Local climate action; counting challenges

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Abstract

One of the challenges faced by local governments in the work with municipal climate action plans concerns accounting for the greenhouse gas emissions; what emissions should be targeted, development of emissions over time, and how to effectively measure the success of local climate action. In this paper, we present challenges in developing a local emissions inventory, looking at the provision of public services in particular. Public services provided by local municipalities require only a small amount of resources directly. However, services trigger resource flow indirectly, which yields the need for indicators such as Carbon Footprint (CF). The CF is based on lifecycle GHG emissions from the products and services purchased by a defined population. It is calculated using Input-Output Analysis. We present an analysis of the CF of public services provided by the city of Trondheim. The analysis is based on the city's accounting system. It allows for a fairly reliable calculation of indirect emissions, and, with some minor modifications, also accurate data on direct emissions. We contrast the CF to the traditional indicator of GHG emission within a municipality's geographical boundaries and argue that the CF is a more useful and less misleading indicator.

Introduction

Climate change due to emissions of greenhouse gases (GHG) is one of the most important scientific and political issues of our time. Cities and local communities have been pointed out as critical arenas for the pursuit of sustainable development [1]. Climate change concerns local governments because they carry the main responsibility for providing infrastructure and services for its citizens. In Norway, the Norwegian pollution control authority (SFT) has sponsored the development of local and regional climate- and energy plans. These plans focus on analyzing the current energy use and emissions patterns, the potential for reductions, and on setting political goals for emissions reductions. In 1997, the Trondheim city council adopted a goal of 20 percent emissions reduction in the period 1990-2000 within the city's borders. Since there was insufficient data to establish the emissions in the Kyoto base year 1990, the base year was later changed to 1991. The city has since revised its climate action plan, extending the deadline for meeting the reduction target to 2010, and looks at new policies and measures to implement [2]. Trondheim's climate task force sees the need for a better understanding of the source of emissions and an annual inventory in order to provide continuous feedback on the performance of the city. Emissions caused by the municipality's own activity are of particular interest. It is within the municipality's own activities action most easily can be implemented.

In Norway, Statistics Norway (SSB) provides a municipal breakdown of the national GHG emission inventory. This breakdown is often used in local climate action plans. However, several element of uncertainty have been identified, that underline the need to either improve the method, or to consider alternative calculation methods [3, 4]. One alternative calculation methods is Carbon Footprint (CF). Taking the *consumer perspective*, CF is the measure of the lifecycle GHG emission of a defined population, measured in units of carbon dioxide equivalents. The consumer perspective proposes a shift in responsibility from the producer to the consumer of a product or service. If a polluting industry is relocated to a neighboring city, the consumer perspective argues that the city of origin is still responsible for the same amount of emission as long as the city's consumption of goods from that particular industry sector maintains. Because of this, the use of the consumer perspective in local climate action will rarely conflict with local industry activities. In this paper the CF will be evaluated as an accounting tool, compared to the more common *producer perspective* which is focusing on emissions from activities occurring within the geographical boundaries of a municipality, be it from industry, commerce, transport or buildings.

Methods

The producer perspective includes all of the direct emissions occurring in Trondheim geographically. Using the producer perspective, SSB provides a municipal breakdown of the national emission inventory. The municipal emission model is using two methods in the calculation [4]:

- Point data emissions from industry
- Calculation from distribution formulas

The distribution formulas are based on background statistics (e.g. number of households with heating boils) and surrogate data (e.g. number of employees within a public service or commerce). Unquestionably, the use of surrogate data does not provide accurate data on GHG emissions, and is not suitable to calculate the effect of actions taken. In addition to the uncertainty in the municipal breakdown, there will also be uncertainty in the national emission inventory and in the sector breakdown, schematically shown in figure 1.

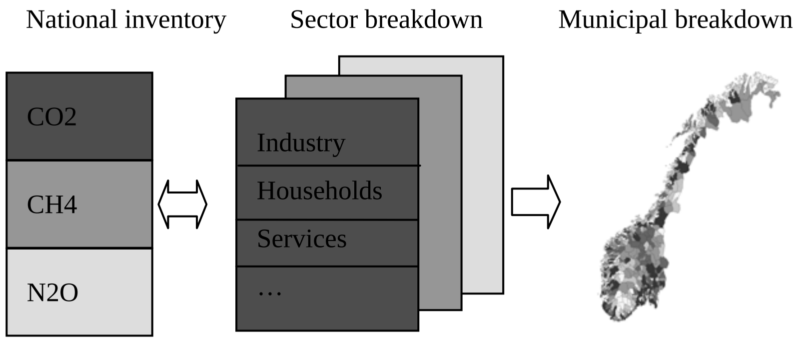

Figure 1: Municipal breakdown of the national emission inventory

The consumer perspective includes direct and indirect emissions of household consumption. Also, in order to calculate the total consumption from all final end users, we need to take into account the direct and indirect emissions from public services, because public services are to a high degree provided for free, and is therefore not included in the household expenditures. The direct and indirect emission from providing municipal public services will be the main focus on illustrating calculation of CF in this paper.

Calculating the lifecycle GHG emissions from the consumption expenditure of a defined population is a comprehensive task. Various methods may be applied in order to calculate CF. In our work we have been focusing on Input-Output analysis (IOA) [5, 6]. This is because the top-town economic technique of IOA works well with the monetary units of the municipalities' account system, and because of the focus on public services in this paper. IOA is a useful tool in evaluating environmental impact of consumption because it captures the entire economy down to production layers of infinite order. This makes IOA highly relevant when operating in a lifecycle context. IO tables describe the flow of commodities between the sectors in the economy, and when combining this with emission intensities for each of the sectors, we are able to calculate the total emission from all the production layers of a demand put on the economy.

Data

The foundation of IOA is the IO tables. IO tables and emission intensities are available at the Statistics Norway webpage. Emission intensities has been slightly modified to better fit the local situation, involving changing the emission intensity for the production of district heating, assuming most of the district heating is produced in the city of Trondheim. To determine the CF of municipal public services we have gained access to the annual accounts of Trondheim municipality, were full detailed level data on purchases made for each of the departments are available. The KOSTRA account system is fixed for all municipalities in Norway. In order to calculate the demand on the IO system, we need to match the KOSTRA account entries with the IO sectors [7]. The matching matrix is a 540 x 58 sized matrix reducing the 540 entries of the account down to 58 IO sectors. Normally the Norwegian IO matrix has the dimension of 56 x 56, but in our case we have expanded it by two sectors to account for the direct emission in the use phase of products. The two processes of direct emissions are; combustion of heating oil and combustion of fuel.

Consumer perspective; Carbon Footprint

To calculate the CF it is necessary to determine the indirect environmental impacts from final end users. Household environmental impacts (HEI) for Norway have been calculated by Peters and Hertwich [8]. HEI is often calculated using consumer expenditure surveys. In Norway, consumer expenditures on public services are to a high degree carried out indirectly through taxes. Public services are therefore often disregarded when using household expenditure surveys to calculate final consumption. Calculating carbon footprint of municipal public services could therefore provide new insight into how these services are produced. The overall result of the analysis on GHG emissions from municipal public services in Trondheim is stated in table 1.

Table 1: GHG emission from municipal public services in Trondheim

	CO_2 equivalents (tons)	**% of total**
Direct GHG emissions	7277	~6
Indirect GHG emissions Trondheim	22757	~18
Other indirect GHG emissions	54894	~45
Electricity assuming a Nordic mix	38197	~31
Total GHG emissions	123125	100

According to table 1, direct GHG emissions only account for 6 percent of the total GHG emission. Further on, indirect GHG emissions occurring in Trondheim are estimated to count for more than 18 percent. This includes for instance the emissions from the fraction of district heating production used in local public buildings. Other indirect GHG emissions, occurring mainly in Norway or rest of the world, are estimated to almost 45 percent. Production and distribution of electricity, assumed a Nordic mix, counts for almost 31 percent of the total GHG emission. This makes “Production and distribution of electricity” the most GHG polluting sector. The top nine polluting sectors are listed in table 2.

Table 2: NACE sectors with highest GHG emission

Sector	**NACE**	**% of total**
Production and distribution of electricity	401	31.0
Other land transport	602	9.8
Manufacture of chemicals and chemical products	24	8.2
Sewage and refuse disposal, sanitation and similar activities	90	7.2
Combustion of heating oil	Direct	4.2
Agriculture, hunting and related service activities	01	3.4
Manufacture of other non-metallic mineral products	269	3.4
Steam and hot water supply	403	3.4
Manufacture of basic iron and steel	271	3.3

Figure 2 shows the result in table 1, broken down to different departments. We can clearly point out “City management”, “Heath care services” and “Schools” as the departments causing most GHG emissions.

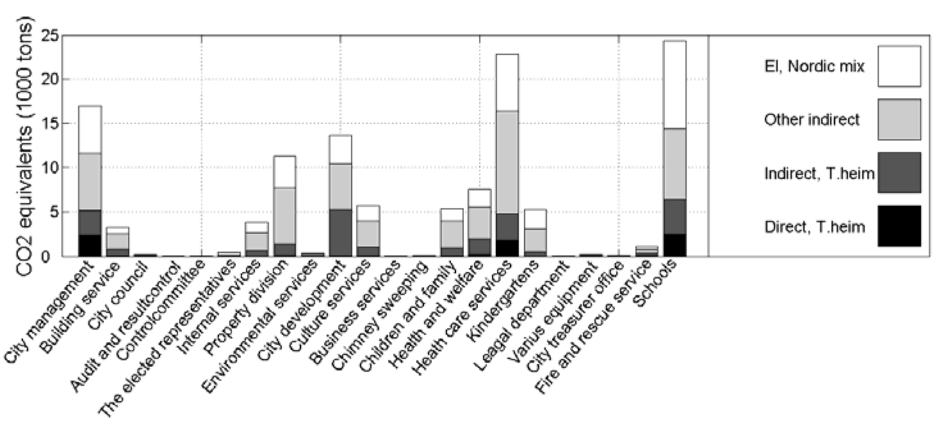

Figure 2: Lifecycle GHG emissions from each of the departments

In order to calculate the total CF of Trondheim we need to include some others county and government services, shown in table 3. In this calculation of CF, electricity is assumed produced with Norwegian technology, because of comparability. The numbers regarding NTNU and RiT are estimates, calculated from putting a demand on the "education" and "health and social work" IO sectors, respectively.

Table 3: Direct GHG emissions and CF from services in Trondheim (tons of CO_2 equivalents)

	Direct	Carbon footprint
Municipal public services	7277	85005
Sør-Trøndelag county public services	1163	9098
NTNU	1855	12298
RiT (Regional hospital)	3839	19616
TOTAL	14124	126017

When the direct GHG emissions and the CF of public services are calculated, it would be interesting to see how these compare to the total. SSB estimates the total direct emissions geographically within Trondheim municipality in 2005 to be 470000 tons of CO_2 equivalents, based on the breakdown schematically shown in figure 1. Municipal public services only contribute with 1.5 percent. The total CF of Trondheim is estimated to be 744000 tons of CO_2 equivalents. This estimation is based on the HEI calculation of Peters and Hertwich [8], combined with the CF of public services. Municipal public services contribute to approximately 11 percent of the CF in Trondheim. The result is displayed in table 4 and figure 3.

Table 4: Services contribution to total GHG emissions

	Municipal public services (tons)	Other services (tons)	Total (tons)	% from municipal public services
Direct emissions	7277	6857	470000	1.5
Carbon footprint	85005	41012	744000	11

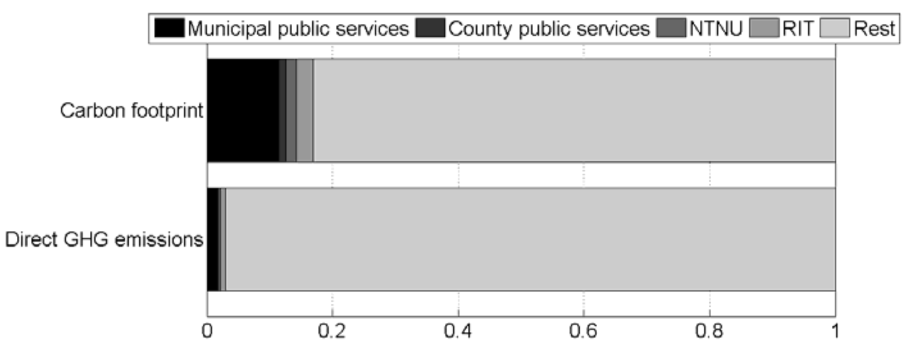

Figure 3: Public services relative contribution to total GHG emissions

Concluding remarks

Even though direct, geographical GHG emissions may function as a starting point in local climate action, this producer perspective is not suited to monitor the environmental performance of the municipality. The consumer perspective has, through the methods of the carbon footprint, proven to be a far better calculation method, especially when looking at the municipality's own activities. The study shows how the indirect GHG emissions by far exceed the direct ones. Still, most of the action is aimed at reducing the direct GHG emissions occurring within the geographical borders. If the CF had been implemented in local climate action, the decision makers would have the possibility to get quantifiable emission reductions from environmentally friendly purchasing policies. In that manner, public institutions could lead the way, creating a market for environmentally friendly goods that will then become available for private consumers as well. Public institutions can be much more sophisticated purchasers than private individuals. At the same time, municipalities could focus on helping their citizens reduce their CF. Municipalities provide infrastructure and services such as child care, schools, elderly care, and they are responsible for planning. They hence create the physical environment in which citizens organize their lives, influencing travel patterns and consumption choices. Further on, insuring the lifecycle perspective with CF, the consumer perspective would not favour actions like shutting down of local industry, which of course reduces the local GHG emissions, but may very well contribute to increasing the global ones.

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