

# Gap analysis of greenhouse gas (GHG) emissions inventory methods for Trondheim municipality

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Trondheim | January 2016

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# Preface

## About LoCaL

This report was written through support from Low Carbon City Lab (LoCaL). LoCaL aims to reduce 1 Gt of CO<sub>2</sub> and mobilize €25 billion of climate finance for cities annually by 2050. It is an innovation platform aiming to provide cities with better tools for assessing greenhouse gas emissions, planning, investing and evaluating progress. Started in 2015, LoCaL is a growing community of more than 20 organisations dedicated to unlocking climate finance for cities. This report was realized as part of the project Closing the Gap through Transformative LoCaL Action (CGTLA) under LoCaL.. LoCaL is a Climate-KIC flagship programme.

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## About Climate-KIC

Climate-KIC is the EU's largest public private partnership addressing climate change through innovation to build a zero carbon economy. We address climate change across four priority themes: urban areas, land use, production systems, climate metrics and finance. Education is at the heart of these themes to inspire and empower the next generation of climate leaders. We run programmes for students, start-ups and innovators across Europe via centres in major cities, convening a community of the best people and organisations. Our approach starts with improving the way people live in cities. Our focus on industry creates the products required for a better living environment, and we look to optimise land use to produce the food people need. Climate-KIC is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union.

## About this report

This report is part of the Carbon Track & Trace (CTT) project. The gap analysis presented here is the result of a research and innovation collaboration between the City of Trondheim, the Norwegian University of Science and Technology (NTNU), and ICLEI Europe– Local Governments for Sustainability. Funding for the project was provided by the Climate KIC Low Carbon City Lab (LoCaL) flagship project along with additional in-kind and monetary contributions from the City of Trondheim, NTNU, Numascale, and Wireless Trondheim. The Carbon Track and Trace (CTT) project is intended to provide the City of Trondheim with a sound empirical basis for the development of more advanced greenhouse gas emissions inventory methods, including the eventual deployment of autonomous sensors and automated software to reduce the cost and complexity of conducting GHG inventories. An additional goal of the project is to help develop better methods of decision-support and planning support for municipal mitigation planning through integration into strategic planning instruments, cost-benefit assessments (CBA) and geo-spatial databases.

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# Executive Summary

Some of the key findings from this study are as follows:

**Challenge I - Calculation versus measurement** Aside from direct measurements of large stationary power/thermal plants and factories, cities that use the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC) methodology rely frequently on calculated or modelled emissions derived from national level figures. In practice, this means that national energy consumption levels are statistically downscaled to regional and municipal levels by oversimplified division of aggregate population. Additionally, the transportation activity data is frequently out-dated and based upon non-validated estimations and travel surveys that are uncorrected for known biases. This is particularly problematic for transportation emissions which comprise 30-40% of all municipal GHG emissions in Norway.

**Recommendation I** Trondheim Municipality should use resources within the existing Miljøpakken (Environmental Package) and other policy instruments to deploy a range of sensors across the city to track emissions from motorized transportation. Additionally, more detailed data sources such as those from tolling stations and real-time traffic counting stations should be collected from national authorities in order to provide a more robust validation procedure for estimated versus actual emissions.

**Challenge II - System boundaries count** The use of either administrative, geographic, or systemic boundaries has significant implications for the overall GHG emissions tied to a city or region. This is particularly true for consumption and production of goods and services, but is also an issue when dealing with aviation, shipping, and through-transport of on-road vehicles. While the GPC recommends using Scope 3, there is currently no standard methodology for accounting for extended upstream and downstream activities that occur outside of the political or geographic boundaries of a city. Basic issues such as what constitutes upstream and downstream emissions in urban agglomerations and peri-urban areas, fugitive emissions from Industrial Processes and Product Use (IPPU) and waste, and emissions from grid-supplied energy from outside a municipality's boundaries are all subject to a wide range of interpretation.

**Recommendation II** Trondheim Municipality should adhere to the BASIC+ framework within the GPC, accounting for Scopes 1 and 2 (direct and indirect grid-supplied energy). While conducting Scope 3 inventories (including carbon foot printing and life cycle assessment) when technically feasible, e.g. in the public procurement of goods and services, the large uncertainties in data quality, lack of a reliable and consistent methodology, and low cost-benefit ratios argue against incorporation of Scope 3 GHG emissions.

**Challenge III - Data quality and reliability** Uncertainty ranges for GHG emissions are still questionable for many city and regional emission inventories, particularly in transportation, grid-supplied energy, and most of the Scope 3 emission sources<sup>1</sup>. Due to the prevalence of downscaling national level statistical data, incomplete or inaccessible energy data from private companies, or the absence of reliable travel data, there is still a significant amount of uncertainty as to the accuracy, precision, and reliability of the reported inventories. When cities are looking for private or public finance to support mitigation actions or to bolster public support for more

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<sup>1</sup> Larsen and Hertwich (2007)

stringent climate mitigation policies, these uncertainties present large obstacles for making a strong business case to support more aggressive mitigation actions in the energy, built environment, and transport sectors.

**Recommendation III** Trondheim Municipality should work both from the top down (national statistics downscaled) and bottom-up (building- and street-level real time emissions sensors). One of the key goals of the Miljøpakken is to reduce emissions from the transport sector by 20%. However, the absence of any kind of emissions data since 2009 would suggest a rather urgent need to fill in data gaps in transport-related emissions inventories. Moreover, while Statistics Norway will re-start the publication of municipal emissions inventories in January 2016, the inventories will lag by two to three years, leaving the city without up-to-date emissions data for a proactive climate policy.

**Challenge IV- The SSB problem** Norwegian cities, including Trondheim, have been operating in a climate information deficit since 2009, which was the last year that Statistics Norway (SSB in Norwegian) produced full city-level emissions inventories. SSB stopped producing emissions figures in 2012 (the inventories have a 2- to 3-year delay) due to concerns of data quality, uncertainties, and lack of confidence in how the figures were being used to support municipal climate change strategies and policies. A further issue with the emissions inventories prepared by SSB is that figures are not disaggregated by specific gases (e.g. CO<sub>2</sub>, CO, CH<sub>4</sub>) but rather are reported in CO<sub>2</sub>-equivalents. One consequence is that the municipality cannot reliably link either increases or decreases in overall emissions to specific point sources. Additionally, the use of national statistics masks large variations in local conditions, such as Trondheim possessing an EV fleet substantially larger than average Norwegian cities. SSB's methodology tends to overstate on-road transport emissions due to inaccurate calculations of average vehicle fleet composition. An uncertainty analysis conducted during the CTT project indicated that while emissions data for stationary energy, agriculture, district heating, and rail/ship/aviation transportation were all of moderate to high validity, emissions data produced for on-road transport, waste, and residential/commercial building energy usage were very low quality and had high elasticities (meaning that emissions outputs are more sensitive to changes in input parameters).

**Recommendation IV** Trondheim Municipality should consider expanding their GHG emissions data collection methodology to include building- and street-level real-time emissions measurements, combined with downscaled satellite measurements as quality checks and validation procedures on the SSB-produced figures. In addition, methods should be developed to check for confidence intervals and uncertainty parameters for emissions data, as well as robust mechanisms to ensure that this information is delivered to policy makers, planners, and politicians in an understandable fashion.

**Challenge V - Multiple Data Sources, Multiple Reporting Platforms** Like most cities around the world, Norwegian municipalities have had to combine GHG emissions data delivered by Statistics Norway (SSB) with local directly measured emissions from local point sources such as stationary energy production, district heating, waste incineration, factories, and so on. Since the SSB data is not aligned with the reporting formats of the Covenant of Mayors Sustainable Energy Action Plan (SEAP) or the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC), Trondheim Municipality is required to spend significant resources to re-purpose the data sets to fit the different reporting formats. Furthermore, it is frequently difficult for the city to perform validation checks on the underlying raw data, for example liquid fuel sales that are kept secret by the Norwegian Government. A consequence is that GHG emission inventories are unnecessarily

difficult to produce on a regular basis, and the data is often not useable to guide strategic or operational planning for mid-term and long-term climate change mitigation goals.

**Recommendation V** As noted in the accompanying Workflow Analysis report, the feasibility of developing an automated software package should be explored in order to extract, analyse, and report GHG emissions inventories in a variety of platforms and formats using the same underlying database structure and syntax.

## Project Background

Municipal GHG emission inventories are frequently expensive and time-consuming to build, maintain, validate, and evaluate. The absence of detailed cost/benefit calculations for ex-ante, ex-durante, and ex-post appraisal means that municipal and regional governments often lack even rudimentary understanding of projected or outturn costs and benefits of their mitigation strategies. Additionally, the lack of fine-grained data inhibits the ability of cities to tie specific climate actions to actual measurable reductions in GHG emissions. The Carbon Track and Trace (CTT) project is divided in two phases. In Phase 1, a gap analysis comparing recommended Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC) inventory methods to current practice in Trondheim Municipality has been produced. To address the identified gaps, a general workflow process will be produced and evaluated to support subsequent development of a scalable software platform to automate many of the GHG emission inventory steps, reducing the cost and complexity of city or regional level GHG emissions inventories. In Phase 2, the CTT project will develop a GPC-compliant software package and run field trials of various types of emissions data collection devices, including flux towers, building-mounted sensor arrays, citizen observatories and transmission networks (including adaptable sensor platforms, smartphones, wearables, wifi base stations, and mesh networks), drones, as well as airborne/satellite data from the National Aeronautics and Space Administration (NASA)/Japan Aerospace Exploration Agency (JAXA) satellites such as the Orbiting Carbon Observatory 2 (OCO-2), Soil Moisture Active Passive (SMAP), Greenhouse gases Observing SATellite (GOSAT), and the Total Carbon Column Observing Network (TCCON). The CTT project has sub-national governmental entities such as cities, city-regions, and regional governments as main target groups, with Trondheim Municipality as local partner and source of expertise.

## Methodology

The data sources that form the empirical basis for this report are primarily comprised of Trondheim Municipality planning and policy documents, relevant datasets published by Statistics Norway, publicly available documentation from the Global Protocol for Community Scale Greenhouse Gas Emissions, interviews with key staff at ICLEI and Trondheim Municipality. Additionally, workshops were held to provide critical feedback on the gap analysis as well as a number of small-group interviews with municipality staff.

# Trondheim GHG Emissions Inventory Policy Background

Trondheim Municipality's climate goals have established targets of 25% reduction in GHG emissions by 2020 and 70-90% reductions by 2030 (using a 1991 baseline)<sup>2</sup>. Better GHG accounting was enshrined as a key priority area in Trondheim's existing Energy and Climate Action Plan. A revised version of this plan will be adopted by the City Council in November 2016, with GHG accounting, more detailed climate change measures, and cooperation with the broader community as prioritized focus areas. Trondheim is working with two main types of GHG inventories: (1) Better GHG emission accounting for Trondheim municipality's geographical area (direct emissions); and (2) GHG emission accounting for Trondheim municipality's activities:

**(1) Better GHG emission accounting for Trondheim municipality's geographical area (direct emissions), with two prioritised areas: transport and stationary energy** In 2012, Statistics Norway (SSB) stopped publishing statistics on municipal GHG emissions because of quality

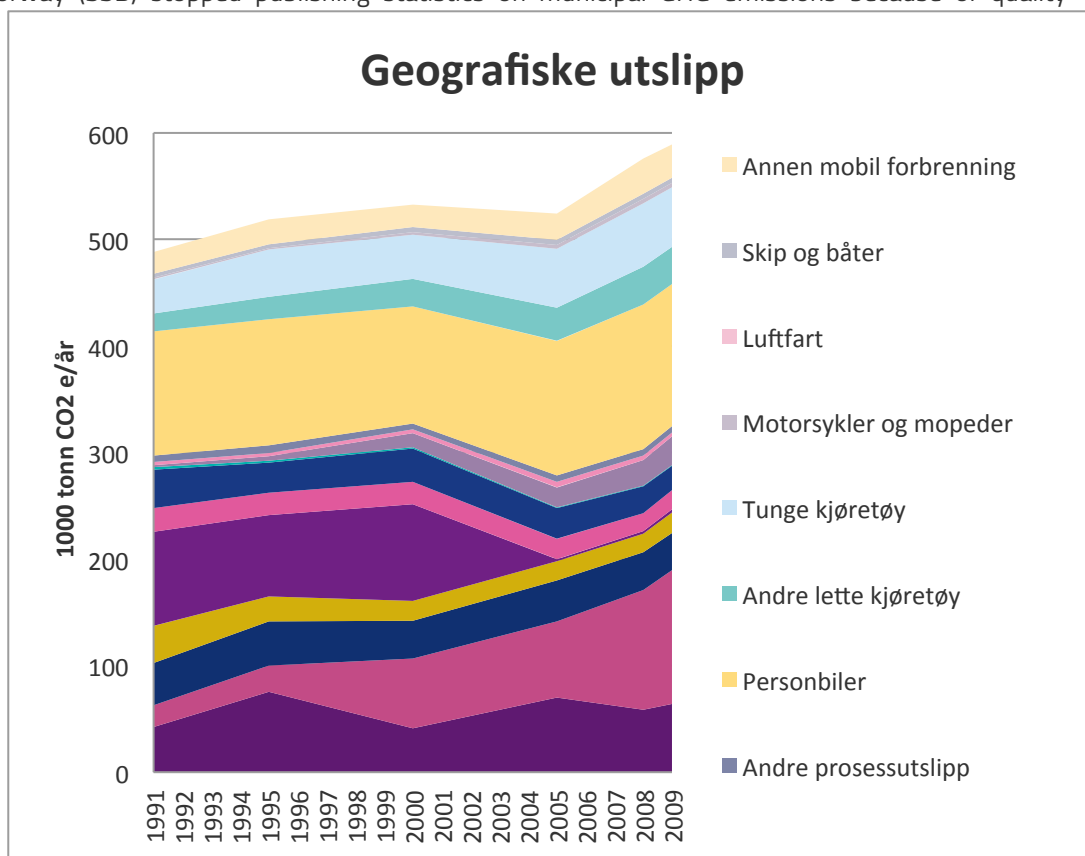


Figure 1: GHG Emission Trends in Trondheim 1991-2009

<sup>2</sup> Trondheim Kommune (2010)

concerns. Hence no national statistics for GHG emission data are available for Norwegian municipalities from 2009 onwards. Figure 1 below shows a general upward trend line for GHG emissions in Trondheim, particularly in on-road transport (the blue and green colours in the graph). Trondheim, Oslo, Bergen and other Norwegian cities have for several years been in dialogue with SSB and the Norwegian Environment Agency on how these statistics can be resurrected. SSB has begun to publish GHG emission data at county level again, the first time in 2014. Just before summer of 2015 SSB announced their aim to publish figures on municipal level again – starting from December 2015 – when they aim to publish GHG emission data for 2009, 2011 and 2013. The city council of Trondheim has made several decisions that emphasize the importance of local GHG emission accounting, stressing that Trondheim will develop local GHG emission accounts if SSB does not resume its work in publishing local GHG emission data. One challenge with SSB's methodology is that the data is published with a 2-year delay. It is therefore interesting for Norwegian municipalities if it is possible to obtain additional methods (e.g., using sensors, Big Data Analytics, etc.) that provide much quicker indications of trends in GHG emissions in the city.

Transport: Trondheim needs better data for GHG emissions from road transport within the city's physical limits, both light and heavy vehicles. Trondheim municipality (and other municipalities) have no access to data for fuel sales in their own municipalities. SSB collects sales figures from the oil companies, but is not allowed to disclose these to the municipalities. Trondheim municipality is working to get better data on transport and associated GHG emissions, and their changes over time. This is time consuming and difficult work, and includes traffic counts (radar loops, toll stations), average annual daily traffic based on noise mapping, data on the car fleet in Trondheim, and pathway lengths distributed across national, county and municipal roads. When SSB hopefully publishes municipality data in December 2015, Trondheim will be able to compare these to its transport database. The Norwegian government has also invited the largest cities to establish so-called Urban Environment Agreements, using government funding incentives to ensure that growth in passenger transport is embedded in public transport, cycling and walking (not private cars). This target will be evaluated by means of travel surveys with figures for the modal split and its evolution over time, as well as monitoring of transport-related GHG emissions; for the latter there are currently no satisfactory methods in Norwegian cities.

Stationary energy: Trondheim has access to good data for the calculation of GHG emissions from district heating (11 heating plants included in the city's district heating network in total). However, there are different methods to calculate GHG emissions from waste incineration and to analyse waste composition. Trondheim municipality would also like to get better data on GHG emissions due to consumption of heating oil, bio energy and gas in industry and construction in Trondheim, for which they have no access to data. This applies both to (smaller) industrial, commercial and residential buildings.

**(2) GHG emission accounting for Trondheim municipality's activities** Trondheim municipality has long-standing efforts to monitor and reduce GHG emissions caused by its own municipal activities, based on an analysis performed by consultant company MISA / Asplan Viak in 2013-2014<sup>3</sup>. The work was approved by the City Council early 2015, and embedded into the municipal Energy and Climate Action Plan with specific emphasis on construction, technical services and infrastructure, and procurement of products and services; direct emissions based on service transport and fuel are embedded as well. The City Council demanded that GHG emission

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<sup>3</sup> MISA (2014)



accounting be performed for direct and indirect emissions every two years, based mainly on the city's financial statements.

It is important to note that the GPC Protocol itself only defines scopes and the way that the calculations, including adaptation factors and multipliers, are done. There are recommendations on commenting and noting data sources, but the actual data acquisition is not part of the standard. According to ICLEI's experience, it takes an experienced city employee around 3 months to prepare a report. For Trondheim, this number can range between 3-6 person months, depending on the scope definition (1, 2, or 3).

# The Global Protocol for Community Scale Greenhouse Gas Emissions (GPC)

In contrast to national guidelines and standards for reporting GHG emissions developed by the Inter-Governmental Panel on Climate Change (IPCC), there are a number of municipal and regional emission inventory methods that either have been used or are currently in use. Unlike the IPCC standards that focus exclusively on production, city-based inventories are more complex since they are affected by not only direct emissions within the city boundaries but also by upstream and downstream activity<sup>4</sup>. Furthermore, there are a number of different standards and methods available to cities to guide their emissions inventories. These include: the Greenhouse Gas Regional Inventory Protocol (GRIP), the International Standard for Reporting Greenhouse Gas Emissions for Cities and Regions (UNEP/World Bank), ICLEI's International Local Government GHG Emissions Analysis Protocol (IEAP - the predecessor to the GPC), the European Commission's Covenant of Mayors, Bilan Carbone (France), and Greenhouse Gases ISO 14064:2006. What little comparative research on the potential differences between these methodologies that has been completed to date indicates that the application of different inventory methods can have dramatic effects on the calculated GHG emissions, especially in the transport sector and indirect emissions<sup>5</sup>. Moreover, as illustrated in Figure 1, the comparability of cities' self-reported GHG emissions may be suspect due to the lack of a single standard methodology<sup>6</sup>.

Therefore the GPC was co-developed by the C40 Cities Climate Leadership Group, ICLEI – Local Governments for Sustainability, and the World Resources Institute (WRI) in order offer a more robust and comprehensive GHG emissions inventory method that would allow for more accurate

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<sup>4</sup> Kennedy, C., Steinberger, J., Gasson, B., Hansen, Y., Hillman, T., Havranek, M., and Mendez, G. V. (2009).

<sup>5</sup> Ibrahim, N., Sugar, L., Hoornweg, D., & Kennedy, C. (2012).

<sup>6</sup> Driscoll, Ahlers and Valsasina (forthcoming).

benchmarking and comparisons between cities and other sub-national entities such as counties and regions.

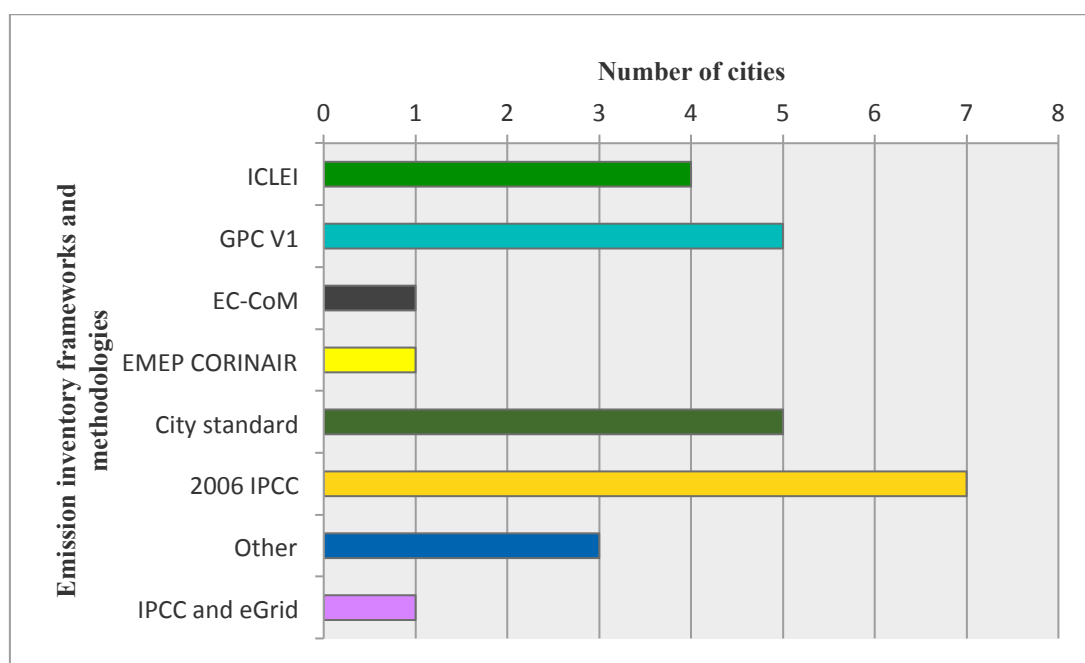


Figure 2: GHG inventory methods employed among 27 North American and European cities

The GPC has undergone several stages of city testing and stakeholder involvement. The latest version (2.0) was launched in December 2014 and contains several improvements from its pilot versions, making it more user-friendly and technically robust. It now includes:

- Boundary setting and reporting levels: The GHG Protocol ‘scopes’ framework has been adapted to suit the needs of a city-level inventory and help clarify boundaries for emission sources and reporting (see Figure 3 below). Multiple reporting levels (BASIC and BASIC+) accommodate city differences in technical capacity and data availability.
- Elaboration of calculation methods and procedures by sector: This includes new guidance on data collection and GHG emissions calculation.
- Comparison with IPCC national inventory practices and other city guidance documents. For cities that have followed other inventory approaches in the past, including adapting national inventory practices to a city, the GPC shows how these different frameworks align with the GPC and to translate these into a GPC-compliant report.
- Clarification on inventory aggregation. Increasingly, city GHG data is shared with national governments and informs national initiatives. The GPC draft identifies how multiple cities’ inventory data can be rolled up or aggregated at the national level while avoiding double counting.
- Guidance on setting goals and tracking emissions over time. The GPC follows international best practices, including those in the emerging GHG Protocol Mitigation Goals Standard, in elaborating how cities can set different types of GHG reduction goals and measure progress consistently as cities change in administrative boundaries or adopt better data and methodologies.

Today the GPC is seen as the most comprehensive GHG accounting and reporting framework for cities around the globe and has become an emerging standard for the Compact of Mayors, ICLEI and C40 Cities amongst others, as it allows local and regional governments to use this consistent standard to:

- Set emission reduction targets
- Track performance, responding to regulations and requirements of local GHG programs
- Build and report GHG inventories which are compatible with international standards (incl. the IPCC national reporting guidelines)
- Allow horizontal aggregating and vertical integrating city GHG data
- Provide solid proof of GHG developments for carbon financing.

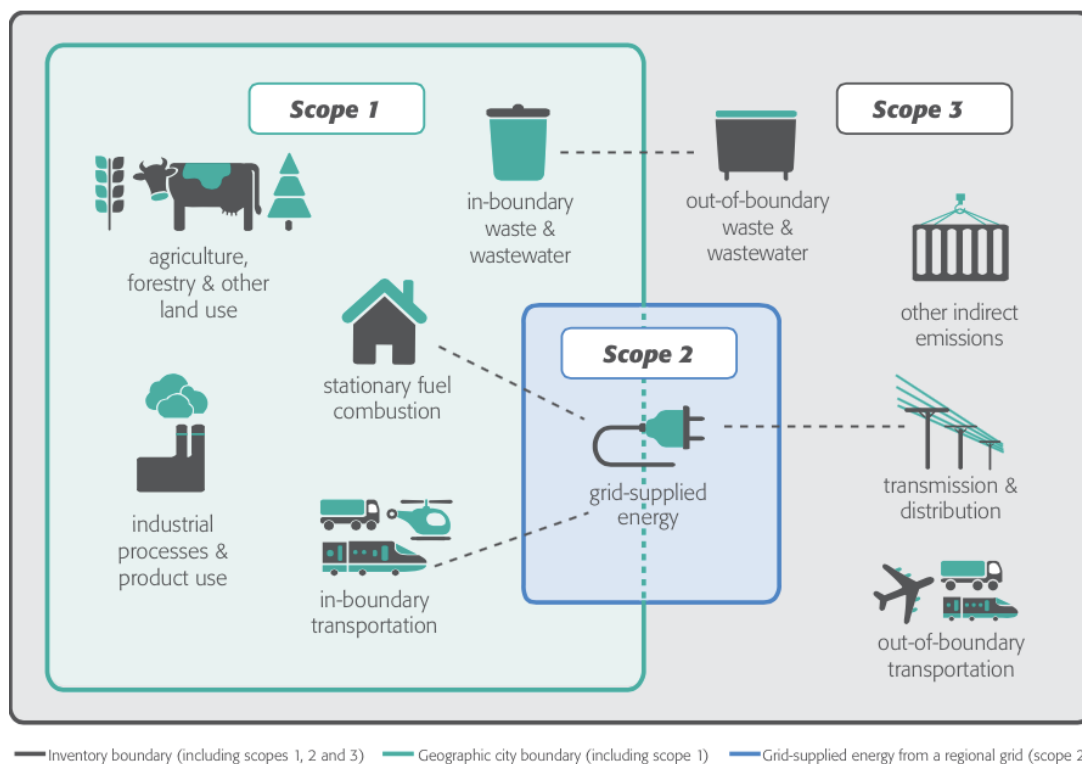


Figure 3: Scope 1, 2, and 3. Source: World Resources Institute (2014)

# The gap between the GPC and current GHG inventory methods in Trondheim

Using the GPC as a benchmark, the state of the art in Trondheim for Scope 1 GHG emissions inventory is quite well-developed for large point-source emissions such as those from stationary fuel combustion, district heating, waste incineration, and IPPU. However, on-road transportation and residential/commercial energy consumption present some challenges in order to comply with the requirements of the GPC. The most pressing need is simply data, since there is no data since 2009. Data acquisition in this area is further hindered by the inability of municipalities to obtain fuel-sales data from the Norwegian government, and the activity data, modal share, energy intensity, and fuel factors are constrained by the poor quality and unreliable estimates provided by SSB. A potential solution to this issue is to combine data sets from tolling stations, traffic counts conducted by the Norwegian Road Directorate, and direct point measurements of on-road GHG emissions. Another potential barrier to adopting the GPC methodology is the treatment of transboundary trips, since there is currently no robust method to assign accurate origin/destination values to trips that pass through the city or region. Furthermore, many of the input values used by SSB for determining Vehicle Kilometers Travelled (VKT), fleet composition, and mode share are still to a large extent modeled rather than measured, which according to the GPC methodology would indicate rather low data quality<sup>7</sup>.

Another issue to flag is that of verification. Currently, Trondheim Municipality does not conduct independent third-party reviews of its emissions inventories, whereas the GPC recommends such practices in order to increase confidence in the reported figures. The conduct of such third-party verification scheme would also increase the likelihood of discovery of poor quality data in various sectors. Poor data quality is not the only barrier toward GPC compliance. SSB acknowledged in 2012 that due to significant variations in the reported bottom-up data from Norwegian municipalities coupled to questionable downscaling methods of national data that it is not even feasible to conduct even rudimentary uncertainty test and confidence intervals on their own data sets.<sup>8</sup> The GPC recommends that reporting cities use a specific annotation scheme to rate the data quality, something that given the current quality of data would not be possible.

In Phase II of the Carbon Track and Trace project (expected start date 01.04.2016, provided successful funding), the gap analysis and workflow analysis will provide the initial guidance for the wider deployment of the GHG emissions sensor system in Trondheim (NO) and Vejle (DK). Furthermore, the inclusion of both ICLEI-Europe and ICLEI-World in Phase II will ensure that many of the issues flagged within this report regarding process and data flows in the GPC (and other) emission reporting frameworks will be systematically addressed by those who were instrumental in the development and application of the GPC.

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<sup>7</sup> WRI (2014)

<sup>8</sup> Statistisk Sentralbyrå (2012)

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