Exploration of EU road vehicle fuel consumption and disaggregation

Service Request 10 under framework contract Ref: CLIMA.C.2/FRA/2012/0006

Executive Summary

Ricardo Energy & Environment was commissioned by DG CLIMA to carry out a project on “Exploration of road vehicle fuel consumption and disaggregation” (reference CLIMA C.2/FRA/2012/0006). This final report provides a summary of the findings of the work completed during the course of this project.

Road transport accounts for more than a fifth of greenhouse gas (GHG) emissions from the European Union, and over two-thirds of all domestic transport emissions in the EU. In the context of the commitment for a 30% reduction of non-ETS sector emissions (vs 2005) by 2030 under the EU climate and energy framework agreed by EU Heads of State, ongoing action to drive down emissions from road transport is essential.

Having a good understanding of the relative shares of road fuel consumption by fuel type, vehicle type and segment is essential to both track the impacts of existing policies aimed at reducing emissions from road transport, and to ensure future policy action is appropriately targeted/scaled.

In this context this work aimed to look at different European road transport energy consumption datasets and methods for disaggregation of energy consumption /GHG emissions between different vehicle/fuel types in order to understand any differences found between them.

The objectives of the project were to:

- Cross-check and validate road fuel consumption time series based on different available data sources and differentiated by fuel type (Section 2);
- Cross-check and validate total road fuel consumption time series based on different available data sources and differentiated by vehicle type (Section 3);
- Develop a detailed disaggregated EU wide analysis of passenger car energy consumption between its different vehicle segments (Section 4).

In order to develop a robust consolidated dataset of road vehicle fuel consumption by fuel type, different datasets for EU road transport energy consumption data (by Member State) were gathered and compared. Four different data sets were included in the analysis:

1. The Fuel Quality Monitoring (FQM) reporting;
2. Eurostat/EEA data on road transport energy use;
3. DG ENER Oil Bulletin;
4. UNFCCC Reporting on road transport energy consumption.

To identify reasons for differences at the EU level a detailed assessment of the data collection methodologies and a quantitative analysis of the time series data was carried out. This analysis was furthermore supplemented with interview and survey inputs from national reporting authorities to assess possible reasons for discrepancies at the Member State level. The focus of the national level analysis was on seven selected countries (DE, ES, FR, IT, PL, SE, UK) for which detailed case studies were compiled.

The analysis has shown that there are a number of different reasons for discrepancies in the datasets. Some of these are systematic and result from the different requirement of the datasets. For example:

a) Eurostat and UNFCCC report on road fuel consumption only and separate out biofuel contents from the fuels. FQM and Oil Bulletin on the other hand report on total fuel consumption for fuel types used in the automotive sector without separating out use by non-road vehicles or biofuels.

b) Differences in data between Oil Bulletin and FQM can be traced back to the different types/grades of fuels covered. While the Oil Bulletin only covers conventional fuels, the FQM dataset includes fuels with declarable biofuels content. The Oil Bulletin also only reports on Euro-super 95 while the FQM dataset covers petrol fuels with octane ratings RON 91 and RON 98.

c) Further discrepancies are caused by different reporting timelines and the resulting use of preliminary data.

d) Finally, some differences can result from the UNFCCC data being updated throughout the complete time series each year while Eurostat data is only updated in cases where errors have been found. The Oil Bulletin data and the FQM data are not being adjusted retrospectively.
In addition to these general differences that apply to each Member State there are country-specific conditions that influence the extent of the differences in the data, including:

e) The methodology used to allocate fuel to non-road transport uses, which can vary from Member State to Member State as well as between authorities within the same Member State: Differences between Eurostat and UNFCCC data can stem from different methodologies to allocate non-road fuel consumption.

f) The number of authorities involved in reporting and the level of coordination between them.

Based on the analysis it was concluded that the UNFCCC dataset is the most detailed dataset available, particularly due to the detailed methodology for allocating non-road fuel consumption required by the 2006 IPCC guidelines. Time series for road vehicle fuel consumption by fuel type were developed for EU28 and all Member States individually, based on the UNFCCC data. As the UNFCCC datasets only report on biomass in total, the shares between biodiesel and biopetrol available from Eurostat were used to supplement this.

This analysis was followed by a comparison of datasets on road vehicle fuel consumption by vehicle type. A range of datasets/models were identified during the project that provide a split of road vehicle fuel consumption per Member State by vehicle type. These include the following:

- TREMOVE model;
- MOVEET model;
- PRIMES-TREMOVE model;
- TRACCS project outputs;
- UNFCCC reporting datasets by EU Member States.

The model outputs/datasets were compared for the years 2005 and 2010, as these were the years where data from all five sources were available. The results are similar for both years. Figure 1-1 shows the results of the comparison for the year 2010. It can be observed that the overall consumption aligns for PRIMES-TREMOVE, UNFCCC, TRACCS, however the distribution between the vehicle types can differ. TREMOVE and MOVEET align less well with the other data sets, which is even more pronounced on the national level.

Figure 1-1: Model dataset comparison of transport energy consumption by vehicle/fuel type, EU28, 2010

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) and MOVEET data

To understand the reasons for these differences the model structures were mapped which revealed that while the models have similar approaches for estimating fuel consumption (e.g. all models base their fuel consumption estimations on the COPERT emission model which provides fuel consumption

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1 This is the specific terminology used in the UNFCCC CRF that correlates to biofuels use
factors), the input and calibration datasets are different in some cases. Further possible reasons for differences are the following:

- Importance of territoriality vs nationality principle both for activity and fuel (fuel sold in a country vs fuel consumed in a country);
- Treatment of second-hand vehicles;
- Resolution of each model i.e. differences in the coverage of trip types, purposes, time, area, car sizes etc.

While all models are based on COPERT (to a greater or lesser extent), for the national inventories under the UNFCCC, different road transport emission models are used, which provide fuel consumption factors. In particular the TREMOD transport emission model based on the HBEFA (Handbook Emission Factors for Road Transport) is important. A review of the literature showed that there is no full comparison of the impact of the choice of emission models for national level inventories is yet available. However, the German Federal Highway Research Institute (BASt), has commissioned a study to understand the difference between COPERT and TREMOD, which is due to report in mid-2016.

As an output from this assessment time series for fuel consumption by vehicle type were prepared for EU28 and all Member States, again based on UNFCCC data and the Eurostat shares for biofuels.

The final part of the project covered the disaggregation of fuel consumption for passenger car data by segment for EU28 and the seven selected Member States. This disaggregation was carried out with SULTAN, a stock-based transport emissions model, developed by Ricardo for DG CLIMA to assess the impacts of policies on transport emissions. First the model had to be set up to allow: yearly data inputs, input of new vehicle registration numbers, accounting for imported (second hand) vehicles and mileage weightings by vehicle age.

Data then was identified and gathered for the following elements for this bottom-up approach:

- **Existing/total vehicle stock**: Eurostat
- **New vehicle registrations by fuel type and by segment**: EU car CO2 monitoring database (2010 – 2014), ICCT Pocketbook
- **New vehicle fuel consumption by fuel type and segment**:
  - NEDC-based: EU car CO2 monitoring database (2010 – 2014), Data from UK SMMT
- **Survival function**: based on TRACCS data

The SULTAN results for the EU showed total fuel consumption values for passenger cars that were somewhat higher (roughly 10%) compared to the results from other models/datasets (PRIMES-TREMOVE, TRACCS, UNFCCC and MOVEET). Possible reasons for these differences are:

i. Mileage estimates may not align fully with some of the other datasets used for input to the model;
ii. Use of higher real-world fuel consumption figures, variation in real-world to test-cycle differences in different regions (e.g. due to differences in climatic and driving conditions in different countries);
iii. LPG and CNG vehicles that were originally registered as petrol vehicles (only potentially significant for Italy and Poland where they comprise a significant share).

To ensure the consistency with the other fuel consumption profiles developed in this project the outputs were normalised to the UNFCCC figures.

Figure 1-2 shows the results at the EU level before and after scaling to the UNFCCC data. While similar observations as on the EU, greater variations can be observed at a country-level.
In conclusion, the project provided a detailed understanding of the available fuel consumption data for road vehicles by fuel type and by vehicle type, highlighting the possible reasons for differences that can be observed between the available data sets. Based on the most detailed and robust data available, fuel consumption times series could be provided for EU28 and all Member States. In addition a bottom-up approach was applied to disaggregate passenger car data by vehicle segment. By scaling the model results to the UNFCCC data a good approximation of the true energy consumption time series split of cars by vehicle segment and fuel type across the EU28 and for the seven case study Member States was provided.
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1 Introduction and overview

1.1 Introduction

Ricardo Energy & Environment has been commissioned to provide technical support to the European Commission on “Exploration of EU road vehicle fuel consumption and disaggregation” (hereafter, the ‘project’) under a framework contract (reference CLIMA.C.2/FRA/2012/0006). The project was commissioned by the European Commission’s DG Climate Action (hereafter ‘the Commission’).

1.2 Context

Road transport accounts for more than a fifth of greenhouse gas (GHG) emissions from the European Union, and over two-thirds of all domestic transport emissions in the EU. In the context of the target of 30% reduction for non-ETS sector emissions (vs 2005) by 2030 set by the EU climate and energy framework, ongoing action to drive down emissions from road transport is essential.

Existing CO₂ regulations for light duty vehicles (LDVs) are driving down emissions from these vehicles, and work is ongoing to better understand the scale of emissions from heavy duty vehicles (HDVs) through the development of a certification process, expected to be in place before 2020. However, there is still significant uncertainty in the actual relative balance in real-world emissions from LDVs and HDVs (and also 2-wheelers), since fuel sales are not typically tracked by road transport mode. In addition, partly due to differences in taxation, there are differences between fuel sales and fuel consumed in different EU countries (at least for those in mainland Europe) that are hard to pin down.

Having a good understanding of these relative shares is essential to both track the impacts of existing policies aimed at reducing emissions from road transport, and also to ensure future policy action is appropriately targeted/scaled to different sectors.

In this context this work aims to look at ways to understand differences between different European road transport energy consumption datasets and methods for disaggregation of energy consumption/GHG emissions between different vehicle/fuel types.

1.3 Objectives of the project

The objectives of the project were updated at the inception phase of the work to reflect the availability of a dataset that is part of the UNFCCC reporting. The amended objectives for the project were to:

- Cross-check and validate total road energy fuel consumption time series based on different available data sources by fuel type;
- Cross-check and validate total road energy fuel consumption time series based on different available data sources by vehicle type;
- Develop a detailed disaggregated EU wide analysis of passenger car energy consumption between its different vehicle segments
2 Identify and compare EU road transport energy consumption time series datasets

The objective for this task was to gather and compare time series datasets for EU road transport energy consumption data (by Member State), identify, explore and explain differences between them and develop a robust consolidated dataset, which will also be used in the rest of the analysis. This work was split into three subtasks. A summary of the work completed in this task is provided in the following subsections.

2.1 Identification and gathering of datasets

The first subtask was to gather datasets that cover road vehicle fuel consumption by fuel type to build a basis for the subsequent comparison. A number of datasets are available that cover consumption by fuel type and are available for the EU and individual EU Member States.

The main datasets that provide information on fuel consumption by fuel type are:

- The Fuel Quality Monitoring (FQM) reporting;
- Eurostat/EEA data on road transport energy use;
- DG ENER Oil Bulletin;
- UNFCCC Reporting on road transport energy consumption.

The following table (Table 2.1) gives an overview of the data sources and the geographical and temporal coverage as well as the fuels covered.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>MS covered</th>
<th>Years covered</th>
<th>Fuels covered</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>FQM</td>
<td>EU28</td>
<td>2001-2013</td>
<td>Different grades of diesel and petrol fuel including fuels with bio content</td>
<td>Up until 2013 Ricardo was collecting the FQM data for the European Commission. A full dataset until 2013 was therefore available for the project team. The 2014 data was retrieved from the 2014 summary report (EEA, 2015).</td>
</tr>
<tr>
<td>Eurostat</td>
<td>EU28 + Norway, Montenegro, Macedonia, Albania, Serbia, Turkey</td>
<td>1990-2013</td>
<td>Gasoline, Gas/diesel oil, Biogasoline(^2), Biodiesel(^3), LPG, Natural gas</td>
<td>Energy statistics – supply transformation and consumption (nrg_10)</td>
</tr>
</tbody>
</table>

\(^2\) This category includes bioethanol, bioETBE (ethyl–tertiary–butyl–ether produced on the basis of bioethanol) and bioMTBE (methyl–tertiary–butyl–ether).

\(^3\) This category includes biodiesel (a methyl–ester produced from vegetable or animal oil, of diesel quality), biodimethylether (dimethylether produced from biomass), Fischer Tropsch (Fischer Tropsch produced from biomass), cold pressed biooil (oil produced from oil seed through mechanical processing only) and all other liquid biofuels which are added to, blended with Gas/diesel oil.

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2 This category includes bioethanol, bioETBE (ethyl–tertiary–butyl–ether produced on the basis of bioethanol) and bioMTBE (methyl–tertiary–butyl–ether).
The range of countries, years and fuels covered varies from dataset to dataset. However, for all sources historic datasets are available for at least the last 10 years covering all EU28 Member States. All sources cover a minimum of petrol and diesel fuel.

### 2.2 Comparison and explanation for differences between datasets

In a next step the methodology behind the different datasets was compared to understand the differences in scope and assumptions to be able to interpret the results correctly and to facilitate the development of a consolidated data series (for the final stage of this task).

#### 2.2.1 Literature review

Fuel consumption reporting methodologies vary according to formal reporting requirements and may also vary according to Member States interpretation of these requirements. Reporting requirements are determined by the ultimate aim of data collection; whether this is to collate information on fuel quality, emissions or fuel prices across the European Union. The tables (Table 2.2 to Table 2.5) below highlight main differences observed between the different reporting requirements.

#### 2.2.1.1 Fuel Quality Monitoring (FQM)

Under the requirements of Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 as amended by Directive 2009/30/EC all EU Member States must yearly report on various types of information relating to the quality of petrol and diesel fuels sold in their territories. To ensure that the fuels are consistent with the requirements of the Directive, the Member States must sample fuels each year and analyse their technical characteristics (Ricardo-AEA, 2014). Table 2.2 provides a summary of the reporting requirements.

Provision of sales data is a reporting requirement, and is provided in order to understand the proportion of fuel sales by sales type and therefore the number of appropriate samples to test per fuel type. However, a description of the method of compilation of this sales data is not a reporting requirement. Looking at the 2014 monitoring reports (available in reporting template format from the European Environment Information and Observation Network (EIONET), many Member States have therefore not provided sales data collection information or any methodology.

Data analysis picked out some major discrepancies with the fuel sales reporting for FQM in 2011 - this could be explained by a change in reporting requirements whereby it became mandatory to report fuels with added ethanol from biofuels from 1st January 2011 under Directive amendment 2009/30/EC. Other changes that were required from 1st January 2011 included: Article 7a – with effect from 1 January 2011, requiring Member States to collect lifecycle GHG emissions characteristics for fuels within their national territories from suppliers with further obligations to reduce GHG emissions according to a predetermined timeline. (Note: this did not happen from 2011 as originally planned). Additionally, Metallic Additives (MMT) specifications changed: Article 8a - MMT to be limited to 6 mg Manganese per litre from 1 January 2011 (with a subsequent reduction in 2014) and a requirement that the presence of MMT in fuels shall be labelled clearly at the point of sale (Ricardo-AEA, 2014).

#### Table 2.2: FQM reporting requirements

<table>
<thead>
<tr>
<th>Fuel Quality Monitoring reporting requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary data sought</strong></td>
</tr>
<tr>
<td>Fuel quality within MS and sampling, testing &amp; reporting methodologies - sales/ consumption data is required by fuel type to calculate samples but not the primary aim of the dataset.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Vehicles covered</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Road vehicles and Non-Road Mobile Machinery (NRMMS) (including inland waterway vessels when not at sea), agricultural and forestry tractors, and recreational craft when not at sea</td>
</tr>
</tbody>
</table>

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5 This includes some farm machinery and construction and demolition vehicles
### Fuel Quality Monitoring reporting requirements

<table>
<thead>
<tr>
<th>Unit of measurement</th>
<th>Tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>The FQM has a focus on the fuels sold at the pump and therefore fuel types are classified according to the commercially available definitions (also requests National name for the fuel types):</td>
<td></td>
</tr>
<tr>
<td><strong>Regular unleaded petrol (minimum RON = 91)</strong></td>
<td></td>
</tr>
<tr>
<td>Regular unleaded petrol (minimum RON = 91) E5</td>
<td></td>
</tr>
<tr>
<td>Regular unleaded petrol (minimum RON = 91) E10</td>
<td></td>
</tr>
<tr>
<td>Regular unleaded petrol (minimum RON = 91) E+</td>
<td></td>
</tr>
<tr>
<td><strong>Unleaded petrol (minimum RON = 95)</strong></td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum RON = 95) E5</td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum RON = 95) E10</td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum RON = 95) E+</td>
<td></td>
</tr>
<tr>
<td><strong>Unleaded petrol (minimum 95 =&lt; RON &lt; 98)</strong></td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum 95 =&lt; RON &lt; 98) E5</td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum 95 =&lt; RON &lt; 98) E10</td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum 95 =&lt; RON &lt; 98) E+</td>
<td></td>
</tr>
<tr>
<td><strong>Unleaded petrol (minimum RON &gt;= 98)</strong></td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum RON &gt;= 98) E5</td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum RON &gt;= 98) E10</td>
<td></td>
</tr>
<tr>
<td>Unleaded petrol (minimum RON &gt;= 98) E+</td>
<td></td>
</tr>
<tr>
<td><strong>Diesel fuel</strong></td>
<td></td>
</tr>
<tr>
<td>Diesel fuel B7</td>
<td></td>
</tr>
<tr>
<td>Diesel fuel B+ (&gt;7% FAME &lt;=30%)</td>
<td></td>
</tr>
<tr>
<td>Diesel fuel B+ (FAME &gt;30%)</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

- Parent grades as specified in Annex I of Directive 98/70/EC with maximum sulphur content of 10ppm.
- E5 denotes fuels/petrol with up to 5 % ethanol content where the ethanol is derived from biofuels (OR where ethanol is of biogenic origin)
- E10 indicates fuels/petrol with up to 10 % ethanol content where the ethanol content comes from biofuels (OR where ethanol is of biogenic origin).
- E+ indicates biofuels blends with > 10 % ethanol. B7 includes diesel fuels with up to 7 % FAME and; B+ represents FAME blends of > 7 %.

### Fuel type distinctions

<table>
<thead>
<tr>
<th>Biofuels component?</th>
<th>Included in fuel sales data as % content where applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual submission deadline</td>
<td>30th June</td>
</tr>
</tbody>
</table>

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2.2.1.2 Eurostat

As set out in Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics all EU Member States have to report annually the energy used in all transport activities irrespective of the economic sector in which the activity occurs. Reports have to be submitted to the IEA, Eurostat and United Nations, annually and should be for the calendar year (not the fiscal year) (European Parliament, 2008). Table 2.3 provides a summary of the reporting requirements.

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### Table 2.3: Eurostat reporting requirements

<table>
<thead>
<tr>
<th>Eurostat reporting requirements</th>
<th>Energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary data sought</strong></td>
<td>Through defining the energy indicator B_101920 (Road) the fuel consumption can be narrowed down to only the fuel consumed by road vehicles. Transport sector — road is defined as:</td>
</tr>
<tr>
<td></td>
<td>• Quantities used in road vehicles. Includes fuel used by agricultural vehicles on highways and lubricants for use in road vehicles.</td>
</tr>
<tr>
<td></td>
<td>• Excludes energy used in stationary engines (see other sectors), for non-highway use in tractors (see agriculture), military use in road vehicles (see other sectors — not elsewhere specified), bitumen used in road surfacing and energy used in engines at construction sites (see industry subsector construction).</td>
</tr>
<tr>
<td><strong>Vehicles covered</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Unit of measurement</strong></td>
<td>Tonnes, Tonnes of Oil Equivalent (TOE), Tera joules (TJ)</td>
</tr>
<tr>
<td></td>
<td>The fuels available in the database and relevant for this project are:</td>
</tr>
<tr>
<td></td>
<td>• Gasoline (without bio components)</td>
</tr>
<tr>
<td></td>
<td>• Gas/diesel oil (without bio components)</td>
</tr>
<tr>
<td></td>
<td>• Biogasoline(^7)</td>
</tr>
<tr>
<td></td>
<td>• Biodiesel(^8)</td>
</tr>
<tr>
<td></td>
<td>• LPG</td>
</tr>
<tr>
<td></td>
<td>• Natural gas</td>
</tr>
<tr>
<td><strong>Fuel type distinctions</strong></td>
<td>Reported separately under RENEWABLE ENERGIES</td>
</tr>
<tr>
<td><strong>Biofuels component?</strong></td>
<td>30th September</td>
</tr>
<tr>
<td><strong>Annual submission deadline</strong></td>
<td></td>
</tr>
</tbody>
</table>

The guidance defines the geographical areas to be covered by national submissions. With their annual submissions Member States are requested to provide country-specific conversion factors. If no national conversion factors are provided then Eurostat default values are applied.

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\(^7\) This category includes bioethanol, bioETBE (ethyl–tertio–butyl–ether produced on the basis of bioethanol) and bioMTBE (methyl–tertio–butyl–ether).

\(^8\) This category includes biodiesel (a methyl–ester produced from vegetable or animal oil, of diesel quality), biodimethylether (dimethylether produced from biomass), Fischer Tropsch (Fischer Tropsch produced from biomass), cold pressed biooil (oil produced from oil seed through mechanical processing only) and all other liquid biofuels which are added to, blended with Gas/diesel oil.
2.2.1.3 Oil Bulletin

The DG ENER Market Observatory datasets take the shape of weekly bulletins\(^9\) that provides fuel prices (with or without tax) in Member States. Table 2.4 provides a summary of the reporting requirements.

<table>
<thead>
<tr>
<th>DG ENER Market Observatory datasets (Oil bulletin) reporting requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary data sought</strong></td>
</tr>
<tr>
<td><strong>Vehicles covered</strong></td>
</tr>
<tr>
<td><strong>Unit of measurement</strong></td>
</tr>
<tr>
<td><strong>Fuel type distinctions</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Biofuels component?</strong></td>
</tr>
<tr>
<td><strong>Annual submission deadline</strong></td>
</tr>
</tbody>
</table>

According to the survey carried out in 2008, prices are largely gathered by the Member State on a weekly basis from either a sample of service stations or directly from oil companies. The survey discovered that: the predominant data source for motor fuels is oil companies. This source is used by two thirds of respondents. Better reporting of data is enhanced in that two thirds of Member States have obligatory arrangement with oil companies to provide information. 63% of respondents cover more than 80% of their motor fuel market (three countries – Malta, Luxembourg and Slovenia have full coverage of the market).\(^{11}\)

2.2.1.4 UNFCCC

In accordance with Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and the relevant decisions of the Conference of the Parties (COP), Annex I Parties to the Convention submit to the secretariat national greenhouse gas inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol. These inventories are submitted annually. Part of the UNFCCC submission is the reporting of sectoral background data of energy which covers road transportation as a separate transport category (UNFCCC, 2015). Table 2.5 provides a summary of the reporting requirements.

The guidance documents for emissions reporting are provided by the UNFCCC\(^{12}\) and are based on reporting requirements originally outline by the IPCC in 2006. Submitting parties are requested to use the methodologies and good practice guidance that has been made available – however there are allowances for Member States to use different methods provided they follow IPCC guidance stating that: In accordance with the IPCC Guidelines, Annex I Parties may also use national methodologies which they consider better able to reflect their national situation, provided that these methodologies are compatible with the IPCC Guidelines and IPCC good practice guidance and are well documented and scientifically based.

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\(^{10}\) 20 November in 2015


In addition, the IPCC guidelines provide default methodology for calculating emissions factors and conversion factors – however methodologies that take into account national contexts are actively encouraged – provided they have been developed using good practice.

Table 2.5: UNFCCC reporting requirements

<table>
<thead>
<tr>
<th>UNFCCC reporting requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary data sought</strong></td>
</tr>
<tr>
<td><strong>Vehicles covered</strong></td>
</tr>
<tr>
<td><strong>Unit of measurement</strong></td>
</tr>
<tr>
<td><strong>Fuel type distinctions</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td><strong>Biofuels component?</strong></td>
</tr>
<tr>
<td><strong>Annual submission deadline</strong></td>
</tr>
</tbody>
</table>

2.2.1.5 Conclusion

The literature analysis suggests that differences in datasets are likely to be influenced by the different aims of the reporting (which may result in data being collected from different parties and/or at different times). While the FQM data is collected for context in monitoring the fuel quality in the EU Member States, the UNFCCC and Eurostat datasets both aim to collect fuel consumption data but for UNFCCC this is ultimately to estimate emissions. The main aim of the Oil Bulletin on the other hand is to report fuel prices. The different objectives of the datasets result in differences of the scope.

The main aspects identified from this literature analysis that have an impact on the comparability of the datasets are the following:

- Definitions for vehicles covered
- Fuel type distinctions
- Units of measurements
- Coverage of biofuels

The first discussions with experts and our experience with the FQM reporting furthermore suggested that the different interpretations of the Member States of the official guidelines, and the fact that in most Member States different organisations are responsible for compiling the different datasets would both have an impact on the resulting datasets.

In order to further understand the differences in interpretation and to investigate other possible reasons for the deviations between the datasets, direct engagement with the authorities compiling the datasets is therefore necessary. The data collection agencies should be able help determine the most common errors, anomalies or assumptions made by national reporting bodies and to find out how these issues are managed (i.e. how are they first identified, then verified or corrected) prior to publication of the data. The stakeholder engagement activities that were carried out as part of this project are further discussed in section 2.2.2.

Additional research was carried out to study national data collection methodologies and papers that explain differences between datasets. These are discussed in the case studies provided in Appendix 3 – Case studies.
2.2.2 Quantitative data analysis

Based on the data available the project team carried out a quantitative analysis of the datasets which disaggregate road vehicle consumption by fuel type (Eurostat, UNFCCC, DG ENERG Oil Bulletin, and FQM) on the European level. As discussed in the initial literature review (Section 2.2.1) the definition of fuels that are covered in each dataset vary. For the comparison therefore the aim was to plot the fuels together that match up best, keeping in mind that they cannot be matched up 100% and the results need to be discussed with care.

2.2.2.1 Diesel and Petrol

All datasets investigated cover diesel and petrol consumption. The following table (Table 2.6) gives an overview of which data have been plotted from each dataset.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Diesel</th>
<th>Petrol</th>
</tr>
</thead>
<tbody>
<tr>
<td>FQM</td>
<td><strong>Sum of Diesel fuel</strong> including Diesel fuel B7, Diesel fuel B+ (&gt;7% FAME &lt;=30%) and, Diesel fuel B+ (FAME &gt;30%)</td>
<td><strong>Sum of Unleaded petrol</strong> including min RON=91, 95, &lt;98 and &gt;=98, for each E5, E10, E+</td>
</tr>
<tr>
<td>Eurostat</td>
<td>Gas/diesel oil (without bio components)</td>
<td>Gasoline (without bio components)</td>
</tr>
<tr>
<td>Oil Bulletin</td>
<td>Automotive gas oil</td>
<td>Euro-super 95(I)</td>
</tr>
<tr>
<td>UNFCCC</td>
<td>Diesel oil (without biomass)</td>
<td>Gasoline (without biomass)</td>
</tr>
</tbody>
</table>

Figure 2-1 shows the deviation of diesel consumption for each EU Member State. In some cases, the agreement between datasets is good. For example, data for Ireland and the United Kingdom all fall within ±5% of one another. In addition, data falls within a ±10% deviation envelope from Eurostat for a further three Member States (BE, FI, LU). Generally, however, the data is highly variable, especially for FQM and Oil Bulletin data, reaching a maximum deviation of +53% for Estonia FQM data. In general, FQM and Oil Bulletin data demonstrates a significant (>10%) positive offset from the Eurostat data, with values of deviation highly variable between Member States. By contrast, the UNFCCC is largely in agreement with Eurostat, with nearly all values falling within ±5% of Eurostat (24 of 28 Member States meet this criteria).
This deviation also varies over time, as shown in Figure 2-2, which displays the values for the EU as a whole. It is noticeable that the FQM and Oil Bulletin datasets are largely well correlated for the period of collection after 2004, although there are some localised deviations, for example, in 2011. In contrast, the Eurostat and UNFCCC datasets are negatively offset, but with excellent agreement with each other. This suggests each of these two pairs of sources are likely to be closer in definition to each other and it would also seem more likely they have been produced from the same original datasets / definitions. Closer examination at the Member State level is needed to confirm this.

Performing such an examination has shown that, in most cases, the time-series associated with Member States show similar relative trends between the different sources. The UNFCCC and Eurostat tends to have a negative offset relative to Oil Bulletin and FQM. However, it is important to note that this general trend is not shown for all countries. In some cases, the deviation between the dataset results is highly variable, for example for CZ, MT and GR. In other cases values for FQM are significantly lower than for Oil Bulletin, and seem to show higher correlation with UNFCCC instead (ES, LU), whilst some show good correlations between all four datasets (UK, BE). This would appear to imply national differences in the definition and sources used to provide the different datasets.

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data\(^\text{13}\)

\(^{13}\) Datasets until 2013 available due to Ricardo Energy & Environment managing and analysing the FQM submissions between 2001 and 2014
Figure 2-2: DIESEL consumption (in TJ) by dataset for the EU, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

For petrol consumption, as Figure 2-3 demonstrates, the correlation between the datasets is much better than for diesel. 20 Member States have a less than ±10% deviation from Eurostat for all datasets. As before, UNFCCC has the best correlation; no Member State has a deviation that exceeds ±10% from Eurostat. Meanwhile, FQM and Oil Bulletin are somewhat more scattered, but in general, the offset between datasets are smaller than 10%. There are only two stand-out anomalies in this scatter plot; both Finland and France illustrate a deviation of greater (more negative) than -30%, for Oil Bulletin data.

Figure 2-3: Comparison of PETROL data across all Member States for the year 2013, deviation of FQM, UNFCCC and Oil Bulletin data from Eurostat data

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

For petrol the deviations between datasets is significantly smaller and in the most recent years all four datasets match up relatively well. It should be noted, however, that this level of consistency between datasets has not always been apparent. Figure 2-4 shows a time-series plot of petrol consumption across all EU-28 Member States since 2001 (where data is available). Prior to 2008, the Oil Bulletin

14 Datasets until 2014 available due to Ricardo Energy & Environment managing and analysing the FQM submissions between 2001 and 2014
dataset shows a significant offset from UNFCCC, Eurostat and FQM. In addition, the FQM data, once again, is systematically positively offset from Eurostat and UNFCCC, although the deviation is not as large as for diesel consumption. The correlation between Eurostat and UNFCCC for this dataset again is extremely good.

Figure 2-4: PETROL consumption (in TJ) by dataset for the EU, including Eurostat (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin and FQM

It should be noted, however, that this level of consistency between datasets has not always been apparent. Figure 2-4 shows a time-series plot of petrol consumption across all EU-28 Member States since 2001 (where data is available). Prior to 2008, the Oil Bulletin dataset shows a significant offset from UNFCCC, Eurostat and FQM. In addition, the FQM data, once again, is systematically positively offset from Eurostat and UNFCCC, although the deviation is not as large as for diesel consumption. The correlation between Eurostat and UNFCCC for this dataset again is extremely good.

On the Member State level, Eurostat and UNFCCC are fairly well correlated in nearly all Member States (MT and GR provide the only real exception to this rule). However, the position of Oil Bulletin or FQM data points relative to Eurostat and UNFCCC is highly variable between Member States. Typically, Oil Bulletin values are significantly lower than the UNFCCC dataset, although this deviation appears to have narrowed through time. In addition, FQM is often positively offset from UNFCCC, but the degree of deviation is variable between Member States. For example, Finland illustrates a deviation that exceeds 10% from UNFCCC, whilst some states show good correlation between the datasets (e.g. CY, SL, PT). As for diesel, this would appear to imply national differences in the definition and sources used to provide the different datasets.

The data on the European level shows that there must be systematic differences between the datasets. In the following sub-sections the potential impact of adjusting the datasets for the following parameters will be assessed, to see whether they might help explain some of the observed variability and bring the datasets into closer alignment:

- Conversion factors;
- Biofuels content;
- Inclusion/Exclusion of non-road vehicles;
- Comparison of same fuel grades for Oil Bulletin and FQM.

Impact of conversion factors

Before concluding that offset between datasets are a true representation of the datasets (and hence data collection methodology), it was necessary ensure that the data manipulation steps taken to reach this stage have not produced a deviation which is an artefact of our assumptions. It was therefore necessary to explore the sensitivity of the datasets to these assumptions. This is discussed below.

Firstly, raw data from each source is given in different units in some cases. In order to compare the datasets, therefore, units must be converted. For example, data from FQM and Oil Bulletin is given in tonnes, whilst UNFCCC and Eurostat consumption is available in Tera joules (TJ). In order to convert
to TJ, the density and net calorific value of the fuel needs to be assumed. In our initial analysis, by default both the Oil Bulletin and FQM data were converted using standard fuel property factors collated by Ricardo Energy & Environment for UK GHG reporting by companies, published by the UK's Department for Environment Food & Rural Affairs (DEFRA)\textsuperscript{15}.

The FQM dataset also included fuel density values, and as such, it was possible to use these values for conversions when available. Therefore the first step taken in the sensitivity analysis for these assumptions was to assess whether using density values given in the FQM dataset in preference to DEFRA-published fuel property values introduced a significant deviation to the dataset. This sensitivity analysis was performed and, as Figure 2-5 and Figure 2-6 illustrate, no significant deviation was found. A systematic offset of -1.03\% is introduced when only DEFRA fuel property conversion factors are used, equivalent to 36,000 TJ in 2013 for petrol consumption for the entire EU. For diesel consumption, the offset is more variable, but never exceeds ±1\% and, therefore, the deviation between the datasets is relatively insensitive to the absolute value of fuel density (so does not explain the size of the variability seen between the original datasets).

Figure 2-5: Difference between the FQM dataset petrol consumption when conversion uses density values given in raw dataset, and when the conversion relies on constants provided by DEFRA for conversion, expressed as a percentage

Source: Analysis of FQM sales data\textsuperscript{16}


\textsuperscript{16} Datasets until 2014 available due to Ricardo Energy & Environment managing and analysing the FQM submissions between 2001 and 2014
In addition to the density conversion, the impact of the conversion of all data to TJ was explored with a second sensitivity analysis. In order to assess whether this conversion had introduced deviation into the plots, a similar comparison was made, but with all data converted to tonnes. Therefore, in this case, it was the Eurostat and UNFCCC data that needed to be adapted in order for a full comparison to be possible. The results of this sensitivity analysis again showed that the conclusions that can be draw from the figures are relatively insensitive to this conversion step (see Figure 2-7 and Figure 2-8).

Figure 2-7: DIESEL consumption (in tonnes) by dataset for the EU, including Eurostat (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

17 Datasets until 2014 available due to Ricardo Energy & Environment managing and analysing the FQM submissions between 2001 and 2014
Impact of biofuels

The initial literature analysis suggested that one reason for the deviation between the datasets was likely to be (at least partly) the biofuels content. The datasets where there is a clear/explicit distinction provided between diesel and biodiesel (Eurostat and UNFCCC) match up well and the values from the datasets that cover fuels including biofuel contents (FQM and Oil Bulletin) are significantly higher. The impact of biofuel content is discussed first for diesel and then for petrol below. In the following we will use the terminology “biodiesel” and “biopetrol” in line with the terms used in Eurostat.

Due to the lack of information on the exact biofuels content in the FQM and Oil Bulletin data, it is not possible to separate out the biodiesel from the conventional diesel. However, it is possible to add the biodiesel to the Eurostat data to see how well it matches with the FQM and Oil Bulletin data. For the UNFCCC datasets, the biofuels (biopetrol + biodiesel) are reported as a single value (biomass). To further disaggregate this dataset (i.e. to separate the biomass between biopetrol and biodiesel), the shares available from Eurostat have therefore been used. The plot for the Eurostat and the UNFCCC data for diesel including biofuel as shown in Figure 2-9 illustrates that this brings the Eurostat and the UNFCCC data closer to the other two datasets, however, there is still a significant difference between them. This suggests that other factors (such as inclusion/exclusion of non-road vehicles) could also be required to help explain the deviations.

When biofuel data is added to the Eurostat and UNFCCC petrol data, it appears to match up relatively well with the FQM data (see Figure 2-10). This suggests that in the case for petrol the main cause for the deviation is the inclusion/exclusion of biofuels. This is in contrast to the observations with the diesel data (see Figure 2-9) where further parameters seem to have an impact on the deviations. However, the result of the inclusion of biofuel data does not always result in a close correlation between FQM and Eurostat at a country level. For many countries, the addition of biofuels to Eurostat data is not sufficient to cover the entire deviation between FQM and Eurostat (for example, DE, FR). In contrast, in some cases, Eurostat with biofuels is positively offset from FQM, although these cases are limited to examples where Eurostat data already exceeds FQM prior to the inclusion of biofuel. Having said this, some Member States do show significantly improved correlation after the inclusions of biofuels (e.g. NL, PL, SE). This suggests again that other national-specific factors are also influencing the outcomes for different datasets. Figures to demonstrate these scenarios are found in Appendix 3 – Case studies.

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18 This category includes biodiesel (a methyl-ester produced from vegetable or animal oil, of diesel quality), biodimethylether (dimethyl ether produced from biomass), Fischer Tropsch (Fischer Tropsch produced from biomass), cold pressed biooil (oil produced from oil seed through mechanical processing only) and all other liquid biofuels which are added to, blended with Gas/diesel oil.

19 This category includes bioethanol, bioETBE (ethyl-tertiary-butyl-ether produced on the basis of bioethanol) and bioMTBE (methyl-tertiary-butyl-ether).
Figure 2-9: DIESEL consumption (in TJ) by dataset for the EU, including Eurostat (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin and FQM

![Graph showing diesel consumption by dataset for the EU, 2004-2013.]

*Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data*

Figure 2-10: PETROL consumption (in TJ) by dataset for the EU, including Eurostat (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin and FQM

![Graph showing petrol consumption by dataset for the EU, 2004-2013.]

*Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data*

One reason for the remaining differences could be the inclusion/exclusion of non-road vehicles in some datasets and not the others. Non-road vehicles primarily use diesel fuels, and hence its absence from the Eurostat and UNFCCC datasets would introduce a much larger deviation in cumulative diesel consumption that it would for petrol consumption. This is further discussed later in the next section.

**Impact of non-road use**

Fuel consumption for non-road vehicles was omitted from the initial comparative analysis (for the datasets that explicitly distinguish between road and non-road fuel consumption, i.e. Eurostat and UNFCCC datasets). In order to assess how significant this omission is to the differences between the sources, the non-road data for Eurostat and UNFCCC was aggregated for each Member State and added to the comparison. As defined in the Oil Annual Questionnaire (Eurostat, 2014), the oil data for road vehicles should only include fuel used by agricultural vehicles on highways and lubricants for use in road vehicles:

- Motor gasoline and diesel used in stationary engines should be covered under “Not elsewhere specified – Other sectors”;
- Diesel oil for non-highway use in tractors under “Agriculture/forestry – Other sectors”, military use should be included under “Not elsewhere specified – Other sectors”; and
- Gasoil used in engines at construction sites should be under “Construction – Industry sector”.

The diesel and petrol consumption for all these categories was therefore aggregated and added to the Eurostat data for road transport.
For the UNFCCC dataset the non-road vehicle use is covered under:

- “Mobile Combustion in manufacturing industries and construction”;
- “Residential: Household and gardening (mobile)”;
- “Agriculture/Forestry/Fishing: Off-road vehicles and other machinery”.

The UNFCCC dataset however only differentiates between petrol and diesel for the last category, the first two only give liquid fuel values in total. This is why only the data available for “Agriculture/Forestry/Fishing: Off-road vehicles and other machinery” was added to the UNFCCC road fuel values.

As expected, the influence this has on petrol consumption is quite small, since off-road vehicles, such as construction vehicles, do not often operate on a petrol engines (see Figure 2-12).

However, for diesel consumption, the inclusion of non-road data generally causes a significant positive shift in the Eurostat and UNFCCC data as shown in Figure 2-11, resulting in an improvement to the correlation between Eurostat, Oil Bulletin and FQM at an EU-level. This pattern is reflected also in comparing results for a number of Member States (for example, AT, PL, PT). However, the introduction of this data can also be deleterious on the correlation of the datasets for some of the other countries. For example, the UK data initially showed good correlation between the datasets, but the addition of non-road fuel consumption data introduces a positive offset between Eurostat and the remaining data sources that was not present before (see Appendix 3 – Case studies).

In some countries (e.g. UK, Spain) the National Energy Balance provides a separation and uses a separate terminology between diesel used for off-road vehicles (e.g. called gas oil or “red diesel”, as this fuel is dyed, in the UK) and road diesel (e.g. called DERV in the UK) that allows to separate off-road consumption from road transport with fairly high confidence. Most other countries just refer to all this fuel as “diesel”, and it becomes more challenging to attribute the fuel to road and non-road sources.

In countries where such detailed distinction can be made beforehand, the off-road data will include the different grades of fuels and including the total of this data will have a negative effect on the alignment of the datasets. As the UNFCCC and the Eurostat data do not differentiate between different grades of diesel, no information is available on the share between different fuel grades for these Member States.

Further differences in early years might be explained with different data collection and processing methodologies and differences in the quality of the data available at the time.

Figure 2-11 DIESEL consumption (in TJ) by dataset for the EU, including Eurostat (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin and FQM

![Figure 2-11 DIESEL consumption (in TJ) by dataset for the EU, including Eurostat (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin and FQM](source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data)
Impact of biofuels and non-road use together

When both biofuels and non-road data are added to the Eurostat and UNFCCC data, the alignment in general increases for both diesel and petrol. Some discrepancies still exist which will be further explored in Appendix 3 – Case studies.

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data
Figure 2-14: PETROL consumption (in TJ) by dataset for the EU, including Eurostat (with biofuels and with non-road data), UNFCCC (with biofuels and with non-road data), Oil Bulletin and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

The analysis has shown that in particular the inclusion of biofuels and non-road vehicle consumption have a positive impact on the correlation between the four datasets. Slight differences still persist, which will be explored in the case studies.

Comparison of same fuel grades between the FQM and Oil Bulletin datasets

It appears to have been established that the main differences between the Eurostat/UNFCCC and the FQM/Oil Bulletin data are likely to be the fact that Eurostat/UNFCCC report on petrol and diesel for road transport only and without biofuels, whilst the FQM/Oil Bulletin on the other hand report on fuel consumption in total. The comparison plots for diesel data also shows that the FQM and the Oil Bulletin data match up relatively well, however, this is not the case for petrol. In particular between 2001 and 2009 comparisons show a significant discrepancy between Oil Bulletin and FQM. Going back to the definitions of fuels covered in each dataset (Table 2.6) it becomes clear that while the Oil Bulletin only reports Euro-super 95(I), the FQM dataset also covers petrol with other octane ratings such as RON 91 and RON 95 as well as fuels with high biofuel content such as E10 and E+. In order to confirm how well the petrol data from FQM and Oil Bulletin compare on the same basis, it is necessary to only plot the FQM fuel grades that match up with Euro-super 95(I). Figure 2-15 shows that for the comparison of RON 95 fuel grades only, the Oil Bulletin and the FQM data match up significantly better. The deviation of the datasets in the past can therefore most likely be attributed to the previously higher market shares of RON 91 and RON 98 grade fuels. The remaining differences might be due to differences in allocation of fuels to different fuel grades: due to Ricardo Energy & Environment's previous involvement in the collection of FQM data, the project team is aware that some countries have different definitions of fuel types.
2.2.2 Biofuels

Biofuel consumption is given in a variety of ways across the datasets. Within Eurostat and UNFCCC, the consumption of biodiesel, biopetrol, and/or biomass is given explicitly and disaggregated from diesel or petrol use. However, in FQM, biofuels are addressed through the consumption of blended fuel types (e.g. diesel fuel B+, B5 or B7) — although higher fuel blends (e.g. E85, B30 and B100) may not be captured. Also the diesel and petrol fuels covered in the DG ENERG Oil Bulletin dataset can include biofuel components. According to a survey conducted with national reporting authorities, the biofuel content can range between 0 and 6% depending on the Member State (Market Observatory for Energy, 2009). The uncertainty of the exact biofuel percentages make it difficult to separate out the biofuels from the FQM and Oil Bulletin data. The focus therefore will lie on the data obtained from UNFCCC and Eurostat data, where this is specifically stated.

Initially, the project team compared the total biomass consumption (biofuel + biopetrol aggregated for Eurostat) across the EU over the past 15 years. As expected, records of biofuel consumption have dramatically increased over this period, ranging from 80,000 TJ in 2004 to 600,000 TJ by 2012. There is good correlation between Eurostat and UNFCCC across this time-frame. Figure 2-16 demonstrates this correlation. For all case study countries the correlation between UNFCCC and Eurostat is good as well. The best match can be found for Poland, while the match for Germany is less good (see Figure 0-47 and Figure 0-21 in Appendix 3 – Case studies). Nevertheless there is a clear correlation between the datasets for Germany as well.

![Figure 2-15: Comparison of petrol RON 95 fuel grade for FQM and Oil Bulletin for EU](image)

Source: Analysis of (DG ENERGY, 2015) and FQM sales data

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20 Unleaded petrol min. RON = 95, Unleaded petrol min. RON = 95 and <50ppm S, Sulphur-free unleaded petrol RON=95, <10ppm S, Unleaded petrol RON equal > 98 < 50 ppm Sulphur, Unleaded petrol 95 equal RON<98, <10ppm S, Unleaded petrol (minimum RON = 95) E5, Unleaded petrol (minimum 95=e<RON<98) E5, Unleaded petrol 95 equal <RON<98
As already discussed, the inclusion/exclusion of biofuel data has a strong effect on the correlations on total fuel consumption. When analysing the data further it can be shown that the inclusion of biofuels with the Eurostat data can account for around 60% and 45% of the deviation from FQM for petrol and diesel consumption respectively. A similar positive shift of the UNFCCC data is also seen with the inclusion of biofuels data. As a quality check, it is possible to compare the ratio of biodiesel to biopetrol consumption to other reported figures. Using data from Eurostat, an estimate of this ratio for 2013 is approximately 80% biodiesel (and hence, 20% biopetrol). This is slightly larger than other estimates derivable from other sources. For example, data from the EU Biofuels Annual 2014 indicates this ratio is closer to 70% biodiesel (and hence, 30% biopetrol). It is unclear what the reason for the difference may be, however, given the small volumes involved the 10% deviation between the two may be due to methodological differences or errors. On average, biofuel consumption composes approximately 5% of total fuel consumption for Eurostat and UNFCCC data for 2013.

### 2.2.2.3 LPG and natural gas

Three out of the four datasets assessed include LPG values. Only for the FQM dataset these values are not available. Figure 2-17 shows the plot over time for those three datasets. Again the Eurostat and the UNFCCC data match up well (suggesting more consistent original sources), whereas the Oil Bulletin diverges from the other two. Nevertheless the all three datasets show LPG values at the same magnitude.

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Figure 2-17: LPG consumption (in TJ) by dataset for the EU, including Eurostat (without non-road data), UNFCCC (without non-road data), Oil Bulletin and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013) and (UNFCCC, 2015)

Natural gas values are only available through Eurostat and UNFCCC. The plots for those are shown below (Figure 2-18). Again both datasets match up well.

Figure 2-18: NATURAL GAS consumption (in TJ) by dataset for the EU, including Eurostat (without non-road data), UNFCCC (without non-road data), Oil Bulletin and FQM

Source: Analysis of (Eurostat, 2013) and (UNFCCC, 2015)

2.2.3 Stakeholder engagement

2.2.3.1 Organisation

To support the findings from the literature and quantitative analysis the project team carried out telephone interviews with the reporting authorities for all four datasets under assessment. The focus for the interviews was limited to the case study countries agreed with the Commission at the start of the project (i.e. DE, ES, FR, IT, PL, SE, UK), to keep the work within the available project resources. Based on internet research and the use of existing Ricardo Energy & Environment contacts (e.g. from previous FQM work and those of the UK emissions inventory team) a list of relevant contacts was compiled.

To support the stakeholder engagement a letter was drafted by the project team and signed by the Commission. This letter included a description of the project and a request to the stakeholders to support the project.

A questionnaire was also developed, based upon the gaps identified in the literature review, as well as initial input/feedback from national contact points, and also from Eurostat and Ricardo inventory experts. The developed questionnaire covered a range of aspects/questions, such as:

- The reporting responsibilities of the responding authority;
- Basis of the data collection:
Establish if the dataset covers fuel production, fuel sales or in-use fuel consumption;
Assess if the consumption data covers consumption by national citizens or fuel consumed on national territory;
Capture any changes in the data collection methodology to explain trends in the data;
- Definition of road vehicles;
  - Are any non-road vehicles covered?
- Types of fuels;
  - Establish which fuels are covered;
  - Identify the data sources by fuel type;
- Conversion factors;
  - Unit of measurement the consumption data is provided in;
  - Conversion factors that are used;
  - Establish whether seasonal changes in fuel properties are taken into account;
- Fuel consumption plots;
  - Reasons for the deviations;
  - Reports that explain the differences;

The full questionnaire can be found in Appendix 1 – National reporting authorities – Questionnaire.

The questionnaire was initially pilot tested with the French Ministry of Finance on 21st December and the French Centre Interprofessionnel Technique d’Etudes de la Pollution Atmosphérique - CITEPA (responsible for UNFCCC reporting) on 18th January. Based on the feedback from those interviews the questionnaire was then further refined and finalised for use with the other participating organisations.

Initial contact was made by email in November 2015, however the initial response rates were low, with those responding indicating that this was due to the time of year. Further collective emails (to all experts in one Member State) were therefore sent out at the start of January 2016. The aim of the collective contact was to attempt to schedule conference calls with all relevant authorities at once, to facilitate a more effective discussion. However, most of the organisations that agreed to participate unfortunately preferred to contribute only individually: only Poland offered a coordinated response with all involved authorities. In this case the Energy Agency (ARE) organised a meeting with all involved organisations and was available for an interview with the project team to discuss the findings.

It was not feasible within the available project resources to interview all organisations for all case study countries (which could have been potentially 28 interview partners). The project team therefore agreed with the Commission to limit the number of interviews to a maximum of 14, focusing on organisations that could give information on more than one dataset. In total 12 interviews were completed, covering all 7 case study countries. For Sweden and the UK, written responses from additional organisations were also received. A full list of the interview partners can be found in Appendix 2 - List of interview partners. For each interview, notes were compiled and sent through to the participants for approval.

While the focus for the interviews was the case study countries, the developed questionnaire was also sent to all representatives of the remaining Member States in late January/early February 2016. Furthermore, the questionnaire to the national authorities reporting on energy data to Eurostat was distributed on our behalf by Eurostat.

Overall the response rate was good, and an additional 55 responses were received from countries/organisations that were not already covered as case studies, covering all Member States.

The table below (Table 2.7) gives an overview of the responses received for non-case study countries.

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22 For questionnaires sent through Eurostat.
Table 2.7: Responses to the questionnaire from non-case study countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of questionnaires received</th>
<th>Datasets covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>4</td>
<td>FQM, Oil Bulletin, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Belgium</td>
<td>1</td>
<td>Oil Bulletin,</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>3</td>
<td>Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Croatia</td>
<td>2</td>
<td>FQM, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Cyprus</td>
<td>3</td>
<td>FQM, Oil Bulletin, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2</td>
<td>Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Denmark</td>
<td>2</td>
<td>FQM, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Estonia</td>
<td>2</td>
<td>Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Finland</td>
<td>3</td>
<td>Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Greece</td>
<td>2</td>
<td>Eurostat,</td>
</tr>
<tr>
<td>Hungary</td>
<td>3</td>
<td>FQM, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Ireland</td>
<td>3</td>
<td>FQM, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Latvia</td>
<td>5</td>
<td>FQM, Oil Bulletin, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Lithuania</td>
<td>4</td>
<td>FQM, Oil Bulletin, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>1</td>
<td>Eurostat,</td>
</tr>
<tr>
<td>Malta</td>
<td>1</td>
<td>UNFCCC</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3</td>
<td>FQM, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Portugal</td>
<td>2</td>
<td>FQM, UNFCCC</td>
</tr>
<tr>
<td>Romania</td>
<td>1</td>
<td>FQM</td>
</tr>
<tr>
<td>Slovakia</td>
<td>4</td>
<td>FQM, Oil Bulletin, Eurostat, UNFCCC</td>
</tr>
<tr>
<td>Slovenia</td>
<td>3</td>
<td>FQM, UNFCCC</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>55</strong></td>
<td></td>
</tr>
</tbody>
</table>

Limitations/obstacles

The main challenge with this exercise was to receive enough responses to be able to get the full picture of the reporting structure in each Member State. The project team was unable to talk to each authority involved in the reporting for each case study country within the available resources. In cases like Poland or Austria (a non-case study country), the involved institutions made sure to coordinate their efforts and were able to give a complete picture of the reporting situation. However, in most cases the picture was much more fragmented. With up to four different authorities involved, it was not easy to get a complete overview. In many cases one authority did not even know who was reporting on some of the other datasets; in some case this turned out to be simply a different department in the same organisation. In conclusion, it was therefore not always possible to close all the gaps. In Appendix 3 – Case studies the existing gaps are highlighted.

2.2.3.2 Findings

The main focus of the stakeholder engagement were the case study countries Germany (DE), Spain (ES), France (FR), Italy (IT), Poland (PL), Sweden (SE), and the UK. For each of these countries, discussions were held with as many of the relevant authorities as possible, to ensure a full coverage of the issues. A detailed description of the reporting structures and individual results can be found in Appendix 3 – Case studies. Nevertheless, the main findings from the assessment are discussed here. These findings are further supplemented with findings from the questionnaire responses received for non-case study countries.

Overall the input from the interviews and the questionnaires confirmed that the main reasons for discrepancies in the data were the ones that have been identified through the literature research and
the quantitative analysis (i.e. inclusion/exclusion of biofuels, inclusion/exclusion of non-road consumption, conversion factors).

2.2.3.2.1 Findings from the questionnaire responses for non-case study countries

Several questionnaire respondents highlighted the fundamentally different aims of the different datasets which naturally result in different values.

In general, most agree that much of the difference between Eurostat and UNFCCC, and FQM and Oil Bulletin, is due to the fact the latter two use fuel sold statistics, and methodological difficulties involved with this (AT, SK). FQM and Oil Bulletin reports may include consumption from other sectors (BG, LV, MT, NL, PT), such as non-road vehicles, industrial applications, or agricultural and construction vehicles.

In addition to this, several attribute the discrepancy of the Oil Bulletin dataset to the fact that they only request RON 95 gasoline data (CY, LV, BE). In fact, BE explain that 15-20% of their consumption is RON 98 and thus isn’t included in the Oil Bulletin reports.

The possible impact of the inclusion/exclusion was raised by five Member States (CY, DK, FI, FI, MT).

In terms of data handling and manipulation, several respondents suggest that variation of the net calorific values may cause some of the error (CZ, FI, FI, HU), or at least, there have been errors or corrections in the data handling stage (AT, SI, NL).

For the Netherlands a study was available that looked into the differences between Energy Balance and the energy use as reported by the IEA, Eurostat and UNFCCC (Centraal Bureau voor de Statistiek, 2010)23. With regards to the fuel consumption by road transport the one point that was highlighted was that there could be differences in how fuel used for international transport is being reported.

Due to the large number of responses received no detailed analysis of all questionnaires could be carried out. The full set of completed questionnaires for non-case study countries are therefore provided to the Commission in a separate file (“Questionnaire responses”).24

2.2.3.2.2 Overall findings

The findings from the submissions by the non-case study countries together with the detailed analysis carried out for the seven case study countries suggests that the main reasons for discrepancies between the datasets are the following.

Non-road use

Separating out the use of fuel by non-road vehicles was identified as one of the main differences between FQM/Oil Bulletin and Eurostat/UNFCCC. A difference in the methodology on allocation non-road use further explains differences between Eurostat and UNFCCC reporting. Most UNFCCC reporting teams use a bottom-up approach to calculate road fuel consumption based on road emission models such as COPERT and HBEFA/TREMOD and estimate the non-road use by comparing against the national energy statistics. Based on available studies on the consumption by different sub-categories of non-road use (e.g. inland water vessels, military use, agricultural use) the fuel consumption is allocated. While the Eurostat Annual Oil Questionnaire also requires that Member States report road use separate from non-road use, in most cases a more simplified top-down allocation is performed. These different approaches can lead to different end results which can lead to small differences, as observed in the UK, or significant ones, as observed in Sweden. In some countries the allocation is done in parallel by different bodies, in other cases the allocation is only carried out by one team and used by the other team. This for example is the case in Poland where the Energy Agency ARE carries out a top down allocation and reports the data to Eurostat through the national statistical office. The UNFCCC team then uses the data as published in Eurostat for their inventory reporting. In this Member State the figures for Eurostat and UNFCCC therefore match up exactly.

Conversion

The national energy balances are usually reported in tonnes which is the unit of measurement that is required for FQM, Oil Bulletin and Eurostat reporting. In these cases the reporting teams do not have to carry out a conversion. The Eurostat data however is online also available in Tera joules. The

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23 Only available in Dutch
24 The questionnaires are only provided for the Member States that agreed to their submission being made available to the Commission.
conversion is carried out by the Eurostat teams either based on conversion factors provided by the Member States, or if not available, Eurostat default values are used. UNFCCC teams on the other hand have to report in Tera joules directly and therefore have to apply conversion factors. These conversion factors do not necessarily match up the conversion factors provided to Eurostat or the Eurostat default values and can therefore be the cause of differences in the reported values. While this is not a big issue for conventional fuels this can be a bigger issue for biofuels. In the case of Spain the difference in conversion factor for 2012 is 2.2%25 for biopetrol, while for biodiesel the deviation is even higher with 8.2%26.

**Reporting timelines**

One issue that has not been investigated before, but was highlighted by several national contacts, is the fact that the reporting timelines are very different for each dataset. In the case study for Poland it was highlighted that the collection and processing of the energy data stretches out over a long period of time and while first results are available early in the year, the data processing and allocation is only finished in September. This is an important issue for the FQM reporting. Due to the reporting deadline for Member States in June, the team requests data on fuel consumption already in February, seven months before the dataset is being finalised. This can result in significant discrepancies for the FQM data. For the Oil Bulletin and the UNFCCC data this is not an issue as their reporting happens after the finalisation of the national energy balance. However, one reason for discrepancies between Oil Bulletin and Eurostat can be caused by the fact that Eurostat data can be updated when errors in the calculations are found, for the Oil Bulletin on the other hand there is no procedure for updating the data.

**2.2.4 Conclusion**

To conclude, there are different reasons for discrepancies in the datasets. Some are systematic and result from the different requirement of the datasets.

- Eurostat and UNFCCC report on road fuel consumption only and separate out biofuel contents from the fuels;
- FQM and Oil Bulletin report on total fuel consumption for fuel types used in the automotive sector but do not separate use by non-road vehicles. Furthermore their fuels can include biofuels content. While FQM covers E5, E10, E+ as well as B7 and B+, the Oil Bulletin fuels can include biofuel content up to the legally accepted limit before the biofuels content needs to be declared27.
- Differences in data between Oil Bulletin and FQM can be traced back to the different types of fuels covered. While the Oil Bulletin only covers conventional fuels, the FQM dataset includes fuels with declareable biofuels content. The Oil Bulletin also only reports on Euro-super 95 while the FQM dataset covers petrol fuels with octane ratings RON 91 and RON 98.
- Further discrepancies are caused by different reporting timelines and the resulting use of preliminary data.
- Finally, some differences can result from the UNFCCC data being updated throughout the complete time series each year while Eurostat data is only updated in cases where errors have been found. The Oil Bulletin data and the FQM data28 are not being adjusted retrospectively.

In addition to these general differences that apply to each Member State there are country-specific conditions that influence the extent of the differences in the data:

- Methodology used to allocate fuel to non-road transport uses. Differences between Eurostat and UNFCCC data can stem from different methodologies to allocate non-road fuel consumption.
- The number of authorities involved in reporting and the level of coordination between them.

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25 27.4 GJ/t (UNFCCC), 26.8 GJ/t (Eurostat)
26 39.8 GJ/t (UNFCCC), 38.8 GJ/t (Eurostat)
27 diesel with up to 7 % by volume biodiesel (B7) and unleaded petrol with up to 5 % ethanol (E5)
28 In some cases updates for previous years are provided, however, this is not common practice.
2.3 Development of a robust consolidated time series disaggregated by fuel

The analysis has shown that the FQM and Oil Bulletin dataset do not report on road fuel consumption in particular but cover the total fuel consumption. In addition to that the Oil Bulletin dataset only covered Super 95 petrol and no fuels with other octane ratings (e.g. RON91, RON98). These datasets are therefore not suitable for reporting road fuel consumption as a whole accurately and completely. More suitable datasets are the Eurostat reporting on energy consumption in the road transport sector and the UNFCCC reporting figures for road transport. As the analysis has shown, the figures from these two datasets often align very closely or exactly with each other. Nevertheless there are cases where the figures show significant deviations from each other (e.g. for Sweden). The input from the interviews carried out for this project has helped to identify the main reasons for these differences.

Whilst the original data in all assessed countries comes from the same data source, the UNFCCC teams often apply also a bottom-up approach based on vehicle emission models (such as COPERT or TREMOD) to calculate fuel consumption and to allocate the consumption to the different types of transport. These more detailed models are typically calibrated against the national energy statistics, while the model allows for a more detailed allocation of the fuels. In particular, the allocation of fuel consumption by Non-Road Mobile Machinery is calculated in detail by UNFCCC teams, whilst the national energy statistics often are based on a more simplified top-down allocation of fuels. This difference in methodologies in allocating the fuel that is consumed by road transport can lead to discrepancies in the reported data. Some countries overcome this issue by ensuring that only one organisation is carrying out the allocation (e.g. in the UK it is done by Ricardo’s emission inventory team) and that the same data is reported.

Due to the stricter reporting regulations for the UNFCCC data, in general the data by the inventory teams is more detailed and more robust. Another advantage of the UNFCCC data is the fact that each year the complete data series from 1990 is reported. Changes to the methodology and assumptions are applied to the whole time series and it is therefore more consistent than the Eurostat data. While backdated changes are sometimes made to the Eurostat submissions, these only cover identified errors or additional data that became available for selected years and not the complete time series.

One limitation of the UNFCCC data is that biofuels are only reported as biomass in total. While the inventory teams often have information on the split of biomass between biodiesel and biopetrol, a full data collection for the last 10 years through the inventory teams was not feasible within the resources of this project; therefore it was decided to use the shares available from Eurostat.

The final data series produced for this project for the last 10 years has been developed for all Member States as well as for the EU as a whole, with the EU plot presented below in Figure 2-19 and Figure 2-20. The full dataset and the individual plots can be found in the MS Excel Workbook “Road Fuel Time Series” which has been submitted to the Commission alongside this report.
Figure 2-19: Time-series for fuel consumption (in TJ) by fuel-type for the EU, showing petrol (without biofuels and without non-road data) and diesel (without biofuels and without non-road data) data only.

Source: Ricardo calculations based (Eurostat, 2013) and (UNFCCC, 2015)

Figure 2-20: Time-series for fuel consumption (in TJ) by fuel-type for the EU, showing LPG, Natural Gas, Biopetrol and Biodiesel consumption only.

Source: Ricardo calculations based (Eurostat, 2013) and (UNFCCC, 2015)
3 Identify and compare EU models/datasets for road transport fuel consumption by vehicle category

In a further step the project team investigated different sources for data on road fuel consumption by vehicle type in order to compare the results and to develop a consolidated data series for the last 10 years by Member State as an output from the project.

3.1 Identification and gathering of datasets by vehicle category

A range of datasets/models were identified during the project that provide a split of road vehicle fuel consumption for EU Member States by vehicle type. These include the following:

- TREMOVE model,
- MOVEET model,
- PRIMES-TREMOVE model;
- TRACCS project outputs;
- UNFCCC reporting datasets by EU Member States.

The TREMOVE model was developed initially in 1997/1998 by K.U.Leuven and DRI as an analytical tool to underpin the second European Auto-Oil programme. Since 2002 Transport & Mobility Leuven further developed the model for DG Environment with updates in 2006/2007 and also in 2009/2010. The model was developed to facilitate for policy analysis of the effects of different transport and environment policies on the emissions of the transport sector. The model covers passenger and freight transport in 31 countries for the period 1995-2030. The model allows estimates for transport demand, modal shifts, vehicle stock renewal and scrappage decisions as well as the emissions of air pollutants and the welfare level, for a range of policies (such as road pricing, public transport pricing, emission standards, subsidies for cleaner cars). (Transport & Mobility Leuven, TREMOVE economic transport and emissions model, 2016)

Also developed by Transport & Mobility Leuven, but more recently (since 2012) is the MOVEET (MObility, Vehicle fleet, Energy use and Emissions forecast Tool) model. MOVEET was developed as an analytical tool to address policy problems related to transport and climate change in particular. The model covers all transport modes for 57 different regions in the world covering the period up to 2050 and consists of four interrelated modules (similarly to TREMOVE): Transport Demand, Fleet, Environmental, and Welfare. (Transport & Mobility Leuven, MOVEET, 2016)

PRIMES-TREMOVE is the transport sub-model of PRIMES, a model that simulates the European energy system and markets on a country-by-country basis and across Europe. Developed by E3MLab, who are part of this project’s team, PRIMES-TREMOVE produces projections of transport activity, stock turnover, technology choice, energy consumption and other externalities. The model has been designed with focus on long-term simulation of conditions which would drive restructuring of the sector towards new, cleaner and more efficient transportation technologies and fuels. The model is therefore developed in a way to fully handle possible electrification of road transport, high blending of bio-fuels in all transport sector and market penetration of alternative fuels including hydrogen.

TRACCS (Transport data collection supporting the quantitative analysis of measures relating to transport and climate change) is not a model, but a data base resulting from a project carried out for DG CLIMA. The project team led by Emisia (with also INFRAS and IVL) collected transport data in Europe to support the quantitative analysis of measures relating to transport and climate change. The data collection focused on historical data for the period of 2005 – 2010. For road transport it was based on publically available statistical datasets as well questionnaires sent out to countries’ experts. (EMISIA I. I., 2013)

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29 In addition the potential to include IDEES (the database that provides input to POTEncIA model of the JRC), was discussed early in the project. However in the end it was not possible for this information to be made available in time for its inclusion within the project.
Finally, the United Nations Framework Convention on Climate Change (UNFCCC) requires Annex I Parties to include road fuel consumption in their National Inventory Submissions. Since 2015 the submissions not only needed to include a disaggregation by fuel type (as previously) but also need to provide a breakdown by road vehicle type. Each year the submitted data includes the complete time series from 1990 until the most recent year.

All these five models or datasets provide fuel consumption values by road vehicle type for all Member States and are included in the comparison discussed in the following section.

3.2 Comparison and explanation of differences between models / datasets

The project team has compared data from the models TREMOVE\textsuperscript{30}, MOVEET\textsuperscript{31}, the TRACCS project\textsuperscript{32} (EMISIA I. I., 2013), PRIMES-TREMOVE\textsuperscript{33} and UNFCCC\textsuperscript{34} for all EU Member States for both 2005 and 2010. A higher resolution of comparison is not possible, since both TREMOVE and PRIMES-TREMOVE outputs are limited to a five-year resolution model output. Comparison of 2015 data is not possible, since the UNFCCC and TRACCS data does not extend to this date.

Figure 3-1 shows a comparison of fuel consumption by vehicle type for 2005. The comparison between these models demonstrates that UNFCCC and TRACCS are similar in their results. In these, the total fuel consumption aligns well and for the distribution of fuel use between vehicle types only the distribution of diesel use between cars and vans is slightly different. The overall consumption of PRIMES-TREMOVE also matches TRACCS and UNFCCC (also being calibrated to similar national energy consumption statistics), however, the diesel consumption for trucks and buses is considerably higher, while car petrol consumption and van diesel consumption are much lower.

The results from TREMOVE do not match with regards to the total fuel consumption. The TREMOVE value lies below the three discussed datasets, while showing a higher fuel consumption by cars (both diesel and petrol). The fifth dataset, retrieved from the MOVEET model, shows a higher total consumption than the other four datasets. This difference in total consumption can be mainly traced back to a significantly higher consumption by petrol cars and diesel trucks and buses.

As shown in Figure 3-2 the similar observations can be made for the year 2010. The only significant difference for 2010 is that the total fuel consumption from MOVEET now lies below the PRIMES-TREMOVE, TRACCS and UNFCCC data but still above the TREMOVE data. This is due to a significant decrease in petrol fuel consumption.

Overall similar observations can be made for the results on a Member State level. The case studies include the plots for seven selected countries. In some cases, however, the differences are further exaggerated (see Appendix 3 – Case studies).

\textsuperscript{30} Model version 3.3.2
\textsuperscript{31} Model version 1.2, data provided by the TML model team in February 2016
\textsuperscript{32} As published in 2013
\textsuperscript{33} Data from “EU Energy, Transport and GHG emissions Trends to 2050 – Reference Scenario 2013”
\textsuperscript{34} 2015 submissions under UNFCCC
Figure 3-1: Model dataset comparison of transport energy consumption by vehicle/fuel type, EU28, 2005

Table 3.1: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), EU28, 2005

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>Diesel</td>
<td>86,857</td>
<td>67,470</td>
<td>70,645</td>
<td>66,702</td>
<td>59,461</td>
</tr>
<tr>
<td></td>
<td>Petrol</td>
<td>109,300</td>
<td>90,096</td>
<td>106,849</td>
<td>105,193</td>
<td>138,074</td>
</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
<td>1,766</td>
<td>6,720</td>
<td>4,576</td>
<td>4,014</td>
<td>1,008</td>
</tr>
<tr>
<td>Vans</td>
<td>Diesel</td>
<td>17,721</td>
<td>13,930</td>
<td>29,754</td>
<td>35,472</td>
<td>12,809</td>
</tr>
<tr>
<td></td>
<td>Petrol</td>
<td>1,575</td>
<td>2,079</td>
<td>4,154</td>
<td>4,747</td>
<td>4,583</td>
</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
<td>0</td>
<td>0</td>
<td>325</td>
<td>213</td>
<td>0</td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
<td>60,920</td>
<td>111,738</td>
<td>78,075</td>
<td>77,844</td>
<td>95,187</td>
</tr>
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<td></td>
<td>Petrol</td>
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<td>0</td>
<td>116</td>
<td>898</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
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<td>48</td>
<td>171</td>
<td>44</td>
<td>0</td>
</tr>
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<td>2-wheelers</td>
<td>Petrol</td>
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<td>3,900</td>
<td>3,543</td>
<td>4,325</td>
<td>0</td>
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<tr>
<td></td>
<td>Diesel</td>
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<td>3</td>
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</tr>
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<td>Gaseous fuels</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Analysis of TREMOVE\(^{35}\), TRACCS\(^{36}\), PRIMES-TREMOVE\(^{37}\), (UNFCCC, 2015) data and MOVEET data\(^{38}\)

\(^{35}\) Available here: [http://www.tmleuven.be/methode/tremove/home.htm](http://www.tmleuven.be/methode/tremove/home.htm)


\(^{37}\) Provided by DG MOVE

\(^{38}\) Provided by the MOVEET modelling team at TML
In order to understand where the differences in outputs stem from, the project team analysed the model structures and data collection methodologies in detail. This analysis has only focused on the modules that calculate road fuel consumption. Figure 3-3 - Figure 3-5 show the structures for the models TREMOVE, MOVEET and PRIMES-TREMOVE. The blue boxes show the input data sources, the green boxes are the different modules, the grey boxes show data used for calibration and the yellow boxes show the model output, which is the energy/fuel consumption by vehicle type and fuel.

The figures show that all three models have a similar structure to calculate road energy consumption by vehicle and fuel type. Based on vehicle stock and activity in combination with specific energy consumption derived consumption from road emission models, fuel consumption by vehicle/fuel type is calculated. Vehicle stock and activity are based on a range of different models and studies, for the specific fuel consumption estimations, however the COPERT model methodologies are used for all three models. Where relevant, the calibration procedure routings ensure that total energy consumption per transport sector (e.g. the road sector) matches historic statistical datasets (e.g. Eurostat statistics).

The differences between the three models stem from the different source data that was used and the datasets used for their calibration. It has to be kept in mind that the models have been developed at
different times and consequently different data of different quality has been available. It is therefore unsurprising that TREMOVE shows high discrepancy from the other models, since the data is based on older information. TREMOVE has therefore not been used for delivering results for EC related projects in the recent years.

**Figure 3-3: TREMOVE - Model structure**

![TREMOVE - Model structure](source)

**Source:** Ricardo analysis of TREMOVE report (Transport & Mobility Leuven, 2016)

**Figure 3-4: MOVEET: Model structure**

![MOVEET - Model structure](source)

**Source:** Input from the MOVEET team at Transport & Mobility Leuven
For the PRIMES-TREMOVE results, it should be taken into consideration that a model update is planned for 2016. Unfortunately the new reference scenario will not be available in time for this project, however, the developers have shed some light on what changes will be made to the model in the future.

With the 2016 reference scenario updates will be made to the underlying databases. The new version of the model presents differences regarding the allocation of the energy of road transport across the transport modes (cars, vans, trucks etc.). Such differences occur due to the update of the databases with new statistics which were not available during the elaboration of the previous Reference scenario 2013. The estimates on the split of road energy demand across transport modes, in the Reference scenario 2016, will therefore be closer to the UNFCCC figures and those of the TRACCS database.

Furthermore the availability of specific transport statistics will allow for a more accurate split of energy statistics for road transport across the various transport modes. The most important part of this exercise involves the split of energy demand between cars and heavy duty trucks.

A further change made in the new Reference 2016 scenario is that transport activity of heavy duty trucks will follow the territoriality principle instead of the nationality principle. The former reflects transport activity of vehicles circulating within a country irrespective of the nationality of the transporting vehicle. Statistics based on the nationality concept reflect the performance of the vehicles registered in the reporting country (transport of national vehicles to/from the reporting country and the performances in and between third countries). For the calibration routines, estimates were provided with regard to the activity of heavy duty trucks in terms of vehicle-kilometres. Such information is important for improving the accuracy of the estimate. In addition, the new Reference scenario includes the most up-to-date database, TRACCS, with regard to road transport statistics on vehicle stock.

In contrast to the above described models the TRACCS database is a collection of historic data, which has been post-processed for internal consistency and gap-filling. Based on fuel consumption factors, vehicle stock and vehicle activity data from national and European statistics as well as studies the road fuel consumption is calculated (see Figure 3-6). The TRACCS project developed a detailed and clean dataset which is complete and consistent, which is critical for further model work and for analytical purposes. This meant using a reconciliation module to ensure the production of a homogenised dataset. As a starting point for this process, TRACCS used UNFCCC data, as this was the most detailed and complete dataset available. Therefore as strong correlation between the total fuel consumption from UNFCCC and TRACCS is expected. Some deviations can be observed in the allocation of the total consumption to the different vehicle types as the UNFCCC datasets did not provide a disaggregation by vehicle type at that point. Further deviations could be due to the changes made to the UNFCCC time series since the TRACCS project was completed.
For the final dataset, the UNFCCC submissions, it is not possible to give an overview of the data collection and processing structure as the methodology is different for each Member State, given national circumstances. National circumstances include the availability of required data, and contribution made by the category to total national emissions and removals and to their trend over time. In Appendix 3 – Case studies the UNFCCC methodology is explained for the seven selected countries. Nevertheless the IPCC guidelines give an overview of possible methodologies to calculate road fuel consumption.

With regards to road fuel consumption the guidelines specify that the emissions from road vehicles should be attributed to the country where the fuel is sold and therefore fuel consumption data should reflect fuel that is sold within the country’s territories. Such energy data are typically available from the national statistical agency. In addition to fuel sold data collected nationally, inventory compilers should collect activity data on other fuels used in that country with minor distributions that are not part of the national statistics (i.e., fuels that are not widely consumed such as compressed natural gas or biofuels). These data are often also available from the national statistical agency or they may be accounted for under separate tax collection processes.

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the EMEP/EEA Emissions Inventory Guidebook 2013 offer a tiered approach for estimating fuel consumption and emissions for road transport. Tier 1 simply takes the total fuel sales for a country and multiplies by a default emission factor (in g/kg fuel or g/TJ) for the relevant fuel; it assumes vehicle activity data are not available so does not allow a separation by vehicle type. A Tier 2 approach in the IPCC Guidelines is similar, but enables country-specific emission factors to be used rather than defaults, but in terms of fuel consumption a Tier 1 and Tier 2 approach are the same. In the EMEP/EEA Guidelines, a Tier 2 approach assumes vehicle km data are available for each main vehicle category, but not by road type. In IPCC terms, there is no Tier 3 approach for estimating CO₂ emissions, but there is for estimating other greenhouse gas emissions and this requires a detailed breakdown in vehicle kilometres by vehicle and technology type and road type. The same definition of Tier 3 is used for pollutant emissions in the EMEP/EEA Guidelines.

Although not required for IPCC reporting of CO₂ emissions, a Tier 3 approach is required to provide a breakdown of fuel consumption by vehicle type if such data are not already available from national statistics sources, which is normally the case. Countries are encouraged to use a Tier 3 approach for inventories where data are available. This should be possible by using the country’s vehicle registration statistics (number of vehicles of different types by age and fuel type) and annual mileage data, using either defaults or from country specific surveys or collection of mileage data from vehicle inspection programmes. Such activity data can be found in sources such as TREMOVE or TRACCS. It can be enhanced through more detailed traffic surveys on different road types. The methodology for carrying
out a detailed Tier 3 approach is described in the EMEP/EEA Emissions Inventory Guidebook which is also referred to in the IPCC 2006 Guidelines. The method itself is incorporated in the COPERT 4 model.

For Tier 3 methods, the MOBILE or COPERT models may help develop activity data. The guidelines furthermore suggest two alternative approaches to separate non-road and on-road fuel use. For the first approach the fuel used by each road vehicle type is estimated from the vehicle kilometres travelled data for each major fuel type. The difference between this road vehicle total and the apparent consumption is attributed to the off-road sector. For the second approach the fuel estimate derived from the first approach is supplemented by a similarly structured bottom-up estimate of off-road fuel use from a knowledge of the off-road equipment types and their usage. The apparent consumption in the transportation sector is then disaggregated according to each vehicle type and the off-road sector in proportion to the bottom-up estimates. (IPCC, 2006)

Conclusion

The analysis of the data and the methodologies for the different models and datasets has shown that, even though there are sometimes significant differences in the allocation of fuel consumption to the different vehicle types, the overall values for most of the datasets lie relatively close together for TRACCS, UNFCCC and PRIMES-TREMOVE. This is not surprising considering that there are a number of linkages between the different databases/models. For example the TRACCS project uses the UNFCCC reporting on fuel consumption for calibration of their road transport figures (EMISIA I. I., 2013). The principal objective of TRACCS in turn was to supply DG CLIMA with a general update of the historical transport data for use in the various activity and emission modelling/projection tools (such as COPERT, TREMOVE, PRIMES, TRANS-TOOLS, SULTAN, EC4MACS/GAINS, etc.) (EMISIA, TRACCS - Project overview, 2015). Overall there is significant overlap in the datasets used as input or for calibration. A further common feature is the use of COPERT as the road emission model. TREMOVE, PRIMES-TREMOVE and MOVEET all base their emission estimations on this model. It furthermore plays a crucial role for emission and consumption estimations in national inventories. However, on the national level COPERT is not the only vehicle emission model used. In the following section, an overview of the existing models will be given and it will be discussed to what extent the choice of vehicle emission models can impact the road fuel consumption estimations.

Reasons that could cause the differences between these datasets could be:

- Importance of territoriality vs nationality principle both for activity and fuel (fuel used in a country vs fuel consumed in a country);
- Treatment of second-hand vehicles;
- Resolution of each model i.e. differences in the coverage of trip types, purposes, time, area, car sizes etc.

### 3.3 The impact of the choice of vehicle emission model on consumption estimations

As it was established above vehicle emission models play an important role not only for the discussed transport models but also the national inventories. Figure 3-7 shows the use of different vehicle emission models across Europe. The figure highlights that COPERT or COPERT-based models are the vehicle emission model predominantly used for the national inventory reporting. Used across three Member States (Austria, Germany, Sweden) and Switzerland is the HBEFA Handbook which is the basis for the road transport module of the TREMOD (Transport Emission Model). Another two Member States (Finland and the Netherlands) have developed their own models.

An understanding of the methodology behind these models and how they affect the inventory reporting and potentially other fuel consumption models is indispensable to be able to carry out a comprehensive comparison of fuel consumption data. For this project we will focus on the differences between COPERT and HBEFA/TREMOD.
Both COPERT and HBEFA estimate emissions as a combination of vehicle fleet consumption and activity data input by the user, and include “libraries” of emissions factors within the model. Since the huge number of driving situations and vehicle categories are impossible to be covered by measurements within reasonable time and financial effort, methods of calculating emissions factors from a reduced amount of measured data points is necessary.

In brief, COPERT IV (Ntziachristos, Gkatzoflias, Kouridis, & Samaras, 2009) is an average-speed model considering three different driving patterns (urban, rural and motorway). This is the model currently integrated in the EMEP/EEA methodology for emissions computation (Ntziachristos & Samaras, Methodology for the Calculation of Exhaust Emissions - SNAPs 070100-070500, NFRs IA3bi-iv, 2012), and is used by most EU countries for their national inventories. HBEFA 3.2, on the other hand, (Kühlwein, J.; Rexeis, M.; Luz, R.; Hausberger, S, 2013) defines traffic situations represented by four main parameters (rural/urban, road type, road speed limit and service level), and then emissions are calculated by an emissions model PHEM which is developed by TU Graz.

**COPERT**

The general approach for the development of emissions factors in COPERT is to plot the aggregated results of various driving sub-cycles with respect to the average velocity of the specific sub-cycle, and to fit a polynomial trend to this data through mathematical regression. These data points are extracted from experiments conducted for specific drive cycles, vehicle classes and technology, from the literature. The resulting formula of the trend-line is the emissions factor that expressed vehicle emissions as a function of mean velocity.

The general methodology is;

\[ E_{TOTAL} = E_{COLD} + E_{HOT} \]

\( E_{COLD} \) are emissions from a cold-start, during transient thermal engine operation.

\( E_{HOT} \) are emissions at normal operating temperatures.

Total emissions are calculated as a product of activity data provided by the user and speed-dependent emission factors calculated by the software. Part of the emissions calculation methodology is to assign regions to being either rural, urban or motorway.
The software application of COPERT 4 methodology has been developed for the compilation of national inventories on a yearly basis, however, it has been shown that the methodology can also be used with a sufficient degree of certainty at a higher resolution too.

COPERT includes an option to estimate exhaust emissions from internal combustion engines used in off-road applications (agriculture, forestry, household, industry, waterways and railways), however, this is not yet covered in COPERT IV but one must still use the separate module of COPERT III.

In terms of input activity data, in theory, the datasets should be available through the national statistics offices of all countries, and from international statistical organisations and institutes (e.g. Eurostat). However, the data is often not robust enough for use within COPERT. This data is almost exclusively vehicle-orientated, with little information referring to the age and technology distribution, and even less with regards to activity (with the exception of fuel statistics). In addition, traffic data needs to be more detailed, and average trip length for cold-start emissions are reliant upon estimates from national experts, which may have since become outdated with progressive urbanisation. (EMISIA, 2016)

HBEFA/TREMOD

In contrast to the COPERT model the Handbook Emission Factors for Road Transport (HBEFA) is intended to be used at finer geographical scales. This model requires more detailed inputs in terms of traffic, and is mostly used in countries where this data is more readily available (e.g. Germany, Austria, Switzerland). The emission factors are dependent on qualitative descriptions of “traffic situations”. A key element of the HBEFA methodology is the use of vehicle simulation model PHEM for emissions calculations over different traffic conditions.

PHEM is a vehicle simulation model capable of simulating hot and cold emissions for different driving cycles, gear shift strategies, vehicle loadings, road gradients, vehicle characteristics (mass, size, air resistance). It has been validated by emissions measurements both in the laboratories and on the road and under different test conditions. It calculates fuel consumption and emissions of road vehicles in 1Hz time resolution, by calculating the engine power and speeds.

- Engine power -> calculates necessary to overcome driving resistances, losses in the drivetrain and to run basic auxiliaries.
- Engine speeds -> simulated by transmission ratios and a driver gear shift model.

Basic emissions are then interpolated from the engine emission maps. Then, depending on the vehicle category, EURO class and exhaust gas component correction functions are applied to calculate exhaust gas mass flow. This approach takes into account realistic factors such as road gradient variations, vehicle loading and gear shift behaviour.

In terms of external input, HBEFA is similar to COPERT. It requires vehicle sub-segments based on emissions legislation, category and technology, averaged daily number of vehicles and the length of link (i.e. to calculate vkm) and traffic situation with different gradient classes.

The key difference between the two is the fact the COPERT considers information about the average speed on different street-categories, whilst HBEFA takes into account traffic situation (e.g. stop-and-go, effects of traffic lights).

The HBEFA emission factors build the basis for the road transport module of TREMOD (Transport Emission Model) which is used on a national level. The model analyses emissions for all means of passenger and freight transport for scenarios until 2030.

Comparison of COPERT with HBEFA/TREMOD

To date the availability of studies comparing emission/consumption values from COPERT and HBEFA/TREMOD are limited. The literature analysis suggests that COPERT to a certain extent is based on HBEFA emission factors (INFRAS, 2014) but given the fundamental methodological differences (average speed versus traffic situation approach) some differences in results are expected.

There have been some studies that used both COPERT and HBEFA to calculate emissions for specific vehicle categories and traffic situations, but mainly for air pollutants, rather than fuel consumption/CO₂.

On a city level a paper by (Borge, et al., 2012) compared emissions between these two methodologies (COPERT IV and HBEFA 3.1) for Madrid. In general, they found the resulting emissions to be higher for HBEFA (for NOₓ emissions were 20.9% higher, which was primarily attributed to differences of
emissions in PC’s, HDVs and buses). It was found that the reason for this discrepancy was because of the differences between the average-speed input in the COPERT model, and the implied speed that HBEFA/PHEM produces in urban areas, primarily as a result of stop-and-go conditions modelled by HBEFA. These differences might also be expected to result in different fuel consumption results, though no comparisons of this were provided in this project.

On the national level, however, currently no study is available that compares COPERT with the TREMOD model. The German Federal Highway Research Institute (BASt), that uses TREMOD, therefore commissioned a study to understand which of the two emissions models is better suited for which aspect of calculating emissions. The project carried out by EMISIA, INFRAS and IFEU will aim to compare TREMOD and COPERT through: (a) Description of the features and expected developments for the two models; (b) Description of the activity data used in the two models; (c) Calculations with the two models for five test cases and assessment of results (BASt, 2015). The project started in April 2015 and is expected to run until April 2016 (EMISIA, 2016).

While no results are available yet, the contact interviewed for the UNFCCC reporting at the German Environment Agency (UBA) highlighted that while there might have been bigger differences between the models in the past, the model teams are now working closely together and only minor differences in the results are expected. This cooperation is coordinated through the ERMES group that oversees the development of the leading vehicle emission models in Europe including COPERT, HBEFA and VERSIT+ (the model developed by TNO and used in the Netherlands). (ERMES, 2016)

3.4 Development of a robust consolidated time series disaggregated by vehicle type

The final sub-task in this area was to develop/report on the complete time-series breakdown of fuel consumption by road transport mode for the last 10 years for each Member State (and the EU as a whole). It was decided to use the UNFCCC data as the basis for these time series, in part to ensure consistency with the dataset for fuel consumption by fuel type, and also because the UNFCCC submissions generally require/have a known high quality and robustness across all Member States.

As for the data by fuel type, the UNFCCC dataset is supplemented with data on the biofuel shares from Eurostat (used to disaggregate the combined data for all biomass). In order to calculate the biofuels share by vehicle type, the total biodiesel consumption (calculated from the total biomass from UNFCCC and the biofuels share from Eurostat) was distributed between the vehicle types proportionally to the diesel consumption, assuming that the majority of biodiesel consumption is blended into diesel. When the calculated biodiesel share was less than 1 (i.e. there was a biopetrol component), the biopetrol consumption was then calculated by subtracting the biodiesel consumption from the biomass by vehicle category available from the UNFCCC datasets. In some cases (e.g. heavy duty truck) the calculated biodiesel exceeded the available total biomass. In order to accommodate the excess without changing the absolute sum and share of biomass the excess biodiesel was shifted to the passenger cars category.

The analysis of the UNFCCC data has shown that for three Member States (Cyprus, Malta, Finland) the road fuel consumption data was not available at a vehicle category level, whilst for a further two Member States (Czech Republic, Slovakia) disaggregation was only partial across the time-frame considered. In these cases, the TRACCS database was consulted for data on disaggregation by vehicle type. As the TRACCS data is only available for the time frame between 2005 and 2010, it was assumed that the split by vehicle type has not changed between 2003 and 2005, and 2010 and 2013 respectively.

In addition, several countries did not provide disaggregated values for biofuels, LPG and natural gas. For the biomass values, the split between vehicle categories was deducted from the diesel and petrol consumption.

For LPG and natural gas, again the TRACCS data was consulted, and where available the UNFCCC data was supplemented with data on the split between the vehicle categories.

39 EE, HR, LT, LU, RO, SI, UK.
40 BE, BG, DE, EE, ES, FR, GR, HR, HU, IE, LT, LU, PT, SI, SK, UK
41 BE, ES, GR, HU, LT, LV, PT, SI, SK UK,
The data series has been developed and submitted in MS Excel format alongside this report (“Road Fuel Time Series”).

**Figure 3-8: DIESEL consumption (in TJ) by vehicle-type for the EU28**

![Graph showing DIESEL consumption by vehicle-type for the EU28 from 2003 to 2013.]

**Figure 3-9: PETROL consumption (in TJ) by vehicle-type for the EU28**

![Graph showing PETROL consumption by vehicle-type for the EU28 from 2003 to 2013.]

Figure 3-10: LPG consumption (in TJ) by vehicle-type for the EU28

Figure 3-11: NATURAL GAS consumption (in TJ) by vehicle-type for the EU28

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42 LPG consumption data for 2-wheelers unavailable
43 Natural Gas consumption data for 2-wheelers unavailable
Figure 3-12: BIODIESEL consumption (in TJ) by vehicle-type for the EU28

Figure 3-13: BIOPETROL consumption (in TJ) by vehicle-type for the EU28
4 Disaggregation of fuel consumption data for cars into different segments

Due to the availability of high-quality datasets on the disaggregation of fuel consumption to different road transport modes from Member States’ submissions under UNFCCC, it was agreed in discussion with the Commission to re-focus the original work programme to:

i. Better understand the primary datasets and methodologies employed, and the trends in this data /comparisons with other datasets; and

ii. Instead develop an approach to disaggregate car fuel consumption by car segment, as well as providing an alternate bottom-up estimate of overall car fuel consumption for comparison with the figures reported to UNFCCC (which generally use alternative methodological approaches).

The approach developed for the disaggregation of car energy consumption is outlined in more detail in the following sections. The results cover the period 2000-2014 for the seven case study countries Germany, France, UK, Spain, Italy, Poland and Sweden, and the EU as a whole.

This section describes the sources and the approach taken to disaggregate fuel by car segment using an adapted version of the SULTAN model. The sum of all car segments provides an alternate bottom-up estimate of overall car fuel consumption for comparison with the figures reported to UNFCCC (which generally use alternative methodological approaches). The disaggregation by car segment covers the period 2000-2014 for the seven case study countries Germany, France, UK, Spain, Italy, Poland and Sweden, and the EU as a whole. Due to the limitations of the data available for biofuels, natural gas and LPG, the disaggregation carried out in this project focuses on petrol and diesel.

4.1 Development of the methodology to disaggregate fuel consumption by car segment

The objective of this task was to develop a consistent time-series estimate of the share of fuel consumption between different car segments up to the most recent year possible with available data.

The approach agreed with the Commission for this task was to adapt the SULTAN model (previously developed for DG Climate Action) in order to estimate the share of total car fuel consumption by segment. This work consisted of modifying SULTAN to enable the production of estimates of car fuel consumption disaggregated by segment and fuel type for the years 2000 to 2014.

4.1.1 Yearly data inputs

Historically, SULTAN has been set up to calculate transport stock characteristics from 2010 to 2050, with input data specified at five year intervals. As most of the input data in this case is forecasted (i.e. looking into the future), the five year intervals are a suitable balance between the effort required of the user and the degree of interpolation performed by SULTAN. This study, however, looks backwards at what has already happened, for which historical data is available for each year and as such it was necessary to increase the resolution of SULTAN’s inputs. SULTAN was thus modified to accept data input for each of the years between 2000 and 2014.

4.1.2 Explicit specification of new vehicle registration numbers

SULTAN’s contemporary method for determining the number of new registrations in a given year is based on a user-defined survival function, which models an exponential decay of stock by vehicle age (see Figure 4-7 in Section 4.2.5 for an example). Once SULTAN has removed the de-registered vehicles from the fleet, the number of new registrations in the year of interest is equal to the difference between the remaining stock and the desired stock. This method is ideal when the user does not know the number of new registrations directly but knows the expected overall projected vehicle stock level, such as when forecasting. Here, however, registration data in each year is known and so could be used to increase the accuracy of the results. As such, SULTAN was modified to accept a specified number of new registrations in each year, to override/supplement the normal survival function estimate. In this modified case, although the survival function no longer determines the total number of de-registrations in this case, it still specifies the proportion of de-registrations by vehicle age.
4.1.3 Accounting for imported (second hand) vehicles

Another new feature introduced to improve the results was the ability to account for imported vehicles, i.e. second hand vehicles registered in the country for the first time. This is especially important when considering countries such as Poland, where the number of second hand cars imported from outside the country was in some years more than five times the number of new car registrations in Poland. Functionality was therefore added to allow the specification of the percentage of newly-registered vehicles (both new and second hand) which are imported in each year. The spread of these imported vehicles across the vintages is defined by a fifth-order polynomial which is also specified by the user (i.e. fitted to available data on this element).

4.1.4 Mileage weightings by vehicle age

The final new feature introduced ahead of this project (implemented for the Service Request 13 project running in parallel with this work) is the ability to account for the fact that vehicles travel comparatively less miles with increasing age (Ricardo-AEA, 2015). SULTAN’s fuel consumption and cost-effectiveness estimates are principally based on the calculated demand for various modes and powertrains, yielding an overall ‘activity’ for each. As such, vehicle mileages are not explicitly specified but are intrinsically included within this activity figure, and previously no account was made for the age of the vehicle. Now, a multiplier has been integrated to introduce this effect.

Fuel type also has a notable impact on mileage profile - for example between petrol and diesel vehicles, where the latter have a higher activity per vehicle. It is non-trivial and beyond the limitations of the study to extend the activity multiplier to this case, thus a proxy method has been employed so as not to omit this important consideration: as opposed to running each powertrain through the model at a time, each fuel type has also been run separately. Running the model in this unconventional way allows the demand for each fuel type to be specified by the user and not assumed by SULTAN.

4.2 Identification and gathering of datasets for disaggregation by car segment

In the following sections, the input data collected to populate the tool are summarised by data category.

4.2.1 Existing/total vehicle stock

For each of the eight cases (seven case study countries plus EU28) we feed data on vehicle stock into the tool for each year. Eurostat dataset ‘road_eqs_carmot’ provides total car stock by Member State for all years up to 2012 with fairly few gaps. Existing gaps were filled using the average of the year before and the year after. Stock for the years 2013 and 2014 was estimated using MS Excel’s TREND function, drawing on the 2009-2012 data to extrapolate to 2014.

4.2.2 New vehicle registrations by fuel type and by segment

For the years 2010 to 2014, the number of new vehicles registered across the EU and the case study countries has been disaggregated by fuel type and segment, using the EU car CO2 monitoring database, drawing on the car segmentation methodology previously applied for the Service Request 4 project (Ricardo Energy & Environment, 2016 (forthcoming)). As a part of the monitoring strategy of Regulation (EC) No. 443/2009 and of Regulation (EC) No. 510/2011, the European Environment Agency (EEA) collects, aggregates and releases yearly datasets that report passenger car and light commercial vehicles registration across EU Member States. The datasets for all five years have been cleaned and each data point assigned a standardised car/van manufacturer and model through a series of search string algorithms, before each model is manually assigned a vehicle segment, based on the technical information available from the manufacturer and the judgment of the study team. The end result is an aggregated dataset of CO2 consumption with known manufacturer, model and vehicle segment.

For use as an input in the SULTAN model, cars are aggregated by four different segments as they were also defined in (Ricardo Energy & Environment, 2016 (forthcoming)): small (mini and supermini cars), lower medium cars, upper medium cars and extra large/other (executive, luxury, sports, van-derived cars). SUVs and minivans are allocated to the segment size from which they are derived (e.g. VW Tiguan and Touran are Golf-derived and thus attributed to the ‘medium’ segment). Figure 4-1 summarises the results for the EU28.
Between 2000 and 2009 there are no comprehensive publically available records of the number of registrations by vehicle model for the given cases. The TRACCS database provides the required data for the years 2005 to 2010. However, as illustrated by Figure 4-2, there is substantial variation in the estimates between TRACCS and the EEA data used for the years 2010 to 2014.

**Figure 4-2: Comparison between TRACCS and EEA data on split of new registrations by segment and fuel type, 2010**

*Note: Segments in the TRACCS data are labelled ‘Small’, ‘Lower-Medium’, ‘Upper-Medium’ and ‘Executive’. In the chart these have been attributed to the ‘Small’, ‘Lower Medium’, ‘Upper Medium’ and ‘Large’ categories, respectively. However, definitions may deviate slightly from those used to categorise the EEA data (see above).*
Therefore an approach of scaling the EEA 2010 data to derive estimates for the years 2000 to 2009 is used. The ICCT’s EU Pocketbook provides a split of new registrations by segment from 2001 onwards at the EU level. In order to estimate the 2000 to 2009 split of new registrations, the 2001-2009 trends from the ICCT data are applied to the case study’s 2010 segment split. For example, there has been a proportionate increase in the number of cars in the ‘small’ segment between 2001 and 2009. The same proportionate change is applied to all case study countries. Data for the year 2000 is extrapolated.

The ICCT segment split does not distinguish between fuel types. However, the EU car CO₂ monitoring data (for 2000 to 2009) provides the number of overall petrol and diesel cars registered in the EU and within each case study country. Therefore, in order to estimate the split by fuel type within each segment, the known proportion of diesel vehicles in 2010 within each segment is scaled by a uniform scaling factor for each of the previous years. The scaling factor for each year is set such that the proportion of diesel cars amongst all cars matches that of the EU CO₂ monitoring data for the given year. Figure 4-3 shows the results at EU28 level.

Figure 4-3: Calculated segment and fuel type split input for SULTAN calculations, EU28

4.2.3 New vehicle fuel consumption by fuel type and by segment

- **NEDC-based:**
  - Between 2010 and 2014: disaggregation using the EU car CO₂ monitoring database, analogous to the procedure for disaggregating new registrations, as described above.
  - Between 2000 and 2009: The EU car CO₂ monitoring data (for 2000 to 2009) does not provide CO₂ figures by segment. Therefore, a further scaling approach is used. The UK SMMT provide a disaggregation of CO₂ emissions by segment and fuel type for the years 2000 to 2009. These figures are then normalised by the overall average emissions for each fuel type in order to derive average emissions within each segment.

- **Real-world uplift:** Data on the gap between test-cycle and real world emissions by year of registration has been systematically compiled by ICCT (2015) for the years 2001 to 2014. The most comprehensive dataset, separating between petrol and diesel vehicles is from the German spritmonitor.de website, which consists of drivers voluntarily reporting their real-life fuel consumption. This data will be used, as plotted in Figure 4-4. It should be noted that the spritmonitor.de data shows levels of divergence below the average for all sources reviewed by
ICCT. For example, for 2014 registrations, an overall average divergence of 40% was calculated, whereas spritmonitor.de average for 2014 models is 36%. Therefore, real-world average uplift may be slightly higher. A likely reason is that those drivers who monitor and report their fuel consumption to spritmonitor.de may tend to be more fuel-economy aware than the average driver and hence more likely to adopt fuel-efficient driving styles.

Figure 4-4: Divergence of spritmonitor.de figures from manufacturers’ test-cycle emissions by fuel type

Source: Ricardo analysis of ICCT (2015) data

The CO₂ values thus calculated are easily converted into specific energy consumption in MJ/km which the SULTAN model requires as input.

4.2.4 Activity (in vkm)

The TRACCs project provides estimates of total vehicle annual vehicle kilometres (vkm) by vehicle age, segment and fuel type for each Member State. It has not been possible to identify any other data sources providing a similarly disaggregated estimate. Therefore, for the period 2005 to 2010, the TRACCS activity estimates were used. For the years before 2005 and after 2010, estimates of car transport activity levels in passenger kilometres from the DG MOVE Pocketbook (European Commission, 2015) were used to scale the TRACCS figures and develop corresponding vkm figures.

In order to disaggregate activity levels by segment and fuel type, activity levels for each segment/fuel type combination were estimated based on their share of in total stock. In addition, a uniform annual vehicle mileage weighting factor for each segment/fuel type combination was estimated based on the 2005-2010 average from TRACCS, in order to account for differences in typical annual vehicle mileage between different segments and fuel types (see Figure 4-5 below). As can be seen, the TRACCS figures closely match those of a detailed German mileage survey undertaken in 2002 (BAST, Fahrleistungserhebung 2002 Teil: Begleitung und Auswertung. Band 1: Inländerfahrleistung 2002. Anhang, 2004) and therefore appear credible.
Figure 4-5: Comparison of annual mileage by segment and fuel type

Source: Ricardo analysis of TRACCS data (EMISIA, 2015) and (BASt, 2004)

As described in sub-section 4.1.4, variations in mileage by vehicle age are also taken into account. An age dependent mileage function is separately calculated for each case study country. Regarding potential input data for this function, Ricardo-AEA (2015) provided a refined estimate of average mileage by vehicle age and fuel type for the UK, based on a large database of vehicles undergoing statutory UK vehicle inspections. Since the TRACCS output is broadly consistent with the comparator source and can be accurately described by a function (see Figure 4-6), the SULTAN input data on activity draws on the TRACCS profile. [Note: the SULTAN age-dependent mileage function distributes the mileage across different vintages according a % weighting profile, rather than actual km].

Figure 4-6: average mileage (km per year) by fuel type and age as estimated in TRACCS (EMISIA, TRACCS - Project overview, 2015) and Ricardo-AEA (2015)

Source: Ricardo analysis of TRACCS data (EMISIA, TRACCS - Project overview, 2015) and (Ricardo-AEA, 2015)
4.2.5 Survival function:

As a further input, SULTAN requires input parameters for a survival function. The survival function provides the model with the age-distribution of the vehicles to be retired from total vehicle stock in each year.

By tracing the stock of cars of a given vintage from 2005 to 2010 in the TRACCS database (e.g. compare the stock of 6 year-old cars in 2005 with 7 year-old cars in 2006, through to 11 year-old cars in 2010), a survival curve (as % of total vehicles newly registered in a given year) can be drawn. The shape of the curve can be approximated by a polynomial function, the parameters of which form the inputs for the SULTAN model. Figure 4-7 shows an EU28 average survival rate for cars extracted from the TRACCS database, and a fitted polynomial curve, the parameters of which are fed into SULTAN.

![Figure 4-7: Survival rate estimated for EU28 cars, based on TRACCS data](image)

4.3 Results from the disaggregation by car segment and by EU national markets

This chapter summarises the results of the SULTAN disaggregation calculations for road vehicle fuel consumption of passenger cars by different vehicle segments for the EU28 and the seven case study countries.

4.3.1 Results at EU28 level

The results of the bottom up SULTAN calculations for energy consumption overall tend to be higher than those of TRACCS and UNFCCC. In particular, petrol consumption tends to be overestimated in the SULTAN results, which often exceed overall recorded total road petrol consumption (see Figure 4-8). Differences between different estimates are to be expected, and the estimates developed in national inventories (and also in the TRACCS project) are based on much more detailed/disaggregated models and datasets than it was feasible to use in this project. However, it is useful to explore the possible factors influencing the observed differences in the estimates.
One potential reason for differences in the estimates from the simplified SULTAN analysis developed for this project is that the mileage estimates from other previous studies are used as inputs for the SULTAN calculations and may not align fully with some of the other datasets. When calibrating vehicle fuel economy and mileage estimates to overall energy consumption, other studies are likely to have assumed lower real-world specific fuel consumption figures than those from the ICCT study which were used in this project, while utilising higher total vehicle mileages. This project then multiplied the higher real-world fuel consumption estimates with the latter vehicle mileage data estimates, thus potentially overestimating the totals. Conversely, the information from the ICCT study on the real-world uplift (based on Spritmonitor data from Germany) assumed for petrol vehicles may be overestimating the impact across the EU28 as a whole. Environmental conditions have a greater impact on the fuel consumption of petrol vehicles versus diesel vehicles (in part due to differences in fuel grades in summer and winter periods). Therefore fuel consumption is likely to tend to be higher (vs standard cycle) in colder countries versus those with warmer climates. The difference between the observed fuel consumption and the standardised test will also be significantly influenced by variations in other typical driving conditions between different countries – e.g. speed and topography. Yet, compared to other data sources analysed in the ICCT review, the Spritmonitor data shows rather modest real-world uplift factors which could in fact underestimate true real-world specific fuel consumption in parts of Europe.

Another potential reason is that the SULTAN calculations only consider new registrations of petrol and diesel vehicles. In some countries, a significant share of cars consuming LPG and CNG are likely to have been registered as petrol vehicles and subsequently converted, resulting in a degree of overestimation of petrol. It is likely that this effect is playing small a role at least, as the difference between the SULTAN estimate and UNFCCC data is particularly high in Italy and Poland, which both have very high shares of gaseous fuel consumption (see below). At the EU28 level, TRACCS data indicates that the share of gaseous fuels in total consumption of petrol plus gaseous fuels is at 4%-6%. Taking gaseous fuels into account would reduce the estimated petrol consumption accordingly.

It seems most likely that a combination of all these effects is the reason for the differentials observed.

Figure 4-8 provides a comparison of SULTAN calculation totals with a wider range of estimates for the year 2010. The figure shows that totals for car diesel consumption tend to be close to TRACCS and UNFCCC figures while petrol consumption estimates are higher, for the reasons discussed above.

**Figure 4-8: Comparison of SULTAN bottom-up calculation of results for EU28 with other estimates of car fuel consumption in 2010 (in ktoe)**

![Graph showing comparison of energy consumption (ktoe) for diesel and petrol across different calculations](source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data and Ricardo calculations)
To ensure consistency with the overall fuel consumption profiles (see Section 3.4), the SULTAN outputs have been scaled to UNFCCC figures for car petrol and diesel consumption. Figure 4-10 shows the results for both the unscaled and the scaled figures; on average, unscaled totals tend to be some 10% above the scaled figures. Most of the difference tends to originate from the petrol consumption estimates, while diesel consumption totals are less affected by scaling. Since the objective of this task was to estimate the relative share of different car segments to the overall total, this is a reasonable approach.

Figure 4-9 illustrates the split of total car energy consumption by segment over time in the EU28. It suggests that despite variations in the share of new registrations by segment, the overall split of car energy consumption has remained fairly constant over time, with only a slight increase in the share of the lower medium segment and slight reductions in the share of the upper medium and large segments. Note that, as shown in the previous graphs, the split between fuel types is very different between segments; generally, the larger the segment, the higher the share of diesel consumption.

**Figure 4-9: Estimated car fuel consumption share by segment in the EU28**

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data
Figure 4-10: Calculated total energy consumption by segment and fuel type for the EU28, as unscaled bottom-up estimate from SULTAN and scaled to UNFCCC data (in PJ)
4.3.2 Results at Member State level

The present sub-section compares the unscaled SULTAN results for each of the seven case study Member States to those of TRACCS and UNFCCC and shows the time-series of disaggregation by segment from SULTAN normalised to UNFCCC data.

4.3.2.1 Results for France

Total fuel consumption estimates for petrol cars in France, as calculated in the SULTAN tool, is around 25% higher than the UNFCCC and TRACCS estimates, while estimates for diesel consumption are much closer. This is significantly higher than for the EU28 as a whole, and the reason for this differential is unclear, but is likely to be due to a combination of the effects discussed in the previous section (4.3.1).

As can also be observed in other Member States, the lower medium segment is estimated to play a significantly greater role for overall petrol and diesel consumption in the SULTAN calculation outputs, compared to the TRACCS data. This is likely to be due to slightly different definitions (e.g. inclusion of MPV and cross-over vehicles in the segment for which they were derived from).

Figure 4-11: Comparison of SULTAN bottom-up calculation results with other estimates of car fuel consumption in 2010, France (in PJ)

The normalised time series data for France shows a shift from petrol to diesel consumption across all car segments. Between 2000 and 2014, the share of energy consumed by diesel cars increased from around 50% to 75%. The total amount of energy consumed remained fairly constant.
Figure 4-12: Normalised estimates for car fuel consumption by segment and fuel type in France

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data

Figure 4-13 shows that in France, the share of energy consumption from small and lower medium cars is significantly above European average, highlighting the importance of smaller cars in the French market. The figure further shows a slight increase in the share of lower medium cars over time, which has been mainly at the expense of smaller cars.

Figure 4-13: Estimated car fuel consumption share by segment in France

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data
4.3.2.2 Results for Germany

For Germany, the total fuel consumption estimates for petrol and diesel cars calculated in the SULTAN tool, tend to exceed those of UNFCCC by just under 20% for both petrol and diesel. In terms of differences between fuel consumption by segment, the lower medium segment plays a significantly greater role in the SULTAN calculations compared to TRACCS, while in TRACCS the ‘large’ segment plays a greater role than the ‘large’ segment in the SULTAN calculations.

Figure 4-14: Comparison of SULTAN bottom-up calculation results with other estimates of car fuel consumption in 2010, Germany (in PJ)

The normalised disaggregated time-series data for Germany shows a continuous shift from petrol to diesel consumption throughout the observation period. The decline in petrol consumption and growth in diesel consumption has been most pronounced among large and extra-large segment cars. Petrol consumption within the small vehicle segment has largely remained flat. Overall, the share of energy consumed by diesel cars increased from around 20% to around 50% between 2000 and 2014 while the absolute amount of energy consumed remained fairly stable.

Figure 4-15: Normalised estimates for car fuel consumption by segment and fuel type in Germany

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data
In Germany, upper medium and large cars account for almost half of car energy consumption which is significantly more than the European average of under 40%. The energy consumption split has remained stable over time, with only a very slight increase of 2 percentage points in the share of energy consumption in the lower medium segment.

**Figure 4-16: Estimated car fuel consumption share by segment in Germany**

![Graph showing estimated car fuel consumption share by segment in Germany](image)

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data

### 4.3.2.3 Results for Italy

The 2010 comparison between UNFCCC estimates and SULTAN calculation outputs of car fuel consumption shows that the latter values are significantly higher for both fuels: For petrol, the SULTAN result is over 50% higher, while for diesel, the estimates are 10% higher.

One contributing factor for what appears to be a large overestimate of car petrol consumption in Italy might be the a large number of cars (37m) relative to the population, which suggests that many cars recorded in the vehicle stock may effectively no longer be in use. In addition, Italy is a large market for LPG and CNG vehicles. While CNG and LPG cars have been excluded from new registration figures, many petrol vehicles tend to be retrofitted to run on gaseous fuels while still being counted as petrol vehicles in the stock figures. TRACCS data indicates that the share of gaseous fuels in total consumption of petrol and gaseous fuels in Italy stood at 16% in 2010. Taking gaseous fuels into account would reduce the estimated petrol consumption accordingly. A further factor that seems likely to contribute to the overall result is the average environmental temperatures, which are higher than in more northern climates. The degree to which the higher average temperature is likely to be counter-balanced by the higher use of air-conditioning is uncertain, however. Other country-specific influences on the actual 'real-world' uplift (as discussed in Section 4.3.1) are also likely to contribute to the size of the differential seen here.
Figure 4-17: Comparison of SULTAN bottom-up calculation results with other estimates of car fuel consumption in 2010, Italy (in PJ)

The time series data for Italy shows a shift from Petrol to Diesel consumption across all car segments. Between 2000 and 2014, the diesel share in energy grew from 30% to 60%, while overall consumption fell by ~14%. There is significant variability in overall consumption between years, compared to Germany, France or the UK. It is not clear whether this is a result of data issues or greater variability in travel demand.

Figure 4-18: Normalised estimates for car fuel consumption by segment and fuel type in Italy based on SULTAN calculation outputs and normalised to UNFCCC data

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data

Similarly to France, small and lower medium cars in Italy account for a high share of total energy consumption. While in the mid-2000s the share of upper medium and large vehicles in energy consumption grew slightly, it subsequently decreased again. The split of energy consumption in 2014 closely resembles that of the year 2000.
4.3.2.4 Results for Poland

The comparison between the bottom up SULTAN calculations and UNFCCC data suggests that the bottom-up calculation overestimates petrol consumption by some 80%. At the same time, the bottom-up estimate for car diesel consumption is much lower – only around half of what UNFCCC estimates. As with Italy, this is likely to be partly a result of the popularity of LPG cars in Poland. TRACCS data indicates that the share of gaseous fuels in total consumption of petrol and gaseous fuels in Poland stood at 31% in 2010. Taking gaseous fuels into account would reduce the estimated petrol consumption accordingly, and reduce the level of overestimation relative to UNFCCC to 27%. Another likely factor for strong variations between estimates is the way in which second hand vehicles have been accounted for. Second hand vehicle imports in Poland exceed new registrations by up to five times (based on numbers from TRACCS). In the SULTAN analysis, the segment and fuel type composition of these imported vehicles has been assumed (to manage complexity) to equal that of new registrations of the same year. This may not necessarily be the case, and account for a significant part of the observed variation between the SULTAN calculation outputs and UNFCCC estimates.

Figure 4-20: Comparison of SULTAN bottom-up calculation results with other estimates of car fuel consumption in 2010, Poland (in PJ)
For Poland, time-series data is only available from 2004 onwards. From 2004 to 2014, the share of diesel in overall car energy consumption increased from 17% to 55%. In contrast to other Member States, the overall segment split stays fairly constant, with a slight increase in the share of upper segments.

Figure 4-21: Normalised estimates for car fuel consumption by segment and fuel type in Poland

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data

In Poland, the share of upper medium and large vehicle in overall car energy consumption appears to have increased over the observation period. The lower medium segment also increased its share over time, mainly at the expense of small cars, whose share in energy consumption decreased from 26% in 2000 to 19% in 2014.

Figure 4-22: Estimated car fuel consumption share by segment in Poland

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data
4.3.2.5 Results for Spain

The SULTAN bottom-up calculation outputs for car petrol consumption in Spain exceed UNFCCC estimates by 34%. However, for diesel cars, the UNFCCC estimate is larger, exceeding the SULTAN bottom-up estimate by a third; the reason for this large differential is not immediately obvious. As for most other case study countries, TRACCS attributes a greater share of total energy consumption to the two larger vehicle segments.

Figure 4-23: Comparison of SULTAN bottom-up calculation results with other estimates of car fuel consumption in 2010, Spain (in PJ)

The time-series data for Spain shows that, similarly to France, the share of energy consumed by diesel cars has grown from around 50% to 75% between 2000 and 2014. The shift to diesel has been less pronounced for small cars, compared to the three larger segments. Total energy consumption grew significantly between 2000 and 2007 (by around 15%), and then fell continuously to 2014. Overall estimated car energy consumption in 2014 was around 5% lower than in 2000.

Figure 4-24: Normalised estimates for car fuel consumption by segment and fuel type in Spain

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data
The split of total car energy consumption by segment has remained fairly stable in Spain, similarly to the other case study countries. The energy consumption share of the lower medium segment is larger than in other Member States and has grown from 47% in 2000 to 50% in 2014, while energy consumption share in the small segment and the upper segments has shrunk by approximately equal measure.

Figure 4-25: Estimated car fuel consumption share by segment in Spain

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data

4.3.2.6 Results for Sweden

For total car petrol consumption in Sweden, the bottom-up SULTAN estimate is 25% above the UNFCCC figure while the SULTAN diesel estimate exceeds UNFCCC by 5%. The observed differential is likely to be due to a similar combination of factors as discussed for other countries.

Figure 4-26: Comparison of SULTAN bottom-up calculation results with other estimates of car fuel consumption in 2010, Sweden (in PJ)
Between 2000 and 2014, the estimated share of diesel in overall car energy consumption grew from under 10% to almost 40%, while total energy consumption slightly grew up to 2007 and has since been decreasing. Overall 2014 energy consumption is some 10% below energy consumption in the year 2000. In Sweden, large cars continue to be the most popular segment.

**Figure 4-27: Normalised estimates for car fuel consumption by segment and fuel type in Sweden**

![Graph showing fuel consumption by segment and fuel type in Sweden]

*Notes: based on SULTAN calculation outputs and scaled to UNFCCC data*

In Sweden, the upper medium segment is the most significant, accounting for over 40% of total car energy consumption (Figure 4-28). This figure has not significantly changed over time. The remaining distribution of energy consumption by segment has also remained fairly static.

**Figure 4-28: Estimated car fuel consumption share by segment in Sweden**

![Bar graph showing fuel consumption share by segment in Sweden]

*Notes: based on SULTAN calculation outputs and scaled to UNFCCC data*
4.3.2.7 Results for the United Kingdom

In the UK, SULTAN bottom-up calculation outputs for car petrol consumption exceed UNFCCC estimates by 8%. For diesel cars the difference is larger, at around 18%. In comparison to TRACCS, the calculation outputs attribute significantly higher fuel consumption to medium and large diesel cars.

Figure 4-29: Comparison of SULTAN bottom-up calculation results with other estimates of car fuel consumption in 2010, UK (in PJ)

The time series data for the UK shows a shift from Petrol to Diesel consumption across all car segments, the share of energy consumed by diesel cars increased from ~15% to ~40% between 2000 and 2014. At the same time, overall car energy consumption fell by around 12%.

Figure 4-30: Normalised estimates for car fuel consumption by segment and fuel type in the UK

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data

In terms of energy consumption by car segment, the distribution in the UK fairly closely resembles the European average, with around 60% of energy consumed by the two smaller segments, and the remaining 40% by the two upper segments. From 2000 to 2014 both the small and the lower medium
segments increased their share in energy consumption. The small segment’s consumption grew by 1 percentage point while the medium segment consumption grew by 2 percentage points.

**Figure 4-31: Estimated car fuel consumption share by segment in the UK**

Notes: based on SULTAN calculation outputs and scaled to UNFCCC data
5 Summary and conclusions

5.1 Fuel consumption by fuel type

In order to assess differences between existing data sets for road vehicle fuel consumption a detailed analysis of four data sets (Eurostat, UNFCCC, Oil Bulletin and FQM) was carried out. Based on a literature and data analysis supplemented with input from stakeholders through interviews and questionnaires the main differences between the datasets could be identified:

- **Different coverage.** While Oil Bulletin and FQM cover the total fuel consumption including the consumption by non-road uses, Eurostat and UNFCCC clearly separate out non-road use

- **Biofuel content.** FQM and Oil Bulletin report on the fuels as they are sold and include the biofuels content in petrol and diesel. Eurostat and UNFCCC on the other hand report on diesel and petrol only and report biomass as a separate figure

- **Conversion factors.** In some Member States (e.g. Spain) the conversion factors used by the UNFCCC teams is different from the ones applied to the Eurostat data and can lead to slight differences in the data.

- **Submission deadlines.** Different submission deadlines mean that some of the data sets are based on preliminary data. In particular the FQM data set is affected by the fact that the national energy balances generally are finalised significantly after the FQM deadline.

- **Number of authorities involved in energy reporting.** In many Member States the number of authorities involved in the road fuel reporting is as high as the number of datasets. Low coordination between the different authorities lead to significant differences in reported data.

The analysis has shown that generally the UNFCCC methodology is the most detailed for estimating road fuel consumption, in particular with regards to the estimation of non-road use (as required by the IPCC guidelines). Based on the UNFCCC data, supplemented with biofuel shares from Eurostat, time series for the time frame 2004 to 2014 were developed for EU28 and all Member States.

5.2 Fuel consumption by vehicle type

Data on road fuel consumption disaggregated by vehicle type is available from several models and datasets. For this project five different data sources were considered. Model outputs from TREMOVE, PRIMES-TREMOVE and MOVEET as well as the UNFCCC datasets and the database of the TRACCS project. A comparison between the data from these sources was carried out for 2005 and 2010. The analysis has shown:

- UNFCCC, TRACCS and PRIMES-TREMOVE align relatively well in terms of overall fuel consumption, however, the distribution of fuel between different vehicle categories can vary significantly

- TREMOVE and MOVEET show significantly different overall fuel consumption, particularly at the Member State level

- Differences and similarities arise from the use of different/similar calibration datasets.

- Other possible reasons for differences:
  - Importance of territoriality vs nationality principle both for activity and fuel (fuel used in a country vs fuel consumed in a country);
  - Treatment of second-hand vehicles;
  - Resolution of each model i.e. differences in the coverage of trip types, purposes, time, area, car sizes etc.

All models analysed (TREMOVE, PRIMES-TREMOVE, MOVEET) are based on the COPERT emission model as are the UNFCCC submissions for the majority of Member States. Some Member States, however, use different emission models. The most important one being HBEFA which is used in Germany, Austria and Sweden. The literature available on comparing the use of both emission models for fuel consumption calculations on the national level is scarce. In an interview with a German authority, however, it was mentioned that there is currently a project being carried out commissioned by German Federal Highway Research Institute (BASi) to investigate this issue.
Based on the UNFCCC submissions time series for fuel consumption by fuel and vehicle type were produced for the time frame 2004 to 2014. To close some gaps in the UNFCCC submissions, data from TRACCS and Eurostat were used.

5.3 Disaggregation of passenger car data by vehicle segment

The objective of this activity was to provide a consistent time-series estimate of the share of fuel consumption between different car segments up to the most recent year possible with available data. The approach taken was to develop a simplified model based on an adaptation of the SULTAN tool previously developed for DG Climate Action. The disaggregation of passenger car energy consumption by segment drew upon the segmentation observed in the EEA database from 2010 to 2014 and the scaling of this data to segment market shares at the European level in the period 2000-2009. This approach has resulted in a slightly different estimates of the split of new cars by segment compared to the TRACCS project (EMISIA, 2013), the main existing disaggregation exercise, which also used four car segments albeit with slightly different definitions.

The estimated specific average fuel consumption for each vehicle segment and fuel type was based on the NEDC test cycle performance data as provided in the EEA databases, multiplied by real-world uplift factors for new registrations of each year estimated by ICCT.

The overall result of the SULTAN-based calculations have shown that, based on the bottom-up estimates of real-world fuel consumption and mileage, total petrol consumption tends to be overestimated to a significant degree using the current simplified input assumptions (i.e. in comparison to the more highly detailed national inventories reporting under UNFCCC), with greater variations seen at a country-level versus the overall EU28 estimates. This is likely to be due to a combination of possible factors, such as overestimating annual mileage per vehicle, variations in real-world to test-cycle differences in different regions (e.g. due to differences in climatic and driving conditions in different countries) and versus the average values developed by ICCT, and to a much smaller degree of not taking into account conversions of petrol cars to LPG and CNG. Finally, some of the differences may also be due to inaccuracies in other sources’ estimates in allocating diesel and petrol between different vehicle types.

The final outputs from SULTAN were normalised to UNFCCC data as a ‘best estimate’ of the total car fuel consumption. Clearly there are limitations to the approach developed, which is necessarily simplified given the resources for this work. However, the quality of input data was good in terms of new registrations and fuel consumption by segment, and credible estimates on the split of vehicle mileage between segments and fuel types were taken from the TRACCS database. Therefore it seems reasonable to assume that the normalised results should provide a good approximation of the true energy consumption time series split of cars by vehicle segment and fuel type across the EU28 and the seven case study Member States up to 2014.
6 References


EMISIA. (2013). TRACCS - Transport data collection supporting the quantitative analysis of measures relating to transport and climate change. A project for DG Climate Action, carried out by Emisia, Infras and IVL. Available at: http://traccs.emisia.com/.


SMED. (2013). Differences between Eurostat and CRF data in Swedish reporting.


Appendix 1 – National reporting authorities – Questionnaire

See next page
National reporting authorities - Questionnaire

1 Objectives of the study

The European Commission's Directorate General for Climate Action (DG CLIMA) has contracted Ricardo Energy & Environment to conduct a study to explore road vehicle fuel consumption and disaggregation.

The EU climate and energy framework has set the target of a 30% reduction in non-ETS sector emissions by 2030 (vs. 2005). In order to meet this target, a good understanding of the relative shares of fuel consumption by fuel and vehicle type within different Member States is essential. This allows an assessment of the impacts of existing policies aimed at reduced road transport emissions, and ensures future policy action is appropriately targeted/scaled to different sectors.

The aim of this study is to cross-check and validate road energy fuel consumption by fuel and by vehicle type and to develop time series based on different available European data sources, i.e. to better understand and explain differences between datasets, and highlight key trends and variations between different EU countries.

If you have any queries, please contact Edine.loehr@Ricardo.com.

If your organisation covers more than one dataset please fill in separate versions of the questionnaire.

2 Background information

2.1 Contact information

1. Organisation name: [Click here to enter text]
2. Contact name: [Click here to enter text]
3. Email address: [Click here to enter text]
4. Telephone number: [Click here to enter text]
5. Member State: [Click here to enter text]

3 Dataset

3.1 Please provide which data sets that cover road vehicle fuel consumption your organisation is responsible for.

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3.2 Is your organisation responsible for collecting the data or only for reporting?

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Which organisation covers the other activity? Please provide organisation and contact.

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Reporting only [Click here to enter text]
Both N/A
4  Data collection basis

4.1  What is the basis for your data set?

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<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel production⁷</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Fuel sales⁵</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>In-use fuel consumption⁶</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>If other please specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Click here to enter text</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2  What is the coverage of the road vehicle fuel consumption data?

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>National citizens</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>National territory</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>If other please specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Click here to enter text</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3  Briefly explain the data collection methodology that you apply. If available, please provide a link to the methodology document.

Click here to enter text

4.4  Have there been any changes to the methodology in the last 10 years (2005 – 2015)?

<table>
<thead>
<tr>
<th>Change</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>If yes please specify when and what changed exactly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Click here to enter text</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5  Definition of road vehicles

5.1  Might fuels used by any of the following vehicles also be included in the road vehicle fuel data set?

<table>
<thead>
<tr>
<th>Type of vehicles</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural and forestry tractors</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Garden equipment, such as hedge trimmers and hand-held chain saws</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Generators</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Bulldozers</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Construction machinery</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Industrial trucks</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Fork lifts</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Mobile cranes</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Military vehicles</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Rail</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Inland waterway vessels when not at sea</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Other</td>
<td>☐</td>
<td>☐</td>
<td>Click here to enter text</td>
</tr>
</tbody>
</table>

⁷ Including import, excluding export
⁵ On national territory
⁶ Please differentiate between consumption on national territory and by national citizens in Q4.2
5.2 Please explain any difficulties with allocating fuels to the different modes of transport (e.g., separating rail diesel from road diesel).

Click here to enter text

6 Types of fuels

6.1 Which fuels, that are relevant to road vehicles, are covered in the data set?

<table>
<thead>
<tr>
<th>Type of fuel</th>
<th>Yes</th>
<th>No</th>
<th>Please specify which fuel grades are covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td></td>
<td></td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Diesel</td>
<td></td>
<td></td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Bio-Petrol(^4)</td>
<td></td>
<td></td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Bio-Diesel(^5)</td>
<td></td>
<td></td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>LPG</td>
<td></td>
<td></td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
<td></td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>Click here to enter text</td>
</tr>
</tbody>
</table>

6.2 Which data sources do you retrieve your data from?

<table>
<thead>
<tr>
<th>Name of dataset</th>
<th>Link to database, if publically available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Diesel</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Bio-Petrol(^4)</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Bio-Diesel(^5)</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>LPG</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Other</td>
<td>Click here to enter text</td>
</tr>
</tbody>
</table>

7 Conversion factors

7.1 What are the units the fuel consumption is provided in?

<table>
<thead>
<tr>
<th>Unit</th>
<th>Original</th>
<th>Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tera joules (TJ)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Litres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tonnes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tonnes of oil equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If other please specify</td>
<td>Click here to enter text</td>
<td>Click here to enter text</td>
</tr>
</tbody>
</table>

7.2 Which conversion factors (if any) are used?

<table>
<thead>
<tr>
<th>Type of fuel</th>
<th>Net calorific value</th>
<th>Gross calorific value</th>
<th>Density</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td>Click here to enter text</td>
<td>Click here to enter text</td>
<td>Click here to enter text</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>Diesel</td>
<td>Click here to enter text</td>
<td>Click here to enter text</td>
<td>Click here to enter text</td>
<td>Click here to enter text</td>
</tr>
</tbody>
</table>

\(^4\) in line with the terminology used in Eurostat. This category includes bioethanol (Ethanol), biodiesel (C8-C10alkanol+DME), butanol (1-butanol), 1-propanol, 2-propanol, and tert-butanol.

\(^5\) This category includes biodiesel (a methyl ester produced from vegetable or animal oil, of diesel quality, biodiesel/ether (diesel/ether produced from biomass), Fischer Tropsch (Fischer Tropsch products from biomass), and all other liquid biofuels which are added to, blended with diesel/fuel.)
7.3 Are seasonal changes in fuel properties taken into account?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If yes please specify how

8 Fuel consumption plots

We have plotted road vehicle fuel consumption for diesel and petrol from the Eurostat, FQM, Oil Bulletin and UNFCCC data sets. For details on the data sources see the Annex.

Figure 1: Comparison of diesel data over time for EU28
Figure 2: Comparison of petrol data over time for EU28

Country specific plots

8.1 Are you aware of any differences in the data sets that could cause these deviations?

8.2 Are you aware of any papers/reports that discuss these differences? E.g. for Sweden we came across “Differences between Eurostat and CRF data in Swedish reporting” SMED (2013) *

9 Other comments

9.1 Please discuss any other issues you feel are relevant.

Thank you for your participation. Please return this survey by email to Edina.toehr@ricardo.com

Annex – Data sources

Eurostat:
Energy statistics – supply transformation and consumption (nrg_10):
  • Supply, transformation and consumption of oil - annual data (nrg_102a)
Products:
  • Gasoline (without biofuels) + Diesel (without biofuels)
INDIC_NRG: B_101920 – Road
Unit of measure: Tera joules

Oil Bulletin:
Weekly Oil Bulletins of DG ENER available here:
Using the consumption values in the Froses over time document.
Sector: Automotive
Fuels: Automotive gas oil, Euro-super 05(l)

FQM:
Original submission data as Ricardo Energy & Environment had been collecting the FQM data up until
2013
Summary report for the latest year (2014) available here:
Sector: road vehicles and non-road mobile machinery
Fuels: Different grades of diesel and petrol fuel including fuels with bio content

UNFCCC:
Consumption data as part of the UNFCCC inventory reporting using the data available for the CRF
reporting to be found here:
http://unfccc.int/national_reports/annex_i_gHG_inventories/national_inventories_submissions/items/8812.php
Sector: 1.A.3.b – Road transportation
Fuels: Gasoline, Diesel oil

Conversion factors:
From http://www.ukconversionfactorscarbonsmart.co.uk/
Appendix 2 - List of interview partners

<table>
<thead>
<tr>
<th>Country</th>
<th>Dataset</th>
<th>Organisation</th>
<th>Date of interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE</td>
<td>Oil Bulletin</td>
<td>The Federal Office for Economic Affairs and Export Control (BAFA)</td>
<td>21/01/2016</td>
</tr>
<tr>
<td>DE</td>
<td>UNFCCC</td>
<td>Federal Environment Agency</td>
<td>12/02/2016</td>
</tr>
<tr>
<td>ES</td>
<td>FQM/Eurostat/DG ENER (Oil Bulletins)</td>
<td>Ministry of Industry, Energy and Tourism-Spain</td>
<td>28/01/2016</td>
</tr>
<tr>
<td>ES</td>
<td>UNFCCC</td>
<td>Ministry of Agriculture, Food and Environment</td>
<td>22/01/2016</td>
</tr>
<tr>
<td>FR</td>
<td>FQM</td>
<td>Ministry of Finance and Public Accounts</td>
<td>21/12/2016</td>
</tr>
<tr>
<td>FR</td>
<td>UNFCCC</td>
<td>Interprofessional Technical Centre for Studies of Atmospheric Pollution</td>
<td>18/01/2016</td>
</tr>
<tr>
<td>IT</td>
<td>Eurostat</td>
<td>Ministry of Economic Development</td>
<td>27/01/2016</td>
</tr>
<tr>
<td>IT</td>
<td>UNFCCC</td>
<td>Institute for the Protection and Environmental Research</td>
<td>25/01/2016</td>
</tr>
<tr>
<td>PL</td>
<td>FQM/Eurostat/DG ENER (Oil Bulletins) /UNFCCC</td>
<td>Energy Market Agency</td>
<td>10/02/2016</td>
</tr>
<tr>
<td>SE</td>
<td>UNFCCC</td>
<td>Swedish Environmental Protection Agency</td>
<td>16/02/2016</td>
</tr>
<tr>
<td>SE</td>
<td>FQM</td>
<td>The Swedish Transport Agency (reporting only)</td>
<td>Written response only</td>
</tr>
<tr>
<td>SE</td>
<td>Eurostat</td>
<td>Statistics Sweden</td>
<td>Written response only</td>
</tr>
<tr>
<td>UK</td>
<td>FQM</td>
<td>Department for Transport</td>
<td>12/02/2016</td>
</tr>
<tr>
<td>UK</td>
<td>Eurostat/DG ENER (Oil Bulletins)</td>
<td>Department of Energy and Climate Change</td>
<td>Written response only</td>
</tr>
<tr>
<td>UK</td>
<td>UNFCCC</td>
<td>Ricardo Energy &amp; Environment</td>
<td>11/02/2016</td>
</tr>
</tbody>
</table>
Appendix 3 – Case studies

For seven Member States (DE, ES, FR, IT, PL, SE, UK) we have carried out a more detailed analysis of the data on road fuel consumption by fuel type and vehicle type. To understand the reasons for differences in the data reported on road fuel consumption the relevant national authorities were contacted and interviews were conducted.

The case studies include:

- An assessment of road fuel consumption by fuel type
  - Data analysis
  - National reporting structures
- Assessment of model outputs/database values for road fuel consumption by vehicle type
- Description of the UNFCCC reporting methodology

It should be noted that for the national reporting structures the sole focus was the reporting process of the road fuel consumption data, primarily diesel and petrol fuels. Due to the limitations of this project, not all involved reporting authorities could be interviewed, therefore there are still some gaps in the displayed reporting structures. These gaps have been highlighted in red.
France

Road fuel consumption by fuel type

Data analysis

Diesel:
When diesel data is plotted for France with Eurostat and UNFCCC data not including biofuels and non-road data, the datasets show big differences (see Figure 0-1). While the FQM and the Oil Bulletin data align well, the Eurostat and UNFCCC data are negatively offset. Overall the latter two datasets, however, show the same trends.

Figure 0-1: DIESEL consumption (in TJ) by dataset for FR, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Adding non-road data does close the gaps between the datasets for more recent years, however, leads to Eurostat and UNFCCC data exceeding the other two datasets by far in the past (see Figure 0-2). In particular the Eurostat non-road values are very high. This suggests that the non-road categories of Eurostat and UNFCCC include a high percentage of diesel fuel that has not been originally reported under road fuel. An initial separation of fuels might have happened based on fuel grades. Therefore only a percentage of the overall non-road use should be allocated, the datasets available, however, from the available information there is no indication what this percentage could be.

Figure 0-2: DIESEL consumption (in TJ) by dataset for FR, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Another possible explanation for the gap between the datasets is the coverage of biofuels. When biofuels are added to UNFCCC and Eurostat data, all four datasets align better (see Figure 0-3). The UNFCCC data almost matches up with the FQM data for earlier years (2004-2006) and more recent years (2010-2013).
When both non-road and biofuels are added to Eurostat and UNFCCC, as expected they both exceed the FQM and Oil Bulletin data, probably due to other diesel grades being included in the non-road data (see Figure 0-4). In terms of alignment, the UNFCCC and Eurostat data now show a significant improvement. This leads to the conclusion that differences between these two datasets are due to different methodologies for separating biodiesel and non-road diesel use from the total diesel consumption.

Petrol:
For petrol the plots show that Eurostat, FQM and UNFCCC align well (see Figure 0-5). The Oil Bulletin data shows a negative offset, which is in line with the observations on the European level and due to the fact that the Oil Bulletin only includes Euro-super 95 petrol and no fuels with other octane ratings.
Figure 0-5: PETROL consumption (in TJ) by dataset for FR, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Including non-road data for petrol does not have any impact on the overall plot as values from both Eurostat and UNFCCC are very low (<1000 TJ) (see Figure 0-6).

Figure 0-6: PETROL consumption (in TJ) by dataset for FR, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When biofuels are included in the Eurostat and the UNFCCC values, both datasets align slightly better with the FQM data (see Figure 0-7).

Figure 0-7: PETROL consumption (in TJ) by dataset for FR, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM
Biofuels:
The biofuel data available from UNFCCC and Eurostat matches up well up until 2010 (see Figure 0-8). For more recent years the datasets show deviations. These might be down to the use of conversion factors. As conversion factors were only provided by the UNFCCC team though, the difference in conversion factors could not be analysed.

Figure 0-8: BIOMASS consumption (in TJ) by dataset for FR, including UNFCCC (without non-road data), Eurostat (without non-road data)

Source: Analysis of (Eurostat, 2013) and (UNFCCC, 2015) data

LPG:
LPG value is available from Eurostat, Oil Bulletin and UNFCCC. The data from all three data sources matches up exactly (see Figure 0-22).

Figure 0-9: LPG consumption (in TJ) by dataset for FR, including UNFCCC (without non-road data), Eurostat (without non-road data), Oil Bulletin

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015)

Natural gas:
The natural gas data that is available from Eurostat and UNFCCC shows significant differences in particular between 2009 and 2011 (see Figure 0-10) From the information collected in the interviews and questionnaires it does not become clear, why there is such discrepancy in the data.

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015)
National reporting structure

In order to understand the reporting structures better and the possible reasons for the differences in the data, the project team has talked to CITEPA (Centre Interprofessionnel Technique d’Etudes de la Pollution Atmosphérique) and the French customs department.

The reporting structure for France is displayed below (Figure 0-24).

The data collection is carried out by the Comité professionnel du pétrole (CPDP) who collect data from producers, importers, refiners or sellers of petroleum products and by the French customs department who provide tax data. The Ministère de l'Environnement, de l’Énergie et de la Mer\textsuperscript{44} uses this data in combination with information on vehicles’ activity and consumption to allocate fuel consumption to road transport. The Ministry publishes the data in the National Energy Statistic and submits data to Eurostat, Oil Bulletin and FQM.

The UNFCCC reporting is carried out by CITEPA. Based on the COPERT IV model the consumption is estimated from the bottom up and calibrated against the National Energy Statistics.

Reason for discrepancies that were mentioned:

- UNFCCC reports on road fuel only, while the other datasets might include fuels sold regardless of the end use
- UNFCCC contains data for mainland and overseas territories, while Eurostat (and maybe others) only contain mainland fuel use

\textsuperscript{44} Previously called the Ministère de l'Écologie, du Développement durable et de l'Énergie
Figure 0-11: Reporting structure for road fuel consumption in France

Road fuel consumption by vehicle type

When the data on road fuel consumption by vehicle type is compared for 2005 for all five models/datasets it can be observed that the overall consumption values align for UNFCCC, TRACCS and TREMOVE (see Figure 0-25). While UNFCCC and TREMOVE also show a similar distribution of fuel between the different vehicle types, the TREMOVE data shoes significantly higher consumption values for diesel cars. The total consumption for PRIMES-TREMOVE and MOVEET is slightly lower than for the other three datasets. Both models estimate a lower diesel consumption for vans compared to the other datasets.

The figures have only marginally changed in 2010, the biggest change being a reduction of MOVEET overall consumption caused by a lower car petrol estimate (see Figure 0-26).
Figure 0-12: Model dataset comparison of transport energy consumption by vehicle/fuel type, FR, 2005

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

Table 0.1: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), FR, 2005

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>Diesel</td>
<td>18,663</td>
<td>14,631</td>
<td>13,935</td>
<td>14,289</td>
<td>15,642</td>
</tr>
<tr>
<td></td>
<td>Petrol</td>
<td>10,693</td>
<td>9,974</td>
<td>10,159</td>
<td>10,172</td>
<td>15,337</td>
</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
<td>0</td>
<td>188</td>
<td>158</td>
<td>153</td>
<td>56</td>
</tr>
<tr>
<td>Vans</td>
<td>Diesel</td>
<td>5,968</td>
<td>3,262</td>
<td>6,609</td>
<td>7,389</td>
<td>2,016</td>
</tr>
<tr>
<td></td>
<td>Petrol</td>
<td>221</td>
<td>737</td>
<td>1,033</td>
<td>839</td>
<td>991</td>
</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
<td>6,508</td>
<td>10,547</td>
<td>10,856</td>
<td>9,883</td>
<td>7,643</td>
</tr>
<tr>
<td></td>
<td>Petrol</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
<td>0</td>
<td>12</td>
<td>41</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2-wheeler</td>
<td>Petrol</td>
<td>298</td>
<td>450</td>
<td>489</td>
<td>588</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Diesel</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>Gaseous fuels</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 0-13: Model dataset comparison of transport energy consumption by vehicle/fuel type, FR, 2010

![Graph showing model dataset comparison of transport energy consumption by vehicle/fuel type, FR, 2010](image.png)

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

Table 0.2: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), FR, 2010

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
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</tr>
<tr>
<td>Vans</td>
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<td>7,389</td>
<td>8,524</td>
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<tr>
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<td>322</td>
<td>269</td>
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<td>566</td>
<td>1,065</td>
</tr>
<tr>
<td></td>
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<td>0</td>
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</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
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<td>9,832</td>
<td>9,303</td>
<td>7,443</td>
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<tr>
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</tr>
<tr>
<td></td>
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<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
UNFCCC methodology for Road vehicles

Road vehicles

The latest National Inventory Report (NIR) for France explains the methodology applied to calculate road vehicle emissions and fuel consumption (CITEPA, 2015).

Consumption and emission values are estimated with the COPERT IV model using the following data inputs:

- Estimated fuel consumption: Estimated consumption in France provided by the Commission des Comptes des Transports de la Nation (CCTN)
- Traffic estimates: based on total fuel consumption and unit consumptions
- Number of total vehicles: calculated based on the total traffic volumes divided by average annual mileage
- Fleet composition: based on numbers on vehicle registrations based on different data sources\(^{45}\)

On the basis of this data the total fuel consumption is calculated and then calibrated against national statistics.

\(^{45}\) CCFA: Comité des Constructeurs Français d'Automobiles, ARGUS, CSNM: Chambre Syndicale Nationale du Motocycle, SOeS : Service de l'Observation et des Statistiques, rattaché au MEDDE
Germany

Road fuel consumption by fuel type

Data analysis

**Diesel:**

When all four datasets are plotted for Germany the Eurostat and the UNFCCC values without biofuels and non-road use align very well, as do Oil Bulletin and FQM (see Figure 0-14).

Figure 0-14: DIESEL consumption (in TJ) by dataset for DE, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

![Diesel Consumption Chart](image)

*Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data*

When non-road consumption is added to UNFCCC and Eurostat, the change is not very significant for Eurostat while the gap between UNFCCC data and FQM/Oil Bulletin becomes significantly smaller (see Figure 0-15). It is not clear why the non-road estimates for Eurostat and UNFCCC are so different. It is surprising that the diesel consumption for non-road use reported in Eurostat is that small. Unfortunately, the interviews could not shed any light on possible reasons for that.

Figure 0-15: DIESEL consumption (in TJ) by dataset for DE, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

![Diesel Consumption Chart](image)

*Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data*

When biofuels are included for Eurostat and UNFCCC, both datasets still align and come closer to the FQM/Oil Bulletin dataset (see Figure 0-16).
Exploration of EU road vehicle fuel consumption and disaggregation

Figure 0-16: DIESEL consumption (in TJ) by dataset for DE, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When both biofuels and non-road are added to UNFCCC and Eurostat, all four datasets come closer together (see Figure 0-17), there is however still a significant discrepancy in the datasets which has been further explored in interviews.

Figure 0-17: DIESEL consumption (in TJ) by dataset for DE, including Eurostat data (with biofuels and with non-road data), UNFCCC (with biofuels and with non-road data), Oil Bulletin, and FQM

Petrol:
For petrol again UNFCCC and Eurostat data align very well, while the FQM data series lies above (see Figure 0-18). The Oil Bulletin on the other hand generally shows a negative offset to the other dataset. There is however an unexpected anomaly in the date between 2008 and 2011, where the Oil Bulletin data shows a significant increase in the data. The only possible explanation that was suggested by the authority responsible for the Oil Bulletin reporting was that, these years possibly include petrol fuels other than Euro-super 95.
Figure 0-18: PETROL consumption (in TJ) by dataset for DE, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Including non-road consumption for Eurostat and UNFCCC data does not have any significant effect as can be seen in Figure 0-19.

Figure 0-19: PETROL consumption (in TJ) by dataset for DE, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When biofuels are included for Eurostat and UNFCCC data the gap between those two datasets and FQM becomes smaller, they are however still systematically lower (see Figure 0-20).
Exploration of EU road vehicle fuel consumption and disaggregation

**Figure 0-20: PETROL consumption (in TJ) by dataset for DE, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM**

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

**Biofuels:**
The biofuels data that is available from UNFCCC and Eurostat aligns well since 2010 (see Figure 0-21). Some deviations can be observed between 2004 and 2010 where the UNFCCC value lies significantly higher than Eurostat.

**Figure 0-21: BIOMASS consumption (in TJ) by dataset for DE, including UNFCCC (without non-road data), Eurostat (without non-road data)**

Source: Analysis of (Eurostat, 2013) and (UNFCCC, 2015) data

**LPG:**
Data on LPG is available from Eurostat, UNFCCC and the Oil Bulletin (Figure 0-22). While the data from Eurostat and UNFCCC aligns very well, the Oil Bulletin data deviates from the other datasets and is significantly lower between 2011 and 2011. The analysis of the questionnaires provided by the organisations responsible for UNFCCC and Oil Bulletin reporting suggest that the discrepancies are due to different original sources for the LPG data. While the Oil Bulletin data is based on estimates made by LPG fuelling stations, the energy tax statistics and estimates and estimates by the petroleum association, the UNFCCC petroleum data is based on the National Energy Balance for Germany and the Official Mineral Oil Data.
Natural gas:
The natural gas values available from Eurostat and UNFCCC align perfectly over the whole time frame assessed (see Figure 0-23).

National reporting structure
In order to understand the reporting structures better and the possible reasons for the differences in the data, the project team interviewed experts at The Federal Office for Economic Affairs and Export Control (BAFA) and the Federal Environment Office (UBA).

The initial data collection is carried out by the Association of the German Petroleum Industry (MWV) who collect data on fuel consumption from producers and distributors of petroleum products. This data is then further processed by the BAFA and the Working Group on Energy Balances for Germany (AGEB). Based on information from the producers/distributors and some modelling the fuel consumption is allocated for road use. It was not possible as part of the project to talk to someone from the AGEB to discuss details of the allocation of road transport, which is why there are some gaps in understanding the full data processing process (as highlighted in Figure 0-24). The processed data then is published in the national Mineral Oil Statistics and reported by BAFA to Eurostat and the Oil Bulletin.

The data is further made available to the UBA who use the total consumption values to report on FQM. The UNFCCC reporting is also carried out by a team at UBA. Based on HBEFA/TREMOD, the road...
Fuel consumption is calculated in a bottom-up approach, which then is calibrated against the Miner...
Figure 0-25: Model dataset comparison of transport energy consumption by vehicle/fuel type, DE, 2005

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

Table 0.3: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), DE, 2005

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
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<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
<td>10,651</td>
<td>15,147</td>
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<td>11,720</td>
<td>19,343</td>
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<tr>
<td></td>
<td>Petrol</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
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<td>19</td>
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<td>2-wheelers</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
UNFCCC methodology for Road vehicles

Road consumption:
The latest National Inventory Report (NIR) for Germany explains the methodology applied to calculate road vehicle emissions and fuel consumption (Federal Environment Agency, 2015).

The road vehicles sector in the inventory reporting includes transport on public roads within Germany, except for agricultural, forestry and military transports. Calculations are made for the vehicle categories of passenger cars (PCs), motorcycles, light duty vehicles (LDVs), heavy duty vehicles (HDVs), buses and motorcycles.

For calculation purposes, the vehicle categories are broken down into so-called vehicle layers with the same emissions behaviour. To that end, vehicle categories are also broken down by type of fuel used, vehicle size (trucks and buses by weight class; automobiles and motorcycles by engine displacement).
and pollution control equipment used, as defined by EU directives for emissions control ("EURO norms"), and by regional traffic distribution (outside of cities, in cities and on motorways).

The fuel consumption is calculated in a bottom-up approach. Gasoline, (bio-) ethanol fuel, diesel oil, biodiesel, LP and natural gas are allocated, within TREMOD ("Transport Emission Model"), to the various relevant vehicle layers. The consumption data that enter into the model, for each type of fuel, are obtained from the National Energy Balances (NEBs). The actual emission calculation is carried out in the Central System of Emissions (CSE), after the pertinent specific fuel consumption data and emission factors have been imported.

For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys are used, co-ordinated, and supplemented, such as:

- the officially published fleet and new registration statistics of the Federal Motor Transport Authority (KBA)
- Mileage data are updated on the basis of the "2002 Mileage Survey" ("Fahrleistungserhebung") and the 2010 road transport census (Straßenverkehrszählung 2010)

Because fuel prices in Germany are higher – significantly, in some cases – than in several of Germany's neighbours, for some time the fuels used in Germany have included fuels purchased in other countries and brought into the country as "grey" imports. At present, no precise data are available on this phenomenon, which is significant for truck and automobile traffic in Germany's border regions and which is referred to as "refuelling tourism" ("Tanktourismus").

**Off-road consumption:**
Data on use of military fuels are available in the Official Mineral Oil Statistics for the Federal Republic of Germany provided by BAFA.

Fuel consumption by mobile sources in the construction sector, commerce & trade, agriculture and forestry is calculated with the help of annually fluctuating split factors modelled in TREMOD.
Italy

Road fuel consumption by fuel type

Data analysis

Diesel:

The data for Italy on road diesel consumption shows high deviations between the datasets in the years prior to 2012 (see Figure 0-27). As expected the Oil Bulletin and the FQM data lie higher than the UNFCCC and Eurostat data plotted without biofuels and non-road consumption.

Figure 0-27: DIESEL consumption (in TJ) by dataset for IT, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

![Diesel Consumption Graph](image)

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When non-road data is added to UNFCCC and Eurostat, the UNFCCC data aligns relatively well from 2007 onwards, while it shows even higher values than FQM and Oil Bulletin prior to 2007 (see Figure 0-28). The difference between Eurostat and UNFCCC data stays the same which means that all four datasets only align from 2012 onwards.

Figure 0-28: DIESEL consumption (in TJ) by dataset for IT, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

![Diesel Consumption Graph with Non-Road Data](image)

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When only biofuels are added to UNFCCC and Eurostat data, the gap between these two datasets and Oil Bulletin/FQM closes slightly (Figure 0-29). The difference between UNFCCC and Eurostat stays the same.

Figure 0-29: DIESEL consumption (in TJ) by dataset for IT, including Eurostat data (without biofuels and with biofuel and non-road data), UNFCCC (without biofuels and with biofuel and non-road data), Oil Bulletin, and FQM

![Diesel Consumption Graph with Biofuels](image)

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When only biofuels are added to UNFCCC and Eurostat data, the gap between these two datasets and Oil Bulletin/FQM closes slightly (Figure 0-29). The difference between UNFCCC and Eurostat stays the same.
When both biofuels and non-road consumption are added to UNFCCC and Eurostat, all four datasets come close together (see Figure 0-30). The UNFCCC generally exceeds the Oil Bulletin and FQM data, while the Eurostat data exceeds FQM and Oil Bulletin before 2006 and after 2012, while it lies below those datasets in the years in between. Still, the discrepancies between the four datasets are relatively significant compared to other Member States. What the reason for this discrepancies is, has been investigated further through interviews with the relevant authorities.

Petrol:
For petrol the datasets match up better than for diesel (see Figure 0-31). Eurostat, FQM and UNFCCC lie close together. Only FQM is shows a negative offset from the other three datasets. Due to the limitations of the project, the project team was unable to carry out an interview with the relevant organisation for the FQM reporting to investigate the reasons for these discrepancies further.
Figure 0-31: PETROL consumption (in TJ) by dataset for IT, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

The inclusion of non-road consumption does not have any impact on the Eurostat and UNFCCC values (see Figure 0-32).

Figure 0-32: PETROL consumption (in TJ) by dataset for IT, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Including biofuels slightly improves the fit of UNFCCC and Eurostat data with the Oil Bulletin data, while it leads to an increase in the differences compared to the FQM data (see Figure 0-33).

Figure 0-33: PETROL consumption (in TJ) by dataset for IT, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM
Biofuels:

Biomass data is available from UNFCCC and Eurostat. Both datasets align very well, except for one deviation in 2010 (see Figure 0-34).

**Figure 0-34: BIOMASS consumption (in TJ) by dataset for IT, including UNFCCC (without non-road data), Eurostat (without non-road data)**

Source: Analysis of (Eurostat, 2013) and (UNFCCC, 2015) data

LPG:

LPG data is available from UNFCCC, Eurostat and Oil Bulletin. All three datasets match up well (see Figure 0-35).
Exploration of EU road vehicle fuel consumption and disaggregation

Figure 0-35: LPG consumption (in TJ) by dataset for IT, including UNFCCC (without non-road data), Eurostat (without non-road data), Oil Bulletin

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015)

Natural gas:

Natural gas is available from Eurostat and the UNFCCC dataset. Figure 0-36 shows that both datasets align.

Figure 0-36: Natural gas consumption (in TJ) by dataset for IT, including UNFCCC (without non-road data), Eurostat (without non-road data)

Source: Analysis of (Eurostat, 2013), (UNFCCC, 2015)

National reporting structure

The project team carried out two interviews with reporting authorities in Italy, the Ministry of Economic Development and the Centre for Environmental Protection and Research. The reporting structure for Italy is displayed below (Figure 0-37).

In Italy fuel data is collected by the Ministry of Economic Development through a questionnaire that is sent out to producers, refiners or sellers of petroleum products. Apart from the volumes sold, the respondents are asked to specify who the fuel is sold to (e.g. army, transport companies, aviation etc.). Based on this information, the Ministry is able to allocate the fuels to the different uses. In the interview with a representative of the Ministry the interviewee emphasized that the data is considered to be very reliable as it is based on sales invoices.

The data is then published in the National Energy Balance (BEN) which gives energy consumption for road transport. The Ministry reports this data to Eurostat and the Oil Bulletin and forwards the information on to ISPRA for the UNFCCC reporting and the Ministry of Environment, Land and Sea for the fuel quality reporting.

While the Ministry of Environment, Land and Sea takes the consumption values as they are and does not process them further, ISPRA is applying a bottom-up approach to calculate road fuel consumption,
using data on vehicle’s activity and consumption based on the COPERT model. The data from the National Energy Balance is then used to calibrate the system.

According to the national reporting experts that were interviewed, the main reasons for differences between the datasets are:

- Different coverage between Eurostat/UNFCCC (which report on road fuel in specific) and FQM/Oil Bulletin (which report on total fuel consumption)
- Different allocation of non-road fuel use for Eurostat and UNFCCC reporting (e.g. diesel for military, agriculture, recreational craft)
- The way Eurostat processes the data from the national energy balance.
- Difference in conversion factors used for the FQM reporting and the density values used by the Ministry of Economic development

![Figure 0-37: Reporting structure for road fuel consumption in Italy](source)

Road fuel consumption by vehicle type

When the data on road fuel consumption by vehicle type is compared for 2005 for all five models/datasets it can be observed that UNFCCC and TRACCS data lie close together (see Figure 0-25). The total consumption of PRIMES-TREMOVE exceeds the consumption from UNFCCC and TRACCS slightly, which is mainly due to a higher consumption of diesel by trucks and buses. TREMOVE shows a smaller overall consumption with lower petrol consumption for cars and diesel consumption for vans compared to UNFCCC and TRACCS. The total consumption of MOVEET on the other hand exceeds all other datasets, with significantly higher car petrol consumption. For 2010 the overall difference between MOVEET and the other datasets is slightly smaller, otherwise the overall observations for all datasets are the same (see Figure 0-38).
Figure 0-38: Model dataset comparison of transport energy consumption by vehicle/fuel type, IT, 2005

![Graph showing transport energy consumption by vehicle/fuel type for IT, 2005](image)

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCC, 2015) data and MOVEET data

Table 0.5: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), IT, 2005

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>Diesel</td>
<td>9,407</td>
<td>5,736</td>
<td>9,514</td>
<td>9,772</td>
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<tr>
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<td>Petrol</td>
<td>10,333</td>
<td>12,404</td>
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<td>11,944</td>
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<td>Gaseous fuels</td>
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<td>0</td>
<td>0</td>
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</tr>
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<td>Trucks and buses</td>
<td>Diesel</td>
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</table>
Figure 0-39: Model dataset comparison of transport energy consumption by vehicle/fuel type, IT, 2010

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

Table 0.6: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), IT, 2010

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
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<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
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<td>Cars</td>
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<td>10,915</td>
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<td>1,965</td>
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<td>991</td>
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<tr>
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<td>5,835</td>
<td>6,208</td>
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</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
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<td>0</td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
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<td>Gaseous fuels</td>
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<tr>
<td>2-wheelers</td>
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<td>933</td>
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</tr>
<tr>
<td></td>
<td>Gaseous fuels</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>
UNFCCC methodology for Road vehicles

Road consumption

The latest National Inventory Report (NIR) for Italy explains the methodology applied to calculate road vehicle emissions and fuel consumption (ISPRA, 2015).

The basis of the emission estimation of the national inventory are fuel consumption values for each vehicle type and average speed calculated from the emission functions and speed-coefficients provided by the model COPERT IV. Once all data and input parameters have been inserted and all options have been set reflecting the peculiar situation of the country, emissions and consumptions are calculated by the model in the detail of the vehicle category legislation standard. From there the aggregated consumption values are determined.

A normalisation procedure is then applied to ensure that the breakdown of fuel consumption by each vehicle type calculated on the basis of the fuel consumption factors once added up matches the Energy Balance by the Ministry of Economic Development figures for total fuel consumption in Italy (adjusted for off-road consumption). A percentage deviation is calculated and on the basis of the obtained deviation value, a process of refinement of the estimates is performed by acting on control variables such as speeds and mileages. These variables values are changed according to the constraints on the national average variability ranges.

Off-road consumption

Four main categories for off-road consumption are considered:

- domestic house & garden
- agricultural power units (includes forestry)
- industrial off-road (includes construction and quarrying)
- aircraft support.

Consumption values are estimated based on machinery sales, EU averages for machinery lifetime estimates, annual usage data and load factors.

Emissions from off-road sources are particularly uncertain. A revisions in the population data produced higher fuel consumption estimates. The gasoline consumptions increased markedly but they are still only a small proportion of total gasoline sales.
Poland

Road fuel consumption by fuel type

Data analysis

Diesel:

When diesel data is plotted for Poland the UNFCCC and Eurostat data (without biofuels and non-road) align perfectly (see Figure 0-40). While there are some deviations between the FQM and Oil Bulletin data, they also match up relatively well, in general showing values significantly higher than UNFCCC and Eurostat.

Figure 0-40: DIESEL consumption (in TJ) by dataset for PL, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When non-road data is added to UNFCCC and Eurostat, the two datasets align significantly better with FQM and Eurostat (see Figure 0-41). Between 2004 and 2006 the UNFCCC and Eurostat data exceeds the FQM and Oil Bulletin data. For 2006 and 2007 all four datasets align, while from 2007 onwards, the Eurostat and UNFCCC lies slightly below the FQM and Oil Bulletin data. In the following we will explore what impact the inclusion of biofuels will have on the accordance between the datasets.

Figure 0-41: DIESEL consumption (in TJ) by dataset for PL, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When biofuels are included for Eurostat and UNFCCC, both datasets still align and come closer to the FQM/Oil Bulletin dataset (see Figure 0-42)
When both non-road and biofuel use are added to Eurostat and UNFCCC data, for Poland all four datasets align very well. There are some discrepancies in earlier years, however, those are expected to be due to revisions being made to UNFCCC and Eurostat data, while FQM and Oil Bulletin, have not been updated. Slight differences between the FQM data, are considered to be due to the use of preliminary data for FQM. More on the difficulties of different reporting deadlines will be discussed in the section on national reporting infrastructure.

Petrol:

When petrol data is plotted for all four datasets, again the UNFCCC and Eurostat dataset (without biofuels and non-road) align perfectly. FQM and Oil Bulletin, again are significantly higher. When plotted in TJ the two latter datasets do not match exactly, however, when they are plotted in tonnes, which is the unit of measurement they are reported in, they again align exactly. The discrepancies are therefore only due to differences in the look-up densities used by the project team for conversion.

One anomaly can be observed for the FQM data in 2007. The exact reason for this deviation could not be identified in the interview with ARE, however, due to the early reporting deadlines, the total fuel consumption values used for FQM is based on preliminary data provided by ARE which. This could have had a higher effect in this year.

It might be surprising that the Oil Bulletin values are as high as the FQM values, even though they only include Euro-super 95(I) and no petrol with other octane ratings, neither do they include fuels with high biofuels content. However, analysing the data in more detail it becomes clear that the use of RON95 dominates the total petrol use. With regards to the biofuels, the data shows that the FQM dataset does...
not include fuels with Ethanol contents of E10 or E+, therefore should the biofuels content not be the cause of any discrepancies between FQM and Oil Bulletin.

Figure 0-44: PETROL consumption (in TJ) by dataset for PL, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When non-road data is added to Eurostat and UNFCCC, no changes to the plots can be observed. While UNFCC does not provide a value for non-road petrol use at all, the Eurostat values are so low that the impact is only marginal.

Figure 0-45: PETROL consumption (in TJ) by dataset for PL, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When biofuels are added to Eurostat and UNFCCC data, all four datasets match up very well, in particular from 2010 onwards. Again slight discrepancies between FQM and Oil Bulletin are due to the use of slightly different conversion factors.
Exploration of EU road vehicle fuel consumption and disaggregation

Figure 0-46: PETROL consumption (in TJ) by dataset for PL, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Biofuels:
Data on biofuels is available from Eurostat and UNFCCC. Figure 0-47 shows the consumption of total biomass over time. Both datasets show a very good accordance.

Figure 0-47: BIOMASS consumption (in TJ) by dataset for PL, including UNFCCC (without non-road data), Eurostat (without non-road data)

Source: Analysis of (Eurostat, 2013) and (UNFCCC, 2015) data

LPG:
Data on LPG use is available from UNFCCC, Eurostat and Oil Bulletin. All three datasets match up perfectly (see Figure 0-48).
Natural gas:

To date no natural gas values are available for Poland. The interview with ARE has shown that the use of natural gas is still very small for Poland. However, there are some places (e.g. Warsaw) where natural gas use has become more important. As of 2016 data on natural gas use will be collected.

National reporting structure

In Poland all the contacted organisations involved in the reporting of road fuel consumption data decided to meet together and discuss the questionnaire and possible reasons for discrepancies. After the meeting an interview was carried out by the project team with the Polish Energy Market Agency (ARE) to discuss the findings. This approach allowed a complete overview of the reporting structures in Poland.

Based on the interview and the responses from the questionnaire a reporting structure was developed which was approved by ARE. The reporting structure for Poland is displayed below (Figure 0-24).

The original data collection is carried out by ARE. Oil refineries, fuel importers, exporters and other fuel market participants report their data to ARE. ARE then is making the necessary data processing and calculations for the international organisations, according to the EU reporting requirements. This includes the allocation of fuel consumption to road use based on information available on non-road use. ARE is responsible for sending data to Eurostat and Oil Bulletin.

The data on total fuel consumption is provided to The Office of Competition and Consumer Production (UOKiK) for their FQM reporting. The issue with UOKiK data is that the date of submission is early. The data is requested from ARE in February for the FQM submission while ARE only finished the data processing in September. This means that the FQM data is based on preliminary data, which is not revised later.

The UNFCCC reporting is done by The National Centre for Emissions Management (KOBiZE). As the UNFCCC reporting deadline is after the Eurostat data submission, the KOBiZE team uses the data already published in Eurostat, including the road consumption allocation. This explains the good accordance between Eurostat and UNFCCC data.

According to the national experts the main discrepancies between datasets are:

- Inclusion/exclusion of biofuels
- Difference between Total Final Consumption as provided by FQM and Oil Bulletin and Road Transport consumption only, as provided in UNFCCC and Eurostat datasets
- Differences in reporting deadlines

In order to minimise the differences due to different reporting deadlines, one action from the meeting between the national reporting authorities, was to find the ideal date to exchange data between the authorities. It was decided that data from ARE would be provided to the teams for Oil Bulletin and FQM at the latest point possible, to ensure that the data is as finalised as possible. It was, however, highlighted that some of the discrepancies cannot be eliminated, due to the deadlines predetermined...
by EU and international reporting. Also the number of different institutions/agencies involved in energy analysis and reporting. These were created according to the legal acts requiring different reporting. In some cases the responsibilities overlap and a good coordination is challenging.

**Figure 0-49: Reporting structure for road fuel consumption in Poland**

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**Source:** Ricardo analysis of interview and survey input

### Road fuel consumption by vehicle type

When the data on road fuel consumption by vehicle type is compared for 2005 for all five models/datasets it can be observed that the results from PRIMES-TREMOVE, UNFCCC and TRACCS align relatively well (see Figure 0-50). The TREMOVE data shows a significantly higher consumption for diesel case than the other datasets, while showing lower values for cars running on petrol and gaseous fuels. The MOVEET results show a surprising deviation from the other results. The total consumption is significantly higher which is mainly tie to a higher use of petrol for cars and diesel for trucks and buses. On the other hand the use of gaseous fuels for cars is lower than for the other datasets.

For 2010 the data from TREMOVE almost not changed at all while overall consumption has significantly increased for the other four datasets, which is mainly due to an increase of diesel consumption across all vehicle types (see Figure 0-51). For 2010 the difference between the values from MOVEET and PRIMES-TREMOVE, UNFCCC and TRACCS is not as big anymore. Remaining differences are again due to a higher use of petrol for cars and diesel for trucks and buses, as well as a lower value for gaseous fuels in cars.
Figure 0-50: Model dataset comparison of transport energy consumption by vehicle/fuel type, PL, 2005

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

Table 0.7: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), PL, 2005

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
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<tbody>
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<tr>
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<td>0</td>
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Table 0.8: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), PL, 2010

<table>
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<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
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<tr>
<td>Cars</td>
<td>Diesel</td>
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<td>6,392</td>
<td>8,655</td>
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<td>Gaseous fuels</td>
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</tbody>
</table>

UNFCCC methodology for Road vehicles

Road vehicles

The latest National Inventory Report (NIR) for Poland explains very briefly the methodology applied to calculate road vehicle emissions and fuel consumption (KOBiZE, 2015).

The road fuel consumption is directly taken from the Eurostat database. As consumption of each type of fuel (used in road transport) in statistics is given without distinguishing on individual vehicle type, for the purpose of the national inventory the fuel consumption was disaggregated based on a report by the Motor Transport Institute (ITS) (ITS, 2014). As the ITS study is only available in Polish, no detailed assessment of the methodology could be carried out.
Spain

Road fuel consumption by fuel type

Data analysis

Diesel:
When the data for diesel is plotted for all datasets with Eurostat and UNFCCC data without biofuels and non-road consumption, there are significant deviations between the different datasets (see Figure 0-52). While between 2004 and 2009 the FQM and Eurostat data align, they deviate for later years. On the other hand there is a difference between Eurostat and UNFCCC data for earlier years. As of 2011, the both datasets align relatively well. The Oil Bulletin shows values that are consistently higher than all other datasets. One possible reason for this that was given by the Ministry of Industry, Energy and Tourism was that the Oil Bulletin data possibly includes diesel type B which is used for agriculture and fishing.

One anomaly in the data can be observed for the FQM data for the year 2010, where the data is significantly higher than for other years. No reason could be given by the interview partners as to why this anomaly could be observed. It was however highlighted that the differences in deadlines for Eurostat and FQM means that some of the information on the split between different diesel types in not taken into account for FQM.

Figure 0-52: DIESEL consumption (in TJ) by dataset for ES, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

When diesel consumption from non-road use is added to UNFCCC and Eurostat, both datasets exceed the FQM data for earlier years (Figure 0-53). From 2011 onwards, however, FQM, Eurostat and UNFCCC data lie close together.
Figure 0-53: DIESEL consumption (in TJ) by dataset for ES, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When biofuels are added to Eurostat and UNFCCC, the datasets align better with the FQM for more recent years (Figure 0-54).

Figure 0-54: DIESEL consumption (in TJ) by dataset for ES, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When both biofuels and non-road consumption are added to Eurostat and UNFCCC, both datasets exceed the FQM data, however are still far off the Oil Bulletin data (see Figure 0-55).
Petrol:

For petrol UNFCCC, Eurostat and FQM data align relatively well, in particular for the years 2004 to 2008 (see Figure 0-56). More recently the deviations have become slightly bigger. The Oil Bulletin data shows a negative offset up until 2011 which is in line with the observations made on the European level. This difference can be traced back to a higher use of RON91 and RON98 in the past. For recent years the total petrol consumption is mainly composed of RON95 petrol and therefore FQM then aligns better with the other datasets. This was also confirmed in the interview carried out with the Ministry of Industry, Energy and Tourism.

For petrol there is no data available in Eurostat for non-road consumption and the non-road consumption values from UNFCCC are so small that they only have a marginal impact on the time series (see Figure 0-57).
Figure 0-57: PETROL consumption (in TJ) by dataset for ES, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When biofuels are added to UNFCCC and Eurostat both datasets align better with the FQM data between the years 2008 and 2011 (see Figure 0-58). Deviations between Eurostat and UNFCCC data that could be observed in the previous plot are now slightly exaggerated. This is surprising as the data comes from the same source as the questionnaires received from the reporting authorities shows. Some differences could be caused by different conversion factors used by the UNFCCC team compared to the default values in Eurostat which are applied as the Ministry of Industry, Energy and Tourism does not provide Spain-specific conversion factors to Eurostat.

Figure 0-58: PETROL consumption (in TJ) by dataset for ES, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Biofuels:
The data available for biofuels from UNFCCC and Eurostat shows a good accordance in the past with slight differences from 2007 onwards (see Figure 0-59). The biggest deviation between the two datasets can be observed for the year 2012 which coincides with a peak in biomass consumption.

The interviews have shown that the Ministry of Industry, Energy and Tourism does not include Spain-specific conversion factors in their Eurostat submission, therefore the Eurostat default values are applied. Comparing the Eurostat values with the values used by the Spanish team for UNFCCC reporting shows that for Biopetrol the difference in conversion factor for 2012 is 2.2%46, while for Biodiesel the deviation is even higher with 8.2%47. The majority of the difference in biomass from Eurostat and UNFCCC therefore can be explained with the differences in conversion factors.

46 27.4 GJ/t (UNFCCC), 26.8 GJ/t (Eurostat)
47 39.8 GJ/t (UNFCCC), 36.8 GJ/t (Eurostat)
Figure 0-59: BIOMASS consumption (in TJ) by dataset for ES, including UNFCCC (without non-road data), Eurostat (without non-road data)

Source: Analysis of (Eurostat, 2013) and (UNFCCC, 2015) data

LPG:
Data for LPG is available from Eurostat, UNFCCC and Oil Bulletin (see Figure 0-60). While the datasets align perfectly since 2008, there have been significant discrepancies in the past where the LPG data from Oil Bulletin was significantly lower than for the other two datasets. The interviews could not shed light on the reason for these discrepancies.

Figure 0-60: LPG consumption (in TJ) by dataset for ES, including UNFCCC (without non-road data), Eurostat (without non-road data), Oil Bulletin

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015)
Natural gas:
For natural gas values are available from Eurostat and UNFCCC. Both datasets align perfectly between 2006 and 2011 (see Figure 0-61). Only the latest two years show slight deviations.

Figure 0-61: Natural gas consumption (in TJ) by dataset for ES, including UNFCCC (without non-road data), Eurostat (without non-road data)

Source: Analysis of (Eurostat, 2013), (UNFCCC, 2015)

National reporting structure
In order to understand the reporting structures better and the possible reasons for the differences in the data, the project team has talked to the Ministry of Industry, Energy and Tourism (responsible for Eurostat, Oil bulletin and FQM) and the Emissions Inventory Unit at the Ministry of Agriculture, Food and Environment.

The reporting structure for Spain is displayed below (Figure 0-62).

The original data collection is carried out by CORES (Corporación de Reservas Estratégicas de Productos Petrolíferos), which is a non-profit public corporation under the aegis of the Ministry of Industry, Energy and Tourism (Minetur). All hydrocarbons sector entities in Spain (+300) are obliged to provide information on a monthly basis on fuel production. The data is then provided to Minetur where the data is further processed. As different grades of diesel are used for different purposes (e.g. Type A for road transport, type B for agricultural vehicles, type C for heating) the allocation of road fuel consumption is made on the basis of this data. Minetur publishes this data in the National Energy Balance and then reports to Eurostat (in tonnes, without providing national conversion factors), Oil Bulletin and FQM.

The UNFCCC reporting is done by the Emissions Inventory Unit at the Ministry of Agriculture, Food and Environment they use the road fuel consumption data from the National Energy Balance. In order to comply with the UNFCCC reporting requirements, off-road industrial machinery diesel consumption is further subtracted.

Reason for discrepancies that have been highlighted by interview partners:
- Differences in reporting deadlines between the datasets. FQM and Oil Bulletin are based on preliminary data as the final figures of the Annual Oil Questionnaire are not available when they need reporting.
- Use of different conversion factors. UNFCCC teams use conversion factors to calculate between tonnes and TJ. The Eurostat data is reported in tonnes and no country-specific conversion factors are provided, therefore the Eurostat default values are applied.
- Differences in scope of datasets. Oil Bulletin and FQM report include biofuels and off road mobile industrial machinery fuel consumption.
When the data on road fuel consumption by vehicle type is compared for 2005 for all five models/datasets it can be observed that TREMOVE, PRIMES-TREMOVE, UNFCCC and TRACCS align in terms of total fuel consumption (see Figure 0-25). The distribution of fuels between the vehicle types, however, varies. The main reason for the discrepancies are the distribution of diesel consumption between cars and trucks and buses. While TREMOVE allocates the biggest amount of diesel consumption to cars, the distribution is about the same between the two vehicle types for UNFCCC. TRACCS shows a slightly higher fuel consumption for trucks and buses, while PRIMES-TREMOVE allocates most of the diesel use to trucks and buses. In comparison to the other datasets, the total fuel consumption for MOVEET is lower, with a lower fuel consumption by diesel cars. A further difference is a significant petrol consumption by vans which cannot be observed for the other datasets.

The figures have only marginally changed in 2010 as can be observed in Figure 0-63.
Figure 0-63: Model dataset comparison of transport energy consumption by vehicle/fuel type, ES, 2005

Table 0.9: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), ES, 2005

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Diesel</td>
<td>13,383</td>
<td>5,435</td>
<td>11,119</td>
<td>9,361</td>
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<td></td>
<td>Petrol</td>
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<td>0</td>
<td>49</td>
<td>48</td>
<td>0</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td>Diesel</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
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<td>16,192</td>
<td>9,414</td>
<td>11,082</td>
<td>10,018</td>
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<td>435</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data
Figure 0-64: Model dataset comparison of transport energy consumption by vehicle/fuel type, ES, 2010

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

Table 0.10: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), ES, 2010

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>Diesel</td>
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<td>6,501</td>
<td>12,358</td>
<td>9,560</td>
<td>7,083</td>
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<td>Petrol</td>
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<td>5,413</td>
<td>5,084</td>
<td>5,640</td>
</tr>
<tr>
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<td>113</td>
<td>20</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Vans</td>
<td>Diesel</td>
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<td>1,515</td>
<td>2,040</td>
<td>1,942</td>
<td>1,889</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
<td>7,478</td>
<td>15,166</td>
<td>8,495</td>
<td>11,416</td>
<td>10,361</td>
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<td>Petrol</td>
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<td>24</td>
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<td></td>
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<td>0</td>
</tr>
<tr>
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<td>Diesel</td>
<td>171</td>
<td>300</td>
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<tr>
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<td>Gaseous fuels</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

UNFCCC methodology for Road vehicles

Road consumption:
The latest National Inventory Report (NIR) for Spain explains the methodology applied to calculate road vehicle emissions and fuel consumption (Ministry of Agriculture Food and Environment, 2015)

The report describes that the road fuel consumption is based on the following sources:
- “Energy Balance Sheets” from Eurostat

Data on natural gas consumption furthermore is provided by SEDIGAS (the Spanish Gas Association).

Off-road consumption:
Up until 2011 the total fuel consumption published in the National Energy Balance was allocated to road transport. In order to comply with the UNFCCC reporting requirements from 2012 the Spanish UNFCCC team subtracts the off-road industrial machinery consumption. This consumption has been estimated based on activity patterns and specific consumptions and estimates on existing equipment which have been developed together with industry experts.
Sweden

Road fuel consumption by fuel type

Data analysis

Diesel:
The plots for diesel consumption in Sweden with Eurostat and UNFCCC not including biofuels and non-road data show that while FQM and Oil Bulletin align relatively well between 2006 and 2014, the UNFCCC and the Eurostat data both show significantly lower values (see Figure 0-65). The difference between Eurostat and UNFCCC data is constant between 2004 and 2012 but further increasing for 2013. This difference between Eurostat and UNFCCC data has been investigated through a study carried out by the Swedish Environment Emissions Data Department at Statistics Sweden, the findings will be discussed in the section below on national reporting structure.

Figure 0-65: DIESEL consumption (in TJ) by dataset for SE, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

![DIESEL consumption (in TJ) by dataset for SE, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM](source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data)

When non-road data is added to Eurostat and UNFCCC the difference between the datasets decreases (see Figure 0-66).

Figure 0-66: DIESEL consumption (in TJ) by dataset for SE, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM

![DIESEL consumption (in TJ) by dataset for SE, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM](source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data)

Also the inclusion of biofuels helps align the UNFCCC and Eurostat data better with the Oil Bulletin and FQM data (see Figure 0-67).
Figure 0-67: DIESEL consumption (in TJ) by dataset for SE, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM.

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When both biofuels and non-road data are added to the Eurostat and UNFCCC datasets, the four datasets align significantly better than before, however, differences still can be observed (see Figure 0-68).

Figure 0-68: DIESEL consumption (in TJ) by dataset for SE, including Eurostat data (with biofuels and with non-road data), UNFCCC (with biofuels and with non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Petrol:
For petrol the datasets align better (see Figure 0-69). For more recent years (since 2008) the FQM and the Oil Bulletin data match up well which suggests that for more recent years most of the total road fuel consumption is covered by Euro-super 95. Eurostat and UNFCCC show lower values and are offset from each other.
Figure 0-69: PETROL consumption (in TJ) by dataset for SE, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM. Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data.

Adding non-road data to UNFCCC and Eurostat only makes a slight difference for the UNFCCC data, for Eurostat no petrol non-road data is available (Figure 0-70).

Figure 0-70: PETROL consumption (in TJ) by dataset for SE, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM. Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data.

Including biopetrol in the plot for Eurostat and UNFCCC leads to a better match between the Eurostat, FQM and Oil Bulletin (see Figure 0-71). The UNFCCC data on the other hand.

Figure 0-71: PETROL consumption (in TJ) by dataset for SE, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM.
Biofuels:
The total biomass consumption has steadily increased since 2004 and the UNFCCC and Eurostat align relatively well over the whole timeframe (see Figure 0-72).

Figure 0-72: BIOMASS consumption (in TJ) by dataset for SE, including UNFCCC (without non-road data), Eurostat (without non-road data)

Source: Analysis of (Eurostat, 2013) and (UNFCCC, 2015) data

LPG:
For LPG only two data points were available from Oil Bulletin for 2004 and 2005, nothing from other datasets. The input from the questionnaire and the interview has shown that LPG use in Sweden is almost non-existent in Sweden, bio-gas powered cars are used instead.

Natural gas:
Natural gas values are available from Eurostat and UNFCCC. While there have been some slight discrepancies in the past, both datasets are aligning perfectly since 2010 (see Figure 0-73).

Figure 0-73: Natural gas consumption (in TJ) by dataset for SE, including UNFCCC (without non-road data), Eurostat (without non-road data)

Source: Analysis of (Eurostat, 2013), (UNFCCC, 2015)

National reporting structure
In order to understand the reporting structures better and the possible reasons for the differences in the data, the project team interviewed the Swedish Environmental Protection Agency who are responsible for the UNFCCC reporting. Further written input was provided by the Swedish Energy Agency, Statistics Sweden and the Road and Rail Department at Transport Styrelsen.
The reporting structure for Sweden is displayed below (Figure 0-74).

In Sweden a lot of different authorities are involved in the data collection. While the Swedish Energy Agency (SEA) is responsible for the National Energy Statistics, they purchase the data on fuel consumption from Statistics Sweden who develop the questionnaires, collect the data and do the quality checks. The SEA carries out a top-down allocation to estimate road fuel consumption which is published in the monthly fuel, gas and inventory statistics. The SEA reports Eurostat and Oil Bulletin data. The stock changes for all fuels reported to Eurostat are based on the Emergency Stocks Inventory.

The FQM data for Sweden is compiled by the Swedish Petroleum and Biofuels Institute based on fuel consumptions from the monthly fuel, gas and inventory statistics and fuel quality data. The reporting then is done by the Swedish Transport Agency.

The data collection for the UNFCCC reporting is done by the Swedish Environmental Emissions Data (SMED) Department in Statistics Sweden who are also carrying out a bottom-up estimation of road fuel consumption using HBEFA. Non-road use is calculated with detailed models and the total fuel consumption is calibrated against the monthly fuel, gas and inventory statistics. The reporting of the data is then done by the Swedish Environmental Protection Agency (EPA) who do not further process the data submitted by SMED.

The differences between the UNFCCC and the Eurostat data are particularly high in Sweden. The Swedish EPA commissioned a study to assess the differences between Eurostat and CRF data in Swedish reporting which was carried out by SMED (SMED, 2013). The study found that the main differences in data reported on gas/diesel oil for road transport were due to:

- Differences in allocating diesel consumption in off road vehicles and mobile machinery. While for the UNFCCC reporting these are reported as a separate category, this is not the case in Eurostat where some for the fuel consumption in such vehicles is most likely included in the transport sector.
- Rounding errors
- Differences in calorific values for biomass
- Double counting of some consumer categories suspected in Eurostat data for 2011

The Swedish Energy Agency is collaborating with SMED in a project that is looking at the differences between the fuel consumption that Energy Agency are producing (to Eurostat) and the one that SMED is producing (for IPCC) comparing methodology and activity data. However, at this point no results concerning the fuel consumption in non-road mobile machinery is available.

Further reasons for discrepancies mentioned by interview partners were:

- The fundamentally different allocation methods that are being applied. While the Eurostat data is a simplified top down allocation, the UNFCCC team uses more sophisticated models to apply a bottom up approach.
- Based on the different reporting requirements different authorities historically have covered the different datasets and developed their own methodology according to the data they need to provide. Little coordination in the past led to differences in the datasets.
- Differences in the actual purpose and scope of the different datasets.
When the data on road fuel consumption by vehicle type is compared for 2005 for all five models/datasets it can be observed that the total consumption varies (see Figure 0-75). While the total fuel consumption for UNFCCC and TRACCS are roughly the same there are differences in the distribution of fuel between vehicle types. TRACCS shows higher values for car and van diesel consumption, while the UNFCCC data shows a higher consumption of diesel by trucks and buses. The total consumption from PRIMES-TREMOVE and MOVEET is higher than the UNFCCC and TRACCS data, which is due to a higher cars petrol and trucks and buses diesel value. TREMOVE on the other hand shows a lower overall consumption with lower petrol consumption for cars, and lower diesel consumption for trucks and buses. On the other hand the diesel consumption for car is higher than for the other four datasets.

The figures have only marginally changed in 2010. The main differences are an increase of diesel consumption for cars across all datasets. Furthermore the difference between the overall consumption from MOVEET and UNFCCC and TRACCS has decreased due to a significant decrease in petrol consumption for cars (see Figure 0-76).
**Figure 0-75: Model dataset comparison of transport energy consumption by vehicle/fuel type, SE, 2005**

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

**Table 0.11: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), SE, 2005**

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
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<td>266</td>
<td>411</td>
<td>611</td>
<td>290</td>
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<td>Petrol</td>
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<td>4,665</td>
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<td>3</td>
</tr>
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<tr>
<td></td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
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<td>1,741</td>
<td>1,339</td>
<td>2,052</td>
</tr>
<tr>
<td></td>
<td>Petrol</td>
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<td></td>
<td>Gaseous fuels</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
UNFCCC methodology for Road vehicles

Road consumption:
The latest National Inventory Report (NIR) for Sweden explains the methodology applied to calculate road vehicle emissions and fuel consumption (Swedish Environmental Protection Agency, 2015)

The emission and consumption of petroleum products from road traffic is estimated by the road traffic model HBEFA. The estimated consumption of gasoline and diesel by HBEFA is slightly modified for all years by a residual of gasoline and diesel. The residual is a result of comparing the national statistics on supply and delivery of petroleum products (top-down approach) to the bottom-up estimated fuel consumption. For the comparison the consumption values for stationary combustion, biomass and diesel in off-road vehicles and other machinery are subtracted from the total deliveries. The residual then is proportionally redistributed to the following sectors: road transportation, domestic navigation, off-road vehicles and working machinery and fishing.
Off-road consumption:

Fuel consumption in off-road vehicles and working machinery is estimated by a complex model taking into account the number of vehicles, average motor effect, working hours, load, age etc.

For railways, information on diesel consumption to UNFCCC data is collected from the Swedish Transport Administration and for Military activities from the Swedish Armed Forces.
UK

Road fuel consumption by fuel type

Data analysis

Diesel:

For diesel all four datasets align very well when Eurostat and UNFCCC data are plotted without biofuels and non-road consumption (see Figure 0-77). This is contradictory to the observations made for the EU as a whole where the Oil Bulletin and FQM values were consistently higher than the other two datasets. One reason for this could be that the UK is one of the countries where based on fuel grades of diesel (e.g. road diesel (DERV) is captured separate from gas oil used for off-road) it is possible to deduce the final use.

One anomaly in the Oil Bulletin data can be observed for the year 2005, where there is a dip in the data. This cannot be observed for any of the other datasets. The same observation can be made for the petrol data. When DECC was asked about the possible reasons behind this the reason given was that while the DUKES data is regularly revised, the Oil Bulletin has not been updated for those earlier years. One of the major changes that affected the DUKES data was the introduction of the Downstream Oil Reporting System (DORS) for collecting monthly data from oil refiners and major importers, which happened in 2005.

Figure 0-77: DIESEL consumption (in TJ) by dataset for UK, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

When non-road vehicles are added (see Figure 0-78), both UNFCCC data and Eurostat data exceed the Oil Bulletin and FQM data. It can furthermore be observed that UNFCCC and Eurostat data do not align as well as before. The interviews with the UK inventory experts and a contact at DECC have shown that the methodologies for allocating non-road fuel use is different for UNFCCC and Eurostat reporting. The detailed methodology will be discussed in the Section on national reporting structure.
Figure 0-78: DIESEL consumption (in TJ) by dataset for UK, including Eurostat data (without biofuels and with non-road data), UNFCCC (without biofuels and with non-road data), Oil Bulletin, and FQM.

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When only adding biofuels to Eurostat and UNFCCC data, the both datasets still align very well but exceed the two other datasets (see Figure 0-80). Only in 2013 the FQM dataset shows the same values as Eurostat and UNFCCC, the Oil Bulletin data however is lower.

Figure 0-79: DIESEL consumption (in TJ) by dataset for UK, including Eurostat data (with biofuels and without non-road data), UNFCCC (with biofuels and without non-road data), Oil Bulletin, and FQM

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

When both biofuels and non-road data are added to Eurostat and UNFCCC, as expected the difference becomes even bigger (see Figure 0-80). Why the difference is as significant and adverse to the European observations could not be explained fully through the interviews.
Figure 0-80: DIESEL consumption (in TJ) by dataset for UK, including Eurostat data (with biofuels and with non-road data), UNFCCC (with biofuels and with non-road data), Oil Bulletin, and FQM

Petrol:

For the petrol data the four datasets do not align as well as for diesel data, compared to other Member States, however, the accordance between the datasets it good (see Figure 0-81). Without including biofuels and non-road fuel consumption the UNFCCC data and the Eurostat data lie somewhere in between the Oil Bulletin (systematically lower than the other datasets) and the FQM data.

The main anomaly observed is the above discussed dip in the data for Oil Bulletin in 2005, which is most probably caused by the Oil Bulletin data not being revised based on changes in the DUKES statistics.

Figure 0-81: PETROL consumption (in TJ) by dataset for UK, including Eurostat data (without biofuels and without non-road data), UNFCCC (without biofuels and without non-road data), Oil Bulletin, and FQM

Adding the non-road consumption does not have an impact on the overall image as Eurostat does not include petrol non-road data at all and the values from UNFCCC are negligible (see Figure 0-82).
When adding biofuels to the UNFCCC and Eurostat data, the values for the two datasets increase slightly and both align relatively well with the FQM data (see Figure 0-83).

**Biofuels:**

The sum of biomass which is available from UNFCCC and Eurostat is shown below. Overall the data matches up really well (see Figure 0-84). While there have been slight deviations between 2007 and 2012, the plots align perfectly for the time before and after that period.
Figure 0-84: BIOMASS consumption (in TJ) by dataset for UK

Source: Analysis of (Eurostat, 2013) and (UNFCCC, 2015) data

LPG:

A similar observation can be made for LPG (see Figure 0-85). While there have been some slight discrepancies in the past, the data from Eurostat and UNFCCC align very well since 2008. Even though the Oil Bulletin covers LPG data, no values have been reported for the UK.

Figure 0-85: LPG consumption (in TJ) by dataset for UK

Source: Analysis of (DG ENERGY, 2015), (Eurostat, 2013), (UNFCCC, 2015) and FQM sales data

Natural gas:

Neither UNFCCC nor Eurostat give values for natural gas. A discussion with our national contacts has shown that the number of vehicles running on natural gas in the UK is still so low that it is not included in DUKES.

National reporting structure

In order to understand the reporting structures better and the possible reasons for the differences in the data, we have talked to all organisations that are involved in the reporting. This included a Ricardo Energy & Environment (Ricardo) inventory expert, a contact at Department for Transport (DfT) and a contact at the Department of Energy & Climate Change (DECC).

The reporting structure for the UK is displayed below (Figure 0-86).
The original data collection and the compilation of the Digest of UK Energy Statistics (DUKES) are carried out by DECC. Through the Downstream Oil Reporting System (DORS) data on fuel production and sales data is collected on a monthly basis from oil refiners and major importers. Due to sampling issues with the DORS return, the consumption of petrol and diesel are matched to the data collected by the HM Revenue & Customs (HMRC). The data then is further processed to compile the UK Digest of Energy Statistics (DUKES). As the fuel data includes information about the specific fuel grades, some assumptions on the end use of the fuel can be made. All sales of motor spirit and road diesel are therefore reported as road fuels only. DECC acknowledges that some volumes within this could be delivered to the non-road sector, however, no estimates are made on these volumes. It is assumed that most of the fuel used for mobile diesel machinery outside of roads is gas oil (also known as "red diesel") which is marked with a red dye indicating a lower rate of taxation. As a fuel with different properties to road diesel coming from a different refinery stream, DUKES is able to report consumption of gas oil separately. Based on the DUKES data, the Oil and Gas Statistics Unit at DECC reports to Eurostat through the Annual Oil Questionnaire. The Oil Bulletin is reported by the Energy Prices Unit at DECC again based on the consumption values from DUKES.

The FQM reporting in the UK is done by DfT. Again the consumption values from DUKES are used and adding information on fuel quality sampling reported to the European Environment Agency (EEA).

The UNFCCC reporting is done by the UK national emissions inventory team at Ricardo. Detailed vehicle activity data and vehicle and speed-dependent fuel consumption factors are used to estimate petrol and diesel consumption by all road vehicles in the UK. The vehicle activity data includes the number of vehicle kilometres travelled per year by different vehicle types and is based on an extensive national traffic census run by the DfT. These are published as national statistics on vehicle km by vehicle and road type each year. The vehicle categories and fuel consumption factors used are taken from EMEP/EEA Emissions Inventory Guidebooks, as recommended for national reporting of GHG emissions to UNFCCC. The bottom-up estimates of fuel consumption have the amount of biofuels subtracted and the remaining fossil fuel consumption estimates are normalised to national fuel consumption data taken from DUKES after it has the small amounts of petrol and road diesel consumed by off-road transport subtracted. Those estimates of off-road consumption are also made by the national inventory team at Ricardo from a bottom-up estimate on the population and usage of different types of off-road machinery. It is assumed that only small diesel machinery used intermittently consumes road diesel, the majority of larger machinery used in agriculture, industry, construction and marine vessels using the lower tax gas oil fuel.

The difference between the bottom-up estimates and the consumption figures in DUKES adjusted for off-road consumption varies each year, but in 2013 the difference was an underestimation by 2.6% for road diesel and 6.9% for petrol.

Overall the interviewed authorities have highlighted that the datasets match up relatively well, which is due to DUKES being the central energy statistic which feeds into all four datasets. Possible reasons for slight differences that were mentioned were:

- Calculation of non-road use of motor spirit and road diesel for the UNFCCC dataset but not DUKES
- Revision practice: while the DUKES data is revised on a regular basis with a three year revision window, there is no such practice for the Oil Bulletin data
- Differences in reporting timelines
- Different geographical coverage. While Eurostat only includes UK figures, the UNFCCC dataset includes overseas territories
- Possible differences in the treatment of biofuels and conversion factors
When the data on road fuel consumption by vehicle type is compared for 2005 for all five models/datasets it can be observed that UNFCCC and TRACCS line up quite well, not only for the total consumption but also the distribution between vehicle types (see Figure 0-87). For PRIMES-TREMOVE the estimated total is slightly lower than for UNFCCC and TRACCS, this is caused by a lower estimate for diesel use by cars and vans. Also MOVEET shows a lower overall consumption mainly caused by a lower estimate for diesel used in trucks and buses, which is opposed to the trend observed at EU level where this value was higher in MOVEET than in UNFCCC and TRACCS. The dataset that least matches the rest of the datasets is the TREMOVE model. The total consumption is significantly higher (opposed to the EU observations), caused by higher values for diesel and petrol use from cars, the trucks and buses diesel consumption on the other hand is lower.

The figures have only marginally changed in 2010. The overall consumption has slightly increased but the observations that can be made with regards to the distribution between vehicle types are the same (see Figure 0-88).
Figure 0-87: Model dataset comparison of transport energy consumption by vehicle/fuel type, UK, 2005

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

Table 0.13: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), UK, 2005

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>Diesel</td>
<td>10,971</td>
<td>4,004</td>
<td>6,053</td>
<td>4,653</td>
<td>6,953</td>
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<td></td>
<td>Petrol</td>
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<td>18,662</td>
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<td>Vans</td>
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<td>4,408</td>
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<td>2,651</td>
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<tr>
<td></td>
<td>Petrol</td>
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<td>0</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Trucks and buses</td>
<td>Diesel</td>
<td>6,326</td>
<td>11,296</td>
<td>9,262</td>
<td>10,668</td>
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<td></td>
<td>Petrol</td>
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<tr>
<td></td>
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<td>0</td>
<td>0</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>2-wheelers</td>
<td>Petrol</td>
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<td>218</td>
<td>307</td>
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</tr>
<tr>
<td></td>
<td>Diesel</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
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<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>
Figure 0-88: Model dataset comparison of transport energy consumption by vehicle/fuel type, UK, 2010

Source: Analysis of TREMOVE, TRACCS, PRIMES-TREMOVE, (UNFCCC, 2015) data and MOVEET data

Table 0.14: Model dataset comparison of transport energy consumption by vehicle/fuel type (in ktoe), UK, 2010

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Type</th>
<th>TREMOVE</th>
<th>PRIMES-TREMOVE</th>
<th>UNFCCC</th>
<th>TRACCS</th>
<th>MOVEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
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<td>13,868</td>
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<td>7,344</td>
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<td>Petrol</td>
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<td>15,852</td>
<td>14,681</td>
<td>15,385</td>
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<td>0</td>
<td>58</td>
<td>11</td>
</tr>
<tr>
<td>Vans</td>
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<td>2,272</td>
<td>4,586</td>
<td>5,327</td>
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<td>47</td>
<td>0</td>
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<td>Trucks and buses</td>
<td>Diesel</td>
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<td>11,787</td>
<td>9,124</td>
<td>10,016</td>
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<td>Gaseous fuels</td>
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<td>11</td>
<td>0</td>
</tr>
<tr>
<td>2-wheelers</td>
<td>Petrol</td>
<td>176</td>
<td>217</td>
<td>183</td>
<td>273</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Diesel</td>
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<td>0</td>
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<tr>
<td></td>
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</tbody>
</table>

UNFCCC methodology for Road vehicles

Road consumption:
The latest National Inventory Report (NIR) for the UK explains the methodology applied to calculate road vehicle emissions and fuel consumption (Ricardo Energy & Environment, 2015).

A Tier 3 methodology is used for calculating exhaust emissions and fuel consumption from passenger cars, light goods vehicles, heavy duty vehicles including buses and coaches and motorcycles. Tier 3 is the most detailed methodology in the 2006 IPCC Guidelines involving country-specific information on vehicle activity data. Lower tiered approaches are used when this information is not available and are based solely on the total fuel consumption data from national statistics to estimate emissions.

Bottom up estimates of petrol and diesel vehicle fuel consumption (and emissions) are estimated using an array of traffic statistics, fleet composition data and exhaust and fuel consumption factors that vary by vehicle speed according to road type. Ricardo Energy & Environment use an in-house inventory model to make optimum use of activity data available in the UK, but the methodology used is that based on the EMEP/EEA Emissions Inventory Guidebook and COPERT IV model for estimating emissions from road transport for different vehicle and fuel types. These estimates are reconciled to national...
energy consumption statistics from DUKES after accounting for consumption by off-road machinery, as described above. This approach provides estimates that are consistent with the 2006 IPCC Guidelines for reporting national inventories for greenhouse gas emissions and include inherent QA/QC in the comparison of bottom-up traffic activity related estimates and top down fuel sales data.

Emissions from vehicles running on LPG are estimated on the basis of national figures (from DUKES) on the consumption of this fuel by road transport. The CO₂ emissions from LPG consumption cannot be broken down by vehicle type because there are no reliable figures available on the total number of vehicles or types of vehicles running on this fuel. It is believed that many vehicles running on LPG in the UK are cars and vans converted by their owners and that these conversions are not necessarily reported to vehicle licensing agencies. Figures from DUKES suggest that the consumption of LPG is only a small percentage (<1%) of the total amount of petrol and diesel consumed by road transport and vehicle licensing data suggest a similar percentage of all light duty vehicles run on LPG.

The UK inventory does not currently estimate emissions from vehicles running on natural gas. The number of such vehicles in the UK is extremely small, with most believed to be running in captive fleets on a trial basis in a few areas. Estimates are not made as there are no separate figures from DECC on the amount of natural gas used by road transport, nor are there useable data on the total numbers and types of vehicles equipped to run on natural gas from vehicle licensing sources. The small amount of gas that is used in the road transport sector would currently be allocated to other sources in DUKES, and therefore the omission of this source does not represent an underestimate in the UK inventory.

The petrol and diesel consumption figures reported in DUKES are consistent with the requirement for international reporting of CO₂ emissions from road fuels in that they exclude consumption of biofuels. CO₂ emissions from biofuels are not included in national totals, but they are reported to the UNFCCC as a ‘Memo Item’. Statistics on the total consumption of biodiesel and bioethanol in the UK are available from HMRC’s Hydrocarbon Oils Bulletin; consumption is reported in litres. These figures are converted to tonnes and energy units using factors in DUKES. The energy content of biodiesel and bioethanol is used to estimate the amount of fossil fuel petrol and diesel that they displaced and these estimates were subtracted from the bottom-up model estimates of fuel consumption before reconciling with the petrol and diesel consumption figures in DUKES.

**Off-road consumption:**

A detailed Tier 3 methodology given in the EMEP/EEA Emissions Inventory Guidebook is used to estimate fuel consumption for 77 different types of off-road machinery used in construction, mining, quarrying, industry, agriculture and household garden equipment, as well as airside mobile machinery used in airports. The approach largely relies on a one-off study carried out by the emissions inventory team in 2004 on the population, lifetime, engine size and hours of use per annum for each type of machinery and the activity data are combined in a model with engine-specific fuel consumption factors in g/kWhr taken from the Guidebook. A separate, but similar model is used to estimate consumption by inland waterway vessels. These equipment and mobile machinery mainly use gas oil, but a small number of smaller devices, mainly used for household or recreational use, are assumed to use petrol or road diesel.

The detailed activity data for non-road mobile machinery cannot be updated on an annual basis because it is a time-consuming and resource intensive exercise – there are no national statistics on the population and usage of these types of machinery in the UK. Therefore, various proxy statistics are used as activity drivers in each year relative to 2004. These are statistics such as amount of construction activity, industrial output or total energy used by the agricultural sector and number of households.

Gas oil is used for many other applications in the UK, including stationary heating in the commercial and industrial sector. EU-ETS data provide consumption data for some sectors. Data on consumption of gas oil by railways are provided directly by the Office of Rail and Road, the regulatory authority for the rail sector in the UK. Although DUKES provides a reliable estimate on total gas oil consumption, figures for individual sectors have much higher uncertainty. After summing up estimates of consumption of gas oil by all sources in compilation of the emissions inventory, a final reconciliation is carried out with the total gas oil consumption figure in DUKES and the gas oil consumption estimates for industrial non-road mobile machinery are adjusted to align the total with DUKES. However, this procedure is unique to gas oil, the dominant fuel used for non-road mobile machinery and is not undertaken for the petrol and road diesel consumption estimates derived for these sources.