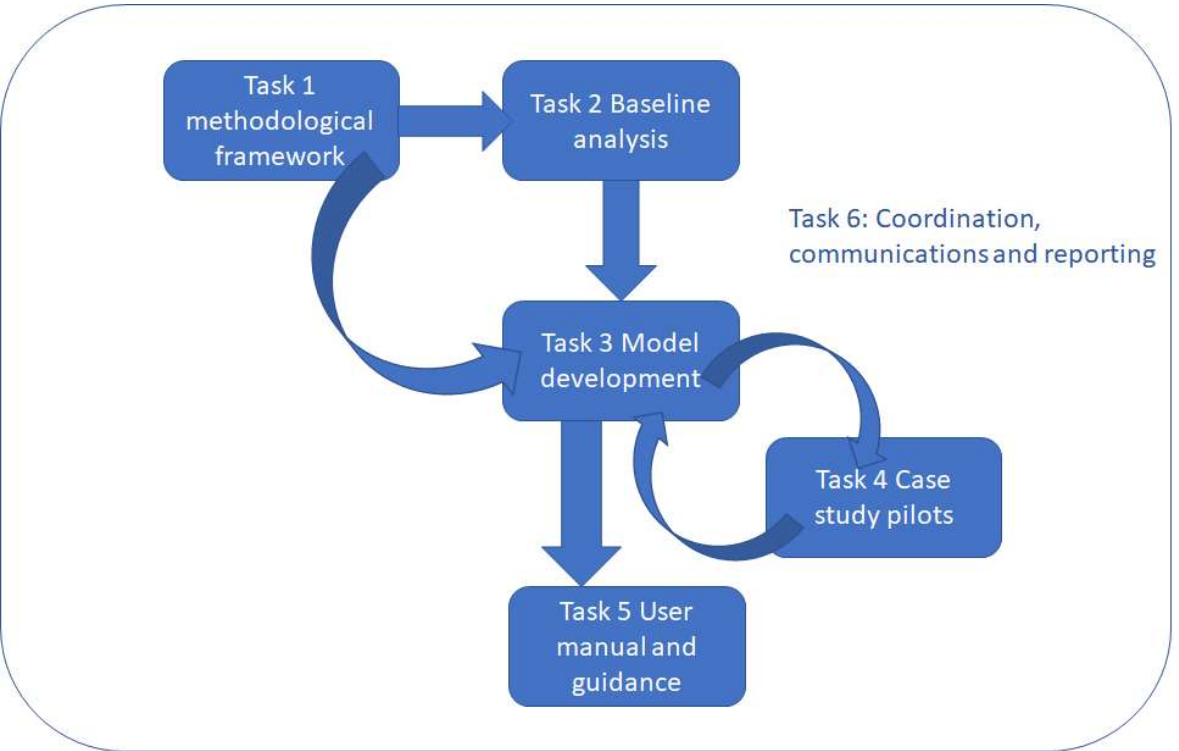


Figure 2: The linkages between tasks

## Task 1 Methodological framework

**Lead:** SEI Tallinn

Support partners: TalTech, Codema, Oivan

Task 1 develops a conceptual and methodological framework including

- the quantitative and qualitative analyses
- approaches to data collection
- model technical design
- indicators
- user interface design, functionality and web hosting

Task 1 also includes a literature review of other methods and an analysis of their strengths and weaknesses.

**Milestone:** A summary report on description of the methodological approach chosen, the indicators selected and sources of data identified (M4).

## Task 2 Baseline analysis

**Lead:** SEI Tallinn

Support partners:

- Codema - data collection assistance for Republic of Ireland, Northern Ireland, & Scotland, and expertise in bottom-up baseline emissions inventories
- TalTech - data collection assistance for Kymenlaakso case area pilot
- Oivan - model technical design, Ecocity Evaluator development

Task 2 includes a complete baseline analysis of the GHG emissions inventories available in the four stakeholder territories. It describes requirements for collection of data and parameters of direct relevance to spatial planning policy, for instance

- the location
- type
- mixture
- phasing of development.

Task 2 identifies needs, reporting deficiencies and data gaps that could hinder the full quantification of emissions. Essentially, it will propose methods for geographically disaggregating, rescaling and simplification of GHG emissions inventories to provide regionally specific data. The coherence of datasets from pilot case studies will be evaluated and responded to in the model and tool development (see chapter 4.2 and figure 3). This will enable the comparison of results.

In order to keep the outcome sensitive for the decisions of spatial planning, bottom-up data collection should be prioritized over top-down approach. Data that is scaled from national statistics (top-down approach) has the drawback that it reflects the national average for a certain emission source but not necessarily the actual local emissions. Data collection at local level (bottom-up approach) guarantees a relatively accurate inventory.

Task 2 develops databases transparently, illustrating the relative comparative impacts of different spatial planning policy options within defined land-use parameters. It will propose a framework for pan-European datasets for comparative purposes, while allowing for differentiated national, regional and local scale datasets to have a placeholder. Open source data (such as National Greenhouse Gas inventories under UN-FCCC, National Energy and Climate Plans, etc) will be used where possible.

Task 2 shall deliver the following outputs:

1. Review of existing tools (including a.o. Space and EcoCity Evaluator) from the perspective of needs to adapt to GHG emission and impacts, gap analysis (delivered in relation to Task 1, please see above);
2. Data collection format of GHG emission data of four case area territories according to the QGasSP methodological approach (developed in task 1);
3. Analysis of data collected from four case area territories, developed into a baseline analysis report

**Milestone:** A report on the baseline analysis of four case area territories (M8).



### Task 3 Model development

**Lead:** Oivan

Support partners: TalTech, SEI Tallinn, Codema

Task 3 converts the method description (Task 1) into a GHG emissions quantification model, which can be applied in spatial planning from regional level down to local detail plans. The model covers both production-based and consumption-based approaches, the latter enables comparisons between European regions. The outcome is a robust model for pan-European application, which has the potential to play a useful role in informing decision-making, improving the SEA process and assisting in building political will for effective long-term climate action.

Based on this model, a simple and flexible open-source web application is developed to support decision-making processes, including SEAs. The tool can be operated both with uniform, harmonized datasets and with more specific local datasets, but in the latter case the tool will indicate that comparisons are no longer possible.

The service will be based on an open-source code, on which various kinds of applications can be created. The service aims at creating an accumulative database from datasheets of projects that have applied the tool. This function enables both benchmarking and the collection of large numbers of pan-European regional datasets.

**Milestone:** The description of the model methodologies, functionalities, necessary datasets and the requirements for the user interface is composed and it can be tested by sector on Excel sheets (one per each sector to be assessed) (M11).

### Task 4 Case study pilots

**Lead:** Codema - Coordinate delivery of all Case Study Pilots. Lead on delivering Case Study Pilots in Ireland, Northern Ireland and Scotland.

Supporting partners: TalTech/SEI Tallinn - Lead on delivering Case Study in Finland - understanding Finnish documents, selecting Finnish spatial plan to be tested and coordinating with Finnish stakeholders.

The model created in Task 3 will be tested in Task 4 through pilot application in the four case study territories, which are selected to represent a wide range of spatial scales. The case study analyses will iteratively test the operability of various stages of the model development through a bespoke quantitative evaluation of specified spatial plans and their likely effectiveness in respect of emissions abatement in differing socio-political contexts. The case studies include a qualitative analysis, through focussed engagement and testing with key local stakeholders and partners at various stages of the model development, to provide continuous practical feedback and insights from policymakers on practical deployment and usability in differing geographic contexts and spatial scales.

**Milestones:**

- Pilots selected (M4)
- Tool testing complete (M10)
- Delivery of draft case study report (M11)
- Delivery of 4 final case study reports (M13)

### Task 5 User manual & guidance

**Lead:** TalTech

Support partners: Codema, SEI Tallinn, Oivan

Task 5 produces an on-line user guide and recommendations in the form of a video manual with hands-on guidance to the tool, dataset criteria and the methodology (to be published on Youtube). This will ensure that the value of the tool in spatial planning policy assessment process is maximised, including how it can be integrated into the SEA process, and will provide effective technical and institutional capacities to address urban- and settlement-related drivers of GHG emissions, thus ensuring less carbon-intensive spatial development patterns. The TalTech team will work closely with Oivan on Task 3, model development, to test and develop the user interface, but will also analyse and report on the process integration in pilot cases. The stakeholders will be engaged in the tool development and testing.

**Milestone:** User Manual Complete (M13)

## Task 6 Coordination, communication and reporting

**Lead:** TalTech

Supporting Partners: Codema, Oivan, SEI

The partners are expert organisations and will work as equal partners in the research consortium.

Due to the COVID-19 situation, the consortium will work on-line.

The consortium partners will each lead on developing the methodological approach in which they have the most expertise:

- Buildings - Codema
- Infrastructure - TalTech
- Land-use - SEI Tallinn Centre
- Model Design & Interface - Oivan

Project reporting to ESPON will take place according to the agreed timeline and Steering Committee decisions.

**Milestone:** All three reports delivered (M13).

## 2.3 Project management

The project management is in accordance with the ESPON handbook. Taltech operates as the coordinator and the service provider, with a service contract with the ESPON EGTC. The duties and decision-making within the consortium is clarified in the consortium agreement.

The stakeholder cooperation agreement between the ESPON EGTC and the lead stakeholder commits the latter and all partner stakeholders to be fully involved in the implementation of this project. This is done by providing data and qualitative input, fostering the operational use of the results and participating in ESPON events and seminars.

The project is guided by the tendering documents, the work plan included in the technical offer, the ESPON project management practices and guidelines, and the feedback from the steering committee. The risk management plan will be a 'live' plan, which will be updated when feedback is received.

The case studies are carried out in close collaboration with contacts, provided by the stakeholders, within this Targeted Analysis Project.

As an internal quality control measure, the team will ask selected peer experts for the feedback on the methodology and the functionality of the tool. The results and methods will be published in peer reviewed scientific journals which will serve as additional quality control.

Exchanges of information between the team will be through regular online meetings and a shared digital working environment, where the progress of each work package will be monitored.

## 2.4 Time table

The project extends over a 12 month period. Annex 2 shows the timeline of implementation of tasks and of deliveries.

## 2.5 Risk management

Risk assessment table is presented in Annex 3.

## 3 Methodological framework

### 3.1 Literature review

It is evident from the scope of the project that a rigorous inventory methodology for quantifying emissions forms only one part of the expected output. In a second stage there is the direct application of the tool to a variety of prospective situations relevant in spatial planning, including its implementation within SEA. Furthermore, this should work at a spatially local scale – in essence, with application down to the single building/development level – and also more broadly to enable comparative analysis of prospective policy implementation, for which high precision data at the single building level is likely to not be as necessary, and obtained values can reflect, for example, building regulations and the degree of compliance, or average traffic data as a function of the degree of development.

Thus, as the project timescale is limited, it will be difficult to provide a precise inventory method that can directly compete with those in existence, either in the published scientific literature or locally applied by relevant authorities that may be scaled and in-tune with the specific needs of a given region. Rather, the project seeks to develop the framework covering the most important emission sources in spatial planning and apply that framework in a variety of situations encompassing differing scales of urban development, spatial range or data availability, and relative importance of emission sectors. Starting from this basis, further emission sources or other important factors, such as air pollution, may subsequently be included in the tool during additional specific projects.

The literature review was, thus, carried out in this context, with a broad survey of the published scientific literature and assessment of the range of situations and standards currently reported. This is followed in subsequent sections by a more detailed look at the specific tools and methods that exist in the target case areas.

#### Background from the scientific literature

Robust accounting protocols for carbon emissions exist at the national level. For instance, GHG inventories are produced annually at this scale through the IPCC methodology (IPCC, 2019). Here, emissions occurring within a country are designated into different categories and subcategories dependent on their source of origin, where for each the amount of emissions is determined by multiplying the frequency of an activity by a coefficient, the emission factor, describing the expected emission from a normalised unit of activity. Such factors are in turn determined by a hierarchy of calculation methods, known as tiers. These are respectively tier 1, which is based on average factors and readily available statistics, tier 2, based on more country or region-specific data, and tier 3, involving detailed local calculations and expected to afford the greatest level of accuracy in the final values.

Whilst such inventories are well established and with rigorous reporting standards to aid inter-state comparability, the procedures followed at smaller scales are more diffuse. This is partly a result of how changing the spatial scale changes the validity of any method applied. At the largest scales envisioned for the QGasSP tool, adopting the IPCC national methodology may indeed be appropriate, but it becomes progressively insufficient at the more local level since a greater number of emissions are outsourced beyond the considered geographical region (Chen *et al.*, 2019). At these smaller scales, for example at the level of a single building, inventories are typically determined through variants of life cycle analysis (LCA), which systematically accounts for embodied emissions in used resources (Sharma *et al.*, 2011). Cities sit between these two extremes and given their importance in the global economy and as sources of emission, as well as nodes of innovation, a great proportion of the published scientific literature has focused on this level (Arioli *et al.*, 2020). Although this does not cover all of the spatial scales envisaged here, it serves as an appropriate point for evaluating the current state of the art in GHG inventories and harmonising an approach that can work at all scales relevant in QGasSP.

The differences in methodology applied at the widest and smallest scales, and as discussed in the introduction, also points to a broader conceptual distinction in accounting methodology. This is between traditional, 'production' based approaches that assign emissions occurring within a given area, and a more recent trend

for 'consumption' inventories that account for all relevant emissions regardless of their geographical origin. A consumption inventory effectively sums the direct emissions occurring within a border with the indirect emissions imported through activities, and may also subtract the direct emissions that can subsequently be assigned to a separate geographical area (Balouktsi, 2020). For example, this might mean that emissions intrinsic to the extraction, processing and transport of fuel, as well as its subsequent combustion are included in an inventory. In this sense it represents an effective translation of the source associated with a particular emission from a geographical point to the end user.

This general dichotomy is also seen in the published literature. For example, in their systematic review published in 2020, Arioli *et al.* broadly grouped inventory methods at the city level into two categories reflecting these distinctions in methodological framework, although in reality many individual approaches applied at the city level will include aspects of both (Dahal and Niemelä, 2017). Both production and consumption approaches should be equivalent on a global level, but at more regional scales they can differ substantially. Indeed, Broekhoff *et al.* (Broekhoff, Erickson and Piggot, 2019) reported that actual emissions can be a factor of 2 to 3 times the size of those reported through production-based accounting. Chen *et al.* also noted a similar proportion in their account of carbon metabolism in global cities (Chen, Chen, *et al.*, 2020). In practice, however, production and consumption-based inventories should be viewed as complementary. Given the conceptual similarity, production-based approaches are more easily harmonised with national accounting, are generally easier to perform at the larger scales using local (or bottom-up) data and more easily avoid any double counting of emissions (Chen, Long, *et al.*, 2020). They may also present a range of emissions that can more easily be controlled through local action. Consumption-based approaches, on the other hand, not only provide a more accurate picture of actual emissions, but also can be more clearly defined on a per-capita or per unit of wealth basis, making them more communicable to individual citizens and other stakeholders (Dodman, 2009).

Given the overlap with national accounts, production-based inventories are more developed, and follow to varying degrees an IPCC-type methodology. Such approaches are often predominantly (though not necessarily exclusively) top-down in nature and may for instance rely on the scaling of the national inventory to match the activities taking place in the city. Attempts have been made to better harmonise the approaches between cities, and in this context the Global Protocol for community-scale greenhouse gas emissions inventories (GPC), published in 2014, is of interest (Greenhouse Gas Protocol, 2014). GPC groups emissions into different scopes reflecting the geographical location of the emissions:

**Scope 1:** GHG emissions from sources located within the target area boundary

**Scope 2:** GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the area boundary

**Scope 3:** All other GHG emissions that occur outside the area boundary as a result of activities taking places within the area boundary.

In most cases scopes 1 and 2 are applied, with scope 3 being more in-line with a consumption-based methodology. Emissions are also reported at either a so-called BASIC or BASIC+ level, depending on the number of sources reported. GPC broadly follows the categorisation of emissions and guidelines found in national reporting, and so widespread adoption would allow more easy comparison to national values, as well as between individual cities within and between countries. Indeed, in their comparison of the GHG accounting methodologies of Helsinki, Stockholm and Copenhagen, Dahal & Niemelä (Dahal and Niemelä, 2017) concluded that adopting the GPC standard across all case study cities as well as in other cities globally would improve the quality of current emissions accounting systems and allow for comparisons between the corresponding cities' emissions results. Conversely, the GPC is also viewed as a complicated protocol (Erickson and Morgenstern, 2016) and an additional layer to be applied below BASIC to assist with limited data variability has also been suggested (Arioli *et al.*, 2020). This problem may also be alleviated by the limited emission sources considered within this project. A second widely used methodology is the Baseline Emission Inventory (BEI), updated in 2018 and applied by several cities in Europe (European Commission, 2010). Both GPC and BEI are of similar scope, including imported electricity emissions and exported waste (Balouktsi, 2020) (although BEI does also provide a framework for LCA type calculations). As a result, utilisation of one of these methodologies would also ensure a clear framework for the addition of further emission

sources beyond the ones considered here in the future. Finally, it is expected that both of these methodologies could be scaled up to a regional assessment given their compatibility with the IPCC guidelines.

Harmonisation is less developed when it comes to consumption-based approaches. Accounting for emissions through a full consumption approach can essentially be accomplished bottom-up through process-based LCA, top-down by using economic Input-Output (IO) matrices that track the embodied emissions through supply chains, or through a hybridisation of the two (Balouktsi, 2020). This discrepancy in approaches poses challenges for harmonisation. Moreover, the varying spatial scales required in the QGasSP tool also provide a complication given each of these methods is most appropriate at the smallest and largest scales, respectively. Indeed, despite high-confidence in their accuracy, it is not expected to be practical to perform full LCA at the level of a city or larger, whilst despite multiple benefits, the issues associated with applying IO tables are well-known, such as the age of the data used in any analysis, or aggregation errors. Heinonen *et al* reviewed over 100 consumption-based approaches, showing them to be applied at a variety of range scales including the entire range relevant for the proposed tool. However, they also comment on a lack of standard terminology and it is not necessarily clear what is included in each of the methodologies (Heinonen *et al.*, 2020). In this context, the attempts to establish standardised consumption methodologies, for example the PAS 270 (BSI, 2013) or the consumption-based extension to the GPC (C40, 2018) are promising. However, these will still broadly rely on the accuracy and suitability of any regional IO tables available in a given area.

Heinonen himself applies **tiered hybrid LCA method**, with the aim of combining the benefits of the two main types of LCA: the comprehensive range of input-output-LCA and the precision of process-LCA. Instead of solely collecting the most recent sectoral datasets available, the tiered hybrid method utilises economic consumption data, overarching all aspects of consumption.

Tiered hybrid LCA method has provided results that have challenged many assumptions of the science community. For example at Aalto University, the five PhD projects applying the tiered hybrid LCA method have questioned the benefits of urban densification strategies and highlighted the importance of embodied emissions i.e. so called “carbon spike” of new construction. The results of professor Junnila’s research team were also notified in the 5<sup>th</sup> IPCC report.

Tiered hybrid LCA method could provide solutions to some crucial challenges related to pan-European methodology, including one of the three key research questions: how to collect consistent and comparable GHG baseline emissions data at national, regional and local levels. The industries (consumption categories) of input-output-LCA would create obvious placeholders for all aspects of consumption for the future development of the tool. Harmonised input-output tables, such as Exiobase (Stadler *et al.*, 2018), also exist for the whole of Europe, and so help to solve issues related to pan-European data availability.

Applying economic consumption data may also help to address one of the questions in the task description: how to link urban morphologies with GHG emissions. As demonstrated by several researchers applying the tiered hybrid LCA method, there is no linear correlation between the population density and the total GHG emissions. The same urban morphology in different European cities may be attributed to very different levels of consumption-based GHG emissions. Säynäjoki *et al.* proposes that the differences in results are not only explained by differences in energy production etc, but also life style, which can be quantified through economic consumption. Thus, morphology of a certain settlement does not directly correlate with the GHG emissions, but the resident profile, income level and consumption patterns.

Taken together, it is clear from the published literature that there are a number of methodologies available that can be potentially used as the basis for the tool. Whilst the methodological framework will only be finalised concretely following the completion of task 1, it is noted that aligning with these other methodologies will aid uptake, particularly something similar to the GPC for the production-based approach, and so is the clear direction of travel at this stage. On the consumption side, the wide spatial scales envisaged in the tool pose complications, and so a hybridised approach, such as the tiered-hybrid method, is targeted aligned to the tool hierarchy.

## 3.2 Sectoral methodologies

### Buildings

The ongoing annual GHG emissions produced by buildings associated with the energy demands (heat and electricity) are dependent on key characteristics of the building's physical attributes and use;

- Building Category - e.g. residential, commercial, industrial.
- Building Specific Use - e.g. office, retail, data centre, etc.
- Building Type - e.g. apartments, detached, semi-detached, etc.
- Year of Construction - e.g. what building codes/standards will the building have to meet
- Total Floor Area - e.g. m<sup>2</sup> office space, m<sup>2</sup> data halls, etc.
- Occupancy - e.g. estimate of persons per household by no. bedrooms/no. offices etc.
- Type of heating system - e.g. gas boiler, oil boiler, heat-pump, district heating.

Open source data will be prioritised and pan-european datasets used where applicable to allow replicability across EU regions. These pan-European data-sets may be more useful for regional analyses, and more specific local data-sets required for more realistic local development plan assessment. When different levels of data are available, the higher level of quality should be selected.

For new developments planned, it is also important to understand when they are planned to be built during the spatial development plan lifetime - if the spatial plan is ten years long and the new development is not due to be built until four years time - the annual GHG emissions totals must take account of the planned construction timeline.

Potential data-sources include:

- Geostat - population density
- Eurostat - NUTS 3 level data
- ODYSSEE-MURE - energy consumption, energy efficiency and CO<sub>2</sub> emissions data across EU
- PVgis for solar energy potential.

National/regional specific data:

- National Census data sources (various geographic breakdown of household data)
- CIBSE TM46 Benchmarks (UK & Ireland)
- Energy Performance Certificates (e.g. Ireland - BER/DEAP, Scotland - Scottish Household Condition Survey, Scottish Heat Map, Statistics Finland)
- CO<sub>2</sub> content of electricity from grid (available publicly from National Energy Agencies, in Finland Energiatieto/Motiva)
- CO<sub>2</sub> factors of heating fuels (available publicly from National Energy Agencies, in Finland Energiatieto/Motiva)
- Tabula Residential Typologies (available for UK and Ireland)
- MapEIRE - Irish GHG mapping project

Local level data:

- Valuation Assessors Floor Area data (Ireland - Valuation Office and GeoDirectory Commercial Database, Scotland - Highland Assessors Corporate Address Gazetteer,)
- Public Building location & Energy data (e.g. Ireland/Scotland - public authorities)
- Local Planning databases (municipality planning systems - applications etc.)

### Going beyond current tools

Building development characteristics can also have knock-on indirect GHG effects that are not often taken into account - such as ability to provide household driveways or off-site car-parks with Electric Vehicle (EV) charging facilities, new developments which have increasing electrical loads (EV charging onsite and electric heat-pumps) and large industrial electrical users (data centres) have potential negative GHG emission impacts on the electricity grid. These aspects will be assessed in terms of what indicators could be used that would be helpful for planners.

The location of buildings can also mean they are restricted to certain fuel types or technologies to meet their energy demands. For example, apartment blocks do not have as much roof-space for PV integration, but are more suited to connection to district heating than individual housing units. How to address these spatial planning considerations in the tool will be investigated.



The methodology investigated for buildings will also look at how to future-proof the tool to potentially add the life-cycle GHGs involved in the building materials and the end-of-life demolition (Scope 3 emissions) - which are important considerations when trying to address global GHG emissions.

## Infrastructure and traffic

Transport represents almost a quarter of Europe's greenhouse gas emissions. The GHG emissions caused by the traffic are one of the key sources of emissions which can be influenced by the decisions and policies related to spatial planning.

European Strategy on the shift to low-emission mobility includes three priority areas: 1) Increasing the efficiency of the transport system by making the most of digital technologies, smart pricing and further encouraging the shift to lower emission transport modes (incl MaaS opportunities); 2) Speeding up the deployment of low-emission alternative energy for transport, such as advanced biofuels, electricity, hydrogen and renewable synthetic fuels and removing obstacles to the electrification of transport; 3) Moving towards zero-emission vehicles. While further improvements to the internal combustion engine will be needed, Europe aims to accelerate the transition towards low- and zero-emission vehicles.

The GHG quantification of infrastructure and transport analysis will be based on publically available datasets. Regarding traffic, the most essential parameters are

- mileage
- modal share
- CO<sub>2</sub> emission factors by the modes of transportation.

The same CO<sub>2</sub> emission factors for fossil fuels are applied in all European regions. The national datasets include a.o. emission factors for the grid electricity and emission factors for the construction and the maintenance of typical road types. Local datasets include for example mileage and modal share.

Examples of data sources which can be used at European level:

- EEA National emissions reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism
- EEA - Approximated estimates for greenhouse gas emissions
- EEA - Member States greenhouse gas emission projections

Examples on national and local level data:

- National Census data sources
- National data sources regarding modal split data sets or surveys
- National databases on emission factors (for example Lipasto database in Finland)
- National data on traffic activity (for example Valtakunnallinen henkilöliikennetutkimus in Finland)
- Vehicle fleet composition
- Fuel consumption
- Regional and municipal traffic models and/or surveys indicating modal split and transport volumes

In a production-based approach, the emissions of all traffic within the target area are accounted for. The average traffic activity is attributed to streets, roads and railroads etc.

In consumption-based approach mobility is allocated per resident, in some studies also per workplace. Mileage, i.e. the total daily travel activity per person is divided into the trips by various modes of transportation by using the modal share, i.e. the percentages of various means of transportation. Finally the daily travel activity per mode of transportation is multiplied with the emission factor of the vehicle type.

The key parameters in consumption-based analysis are influenced by the decisions of spatial planning or policies related to it. For example the proximity of high-quality public transportation or fluent MaaS (mobility as a service) solutions have an impact on the average modal split. The share of electric vehicles (EV) can be increased through economic incentives for example. The technological development changes the emission factors of combustion engines, and the changes of grid electricity emission factors reflect on the emission factor of electric vehicles and trams.

Quantifying traffic in new settlements requires an input of a traffic model. The scope of the current project does not accommodate traffic modelling.



## Land-Use

A detailed approach (and the one currently targeted) for quantifying the influence of spatial planning policies on GHG emissions in the land-use and land-use change sector in a transparent, comparable and consistent manner at national, regional and local administrative levels across different countries could be implementing the IPCC LULUCF (land-use, land-use change and forestry) greenhouse gas inventory approach (IPCC, 2019). The latter has been developed for estimating GHG emissions and uptake on a national level, however the structure, methodology and data requirement is also applicable on smaller scales. According to IPCC guidelines the emissions and removals of CO<sub>2</sub> for the LULUCF sector<sup>1</sup>, based on changes in ecosystem carbon stocks, are estimated for each land-use category (including both land remaining in a land-use category as well as land converted to another land use). In the current project, only land use change is addressed, for example regular forest management activities (sanitary logging, clearcutting etc) will not be included in the tool, however the impact of afforestation and deforestation will be quantified.

IPCC methodology divides the land-use sector into subcategories such as forest land, cropland, grassland, wetlands, settlements and other land. Both, the carbon sinks and sources are accounted for, thus, the potential of GHG mitigation and adaptation actions could be estimated as well when making comparisons between the emissions trajectories of different spatial planning levels and strategies.

At the country level, and in some cases regional level, verified land-use related activity data and country-specific emission factors can be derived from annual national greenhouse gas inventories submitted to the UNFCCC. In addition, several cities in Europe have conducted carbon footprint analysis and developed Sustainable Energy and Climate Action Plans to support the implementation of the EU greenhouse gas reduction target and to accelerate the decarbonisation of their territories in the frame of European Union climate policy and/or its supporting initiatives, e.g. the Covenant of Mayors. Thus, baseline data is available to a considerable extent, however harmonization of the data is necessary.

Data sources used at Pan European level:

- Annual greenhouse gas inventory submissions consisting of the national inventory report (NIR) and common reporting format (CRF) of all Parties included in Annex I to the Convention (UNFCCC)
- EEA Corine - GIS land cover using 44 classes of 3-level Corine nomenclature
- EEA European Soil Sealing - GIS shapefiles
- EEA Urban Atlas - GIS shapefiles

Land use change is a key component in GHG quantification especially in territorial studies and in SEAs considering the spatial planning of new construction or major infrastructural investments. The quantification methods related to land-use change and forestry is the main focus of work package 1, and the results are described in the report chapter on methodology.

### 3.3 Contextualising the tool use within spatial planning

The envisaged tool is expected to be applied to a wide-range of different spatial scales, ranging from the highly-local/district level, all the way up to the regional or (sub-) national scale. As a consequence of this, the methodologies also differ between these scales. For example, embedding the tool within SEA process was extensively referenced within the project terms of reference. SEA is the clear vehicle for assessing the impacts of strategic choices in a systematic and transparent way. Here, the tool would have twofold purpose. Firstly to enable the planners to understand the potential impacts of planning options on the environment, in terms of GHG emissions in particular. And secondly to link the SEA reports to the planning proposal. More details on the design of the tool and its applicability to users of varying experience level is given in **chapter 4.4**.

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<sup>1</sup> LULUCF is also referred to as Agriculture, Forestry and Other Land Use (AFOLU) sector in the newest IPCC guidelines.

## Design level – use by non-experts

Here, perhaps at the very beginning of a new project, it is less important for the tool to use specific values as inputs or to produce highly precise results. Greater emphasis should instead be placed on allowing illustrative results to be obtained by non experts and help guide decision making during the early stages of a project. The results may also be at a larger scale or may reflect changes between specific national or sub-national policies, in which case precise values for individual developments can be replaced by statistical averages. The main purpose of this use level is to inculcate an understanding of potential GHG impacts in the early design stages of a spatial planning policy or development, and suggest whether such developments are in accordance with all relevant GHG targets, it may also include changes that do not include any specific urban development, such as the conversion of farmland to forestry or similar. Finally, it should be noted that such use of the tool does not preclude a subsequent more detailed application by an expert user at a later stage within a project.

## Development level – use by experts within SEA

As the strategic environmental assessment is being applied throughout Europe as the SEA Directive sets out mandatory procedure for spatial and strategic sectoral plans. Thus, it is considered as the principal way by which the QGasSP tool can gain widespread adoption. From the review of existing tools described below, it is understood that only the SPACE tool was designed directly for integration within the SEA framework (The Scottish Government, 2012). This tool is used to understand prospective use of the QGasSP tool within SEA process, as well as to establish additional beneficial functionalities that can be targeted during the development of a spatial and sectoral plan. The proposed tool is at present only targeted to assess the impacts on GHG emissions. However, as this is an aspect of SEA that is currently considered weak, the tool has the potential for significant acceleration of the approach.

SEA assesses the environmental consequences and mitigation potential of a prospective development and consists of several distinct stages. These are respectively known as screening, scoping, environmental report, and adaption and monitoring, and are summarised below:

Screening stage	Here, the responsible authority assesses the likely environmental impacts of a plan and considers the need for SEA.
Scoping stage	The range of environmental issues to be considered by SEA is defined, and 'reasonable alternatives' are determined. The reasonable alternatives will subsequently be assessed against the proposed development plan.
Environmental report	The environmental consequences of the proposal are assessed against a baseline. An assessment is made against the reasonable alternatives and measures to mitigate potential drawbacks are developed.
Adaptation and monitoring	The decisions taken are subsequently assessed following the development.

In principle, the tool could first be used in a more simplistic sense (possibly by a non-expert using generic datasets at the design level) during screening and scoping to inform on the necessity of continuing with the subsequent stages. However, ordinarily SEA would be required for all urban developments, but the existence of a trusted and communicable methodology for assessing GHG would help to build stakeholder engagement before commencing the later stages.

More specifically, the tool will be targeted for widespread adoption **during the preparation of the SEA report**. At this stage the tool will be used by SEA experts, and may involve the use of specific regional datasets directly relevant for the envisioned development that have been compiled by the expert during the project. In this sense, the tool can provide a Pan-European standardised methodology for the assessment of GHG emissions within the SEA process. The key functionalities required of the tool in this context are hereafter described.

Considering the structure of SEA outlined above, it is critical to target comparability between the proposed development, baseline scenario and the established reasonable alternatives. This necessitates that the tool is easy to use and can allow fast comparison between different scenarios in a way that is clearly understandable to the different stakeholders. As discussed below, such comparability is feasible within SPACE and so should also be targeted in QGasSP (although it is noted that this tool does not include a dedicated baseline scenario).

However, for greatest impact it is also important to go beyond this. Automatic reports are generated through the reference tool, Ecocity evaluator, and this can aid transparency and communicability of the results. Moreover, to achieve the target of Europe-wide comparability, the emissions should not only be relative (as with SPACE), but also absolute against the baseline scenario. This would further allow the results to be contextualised by showing whether they are in accordance with national policies or the COP 21 Paris accords. Finally, the tool could also be integrated into the final stage of SEA by including future emissions that the actual development could then be assessed against. Revised GHG projections could also be included using more recent or more specific data.

It is considered critical that the tool contains the following functionalities:

- Quantitative assessment of absolute baseline scenario emissions;
- Quantitative assessment of the proposed plan and relative assessment of this against the baseline scenario and proposed reasonable alternatives, as directed by an expert user;
- Projection of all emission scenarios into the future;
- Generation of automatic reports that represent graphically the future GHG implications of the different scenarios, and that describe the datasets and assumptions included within the model;
- Assessment of the proposed plan against relevant GHG emission reduction targets enacted by the relevant decision making authority of the region.

## 4 Model development

### 4.1 Tools available within the case study areas

This review was conducted to analyse the available tools that could be applied within the case study areas. The tools were analysed with particular focus both on the outcomes of the review of the scientific literature, and the critical appraisal of the necessary features to embed the tool within SEA, as outlined above.

The first tool to be considered is the aforementioned **SPACE** tool, developed by the Scottish government (The Scottish Government, 2011, 2012) and applicable to Scotland. This tool was built directly for quantifying emissions associated with spatial planning decisions. Next, the **MapEire** tool, developed through a research project at Aarhus university in Denmark (Plejdstrup, Nielsen and Bruun, 2018; Plejdstrup *et al.*, 2019; Plejdstrup, Bruun and Nielsen, 2019; Nielsen *et al.*, 2020) was also considered. MapEire is a geospatial tool for desegregating and allocating emissions from the Irish national GHG inventory. A relatively similar model has been developed in Finland (GISPO, 2018; Hastio, 2019; Mäkinen, 2019; UBIGO, 2019). The **SYKE** tool was built through a collaboration between the Tampere government and two Finnish software companies ('Ubigo' and 'Gispo'). It has also so far only been applied in the Tampere region. A final tool applied within the case study areas is known as **SCATTER** (Nottingham City Council *et al.*, 2019). Although this tool can only be used within the United Kingdom, since it implements the GPC methodology it was taken as a representative tool for several others that have been applied to different regions, such as the 'local GHG inventory tool' by the environmental protection agency in the US, or the 'Environmental insights explorer' by Google). Additionally, the reference tool for the project, **Ecocity Evaluator** was also included in the comparative analysis. This was developed by Oivan (formerly IWA) in collaboration with Epecci Ltd. A fuller consideration of the most important details regarding each of these tools is provided in Annex 4.

These tools differ substantially in scope, complexity and purpose, which complicates the extent to which they can be directly compared. For example, whilst SPACE and Ecocity Evaluator are essentially tools for comparing different spatial planning decisions, SCATTER is first and foremost a tool for compiling a baseline inventory. Ideally, the QGasSP tool should be capable of both aspects. The other factors considered were the emission types and sectors included, with a separate section for land use as this was judged to be an element only partially included in many of the tools. Besides these factors, it was also important whether the tools considered emissions from a production or consumption perspective, how widely they could be applied across Europe and integrated within SEA, and the nature of their user interface, and whether they were appropriate for both expert and non-expert users. Finally, the communicability of the results was also considered. The results from the comparative analysis are summarised in the following table, which also includes a consideration of the proposed QGasSP tool, the details of which are further elaborated in the following section.

**Table 1: Comparative analysis of tools within the case study pilots**

	SPACE	Ecocity Evaluator	MapEire	SYKE	Scatter (representative GPC)	Proposed QGasSP tool
GHG	GHG only	GHG only	GHG+.	GHG only	GHG only	GHG only*
Sectors (exc LULUCF)	Building energy use, transport and waste.	Building life-cycle, building energy use, infrastructure and transport	All sectors from UN-FCCC national reporting	Building life-cycle, building energy use, transport	building energy use, transport, waste, industrial processes and product use	Building life-cycle, building energy use, infrastructure and transport

Land use (LU-LUCF)	Land use change only; only four land categories	Land use change only, 3 Land categories, outdated data	All sectors and land types from UNFCCC national reporting (6 Land categories). Includes sources and sinks.	Land-use change and carbon sinks	IPCC LULUCF methodology, 6 land categories	IPCC LU-LUCF methodology, 6 land categories
Baseline inventory	X	X	✓	✓	✓	✓
Comparative assessment	✓	✓	X	~	~	✓
Production account	✓	✓	✓	✓	✓	✓
Consumption account**	X	X	X	X	X	✓
Model design and interface (incl any geospatial components)	Excel based. No geospatial component.	web-based application. Limited Geospatial component	Application based. Geospatial component	Application based. Geospatial component	Web-based application. No Geospatial component	Web-based application
Pan-European applicability	X	X	X	X	X	✓
Linkages with SEA report	✓	~	X	X	X	✓
Usability and communicability	Expert use; no automated reports	non-expert use; automated reports	expert use; no automated reports	Expert use; no automated reports	non-expert use; automated reports	non-expert use; automated reports

\* The QGasSP project could be modified in the future to include additional functionalities relevant to spatial planning. \*\* Whilst some tools include aspects of consumption accounting, none do so in a complete or systematic manner.

~ refers to an element of a particular tool judged to be partially fulfilled, or valid in certain cases.

It can thus be seen that no tool adequately covers the range of applications envisioned within the project brief. However, it is clear that Ecocity Evaluator sits closer to the centre of the project brief than any of the other tools reviewed. The tool is browser based and easy to use, aggregates emissions into a single number and projects the emissions into the future. Moreover, it allows comparative emissions between different spatial planning choices, though perhaps not to the extent of SPACE, and the automatic reports are valuable since many users may be non-experts. Ecocity evaluator suffers, however, when applied to the largest scales such as whole regions, where a prospective user may wish to look at changes in policy components over wide areas, rather than any single area or development. Evidently, to work at different scales, the tool needs to assess specific changes within local developments, perhaps reaching down to the single component level, and also to assess how changes in circumstances or a policy (e.g. building regulations) might lead to changes in a range of sites. Ecocity Evaluator is also considered to represent the land-use sector relatively poorly, only has data suitable within Finland/Netherlands, and, whilst it includes some consumption aspects, it does not include a separate systematic assessment of consumption based emissions. SPACE was also seen to have many of the aspects considered important within the tool. However, it further suffered in relation to Ecocity in terms of the usability assessment, the emission sources considered and the lack of aggregation of the results into a single number. Critically, all of the tools suffered in the sense that they were only designed or included data for subsections of Europe. Further details on the other tools considered are provided in the Annex 4.

Although some features and functionalities of Ecocity Evaluator tool are considered suitable for the purposes of this project, the new ESPON tool cannot use any components of existing tools for IPR reasons. The new tool will be created from scratch, adding new functionalities required for the cross-European applicability.

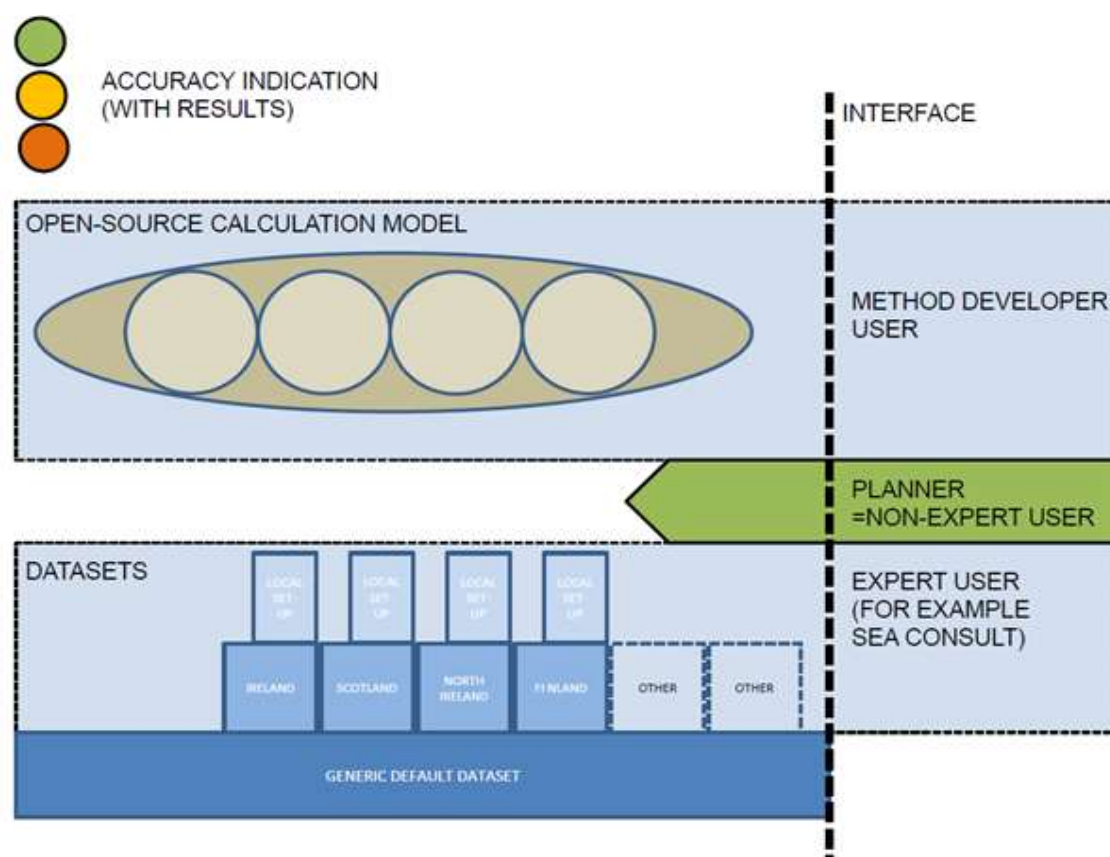
## 4.2 Model design

As stated and discussed in the literature review, the widely varying methodologies applied across Europe has so far hindered reliable inter-region comparability and provides a barrier to cross-EU cooperation for climate mitigation. Moreover, the lack of a widely applied structure or process to standardise GHG emissions quantification within SEA also limits the effectiveness of this process. A key objective of the tool is therefore to be suitable for integration within SEA to improve its usefulness towards targeting emissions reduction. But the tool is also aimed to be applied more broadly. For example, it would also be of great benefit if the tool could be used by non-experts. In this way, it could also help to develop an understanding of strategies for emissions reduction within the initial design stages of spatial planning or policy development. Encompassing a range of spatial scales is also a key challenge of the project brief. This can in one sense be seen by considering the two tools most readily applicable to spatial planning from the analysis above. Whereas Ecocity evaluator is principally built up from detailed descriptions of individual developments, SPACE works more from averaged results for buildings of a given type within a local authority, and can further be aggregated into wider policy components more applicable at the larger sub-national scales. At this larger scale, specific details of, for example, individual buildings become less important and so parameters can be obtained through averages or the degree of adherence to building regulations.

Such a tool encompassing large ranges of data availability, spatial scale and user experience clearly entails a great deal of flexibility. As such, the tool development will proceed with a future-orientated perspective, whereby greatest emphasis is placed on establishing a standardised methodology and data-framework, as well as on maximising the degree to which non-experts can use the tool and immediately derive meaningful results.

Figure 3 outlines the generalised methodology of the tool. It should include a user-friendly interface suitable for non-experts behind which exists an open-source model segregated into different components or emission sectors, allowing future developers to add additional functionality. This shall mean that a non-expert spatial planner or policy maker in local government can obtain illustrative results quickly. The quantitative model shall itself be built upon hierarchical datasets, in order to ensure the tool can maintain applicability between areas with and without specific and high-quality data. At a first level, default data based on European averages shall be input, which ensures from the outset pan-European application. On top of this, more detailed national/sub-national and eventually local city or area-specific datasets can be incorporated (and replace the generic datasets in the calculations) to improve accuracy when such data is available and necessary for the application. Here it is assumed that the second level of user, for example those applying it to SEA would obtain and incorporate such data and, given the target of pan-European applicability, it is hoped that a wide-range of datasets could quickly be built up following the completion of the project.





**Figure 3: Generalised diagram highlighting the hierarchy encompassed in the tool**

To ensure compatibility, the project service providers will propose how the data shall be formatted, and also introduce a traffic-light system to illustrate to the user the expected accuracy of the results. For example, a user shall obtain 'green' results if the calculation is made using more recent and more locally-specific data. Moreover, exemplar higher-level datasets shall also be produced during the project based on the case target pilots.

This also explains how the different tiers link to each other. For example, when using the tool to analyse the emissions from a city, higher level data (i.e. more regionally specific data) suitable for that city can be used to replace data that is more generic (for example the equivalent data for the country in which the city resides). The calculations will work the same regardless of the choice of data as the form of the data will be the same in all cases, and indeed the choice of data will always be at the discretion of the user. Without organising the tool in this fashion, there would be a risk of compromising accuracy at the expense of being operational throughout Europe. This could for example hinder the up-take of the tool in large cities who would otherwise be forced to use poorer quality or less relevant data than they might have available. This will also serve to answer an important question regarding the sensitivity of the results to the level of data, where the results obtained with different levels of data can be compared for the same region.

### Placeholders

The new tool shall be designed and constructed with a modular structure. At the first stage, it will include three detailed quantification modules, which will cover the most important aspects of GHG emissions relevant to spatial planning: 1) land use and land-use change, 2) energy use in buildings and 3) infrastructure and transportation. Other aspects of GHG emissions will be included as placeholders, i.e. modules, which as a first stage may use constant default values or a simplified model for quantification. This ensures that the overall result of the GHG quantification always covers all relevant sectors of emissions, even if the precision of the impacts from less important sectors is poor at this first stage. The modular structure enables updating of the calculation methodology module-by-module according to possible new standards or according to more accurate quantification methods of the future. The modules for quantifying other sectors of GHG emissions can be developed to replace the placeholders at any time. It should be noted though, that typically each module (eg. Land Use) has its own parameters and UI section to modify them, and for each subsequent



module not-yet-defined, these UI sections need to be constructed separately according to separate specifications. But this is exactly what the open-source nature of the tool makes possible.

### Future operation and hosting

As requested in the tendering document, the service provider will include all the information needed for hosting and developing the tool in the final project report. The tool will be designed to be operational without the need to include private datasets and any dependency on the service provider.

It should be noted that the tool would need some upkeep, thus someone needs to be responsible for the hosting and maintaining of the live software. It is important that the software is kept up to date for both user experience and security reasons. This would mean that possible problems are promptly investigated and resolved, any cyber/data privacy threats are addressed immediately, and that when the open-source community develops the software further, someone takes care of curating, accepting and deploying these changes.

In order to future-proof both the methodology and tool, the research team proposes an open source tool with a modular structure, where the calculation modules can be updated and developed. Furthermore, the tool will have placeholders for new calculation modules, which will extend the scope of GHG quantification.

Open source means that the software's source code is available for users to download, examine and modify. Most open source projects have a public code repository on a website, that contains the full history of the project (code changes), documentation, possibility to download the full project and often, also a link to the actual live and running version of the project's code (working application).

An open source approach enables the use of best practises even as the methodology of GHG quantification would still be developing. The modular structure allows for updates on sectoral calculation models, for example when a methodology is standardised or widely adopted by professionals, then this can be updated in the tool as its modular structure would allow for any updates. In principle, a region or city can implement its own, unique quantification methodology in the tool and continue using it for GHG quantification, but this would then mean that the opportunity of comparison would be lost.

The **version control system** is a solution applied by almost all software developers. It allows users to view changes and go back to earlier versions of the tool, this gives access to the full history of changes made to the code. The version control system allows the developers to remove problematic changes, track issues, and merge changes made by multiple developers to the same files in the code base.

**Code repository** is the physical manifestation of the version control system, containing the current code version and all its historical incremental iterations.

**Git** is the most popular free open source, and arguably the most sophisticated version control system available. Git is used to manage the changes in the code, this is used by large organisations and is even used in small open source projects. It is a means of managing code in a safe and coordinated manner, sharing and collaborating on the same codebase.

**Github** is at the time of writing the most popular platform for hosting Git code repositories. It offers the users an easy way to set up a Git repository for their code, and share the repository with other developers. A typical Github repository is an open source project that has been created to solve a problem, and then the solution can be shared with everyone. Github allows the developer to set up a project website to communicate the project and to publish documentation. What often happens is that users who benefit from this open source project come up with a solution to improve it, and contribute to the project. Github offers mechanics for this, so that users can submit issues, and/or solutions to them, and the "owner" of the project can review and merge these improvements into the project, after validating them.

Github is completely free to use for public repositories, and utilising it creates no permanent dependency for the users, as a developer downloads the repository from the Github, it is always a complete copy of the Git repository, with its full history and documentation etc. Github also offers the developer a safe backup "in the cloud" so that the code is never stored only in one location which might be lost.

A platform like Github can offer the project a location where the code can be safely stored and shared, documentation published. It should be noted that the tool is not operable in Github, but only the code can be accessed through Github. So the calculator software needs a hosting environment where it is operated.

**A hosting environment** for a web application is essentially a server that runs a database, the code from the repository and web server software that serves the web page (UI) to the user from the web address. The database on the server holds any data the project administrator have input, this is usually information that is required by the software to function (e.g. CO<sub>2</sub> emission factors), and captures any saved changes made by the users (eg. calculation projects, results etc). The code running on the server is responsible for this and executes calculations for the user, or processes saved data from the database.

An open source repository needs an operator who takes responsibility and maintains the repository. Despite it being transparent, in practise it is not feasible to allow everyone to make changes how they want, as unfortunately, there might be developers who would use the opportunity to hide malicious code (virus) in the project, in order to gather sensitive information. The maintainer of the open source project acts as the moderator and gatekeeper for any such unwanted changes, and reviews any “change requests” and takes care of physically updating the code repository with only the changes that actually benefit the project.

To function in this role, and keep the code base stable and safe for both developers and users of the software, the maintainer needs to have a good understanding of the code base and the functionality the program offers. Therefore, typically the maintainer is the original developer and/or main contributor of the open source product.

**The software**, as described earlier, a web-based GHG emissions calculator, runs in the hosting environment. This environment is like any machine – it needs to be operated, and maintained.. An error may occur, the application halts and needs to be restarted. Even more importantly, every single online system is under constant bombardment from automated hacking attempts. Since essentially all end-user facing software developed is based on some other software, security holes found in them (e.g. the database engine, server's operating system etc) potentially compromises every application utilising them. A compromised system can result in users' personal information like passwords being lost to the hackers, and often this information can be used to break into other, more sensitive services used by the same users. Therefore, every online system needs constant updates to keep secure.

Outside “everyday” stability and security maintenance, there is always a need to update the software itself (eg. calculator). If a user notices a bug in the software, they can check the source code in Github, locate the reason, and submit a change request to the repository maintainer, to update the code base with the fix. If the maintainer does this then the code repository is updated, but not the software running the code that the users are using online. It is up to the software operator to deploy a new version of the code to the server (hosting environment), in order to get an updated version of the software up and running. The same applies for the data in the database, if it contains false information or there is a new set of data, this needs to be input into the database (eg. new type of emission factors as part of a new module etc).

There are good tools for hosting, and even for automating some error recovery and update scenarios, but these are for the sake of efficiency and saving time and effort. In any scenario, the live software requires someone that is responsible for its stability, security and updates

The research team proposes that collecting relevant, accumulative regional and local data would be done by the users of the tool, generating an open database available for all users. For accurate results, use of local datasets should be preferred. As the number of European territories, cities and municipalities is so high, any project aiming at producing datasets for all of them would not be feasible.

## 5 Case study pilots

### 5.1 Overview

Codema is coordinating the delivery of all case study pilots and will lead on delivering the pilots in Ireland, Northern Ireland and Scotland. TalTech will lead on delivering the case study in Finland – understanding Finnish documents, selecting Finnish spatial plans to be tested and coordinating with Finnish partners.

The tool that is created for this project (created in Task 3) will be tested in Task 4 through pilot application in four case study territories included in this Targeted Analysis Project. The case study pilots will be linked to relevant policy processes and the involvement of the stakeholders will be key to ensure that the link between case study and relevant spatial planning policy is present. The case studies include a qualitative analysis, through focussed engagement and testing with key local stakeholders at various stages of the tool development, to provide continuous feedback and insights from policymakers on practical deployment and usability in differing geographic contexts.

The scope of the case studies is to be able to test the tool in a variety of contexts. The service providers have committed to use a range of spatial scales for the pilots, this is shown through the case study selection that vary in their urban context i.e. rural, urban and suburban, whilst differing in population sizes and geographic contexts.

Codema and the supporting partners, along with the stakeholders' advice, will select the most relevant spatial plans to test the tool in the 4 regions. The pilot case studies should, where possible, reflect the stakeholders envisaged use of the tool in each territory, this includes for example local authority spatial plans, development plans and national planning frameworks.

The GHG analysis of the case study plans will follow the breakdown into key emission sections;

- Infrastructure - including traffic/transport changes
- Buildings - changes in electricity and heating demands
- Land Use - changes in land use including carbon sinks

The policies affecting each of these three areas will be tested and a report outlining the findings of this testing period will be produced. The case studies and testing are essential for the success of the final tool development, and will be strengthened greatly by the collaboration and input of the Steering Committee and the local stakeholders. The service providers will engage with the stakeholders as early as possible in the delivery of this task to gain a better insight into the individual needs of the stakeholders across the different regions.

#### Milestones

Task 4 shall deliver the following milestones:

- Pilots selected by January 2021 (M3)
- Tool testing complete by July 2021 (M9)
- Delivery of draft case study report by August 2021 (M10)
- Delivery of final case study report by October 2021 (M12)

**Table 2: Task 4 – Case Study Pilots**

		2020		2021									
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
M1	Pilots selected			☆									
M2	Gathering of local level data and spatial planning frameworks/policy documents												
	Tool testing complete									☆			
M3	Delivery of draft case study report										☆		
M4	Delivery of final case study report												☆

The steps to achieving the milestones in Task 4 are outlined below:

- **M1 Pilots selected** – To deliver this milestone the service providers have had to engage with the stakeholders early on in the project, starting from October 2020 till January 2021. This includes one-to-one meetings between the stakeholder and service provider representatives, this was done

to better understand the needs of the stakeholders and to also help with the process of selecting the pilot case studies.

- **M2 Tool testing complete** – To complete this milestone a few steps are involved namely; the gathering of local level data and the relevant spatial planning frameworks and policies that will be tested by the tool, this will be done over the period of January through to March. As a part of this process, engaging with stakeholders would be essential to ensure that the relevant data and documents have been gathered.

Task 2 Baseline Analysis will be complete in the month of May and during the period between February and May, the service providers will be reviewing and analysing baseline data sources for each region and this analysis will form part of the Case Study reports.

Over the months of April and July, the service providers will test the tool using the case study pilots' spatial planning policies and will assess the effect they have on GHG emissions. Over this period the service providers will also have time to adjust the tool accordingly, thus ensuring that it meets the stakeholders' needs.

- **M3 & M4 Delivery of case study pilot reports** - Delivery of the final case study reports will be in October 2021, work on the delivery of these reports will require liaising with the stakeholders and this will be an ongoing process. As suggested by the feedback of the stakeholders in the inception report, a draft report will be shared with the stakeholders in August, so that they can have the opportunity to comment on the report, which will then be updated to reflect the feedback received. The stakeholders will be given two weeks to get back with feedback, which will give the service provider time to update the document accordingly.

## 5.2 Progress to date

Work on this Task has started early in the project, with an overlap with information gathering for Task 2 Baseline Analysis, where a comprehensive overview and analysis of baseline data sources for each region tested will form one of the sections in the Case Study reports. Plans that are likely to be tested will be reviewed early in order to gain a deeper understanding of what key emissions the tool will assess.

Currently, the case study pilot selection in the four regions is almost complete, with the service providers engaging with local stakeholders to select the most appropriate case studies. The selection of pilot case studies was carried out over the months of November to January, this was done by liaising with the stakeholders, discussions included meetings between the stakeholders and the service providers, Codema for Ireland, Northern Ireland and Scotland and TalTech for Finland. These one-to-one meetings helped the service providers to get a better understanding of the stakeholders' needs and their expectations of this project. The service providers also made suggestions for the case study areas, regarding suitability and location, and supplied a list of data requirements that would be needed from the stakeholders, this data will be used to create an energy and emissions baseline and will also be used to carry out the testing of the tool on the pilot case study areas.

Using local data, where possible, will be a priority in the GHG quantification method. Utilising national datasets mean less relevant results, which reflect the problems and opportunities on the national level rather than territorial, regional or local level. However, it is important that GHG quantification is possible also when the local data is not available. To gather the regional datasets which capture these local characteristics, Codema and TalTech have engaged with the stakeholders to discuss the data availability and detailed lists of datasets are currently being gathered for the four case study areas. This process of data gathering and gathering of relevant policy documents will continue on through to March, in parallel to this, datasets that have already been gathered will start being analysed as a part of Task 2 Baseline Analysis.

## 5.3 Case Study Pilots

In order to ensure the tool is robust and applicable to different countries, the selection process of the case study pilots should ensure a diverse variety of situations that might be encountered by spatial planners. Therefore, the stakeholders were asked to provide pilot case studies that cover a range of different urban types, spatial scales, and with both high quality and more limited data availability.

For case study areas which have detailed information available, it may also be good to compare results with those calculated using more general national data sets. This will indicate the magnitude of the gap using both sets of data and can highlight the most critical data sets when searching for detailed regional data by running a sensitivity analysis for each data set.

## Ireland

Codema along with the Irish stakeholder - the Eastern Midlands Regional Authority (EMRA), have suggested using county Meath as the case study pilot for Ireland, with the possibility of using county Fingal (Fingal is located within the Dublin Region) as a substitute if the datasets for Meath are not as detailed.

County Meath makes part of the Greater Dublin Area (GDA), which includes Dublin (made up of Dublin City, Dún Laoghaire-Rathdown, Fingal and South Dublin), Kildare, Meath and Wicklow. Meath has a population of around 195,000 (Census 2016) and covers an area of 2,342 km<sup>2</sup>. County Meath's close proximity to Dublin, makes it a commuter region and provides a good mix of spatial attributes, having both rural, urban and suburban areas. Over the recent years, Meath has experienced a rapid growth in population which has resulted in an increase in land use change, increase in traffic and has boosted the economy in the area. Its proximity to Dublin and Dublin's educational and transport infrastructure means that Meath offers a location which has some of the advantages of the capital city but with significantly lower costs.

It is also worth noting that the county has been proactive in the area of climate action and have committed to reducing their emissions by at least 40% by 2030. Meath's Climate Action Strategy (which covers the period from 2019 to 2025) is ambitious but pragmatic with the ability to enable others to take action and inspiring them to lead on climate action. It should be noted that Meath is currently in the final process of developing their Meath County Development Plan 2021-2027, Meath's Climate Action Strategy is very much linked to their County Development Plan. Meath County Council has also acknowledged that local authorities are best placed to identify risks and vulnerabilities, and to act on them across a wide range of areas and under EU, National and Local Policies and Regulations.

The stakeholders in Ireland, the Eastern and Midlands Regional Assembly, have provided a list of data availability. Codema and EMRA are already in the process of organising data sharing agreements, which will help speed up the process of data collection.



**Map 1: Location of County Meath. Source: Central Statistics Office, Census 2016 Sapmap Area**

Choosing such a case study will allow the service providers to test the robustness and applicability of the approach based on datasets and typical characteristics for areas that have a variety of settlements and are not in the immediate commuter belt.

## Northern Ireland

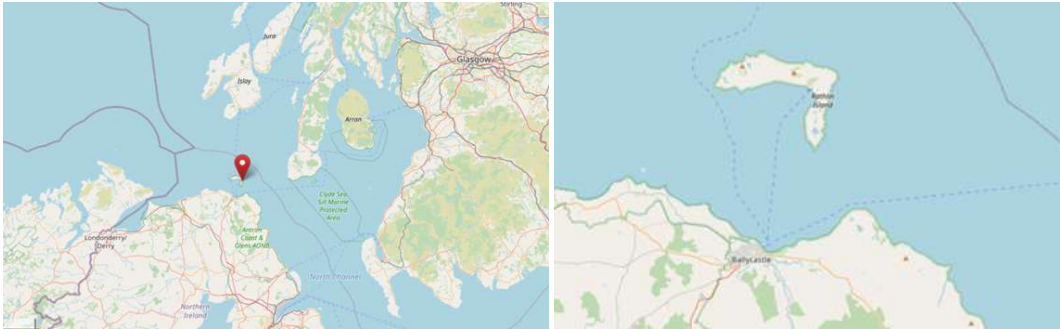
The Department of Infrastructure in Northern Ireland has proposed Rathlin Island as a case study pilot. Rathlin is Northern Ireland's only offshore inhabited island, which can be found 10km away from the north east coast of Antrim. The island is mainly rural, with approximately 160 inhabitants, which is a steady increase in recent years, from 101 inhabitants in 2011 (Northern Ireland Statistics and Research Agency). Rathlin Island covers 14 km<sup>2</sup> of area and enjoys a seasonal population increase, with 30,000 tourists visiting Rathlin annually, most of these visiting during the summer months (Causeway Coast & Glens Borough Council, 2016).

Rathlin Island has a number of natural energy resources, including wind, biofuel and geothermal; these renewable energies, however, are not being used to their full potential by the local community.

Rathlin has ambitious climate goals and aims to become carbon neutral by 2030. The Rathlin Island Action Plan 2016 - 2020 outlines policies to improve energy efficiency and support renewable energy development, with a long-term goal for Rathlin to become carbon neutral. Following on from the Rathlin Island Action Plan, the Causeway Coast & Glens Borough Council is currently developing a Local Development Plan 2035 (LDP) that will cover the area of Rathlin. The LDP forms the basis of land use planning, decisions on planning applications and sets out how the council area land should be used and developed.



It is recognised that the challenges that are faced by this island will vary greatly to the challenges faced on the mainland and thus would have to be addressed differently. The local stakeholders have suggested that one of the spatial planning policies the tool could test out would be the ongoing LDP process in Northern Ireland.

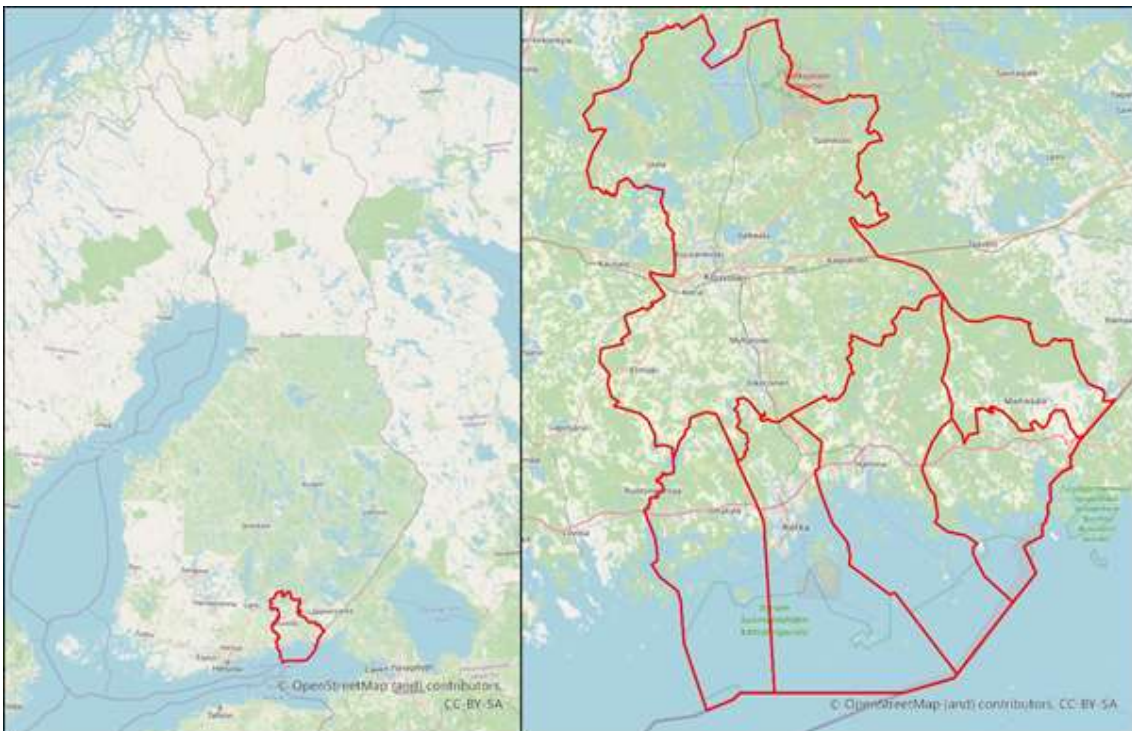


**Map 2: Location of Rathlin Island. Source: OpenStreetMap**

## Finland

The region of Kymenlaakso, in South-East Finland, has a population of 174,000. The largest cities are the harbour city Kotka (55,000 inhabitants), Kouvola (88,000 inhabitants) and the old bastion town Hamina (20,000 inhabitants).

The Kymenlaakso region aims at carbon neutrality by 2040. According to the Carbon Neutral Kymenlaakso 2040 roadmap, the most important greenhouse gas emission reduction potentials are in industry, energy use and traffic. As the population in the Kymenlaakso region is aging and declining, planning of new areas is rare.



**Map 3: Location of Kymenlaakso region, Finland. Source: Regional Council of Kymenlaakso.**

By the proposal of the local stakeholders, the Finnish case study will focus on the greenhouse gas emissions caused by the traffic in the entire Kymenlaakso region. The study is connected to the on-going preparation of the national transport system plan *Liikenne 12* (2021-2032) and the regional transport system planning. The case study will quantify a.o. the impacts of the policies which aim at increasing the modal share of bio gas fuelled vehicles, electric vehicles and public transportation. The alternative policies do not include such infrastructural investments which would require traffic modelling.

The recently collected data and the results of the Carbon Neutral Kymenlaakso Roadmap will be available. It contains municipal level information on traffic, mobility and greenhouse gas emissions. This study includes also quantification of carbon sinks per land use type in accordance with the IPCC guidelines.

## Scotland

The service providers are still in discussion with the local stakeholders and it has been suggested that Edinburgh might be the Scottish case study pilot. Scotland's capital city, Edinburgh is home to over 901,000 inhabitants, of which a population of over 518,000 live in the City of Edinburgh council area. According to the National Records of Scotland the City of Edinburgh has had the 2<sup>nd</sup> highest population in 2018, out of all 32 council areas in Scotland. Edinburgh covers an area of 264 km<sup>2</sup>, it has long been a centre of education, and has been reported as the second largest financial centre in the United Kingdom after London. The City's historical and cultural attractions have made it the United Kingdom's second most visited tourist destination attracting 4.9 million visits including 2.4 million from overseas in 2018 (City of Edinburgh Council).

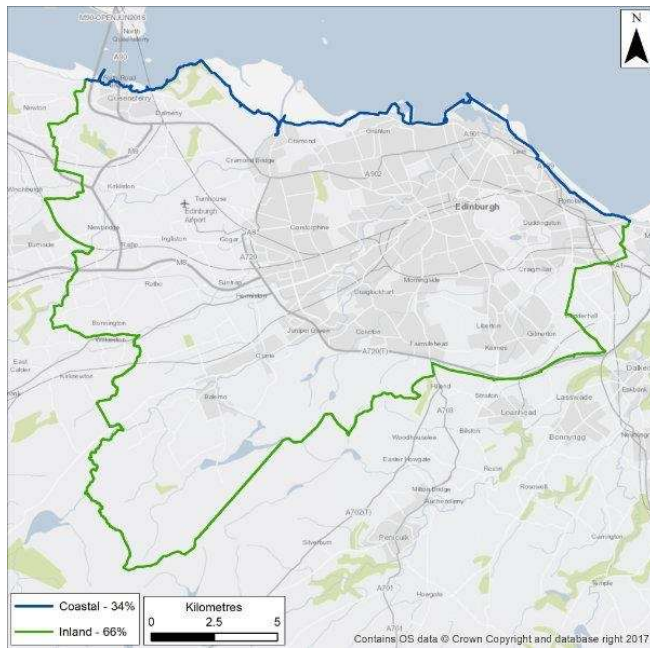
It must be noted that Scotland has been very ambitious in its climate goals and has set a target to reach net zero emissions by 2045. The 2019 Climate Act embeds the principles of a 'Just Transition', which means reducing emissions in a way which tackles inequality and promotes fair work as a way to reach the net zero emissions target. Spatial planning and policy makers can help contribute to national targets, while also trying to address these other economic aspects of the transition.

The local stakeholders have suggested that one of the spatial planning policies the tool could test out at a national level could be the third National Planning Framework. This framework sets out a long-term vision for development and investment across Scotland over the next 20 to 30 years. It brings together all the Scottish plans and strategies in economic development, regeneration, energy, environment, climate change, transport and digital infrastructure to provide a coherent vision of how Scotland should evolve over the next 20 to 30 years. This vision will in turn, help inform future policies and prioritise investment decisions.

At a regional level, stakeholders have suggested testing out the tool on the new Local Development Plan for Edinburgh called the City Plan for 2030. This plan is currently being prepared and will set out policies and proposals for Edinburgh up to the year 2030, it will set out how the city will be developed sustainably over the coming years.

The stakeholders in Scotland, the Scottish Government Planning and Architecture Division, have provided a detailed list of data availability for the sectors that will be analysed (buildings, infrastructure and land use).





**Map 4: Location of Edinburgh, Scotland. Source: Edinburgh.org.**

Choosing Edinburgh as a case study will allow the service providers to test the applicability of this approach based on datasets and typical characteristics for developed urban areas, which have a relatively moderate density and contains a good mix of building uses and transport infrastructure.

## 6 User manual & guidance

Task 5 (carried out during the three last months of the project) produces an on-line user guide in the form of a video manual (to be published on Youtube and linked from the tool site) which will include a hands-on guidance on

- process integration (early stage evaluation and the SEA process)
- use of the tool, for expert and non-expert users
- dataset criteria
- methodology
- developer functionality (how to utilize and develop the open source code) .

The purpose of providing guidance is to ensure that the value of the tool in the spatial planning policy assessment process is maximised. This will include methods how the tool can be integrated into the SEA process and will also provide effective technical and institutional capacities to address urban- and settlement-related drivers of GHG emissions, thus ensuring less carbon-intensive spatial development patterns.

## 7 Coordinating, communication and reporting

### 7.1 Coordination

Due to COVID-19 situation, the consortium works and regularly meets online. Online working sessions are organised on a weekly-basis over Microsoft Teams, Taltech applies project management tools found on Microsoft Teams to coordinate tasks and all project documentation is collected on Google Drive. Some of the online working meetings will be open for stakeholders to participate.

Codema is responsible for communication with the resource persons in Ireland, North Ireland and Scotland. Taltech is responsible for the communication with the resource person in Finland, native-speaker contact ensures fluent communication between the team and the stakeholders.

### 7.2 Communication

The stakeholders are expected to both supply the required data for the case studies and disseminate the information and results. Through the steering committee, they are able to provide feedback and guide the work of the consortium.

**Table 3: Resource persons in the stakeholder organisations**

Eastern and Midland Regional Assembly (IE)	Nicci Nolan
Scottish Government (UK)	Simon Bonsall
Department of Infrastructure, Northern Ireland (UK)	Simon Kelly
Regional Council of Kymenlaakso (FI)	Elina Ronkanen

### 7.3 Reporting

Reporting is arranged in accordance to the submitted tendering documents, service contract and the technical offer. The deliverables are integrated into three reports outlined below:

- 1) Inception report (this report) November 16, 2020
- 2) Interim report April 15, 2021
- 3) Final report. October 15, 2021.

The three reports are created as online Google documents which are open for the whole team to collaborate on. The ESPON templates and maps are used for all reporting and presentation materials.

The consortium will receive written feedback from the ESPON EGTC and the steering committee on each of the above mentioned deliverables within four weeks after receiving them, including advice on the research. The feedback will be discussed during the weekly consortium meetings, and project workload and plans will be adjusted accordingly.

# Annex

## A1 Pilot Case Studies Data Requirements

### Energy use in buildings

- Residential data which is usually gathered through the census or tabula residential typologies for UK - this should be broken down by type of dwellings (apartments, terraced, detached, semi-detached), period built and if possible, occupancy per dwelling
- Database for Energy Performance Certificates or similar, should show the energy performance of different households and ideally includes fuel type, energy use for space and water heating, ventilation and lighting
- Database of all commercial properties, which includes: floor area and property type
- Public bodies' location and energy data - in Ireland this is done through monitoring and reporting of the public sector buildings
- National emission factors for heating fuels and electricity

### Traffic and infrastructure

- Statistics on economic consumption per resident
- Traffic activity statistics
- Mobility statistics
- Modal share
- National GHG emission factors per mode of transportation
- Future prognosis related to mobility, technical development of vehicles and modal share
- Grid electricity emission factor and future prognosis

### Land-use and land-use change

Area of different land-use classes under spatial planning (ha):

- 1. Forest land
- 2. Cropland
- 3. Grassland
- 4. Wetlands, including peat extraction sites
- 5. Settlements
- 6. Other land

Carbon pools considered in all land use classes:

- Biomass: growing stock present before land-use change. Country-specific data can be derived from national inventory reports, national forest inventory or other data sources specified by the stakeholder. Root-shoot ratio (available in the IPCC guidelines if not specified by stakeholder) will be applied to estimate the share of above- and belowground biomass.
- Dead organic matter: litter and dead wood. Country-specific data can be derived from national inventory reports, national forest inventory or other data sources specified by the stakeholder.
- Soils: area of mineral and organic soils (all soil types should be classified under two main groups: mineral and organic soil). Soil carbon emission factors can be derived from national inventory reports or other data sources specified by the stakeholder or default EF-s from the IPCC guidelines can be applied.

## A2 Time table

	2020				2021									
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Task 1				☆										
Task 2								☆						
Task 3											☆			
Task 4				☆						☆	☆		☆	
Task 5													☆	
Task 6													☆	
Delivery 1		☆												
Delivery 2							☆							
Delivery 3													☆	
Kick-off meeting	☆													
Steering Committee Meetings[RC1]				1st				2nd						3rd
Mandatory outreach events							☆			☆			☆	

☆ = Milestone

## A3 Risk assessment

Project management		
Challenge	Impact	Mitigation Measures
Coordination of 11 staff across 4 organisations and 3 countries	Uncoordinated work delivery leading to suboptimal outputs	Strong internal communications plan to be led by the Project Manager, TalTech. Regular online meetings & documented minutes
Language barriers	Mix of English and Finnish documents that are not fully understood by all partners	Mix of English and Finnish speakers in the consortium to help translate and to provide translations
Time management - 12 month project	Time not managed well and deliverable timelines not achieved	The consortium brings experience from previous projects and tool development as a starting point for the project which will save time, and the PM will ensure deadlines are met. The consortium has set regular video-meetings
COVID-19 restrictions are continued and face-to-face meetings, including project team, Steering Committee and case area focus groups meetings, cannot be held	Timeline of meetings may need adjustments	Meetings will be transferred to the video-conferencing platform (Microsoft Teams)
Data collection		
Challenge	Impact	Mitigation Measures
Consistent and comparable data availability for baseline analysis	Inconsistent baseline analysis, data incomparability	Engaging with the stakeholders for data collection; reducing the input data to ensure data consistency and comparability; identifying the data needs for further research
Tool and method viability		
Challenge	Impact	Mitigation Measures
Meeting user requirements	Low uptake of the tool by target audiences	Involve external focus groups, which includes both expert and non-expert users, from early development stage
Process integration	The proposed methods and tool are not adopted by the users	Investing in user interface and developing on-line guide materials; collecting feedback from SEA professionals during the tool development; utilizing the experiences from EcoCity Evaluator tool; promotion of the method and tool.
Method viability in various situations and planning systems	The proposed methods and the tool are not adopted by the users	Expert feedback is collected from various countries during the development; case studies are diverse in scale and level of urbanisation
Ensuring universal (Europe-wide) tool application	The tool fails to achieve both broad usability and the support of non-expert stakeholders	Ensure pilot projects are tested with a wide range of user profiles and based on them having a wide range of data to input both in terms of quality and quantity
Future-proofing	Limited value gained from the tool due to evolving standards and regulations making it outdated	Producing an open-source tool with modular structure; planning of future hosting; proposing continuation projects

## A4 Additional details on the tools within the case study areas

### A4.1 Tool methodologies

The first tool to be considered was SPACE. In relation to others that will subsequently be described, such as MapEire or the SYKE tool, SPACE only considers a limited number of emissions sectors, as well as mostly, but not exclusively, calculating emissions occurring during the lifetime of the building. That is, it is mainly production-based. These sectors are respectively defined as energy use, including electricity, waste, land-use change and transport. Used as standard, the tool effectively only assesses CO<sub>2</sub> equivalent based emissions (unlike the SYKE tool and MapEire) and also generalises building emissions into broad categories; Housing, Commercial and other buildings, such as schools and hospitals. Housing and Commercial buildings can further be subdivided into components, which for housing are flats, terraces, or (semi-) detached houses. Additionally, further greenhouse gases that may also be important for specific developments could be included, effectively through placeholders. However, the value of this is uncertain given that the tool does not aggregate emissions into a single number, instead leaving separate the results from each sector. Emission reductions are projected into the future through reduction in electricity and fuel emission factors, but not through any changes to lifestyle.

In contrast, the emissions considered within MapEire are extensive, encompassing 32 pollutants from 138 sectors, including all 7 GHG mandated by the UNFCCC and all non-GHG pollutants required under the European CAFE and CLRTAP directives. This makes it applicable to other factors important in spatial planning, such as air quality. It adds additional value by considering carbon sequestration through the LULUCF sector, which is not included in SPACE.

In further contrast to SPACE, MapEire does not directly calculate emissions per se. Instead, it seeks to determine relative emissions from different geographical regions for each of the sectors considered, and then assign a proportion of the Irish national emissions inventory based on known pollutant or activity data, or proxies if these are not available (it is thus a top-down methodology). The emissions are assigned to a map of Ireland with a resolution of 1 by 1 km, with higher resolutions also feasible and demonstrated in the Dublin area. It can be moreover envisaged that similar data could also be used based on other extensive national or regional inventories, whilst the geographical desegregation is also clearly of value in spatial planning, as well as potentially making the results obtained in a potential comparative analysis easily communicable to relevant stakeholders.

A relatively similar model has been developed in Finland (GISPO, 2018; Hastio, 2019; Mäkinen, 2019; UBIGO, 2019). The SYKE tool was built through a collaboration between the Tampere government and two Finnish software companies ('Ubigo' and 'Gispo'). It has also so far only been applied in the Tampere region. The tool runs as an extension to an open-source GIS programme (QGIS) and is mostly based on national and regional level data, although with a framework provided for including more accurate local level data if available.

The tool considers a greater number of sources than SPACE and appears to follow a more life-cycle based approach, for example considering construction, repair and demolition emissions for buildings. It is also strongly focussed on future emissions, which are considered through different parameters representing a range of policy engagements towards minimising and mitigating carbon emissions, and feasible scenarios for population growth within the city. The user therefore has a greater degree of control over how emissions will progress into the future than in SPACE. This is a key strength given the timescale of building development and use and the subsequent lock-in of harmful or positive aspects. As discussed, this is therefore something that should be considered a useful component to be included in the QGasSP tool.

A final, recent on-line tool is known as SCATTER (Nottingham City Council *et al.*, 2019). This was developed for UK-wide application by local governments in Nottingham and Manchester, along with the Tyndall centre for climate research and 'Athesis', a company from the private sector. Scatter is a browser-based tool for establishing a carbon inventory based on the GPC methodology at the BASIC level. The authors further note that similar tools for establishing a GPC inventory are also available for different regions.

It is broadly based on UK national statistics subsequently assigned to local authority regions (and is thus largely top-down and production-based). In contrast to some of the published literature, this also points to



the feasibility of the GPC methodology. Moreover, like SYKE the tool provides emissions trajectories until 2050 that can be modified by a large number of different macroscopic policy scenarios. Whilst this would not be appropriate for the more detailed, project-specific developments, it could be beneficial when considering the larger spatial scales. It is also the only tool that provides a clear basis for developing systematic baseline inventories without requiring a high-level of expertise by the end user.

## A4.2 Ecocity Evaluator

In Ecocity Evaluator, specific developments are computed, and emissions are considered from buildings (including the life-cycle emissions), infrastructure, energy (heating of air and water, ventilation and electricity), traffic and land use. Infrastructure is determined based on the existing street network of the region considered for the development. Emissions from electricity (and any electric heating) are established based on an understanding of the regulations followed, in order to determine consumption, scaled by pan-Finnish emission factors. Alternatively, district heating emissions follow municipality-specific fuel distributions. Traffic is separated into commute and freight categories, (to our best understanding) with surveys used to determine activities at the target region, and Finnish-specific emission factors (including emission from production). Finally, land use emissions are determined using global values for deforestation.

Consequently, the methods applied are actually similar to SPACE, with some exceptions – for example including building life cycle emissions. As with SPACE electricity and heating emissions are seen to decrease through decreased emission factors (although Ecocity Evaluator does include a separate solar energy calculation, unlike SPACE), but there are additional considerations in terms of traffic, where social aspects such as a greater uptake of low emissions vehicles and changes in travel habits are considered. Moreover, individual building designs can be imported into the software to improve the accuracy of calculations, as well as a basis for determining results for future developments of a similar type. In practice, this means that for most emission factors, there are 3 additional multiplier sets that can be applied in the UI, that reflect the (technological or behavioral) development either pessimistically, conservatively, or optimistically.

## A4.3 Usability and Suitability

Considering the tools in the context of the QGasSP brief, they differ in many important aspects, with no single tool apparently suitable to cover the breadth of applications targeted. For example, whereas MapEire and the SYKE tools have graphical user interfaces and are essentially stand-alone applications, the SPACE tool is excel-based, and SCATTER has an online interface but no geospatial component.

Looking first at SPACE, one advantage is that it is highly comparative as different scenarios can be quickly produced and considered against each other in real time. This is of clear value when used by non-experts by making prospective changes communicable. The SCATTER tool also appears to have a comparative aspect, at least at the policy level. Moreover, both SPACE and SCATTER appear to have much lower data and computational requirements than MapEire or SYKE. Finally, SPACE is the only analysed tool with direct application to SEA built into the development process (for which assessment of reasonable alternatives is a key aspect).

However, it is also limited in several respects. For one, it does not allow emissions to be aggregated into a single number, and this critically hinders comparability between different regions, or even different developments. It also makes it harder for the tool to be used by non-experts due to the lack of advice on how to interpret the respective weights of the individual components. Moreover, future emissions over time are only considered very generally through perceived changes to electricity and transport emission factors (and have to be built as separate calculations by the user for each year considered). Turning again to SCATTER, although this is clearly a useful tool for allowing regions to understand their GHG emissions, it is currently only applicable and indeed accessible to local governments in the UK. Furthermore, given the proposed Europe-wide use of the tool, the UK specific methodology would require some modifications for other regions, whilst attribution of top-down national data may limit the level of granularity when applied to the smallest scales. Moreover, like SPACE and unlike the reference Ecocity evaluator, it again does not include a consumption-based approach. It also does not seem appropriate to SEA practitioners or seemingly allow the degree of flexibility necessary for more advanced or region-specific policy analysis, although it is expected this could be easily introduced.

The geospatial components of MapEire and SYKE have benefits for interpreting results along with promoting stakeholder engagement. The levels of detail, moreover, have clear advantages, but can also be seen as a hindrance in comparison to SPACE and SCATTER. For example, calculations in MapEire can take up to a day to calculate data for a single year, at least for the baseline calculations. This also calls into question the usability of the tool by non-experts, and the computational requirements preclude a web-based tool unless the calculations are sent to an external server. No information is provided on the time taken for calculations in SYKE, but the similarity to MapEire, albeit over a much smaller area, also suggests a longer timeframe.

More critically, it does not appear that either tool includes any facile method for performing comparative analysis between different scenarios. In practice, they are tools for geographically desegregating emissions, and not something directly applicable to spatial planning as envisaged in the project brief.

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