Leaders and Laggards in Low Transport CO_2 Emissions: The Challenges and Outcomes of Benchmarking Sustainable Urban Transport Systems across Europe

Dr E. Owen D. Waygood*

Research Fellow

Dr Tim Chatterton†

Senior Research Fellow

Dr Erel Avineri*

Reader

***** Centre for Transport & Society

† Air Quality Management Centre

University of the West of England, Bristol

Abstract

The transport sector represents roughly 18% of the CO_2 emissions in the EU and is the only sector that has continued to increase emissions. As most people live and work in cities in the EU, it is important to identify the leaders and laggards with regard to efforts to decrease CO_2 emissions from transport. Further, to help support change, identification of correlations between transport emissions and other policy levels would be beneficial. Yet,until recently, there was no city-level results available related to emissions across the EU. Now, the European Pollutant Release and Transfer Register (E-PRTR) inventory of diffuse sources allows for analysis of a range of atmospheric emissions at a 5 km resolution. However, before applying this data to inform practitioners and policymakers, validation of the data would be required by having it compared to the CO_2 emissions estimated by an alternative methodology. The UK government maintains a higher (1 km) resolution emissions inventory based on a 'bottom-up' methodology. The UK National Atmospheric Emissions Inventory (NAEI) has been used to assess the reliability of the new E-PRTR data. This paper first confirms the reliability of the E-PRTR data at city scales, and then gives examples of ranking and finally associations with other indicators in both transport and other policy areas.

Introduction

Transport is one sector of the many that contribute to greenhouse gas (GHG) emissions that cause climate change. A target of keeping average global temperature increases below 2ºC on pre-industrial levels (and preferably below 1.5ºC) has been set by the United Nations Framework Convention on Climate Change (UNFCCC). This target is based on scientific assessments compiled by the Intergovernmental Panel on Climate Change (IPCC). The IPCC research that introduced the two degree target details the consequences of failing to meet this target. Negative impacts will be social, economic and environmental and range from water availability (drought and flooding) to ecosystem weakening (including the risk of extinction of numerous species), and the changed distribution of factors such as health vectors and food availability (IPCC 2007).

It is apparent that considerable reductions in emissions will be required from all sectors to meet the two degree target, but it has been explicitly recognised that it cannot be met without climate change mitigation from the transport sector (European Environment Agency (EEA) 2010). In the European Union (EU), transport (excluding air travel) represents 18% of all CO_2 emissions (EEA, 2011, pg.36). The majority of those emissions come from urban centres as they represent roughly three-quarters of the European population (Feldmann 2008).

However, although on an aggregate level they contribute most of the emissions, on a per-capita basis emissions from cities are lower than for rural areas (Jukka Heinonen and 2011). So, although cities represent a concentration of GHGs, they also offer a means to reduce individual impacts.

In the last decade cities around the EU have introduced a range of transport strategies and policies that are likely to result in varying reductions in CO_2 emissions. However, two cities of the same population size could have quite different emission profiles. This could be the influence of economic conditions, but is also likely associated with the built environment (Sun *et al*. 2009; Ewing and Cervero 2001). The built environment relates to both land-use and transport infrastructure. If one city has low-density and segregated land-use, it will likely have a much different emissions profile to a city that is dense with mixed land-use. Transport planning needs to go hand-in-hand with land-use and housing planning if reductions in transport CO_2 are to be accomplished, however, such research typically looks at only one city at a time and it is not clear whether evidence from one city would hold across various cities or in different countries. Early estimates by Newman and Kenworthy (1999) found that European and Asian cities produced lower CO_2 emissions than North American and Australian cities. One explanation may be that cities of those regions are dense with mixed land-use. A total of 11 European cities were included in that study with Munich, Amsterdam, and Vienna having the lowest per capita CO_2 levels.

Currently there is a gap in the availability of information at the city level related to CO_2 emissions. Although the European Commission's Urban Audit database[1] provides many city-level indicators exist, CO_2 emissions are not represented. Although other emissions have been monitored and reported at a city level for decades (e.g. particulate matter, nitrogen oxide, ozone), GHG gases such as carbon dioxide (CO_2) have only recently begun to be estimated and monitored at such a level. As a result, the EU Framework 7 project Carbon Aware Travel Choices (CATCH)[2] set out a goal of filling this gap, and to examine influences on the production of CO_2 emissions.

Experience suggests that CO_2 is rarely likely to be a significant enough concern for individuals to change their travel behaviour (e.g. Chatterton *et al.* 2008). This then hinders policymakers in promoting policies solely based around CO_2 reduction. Research on both groups (Avineri and Waygood 2010; Waygood and Avineri 2010) suggests that promoting other related benefits could act as triggers for behaviour change in individuals or support the development of policies aimed at CO_2 reduction. Numerous indicators exist in datasets such as Eurostat at the city level that could be used as a first step to examine associations - if city-level CO_2 information was available.

Benchmarking cities, as was done with Newman and Kenworthy's (1999) work, helps researchers and policymakers alike. Researchers can examine why certain cities are performing well, while others are struggling. Policymakers can use benchmarking to stimulate change or identify peers who might contribute to positive change. Benchmarking can also be used to identify which cities should receive funding in order to disseminate solutions. Furthermore, the provision of benchmarked information on transport-related CO_2 emissions to planners and policymakers can be seen as an instrument for increasing the likelihood of more sustainable policies being made by them, through increasing the perception of competition between cities. Framing effects, studied in a range of contexts, can be used to highlight those who perform better (or worse) than others and enhance the motivation of policymakers to have their cities at the top of the league table (for a discussion on framing effects, see Avineri & Waygood, 2011).

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[1] http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/city_urban/data_cities/database_sub1?_piref1715_3143760_1715_3143753_3143753.p=h&_piref1715_3143760_1715_3143753_3143753.nextActionId=2

[2] www.carbonaware.eu

Once a baseline is established, further years of data allow for trend analysis and to gauge whether cities are moving in the desired direction. This too would allow researchers and policymakers to identify trends and who the leaders and laggards were in the move to a low CO_2 impact transportation system. It could also be used by citizens to judge whether political choices are providing the results that are necessary.

First though, the baseline must be established. Although such baselines exist for nations, urban centres are where decisions are most often made that affect day-to-day travel for most citizens. It is therefore necessary to develop an indicator that is relevant to cities to allow for comparison and trending. Citizens may also feel a greater association to results, the more local they are, and potentially take greater ownership of the change process.

In 2011, the European Environment Agency (EEA) made a new spatial emissions database available as part of the European Pollutant Release and Transfer Register (E-PRTR) at a 5km resolution. This made it possible to estimate CO_2 emissions for cities based on geographic boundaries. However, several important questions existed related to its use. First, the methodology used was basically a top down methodology, based on the spatially disaggregation of nationally reported totals,, and it can be questioned whether this type of methodology at the European scale is capable of producing accurate results when examined at the city level. Secondly, there are issues relating to the appropriate way of comparing cities in respect of their geographic boundaries. The Urban Audit has already identified three such boundaries: Kernal, City and Larger Urban Zone. In the UK there are also a range of other political boundaries as well such as District or County authorities.

In order to answer these questions, this study compares data obtained from the E-PRTR with the UK National Atmospheric Emissions Inventory (UK-NAEI). The UK-NAEI data is constructed using a bottom-up methodology (that in turn is used to provide the national figures on which the E-PRTR data is based).

The remainder of the paper will be as follows: the E-PRTR data is introduced along with its methodology for assigning transport CO_2 spatially; the UK-NAEI data is then introduced along with its methodology; the comparison methodology is then explained; results of that comparison follow; after which an example of how a UK city compares within the UK and across similar EU cities; following that initial correlation analysis is conducted with transport and other policy relevant indicators; finally results are summarised in the concluding section.

The European Pollution Release and Transfer Register

Spatially disaggregated emissions inventories for CO_2 at a national level are not commonly produced within Europe. Therefore, the publishing in 2011 of a spatially disaggregated inventory of a range of diffuse atmospheric emissions based on the E-PRTR marked a significant advance in understanding variations in emissions from various sources Europe. The E-PRTR Diffuse Air Emission Datasets[3] are produced by the European Commission (EC) and EEA under the conditions of Article 8 of the E-PRTR Regulation (No., 166/2006). They consist of 32 maps at 5 km x 5 km resolutions, projected using the World Geodetic System (WGS84). The maps cover emissions of six atmospheric pollutants (nitrogen oxides (NOx), sulphur oxides (SOx), carbon monoxide (CO), ammonia (NH_3), carbon dioxide (CO_2) and particulate matter (PM_{10})), and divide the emissions across seven sectors (Agricultural, Domestic Aviation, Domestic Shipping, Industrial Releases, International Shipping, Non-Industrial Combustion, and Road Transport). The maps are intended to cover all EU27[4] states and the European Free Trade Association countries (Switzerland, Lichtenstein, Norway and Iceland), 31 countries in all. Whilst the data for conventional air pollutants is based on official submissions to United Nations Economic Commission for Europe under the Convention on Long-Range Transboundary Air Pollution, the CO_2 emissions are based on

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[3] http://www.eea.europa.eu/data-and-maps/data/european-pollutant-release-and-transfer-register-e-prtr-regulation-art-8-diffuse-air-data/

[4] http://europa.eu/about-eu/27-member-countries/index_en.htm

national submissions to the United Nations Framework Convention on Climate Change[5] (UNFCCC). The inventory is produce using a ‘top–down’ methodology (see Lindley *et al.* 1996) based on the spatial disaggregation of nationally reported emissions totals. The following provides a short description of the methodology behind the datasets (for a detailed description of the methodology see Theloke *et al*., 2011).

The first stage is for the national sector specific emissions to be allocated to region level within countries (e.g. NUTS3[6]). For Road Transport this is done on the basis of traffic count information. The second stage is to distribute these into a 5 km x 5 km grid using geospatial referenced datasets (such as road networks for road transport emissions). For industrial sources a process has had to be derived for distinguishing between those sources reported as point source emissions under the E-PRTR and those that need to be treated as diffuse sources. This process is not relevant for road transport sector emissions which are all counted as diffuse emissions.

Disaggregating Road Transport

UNFCCC submissions report Road Transport emissions under the IPCC Common Reporting Format (CRF) source category 1A3b. This category is not disaggregated according to either vehicle type (e.g. passenger cars, light duty vehicles, mopeds, etc.) or road class (e.g. highway, urban, rural), and CO_2 emissions are therefore disaggregated for both of these according to the proportions indicated by the TREMOVE model[7].

The resulting road and vehicle classes are then ‘harmonised’ with the road network from the TRANS-TOOLS model[8]. This only covers highways and major rural roads. It is assumed that only 50% of rural road emissions can be allocated to the roads covered by TRANS-TOOLS, the remaining 50% are simply allocated as ‘rural road emissions’. Whilst highways are all counted as line sources, rural and urban roads are split between line and area sources (70:30 and 50:50 line:area for the remaining rural and all urban roads respectively).

These are then distributed on the 5 km grid using mapped road segments for line sources, or geographical statistical information and land cover/land use data as a proxy for area sources.

Therefore according to the 2-step process described earlier:

1: National emissions are regionalised according to traffic volume data for each road section covered by TRANS-TOOLS, and population density for those roads not covered by TRANS-TOOLS.

2: The regional emissions are then gridded according to:

i. Traffic volume and road network from TRANS-TOOLS for highways and partly for rural roads;

ii. Road network divided by road type from GISCO (ROAD) (GISCO, 2011) for the roads not covered in TRANS-TOOLS (secondary and local roads);

iii. Gridded population density as weighting factor for line sources in relation to rural and urban roads not covered by TRANS-TOOLS. Additionally as distribution parameter for rural and urban area sources.

iv. Degree of urbanisation (GISCO, 2011)

Allocation to Boundaries

To carry out comparisons of the E-PRTR data and allocate values to pre-deterimined boundaries, the X-Tools (www.xtoolspro.com/) *Shape to Centroid* command was used to convert the polygon grid data format of the E-PRTR data to create points. These were then

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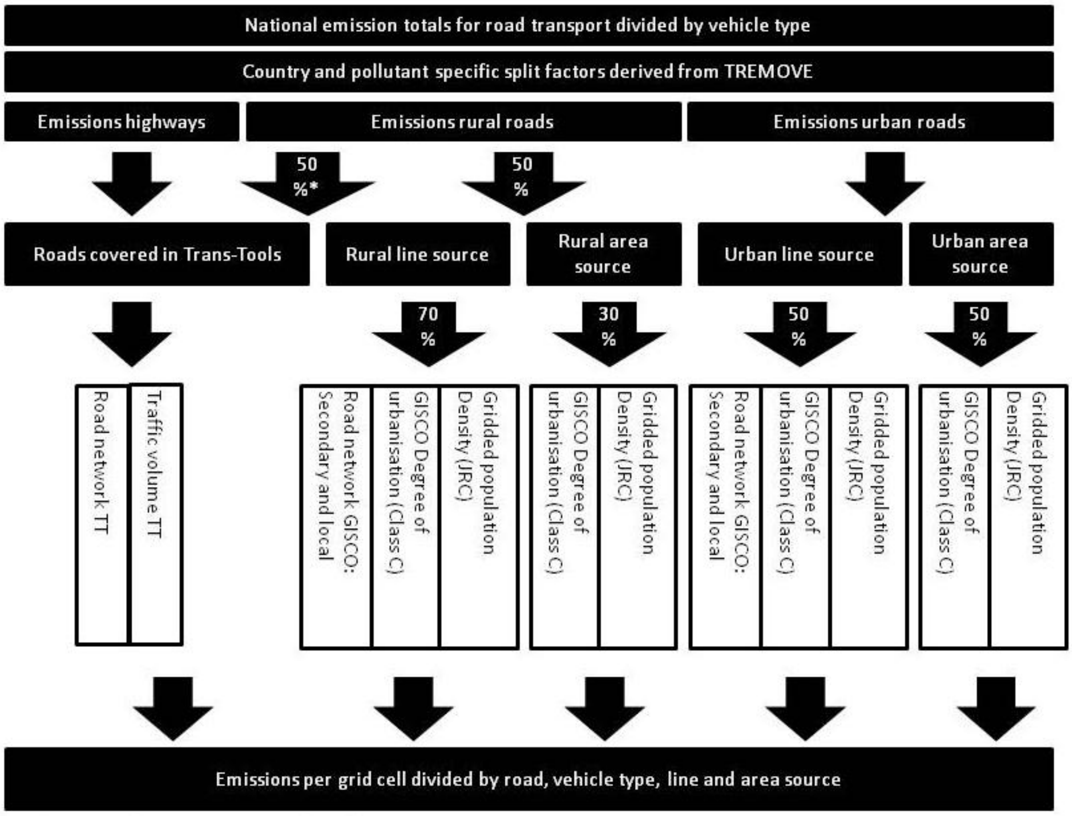
[5] http://unfccc.int/national_reports/annex_i_ghg_inventories/reporting_requirements/items/2759.php

[6] http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction

[7] http://www.tremove.org/

[8] http://energy.jrc.ec.europa.eu/transtools/

allocated to the administrative boundary in which they fell. That method was chosen as an alternative to a more conventional *Intersect* command in order to avoid having to divide emissions for a grid cell across two administrative units where cells fell across boundaries. When allocated at a country level, this resulted in 4753 grid cells being unattributed to countries, along with some cell values also being attributed to Turkey and Croatia (which were not part of the dataset). Therefore a revised methodology was adopted that allocated emissions from each centroid to the nearest of the 31 countries covered by the dataset.



**Trans-Tools covers major rural roads*

Figure 1: Overview of the applied methodology for the spatial distribution of the road transport (adopted from Theloke *et al.*, 2011)

Verifying Boundary Methodology

Country totals were then compared from the 5 km data and with the country data taken from the EEA-website reporting the original UNFCCC figures for 2008[9]. For 30 out of the 31 countries, the summed country totals from the E-PRTR data were between 88.73% (Bulgaria) and 100.03% (Malta) of the emissions reported for the UNFCCC (see Figure 2). The one exception was Liechtenstein where summed totals were only 31.64% of the UNFCCC reported figures. This may be partially due to the very small size of the country (160 km^2) and that only 3 grid cells (75 km^2) were attributed to it, suggesting that many of its emissions might have been allocated to neighbouring countries. In comparison, Malta may be the most accurate as it shares none of its grid cells with other countries. In general this comparison indicated that the disaggregation of the emissions to mapped data still preserved their relationship to countries, and in total over 98% of emissions were preserved in this process.

Comparison with UK data

As described above, spatially disaggregated emissions inventories at a national level are few and far between in Europe. Three countries were identified for which these are known: the

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[9] http://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-unfccc-and-to-the-eu-greenhouse-gas-monitoring-mechanism-4

United Kingdom, the Netherlands and Sweden. The data for these was only available for the UK at the time of writing this paper and further work is planned to compare with all three countries if and when the datasets can be obtained.

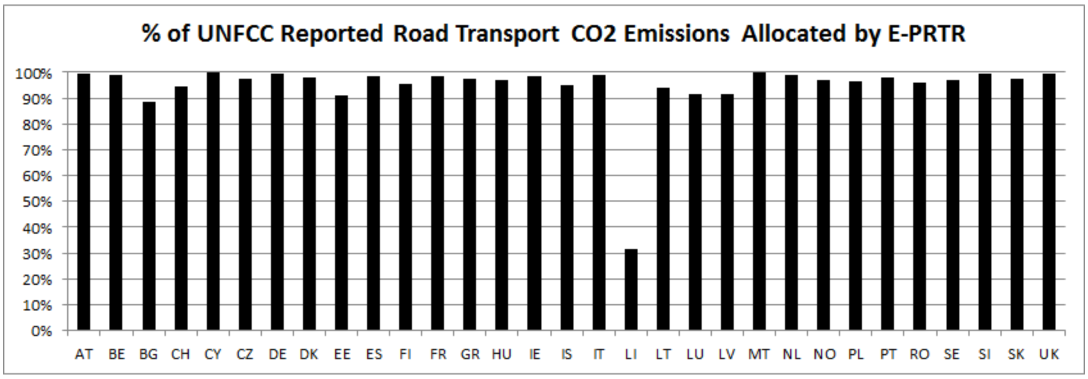

Figure 2: Comparison of mapped country totals with original Road Transport Emissions reported to UNFCCC

Comparison of emissions inventories is not commonly done between scales. Winiwarter *et al.* (2003) have discussed methods for comparing urban scale emission inventories that are based on the same grids but compiled using different methodologies. This work has some relevance to the task undertaken here and has been used to inform our analyses, but we argue that the differences in scales, and the purposes of the inter-comparison (i.e. verification of the E-PRTR data at a city scale) means that there are some differences. Lindley *et al.* (2000) describes a comparison of emission inventories produced at different resolutions. This again has informed our analysis, but does not provide a simply transferable methodology.

UK Emissions Inventory

The UK National Atmospheric Emissions Inventory (UK-NAEI) is produced annually, disaggregated across a 1 km x 1 km resolution grid that is based on the Ordnance Survey Great Britain (OSGB) grid system. The inventory is produced for CO_2 as well as 24 other air pollutants and GHGs. The mapping methodology for the inventory is set out in detail in Bush *et al*. (2010). A summary of the process for road transport is provided below. It is important to note that the UK-NAEI is used to calculate the emissions reported to the UNFCC, and which in turn are disaggregated by the E-PRTR inventory.

Road transport emissions for the UK-NAEI are calculated using a ‘bottom up’ methodology (see Lindley *et al.*, 1996). Whilst conventional air pollutants in the inventory are calculated on the basis of speed related emission factors, the spatial distribution of CO_2 is based on fuel consumption as a proxy. This in turn is based on speed related fuel consumption factors multiplied by vehicle flows.

Census point traffic flow data is available for all major roads (motorways and A roads) covering Annual Average Daily Flow for light and heavy duty vehicles. Where traffic flow data have been available for minor roads, this has been used in the same manner. For all other minor roads, regional average flows by vehicle type have been attributed for each type of road. In the 2007 methodology, this was improved so that the regional averages were at a County level. The age of the fleet is not varied regionally. 90% of Light Goods Vehicles are assumed to be diesel. From 2007, different fuel splits were assumed for passenger cars for urban, rural and motorways.

Each major road link is attributed an ‘area type’ using Department for Transport (DfT) definitions of urban areas. The vehicle kilometre (VKM) estimates by vehicle type are then multiplied by the fuel consumption (or emission factors) for each road link, based on the DfT average speed based on the Urban Area Type. A similar calculation is undertaken for minor roads, but differentiating fuel consumption and average speeds used for different types of minor road.

Additional emissions due to vehicles running under 'cold start' conditions are also calculated. These are classified as "home to work", "home to other locations" and "work based" trips. They are based on census travel to work information, mapped data on ownership of cars, and mapped information on the distribution of employment across the UK.

The two methodologies (the UK-NAEI and the E-PRTR) offer two very different methods (bottom-up vs top-down) of attributing road transport based emissions of CO_2 on a spatial basis.

Comparison Methodology

The UK 1km resolution emissions inventory for CO_2 (as carbon) was obtained from the UK NAEI data warehouse[10] (originally in the format of ASCII file for generating a raster coverage in ArcGIS) was converted into a polygon grid, that was then transformed from the UK OSGB national grid projection to the World Geodetic System (WGS84) projection used for the E-PRTR 5km data. Then using X-Tools, centroids were created for each of the 1 km polygons. Using the *Intersect* command, these were then each attributed to one of the 5 km E-PRTR grid cells. Finally, using the *Dissolve* command, statistics were created for the number of 1km UK-NAEI cells within each 5km E-PRTR cell along with the sum, mean, min and max of their related emissions. In order to match the units between the UK-NAEI and E-PRTR reported figures, the UK figures were then multiplied by a factor of 3.664173[11] to convert from CO_2 as carbon to its full mass, and multiplied by 10^{-3} to convert from tonnes to kilotonnes. X-Tools were used again to for the 5 km grid cells. This then allowed the two datasets to be compared at a number of spatial scales: UK, GB, 5km cells, Urban Audit[12] (UA) City, Large Urban Zone[13] (LUZ), UK district/unitary, and UK county. Comparisons have been presented for both the United Kingdom and Great Britain, as there are differences in the quality of the data used in Northern Ireland that may affect the accuracy of the disaggregation (Table 1). The results are presented below.

Results of comparison at national level

The number of cells and total road transport CO_2 emissions for the 5 km resolution E-PRTR data for the UK and GB, and for the UK-NAEI data at raw 1 km resolution and when aggregated to 5 km resolution on the E-PRTR grid are shown in Table 1. The comparison indicates that there is a 301 kt (0.26%) difference between the total emissions inventories at the UK level. For Great Britain this difference is slightly higher at 425.5 kt (0.38%). There has been no attrition in the methodology so total emissions have been conserved in the UK inventory within the aggregation process. However, there are 64 E-PRTR grid cells that have no UK-NAEI cells attributed to them where the E-PRTR predicts emissions and the UK-NAEI doesn't. These cells were predominatly along the coast, on islands, and extreme rural areas such as the Highlands of Scotand. They varied in emissions between 0.1 and 13.1 kt compared to an overall mean value of 12 kt and a maximum of 331 This was therefore not considered to be a very significant problem.

Table 1: Number of cells and total CO_2 road transport emissions for E-PRTR data and UK-NAEI data at 1 km and 5 km resolutions

	Emissions Inventory and Resolution	UK	GB
Number of Cells	E-PRTR 5km	9698	9088
	UK-NAEI @ 1km	176,234	163,446
	UK-NAEI @ 5km	9634	9033
CO_2 (Road Transport)	E-PRTR	116,971.3	112,734.4

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[10] http://naei.defra.gov.uk/data_warehouse.php

[11] Derived from atomic weights of Carbon = 12.0108 and Oxygen = 15.9994 taken from http://www.webqc.org/periodictable.php

[12] Eurostat initiative to gather city-level indicators across Europe.

[13] Eurostat definition related to the functional city size as opposed to political boundaries.

Emissions Kt	UK-NAEI @ 1km	116,670.3	112,308.9
	UK-NAEI @ 5km	116,670.3	112,308.9

Comparisons have been undertaken at the level of individual 5 km cells and Urban Audit City and LUZ levels, as well as for a range of UK local authority areas (district, London borough, metropolitan borough, unitary, and county). Slope and R^2 have been calculated using a zero intercept.

Table 2: Comparison statistics for E-PRTR and UK-NAEI data at 7 spatial scales

	Cell	City	LUZ	County	London Borough	Unitary	Metropolitan
n	9698	106	26	28	33	35	108
Slope	0.64	0.76	1.03	0.93	0.73	0.98	0.80
R^2	0.66	0.96	0.99	0.90	0.75	0.93	0.82

The correlations indicate that there is a strong relationship between the E-PRTR and the UK-NAEI datasets. As would be expected, correlations are weakest at the level of individual cells (R^2=0.66 and slope of 0.64). The strongest correlation (R^2=0.99 and slope of 1.03) was found for the comparison at the LUZ level. This gives weight to the use of the LUZ based on a 'functional urban region' (EC, 2004) as the most appropriate area on which to benchmark road transport emissions.

Although the findings suggest a high correlation between the UK cities in the E-PRTR and the UK-NAEI datasets, it is not completely clear whether this holds for other European cities. Further research that includes other European countries would help to establish whether cross-country comparisons are truly valid. Further comparisons are planned against data for the Netherlands and Sweden once the necessary data has been acquired. For the time being, we will assume that due to this result we can use the information with a reasonable level of trust.

Example of Results

The above research suggests that, at least for the UK, the E-PRTR is reasonably reliable (high R^2) at a city and Large Urban Zone (LUZ) aggregation. This section will demonstrate how this information might be used to rank cities by CO_2 per capita with respect to same nation or similar population. CO_2 per capita[14] is used so that the size of the city does not distort individual efficiencies. For example, it would not be fair to say that a town is more CO_2 friendly because its total emissions were 1/10th of a city 20 times its population size. The individuals in the town are producing twice as much CO_2 per capita, so if a policy only considered total emissions and worked to replicate 20 towns based on that, the resultant CO_2 would be twice as much as previously for the citizens of the city.

The UK city of Bristol will be used for the examples. If it is compared with only UK cities in the E-PRTR data, then on a per capita basis Bristol is the fourth best performer (Table 3). This might suggest that Bristol could learn from the better performing cities of Newcastle, Manchester, and Greater London. From this ranking, the cities of Lincoln and Worcester would particularly need to improve, with Leicester and Liverpool also falling into the bottom quarter.

TABLE 3 Rankings of UK cities in the E-PRTR data.

Quarter	Ranking	City	CO_2(tonnes)/capita
1	1	Newcastle	1.44
1	2	Manchester	1.51

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[14] Population data for the LUZ areas were obtained from ec.europa.eu.

1	3	Greater London	1.58
1	4	Bristol	1.84
2	5	Glasgow	2.13
2	6	Cardiff	2.18
2	7	Birmingham	2.24
2	8	Cambridge	2.26
3	9	Sheffield	2.30
3	10	Portsmouth	2.37
3	11	Exeter	2.41
3	12	Wrexham	2.57
4	13	Liverpool	2.68
4	14	Leicester	2.69
4	15	Worcester	3.62
4	16	Lincoln	4.07

However, it could be argued that those cities represent a range of populations comparisons are not “fair”. If Bristol is then compared against cities of similar population size (Table 4) in Europe, other relevant leaders emerge. By population size, Bristol is now in the bottom quarter in comparison with European cities. The leaders that emerge are Ostrava (Czech Republic), Riga (Latvia), and Bordeaux (France). So, although Bristol performed well (a leader) within the context of the UK, when it is compared with its peers across Europe, it would be considered a laggard.

TABLE 4 Rankings of European LUZs in the population range of 900,000 to 1,200,000 (Bristol’s LUZ population +/- 10%).

Quarter	Ranking	City	Population	CO$_2$(tonnes)/capita
1	1	Ostrava, Czech Republic	1,152,390	0.91
1	2	Riga, Latvia	1,003,950	1.21
1	3	Bordeaux, France	999,149	1.411
2	4	Newcastle, United Kingdom	1,067,400	1.44
2	5	Rotterdam, The Netherlands	1,186,820	1.451
2	6	Porto, Portugal	1,109,990	1.56
3	7	Gothenburg, Sweden	914,923	1.59
3	8	Leipzig, Germany	901,555	1.62
3	9	Bonn, Germany	916,174	1.67
4	10	Toulouse, France	1,102,890	1.68
4	11	Dresden, Germany	914,415	1.70
4	12	Bristol, United Kingdom	1,071,000	1.84
4	13	Oslo, Norway	1,162,260	3.00

As shown by these examples (Table 3 and 4), the context might affect perceptions. The presentation of this information could be improved by contextualising it with respect to sustainability, rather than just in comparison to other cities, as this will affect perceptions of sustainability (Waygood, Avineri 2011). Data from the UK (National Indicator 186) suggests that current (2008) UK per capita CO_2 emissions are 7.0 tonnes[15]. The European Union has a “20-20-20” target of reducing carbon emissions to 20% that of 1990 levels (EC 2010). Europe has already made an 11% reduction of overall carbon emissions (EEA 2011). For the purposes of this example, assume that the UK has followed this trend and that transport represents 18% of total emissions (in the UK it is 24% (DECC 2011)). Then a 2020 target level would be roughly 1.1 tonnes (i.e. 7.0/(1-0.11)*0.18) per capita (1.5t in the UK). This contextualisation would then suggest than only Ostrava is performing well (or if the UK’s 1.5t, Newcastle).

Factors Associated with Urban Transport CO_2

Ranking is one way to stimulate motivation to change and highlight peers that might act as good examples. However, it is also useful to look for associations that might help reduce CO_2 or that link to other policy considerations. Although some correlation is possible with the sixteen UK cities, more might be learned from combining indicators with another wealthy EU country.

Germany has the most cities represented in the database with 32 cities, and also has more indicators available in from the Eurostat database at the LUZ level than the UK. If the two countries (UK and Germany) are combined (total 48 cities) there are nearly 20 indicators with significant correlations (Table 5). As can be seen, there is an important distinction between measuring per capita impacts as opposed to totals as total injuries and fatalities have a negative association (implying that as injuries and fatalities increase, CO_2 per capita decreases). However, when the fatalities and injuries per 1,000 citizens are considered, a positive association is seen.

Most of these indicators are clearly transport indicators. However, there are some that are not. These include population, geographic size, jobs, apartment costs, and the mortality rate u64 (defined as: mortality rate for persons aged 64 or less from heart diseases and respiratory illnesses living in Urban Audit cities - number of deaths per 1,000 inhabitants). The correlations found here suggest that more jobs in the city are associated with less CO_2 per capita, and that lower mortality rates are associated with lower CO_2 emissions per capita. These two results in particular may support a reduction in transport CO_2 from other policy areas. However, this is preliminary analysis and further investigations or policy implications into these links must be left for future research.

TABLE 5 Significant correlation results for the combined data of Germany and UK cities. Where n = 32, the data is only from Germany. Where LUZ is not included in the indicator name, the indicator is only for the city’s political boundary as defined in the Eurostat’s Urban Audit.

Indicator	Pearson’s correlation	Significance (2-tailed)	n
LUZ JtW % by public transport	-.537	.000	44
LUZ Fatalities per 10,000	.508	.000	47
JtW % by car	.504	.000	47
JtW % by car or motor cycle	.504	.000	47
Regional population	-.416	.003	48
LUZ registered cars	.415	.004	47
City’s population density	-.382	.007	48
LUZ JtW % by car	.463	.008	32
Area of city	-.378	.008	48
Jobs	-.355	.013	48
Apartment costs per m^2	-.353	.014	48
Total road injuries	-.350	.015	48

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[15] http://www.decc.gov.uk/en/content/cms/statistics/local_auth/co2_las/co2_las.aspx

LUZ Iinjuries from crashes per 10,000	.350	.016	47
City population	-.339	.018	48
Passenger cars per 1,000	.338	.019	48
LUZ Total land area	-.337	.021	47
Number of annual road fatalities	-.332	.021	48
Mortality rate u64	.292	.044	48

Conclusions

The reliability of the E-PRTR results for LUZ level transport CO_2 emissions was found to be high based on a comparison with the UK-NAEI data. However, it is not yet completely clear whether this holds across other European countries. The next step in this research will be compare with bottom-up data from other European countries. However, the comparison with UK data has suggested that the E-PRTR dataset may be a very valuable tool in addressing the very significant gaps in our previous picture of how emissions varied across the Union. We recognise that the ability to test the accuracy of the E-PRTR data is limited to those countries that have produced their own spatially disaggregated emission inventories. The presence of such inventories indicates a sophisticated level of emissions management, and therefore a potentially more accurate level of emissions reporting to the UNFCCC. As it is these nationally reported totals on which the E-PRTR is based, there are limitations to assessing how accurate actual quantities of emissions are compared to the patterns of spatial aggregation (which is what was principally tested in the work presented in this paper).

An example was given using the LUZ based around the British city of Bristol. This example showed how although it is performing the top quartile within the UK, it is near the bottom of a ranking based on similar LUZ populations across Europe. This suggests that such a city could learn from its neighbours in Europe, but also highlights how context is an important consideration when presenting such information.

Finally, a correlation was carried out using UK and German cities from the CATCH database. This correlation looked at both transport and other policy relevant indicators and found that a number of non-transport indicators were significantly correlated with per capita transport CO_2 in those countries. Those indicators were population (-), geographic size (-), jobs (-), apartment costs (-), and the mortality rate of under 64 years (+). This result suggests that reductions in transport CO_2 can be supported through other policy directives.

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