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EUROPEAN COMMISSION
DG ENER

STUDY ON ACTUAL GHG DATA FOR DIESEL, PETROL, KEROSENE AND NATURAL GAS

PROJECT EXECUTIVE SUMMARY

WORK ORDER: ENER/C2/2013-643

JULY 2015

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Introduction

The overall objective of this project is to provide information about the lifecycle GHG emissions of fossil fuels used in transport based on collection of actual data to the extent possible. The considerable information uncertainty related to the collection and elaboration of these data, as well as to the required regional/geographical specification of data has been tackled with the assessment of the range of the GHG emissions in the form of minimum, maximum and weighted average (w.a.) values.

In this study[1], the lifecycle Carbon Intensity (CI) of petrol, diesel, kerosene and natural gas have been assessed in a "Well-To-Tank" (WTT) approach. A chain of significant process stages of oil and gas, such as exploration, exploitation, upgrading, transportation, transmission, refining, distribution, dispensing etc. are considered; thus excluding the final stage of combustion in the vehicle internal combustion engines, i.e. the Tank-To-Wheel (TTW) stage.

The Study is organized in 6 distinct Tasks. In Task a, a literature survey for the collection of all relevant documents and studies is conducted. In Task b the methodology for assessing the GHG emissions is developed and based on this methodology the relevant actual data and inputs for the models have been collected. In Task c the three models (OPGEE, GHGenius and PRIMES-Refinery) are adapted to the needs of the study in order to assess GHG emissions and the relevant calculations are made. Task d deals with the assessment of indirect emissions related to oil and natural gas value chain. Task e analyses issues related to sustainability, while Task f elaborates the projections of fuel supply and demand and eventually the estimation of GHG emissions for the year 2020 and until 2030.

Collection and use of actual data

A number of 35 conventional crude oil pathways in the upstream and midstream stages were considered covering approximately 88% of the crude oil imports in the EU in 2012. Finally, 105 streams (35 for each one of diesel oil, petrol, kerosene) of oil products are considered in the downstream stage up to the tank of transport means. The analysis is based on the concept of the Marketable Crude Oil Name (MCON), which correlates methodologically the upstream stage (oil field) with the downstream stage (refineries)[2].

[1] The project has been assigned through the REQUEST NO: ENER/C2/2013-643 and has been implemented by EXERGIA S.A. (leader), in collaboration with E3M-Lab (Economics Energy Environment Modelling Laboratory) of the National Technical University of Athens and COWI A/S.

[2] The starting point of this study is the list published by DG ENER regarding imports and deliveries of crude oil for 2012 (baseline year of the analysis), as this has been considered the most reliable source of the crude oils imported in Europe.

Collection of actual data from oil companies and national authorities.

Official letters requesting the provision of actual GHG emission data were sent to oil and gas companies/operators with virtually no responses. Therefore, the emphasis was placed on the collection of actual CI data through international organizations and environmental associations. The main sources of data were either oil companies through their sustainability reports, national authorities responsible for oil activities (e.g. Norwegian Petroleum Directorate - NPD), environmental authorities (e.g. California Air Resources Board - CARB), research entities (main source of flaring emissions has been the NOAA/GGFR), etc.

Modeling of upstream and midstream emissions in the OPGEE model

The main effort concentrated in obtaining actual GHG emissions data on a field or MCON level to be used as input in the OPGEE model. The rationale and the structure of the OPGEE model concentrates on simulating the upstream and midstream processes per oil field, therefore detailed engineering data were required and collected.

Estimation of midstream GHG emissions

The precise input blend of refineries and quantities are unfortunately unavailable as it is of high commercial value for refineries and has therefore been impossible to find this information in a consistent and reliable manner. Therefore, appropriate assumptions have been made, based particularly on confidential data provided by DG ENER.

Estimation of GHG emissions during the refining process

This step refers to the calculation of the GHG emissions that are related to the refining of crude oil. Data for the EU refineries have been collected from various sources and particularly from Oil & Gas Journal (OGJ's) proprietary database.

GHG emissions of unconventional fossil fuels

The rationale for the assessment of the GHG emissions from unconventional crude oil is similar to that of crude oil. In 2012 unconventional fossil fuels were not present in the EU fuel mix. Thus, based on current market trends, literature survey and own assessments, the MCONs and gas streams which constitute reasonable options for the EU relevant demand have been projected by the PRIMES model. The unconventional MCONs or gas streams that are analyzed are the following:

- Syncrude as representative of Alberta Oil Sands,
- Petrozuata as representative of Venezuela Bitumen,
- Marcellus as representative of US Shale Gas.

The assessments of GHG emissions for Syncrude and Marcellus shale gas were based mainly on actual data, whereas for the Petrozuata crude oil the OPGEE estimations were mainly considered.

Methodology for assessing conventional natural gas GHG emissions

The lifecycle of natural gas is divided into 3 main stages: upstream, midstream and downstream, with the upstream stage containing the natural gas production and processing sectors. The midstream stage contains the transport of natural gas from the producing region to the consuming region.

The downstream stage contains the transmission and distribution of natural gas inside the EU regions in the form of CNG or small scale LNG.

The EU has been divided into 4 consuming regions, namely South East EU, Central EU, North EU and South West EU. In order to determine the major natural gas suppliers of the EU, the annual IEA data for 2012 regarding natural gas imports and indigenous production by country of origin were used. Imports of natural gas quantities and EU domestic production are transported to the national transmission systems either through LNG or by transportation pipelines. 29 transport pipeline streams and 9 LNG streams were considered.

The GHGenius model is set up for the assessment of GHG emissions of natural gas fuels.

GHG emission modelling

The use of specialized models, namely OPGEE for oil upstream and midstream, PRIMES-Refinery for oil downstream and GHGenius for gas, are used to estimate the necessary GHG emissions. These models are modified to adapt to the EU reality in terms of gas and oil imports, transmission, processing up to distribution and dispersion to tanks of final consumers. Differentiated oil pathways based on the selected Marketable Crude Oil Names (MCONs) are used for oil types reaching the EU refineries. Respectively the main gas streams of gas are used to represent the gas pathways from the main gas producing fields up to their entry to the transmission systems of the EU countries and their transfer to distribution to final consumers in the form of CNG or LNG.

The study estimates GHG emissions of oil products in the upstream and midstream sectors at world level, i.e. feedstock originating from all continents will be taken into account. However, only the EU refinery system has been taken into consideration in regard to the processing of the fossil fuels at downstream operations. In order to associate emission factors to the concrete refinery output products (diesel, petrol, kerosene) in a more adequate manner, the study uses a methodology, which allows calculation of both average emission and marginal emission factors. The allocation of refining emissions to individual products is based on the marginal emission content.

A sensitivity analysis was performed in OPGEE over the most critical parameters that can influence the outcome of the CI of various crude types. The scope of this analysis is to show the importance of specific oil field characteristics for the calculations of the GHG emissions. The main parameters included in the sensitivity runs are: API gravity, Water to Oil Ratio (WOR), Flaring to Oil Ratio (FOR), Venting to Oil Ratio (VOR) and Marine transport distance. It has been found that Flaring to Oil Ratio is the most important parameter determining total GHG emissions.

With regard to PRIMES-Refinery, the model has been upgraded to respond to the needs of this study and account for the large diversity of crude oil types and simulate better the refining processes. Refinery gas, fuel oil, petroleum coke and electricity and gas consumption have been further disaggregated for the calculation of related GHG emissions. Furthermore, refinery specific data are drawn from the EUROSTAT balances and the calibration of PRIMES database to past years.

The structure of GHGenius has been changed to adapt to the provision of the desired results of this project. The number of regions that the model is capable of analyzing has been expanded with the addition of 4 more regions for Europe; however the analysis of data takes place at EU MS level. The gas transportation system through pipelines from Russia, Algeria, Azerbaijan, etc. has been distinguished from the national transmission systems of the EU MS and consequently the related GHG emissions are separated accordingly. Three types of emissions are estimated: resulting from the purification of the raw gas to pipeline specifications, resulting from the use of energy in all stages of the supply chain and leaks of methane from the system.

The WTT CI of oil products for each stage of supply chain and for each MCON have been estimated through the use of OPGEE and PRIMES-Refinery. The weighted averages of these values for petrol supplied to the EU are presented in Figure ES-1. Similar results have been calculated for diesel oil and kerosene[3].

The results of the GHGenius model regarding breakdown of CI of natural gas pathways by supply chain stage, EU country and region have been assessed. Indicative analysis of average CI values for CNG supply in each region and in the EU is presented in Table ES-1.

[3] All results presented in the following paragraphs are calculated on a lower or net heating value basis.

Figure ES-1 Total GHG emissions for the MCONs examined per process of the supply chain for petrol (grCO_2eq/MJ)

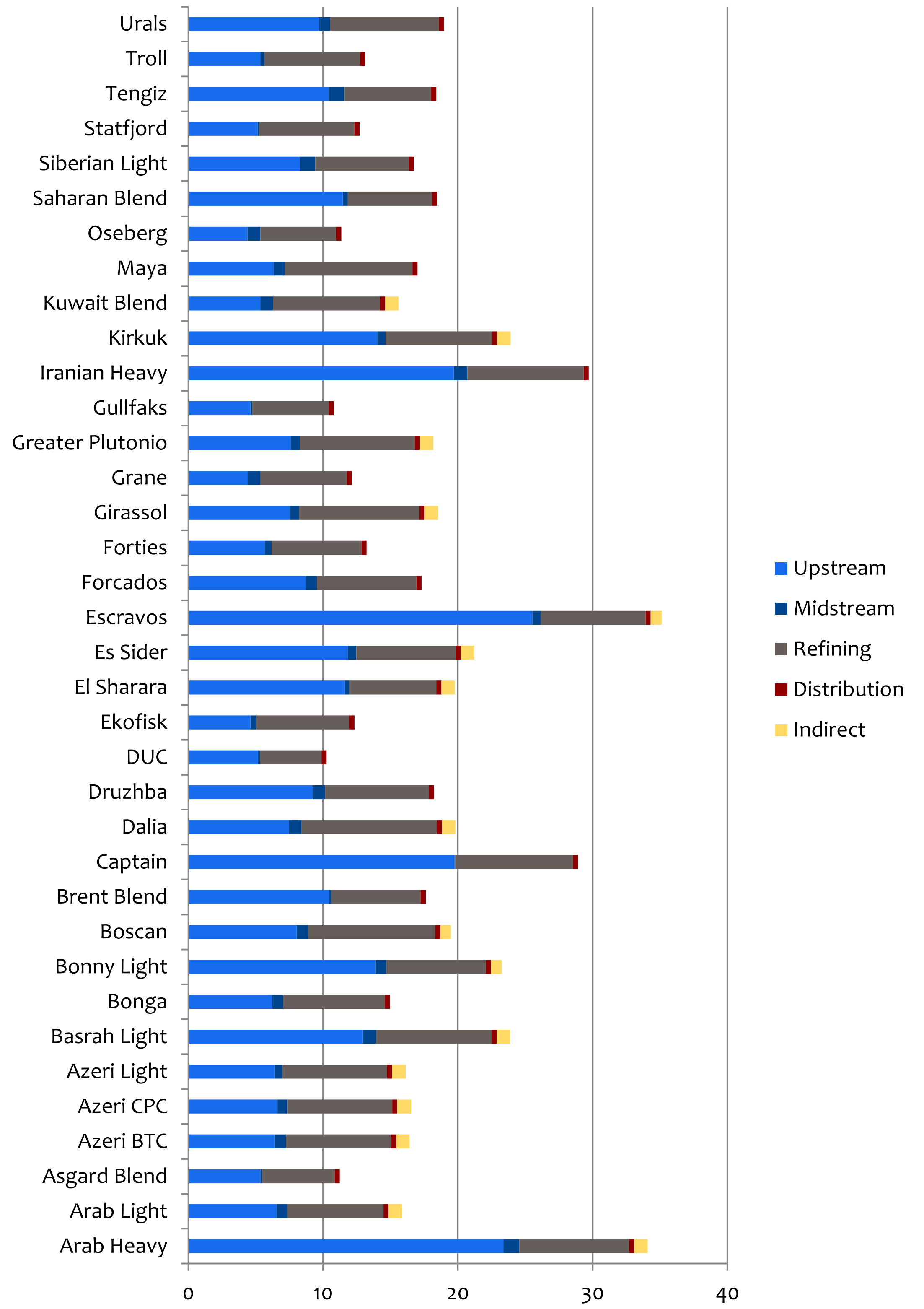


Table ES-1 Average Carbon Intensities of Natural Gas for the considered EU Regions

Reference scenario	EU average	EU North	EU Central	EU South East	EU South West
CNG	**grCO2eq/GJ**				
Fuel dispensing	**3,819**	3,519	4,112	4,221	2,790
Gas distribution, transmission and storage	**2,964**	1,249	2,804	6,616	1,158
Feedstock transportation (pipeline, LNG)	**6,633**	2,436	8,287	9,119	5,142
Fuel production and recovery	**5,395**	4,820	3,352	7,858	9,559
CO_2, H_2S removed from NG (gas processing)	**366**	238	201	768	517
Total	**19,177**	**12,262**	**18,756**	**28,582**	**19,166**

The most important GHG emissions appear in the South-East EU region, with an average CI of 28.6 grCO$_2$eq/MJ. This happens mainly due to the fact that this region receives significant quantities of Natural Gas from countries with a big amount of upstream emissions, namely Algeria and Libya. In addition, the streams originating from Russia, which is an important supplier of the South-East region, have important midstream emissions, due to the length of the transport pipelines bringing gas to the consumers.

Indirect emissions

The objective of this Task is to evaluate the importance of the various sources of indirect GHG emissions identified within the existing literature and data sources[4]. Indirect emissions were found to be of small scale compared to the total lifecycle emissions. More specifically, the total indirect emissions from oil products consumed in the EU transport sector are estimated between 0.36 up to 1.17 grCO$_2$eq /MJ, while the indirect emissions from natural gas are estimated to be between 0.19 and 0.62 grCO$_2$eq /MJ. The indirect emissions from natural gas consumption are lower compared to indirect emissions from oil consumption. The main reason is that natural gas supply to the EU relies heavily on extraction from the North Sea and other regions with low, indirect emissions.

[4] The most significant sources of indirect GHG emissions of fossil fuels include (among others): a) Emissions from accidents outside of normal operation conditions; b) emissions from induced land development; c) emissions caused by military involvement.

Other issues related to sustainability

International trade issues

Most of the consumed quantities of oil and gas are imported in the EU, so there could be concerns in case the Carbon Intensity (CI) reduction policies were implemented on the basis of lifecycle GHG emissions of fossil fuels. The international obligations to which the EU has committed itself, especially those in the field of international trade law under the auspices of the World Trade Organization (WTO) have to be taken into account.

The study examined what the possible WTO implications would be in the context of two hypothetical scenarios: (a) the EU takes no action; and (b) the EU adopts legislation restricting the production, sale, consumption, importation (or any one or more of the above) of fossil fuels not meeting a certain specified GHG emission limit.

Should the European Union adopt restrictions on fossil fuels, the assumption is that these will be adopted in conjunction with restrictions on domestic production or consumption. However, even if such measures would be adopted in conjunction with restrictions on domestic production or consumption, a seemingly even-handed measure might impact the products of various WTO Members differently.

In sum, the crux of the issue would be whether the measure(s) at issue would be objectively justifiable, rather than arbitrary, and whether they would be the least trade restrictive option possible to fulfil the regulatory objective, i.e. to limit GHG emissions from the consumption of fossil fuels. Indeed, with the right effort, there is no reason why such measures would not meet the EU's WTO obligations.

Sustainability questionnaire

In order to assess the impact of the methodology followed for the purpose of the present study, the project team in collaboration with the EC Project Officer has distributed a questionnaire to a great number of stakeholders concerned with the calculation of GHG emissions of transport fuels. The project team received 114 replies in total.

The quantitative and qualitative analyses of replies by stakeholder category and type of answer have concluded to certain messages, the most significant of which are:

- The biofuels industry and other stakeholders insist that actual GHG data should be collected for all the streams supplying oil and gas to the EU transport consumers in order the European Commission to be able to organize a rigorous and effective policy, which aims at substantial and justified GHG emissions reduction.
- The biofuels industry and other stakeholders insist that a transparent and fair approach to GHG emission has to be developed for all fuels used in the EU whether bio or fossil. Fossil fuels must undergo the same scrutiny as biofuels since they are the main emitters of GHG.

- A consistent verification of actual GHG data has to be developed, as in the case of biofuels the EU could develop its own system and try to harmonise it later into a global one, especially for oil and gas originating from regions outside Europe and North America.
- The Oil and Gas industry estimates that there will be impact on international trading by any policy measures by the EU that will be based on disaggregated reduction of the CI content of fossil fuels.
- The oil and gas industry is negative to sustainability criteria changes insisting that regulatory stability should be maintained with no changes at present.

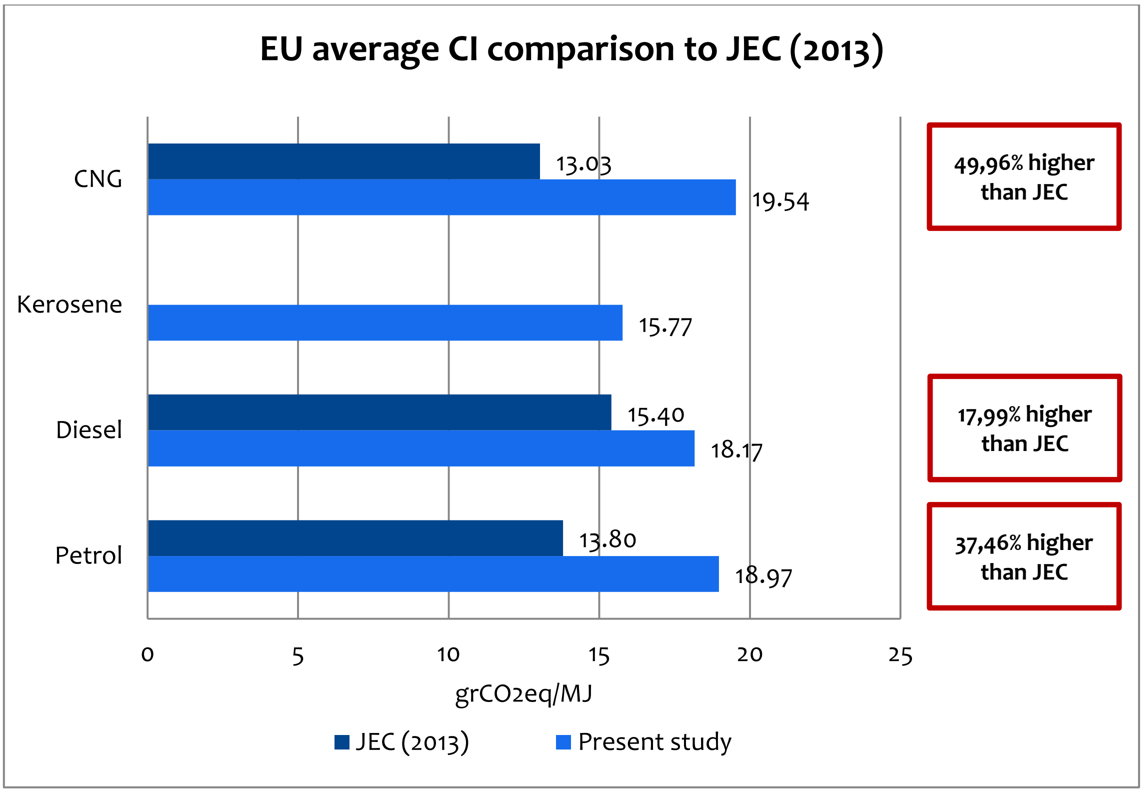
Substantial study findings

Probably the most significant finding of this project is the great range of CI values (direct + indirect) depending on the fossil fuel streams imported in the EU and that is evident for both oil and gas streams. The spread of the gas streams CI values (CNG case) for four EU regions are presented in Figure ES-3. The significant range of CI values could be easily observed among the streams of different producing countries, for example the lower value has been calculated for the Dutch gas supplying Northern Europe in the order of 6.5 grCO2eq/MJ, whereas the Algerian LNG stream reaches up to 55 grCO2eq/MJ. In general, the CI is high in gas streams related to long pipelines and/or long distances of transport in the form of LNG, and/or high methane fugitive emissions; therefore the CI of the Russian gas, which is the most significant gas importing stream in the EU, is calculated in the range of 29 to 40 grCO2eq/MJ depending on the EU region directed. The high values are a function of the transport distance and the difference between the min/max values is a function of the different methane emissions in the transmission and distribution systems. On the other hand, the less emitting natural gas streams belong to local EU sources and Norway, which benefit from shorter transport distances and lower fugitive emissions. It is estimated that the gas CI is generally higher in the EU south east region with an average CI calculated to 28.9 grCO2eq/MJ, whereas the same average in the EU north region is only 12.6 grCO2eq/MJ and the EU average value is 19.54 grCO2eq/MJ.

The total (direct + indirect) CI of the most significant crude oil MCONs for the EU, which have been considered in our study, are presented in Figure ES-4. In general, the CI of petrol is higher than the diesel oil CI, which is higher than the kerosene CI. The difference is subject to the characteristics (API and sulphur) of each MCON, the structure of the EU refineries and particularly to the assumptions of the GHG allocation method to the final refinery products. The range of CI values for petrol is evidently large, from around 37 grCO2eq/MJ for the Nigerian crude Escravos down to around 10 grCO2eq/MJ for the Danish crude DUC. Proportional variations are observed for the other two oil products, namely diesel oil and kerosene. It is also evident that the highest CI values are observed in heavy crudes from regions with less stringent environmental legislation and care for the reduction of GHG emissions in the upstream activities and particularly flaring. On the other hand, the lower values are related to lighter crudes produced in countries with substantial environmental measures for the minimization of GHG emissions in upstream and other oil process stages.

The EU average CI WTT values of kerosene, diesel oil and petrol streams are estimated to 18.87 grCO2eq/MJ for petrol, 18.17 grCO2eq/MJ for diesel oil and 15.77 grCO2eq/MJ for kerosene. The comparison of the average CI values of oil products and gas streams of this study with the respective JEC values is presented in Figure ES-2. In general, the CI estimations of the present study are higher than the values of JEC. More specifically, the CNG CI value is higher by 49% compared to the JEC value, whereas the respective percentage is higher by 17% for diesel oil and 37% for petrol.

Figure ES-2 Comparison of average CI of oil products and gas streams with JEC values



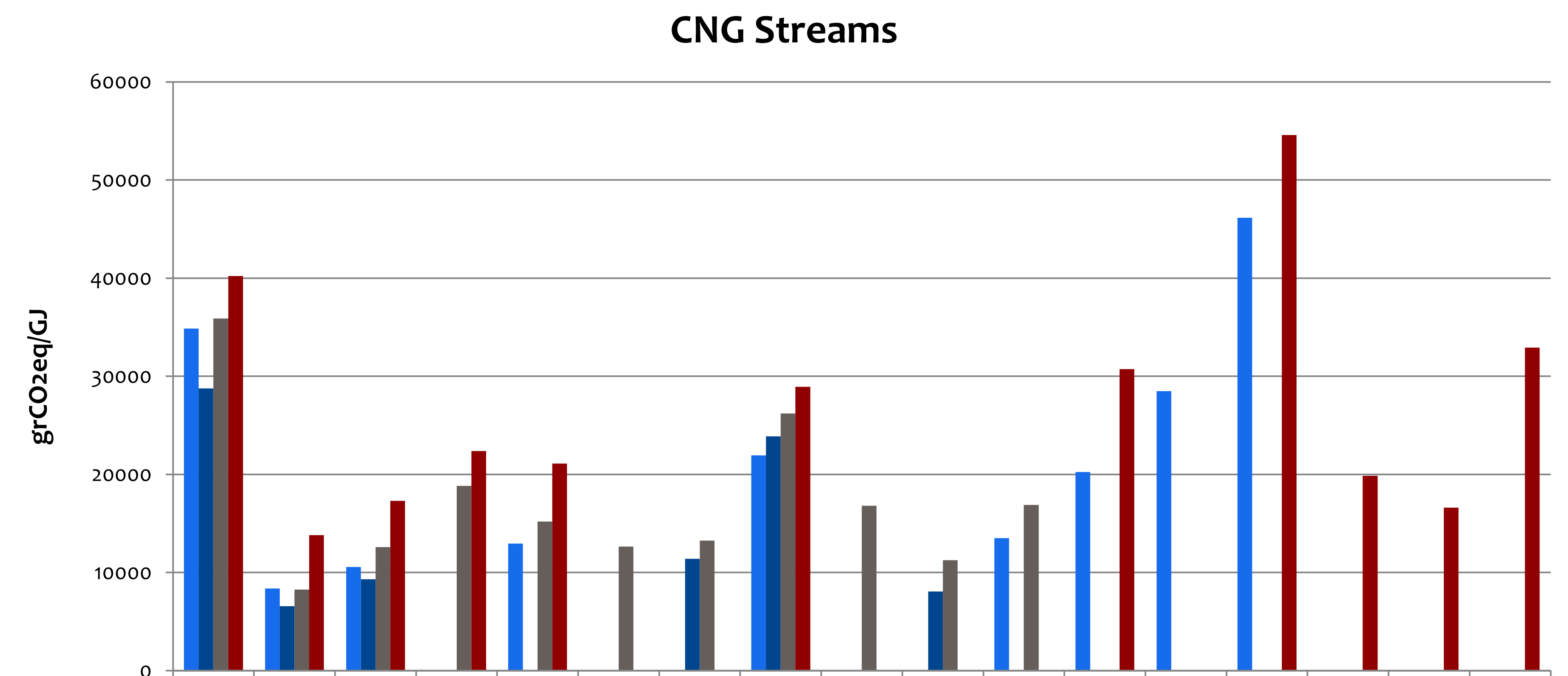
The comparative presentation of the WTT CI values of fossil fuels estimated in this study and increased by the average TTW values of the JEC study, the respective WTW values of JEC study for fossil fuels and the respective WTW CI values of a variety of bio fuels as they have been assessed by the JEC study (2013) are presented in Figure ES- 5. Min/max and weighted average of the conventional and the average CI values of the unconventional fossil fuels of this study are also presented. The spread of CI WTW values of conventional fuels (this study) are compared with the respective CI spreads of conventional and advanced biofuels (JEC terminology) and the relevant percentages of GHG savings are calculated.

What is clear due to this study is that the range of the estimated WTT, but also of the WTW, CI values of conventional fossil fuels is particularly large compared to the respective weighted average CI values; the uncertainty min/max assessment intensifies further this range of CI values. Yet, the CI values of unconventional fossil fuels are at the highest levels compared to the respective values of conventional fuels. Therefore the consideration of weighted average values instead of actual aggregated values for fossil fuels might mislead GHG efficient reduction efforts in the context of pertinent EU policies, because the average CI values favor the high CI fossil fuels and the reasons for this situation (flaring, poor maintenance, fugitive, etc.) against the less emitting, well regulated fossil fuels.

The above approaches could be interpreted into policy options on CI reduction of fossil fuels used for transport in the EU; a reasonable set of indicative options is presented below:

1. Do nothing, leave things as they are.
2. Update the fossil fuel comparator as reported by the FQD.
3. Revise the FQD with a max CI value for fossil fuels that are allowed to be used in the EU.
4. Revise the FQD with a max CI value for fossil fuels that are allowed to be used in the EU considering as well security of supply
5. Define a max CI value for unconventional fuels
6. Develop a certification and verification system for fossil fuels
7. Take into consideration WTO implications

Figure ES-3 Spread of CI for well-to-tank (CNG) gas streams for EU regions



	Russia	Netherlands	Norway	Other	Germany	Poland	UK	Qatar LNG	Hungary	Denmark	Norway LNG	Algeria	Nigeria LNG	Algeria LNG	Romania	Italy	Libya
EU South-West	34858	8373	10558		12949			21934			13508	20239	28477	46154			
EU North	28774	6576	9330				11405	23875		8076							
EU Central	35879	8263	12589	18823	15200	12636	13265	26217	16797	11268	16891						
EU South-East	40215	13807	17298	22369	21112			28924				30743		54575	19868	16607	32916

Figure ES-4 Average WTT CI of kerosene, diesel oil and petrol streams of significant MCONs

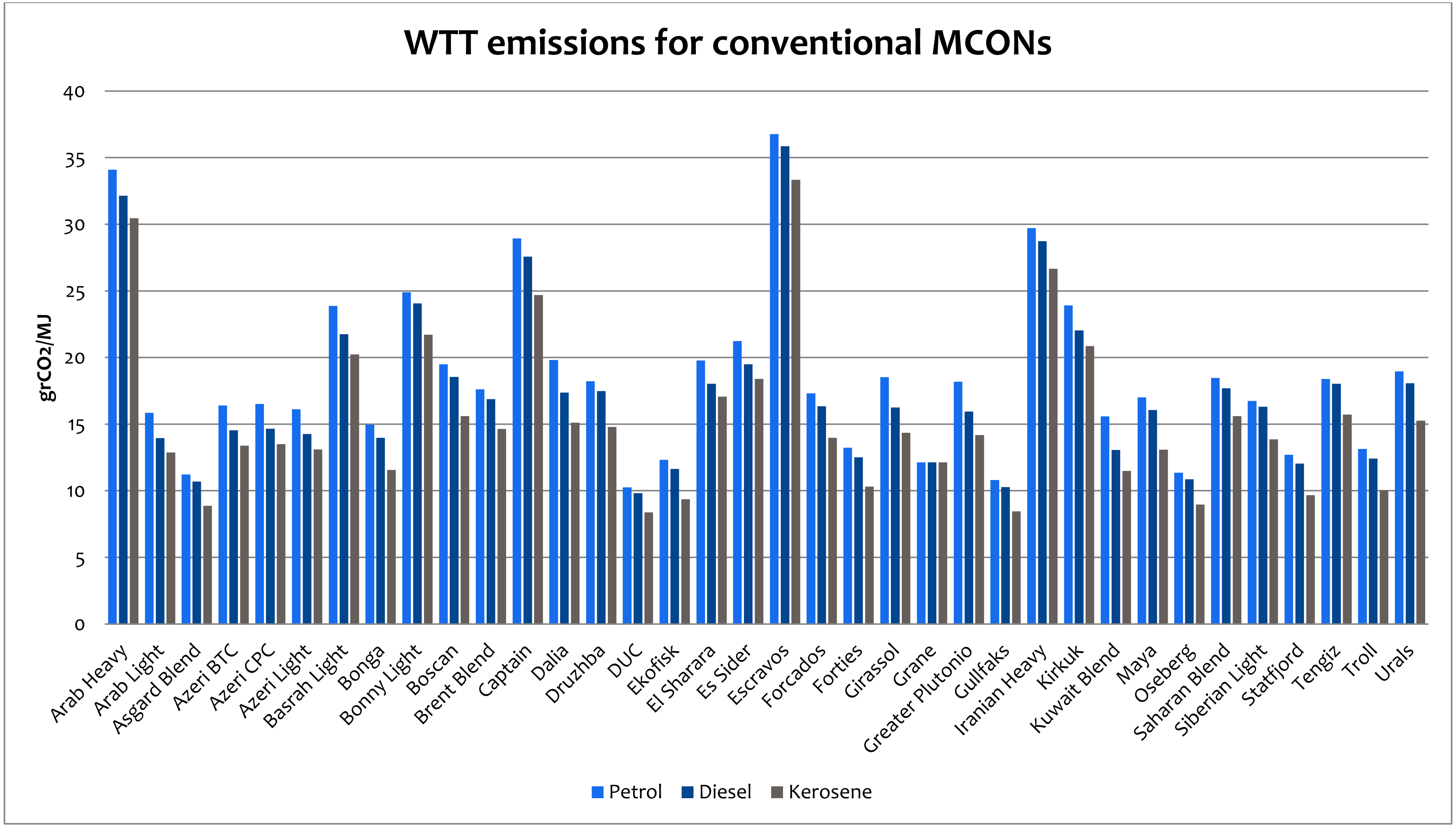


Figure ES-5 Comparison of CI values of fossil (this study) & bio fuels (JEC study), GHG savings of biofuels on average, min/max values of fossil fuels