THE POTENTIAL ENVIRONMENTAL IMPACTS OF *DIESELGATE* IN IRELAND

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Abstract

Transportation sector is the greatest contributor to overall greenhouse gas emissions. With the booming demand for transportation, reducing it has become one of the main concerns to the researchers. Therefore, emission standards are becoming more stringent with each progressive emission standard directive. EPA emission standards are designed to protect air quality and human health. Diesel Euro 5 NOx has become a matter of disquiet since recently it has been found that NOx emissions are significantly exceeding the standard limit. This paper presents a study to estimate real world NOx emission levels resulted from all diesel Euro 5 passenger cars (PC) as well as light commercial vehicles (LCV) that are present in Ireland. The diesel Euro 5 NOx emission levels have been calculated using COPERT 4 and the same has also been estimated based on Portable Emission Measurement System (PEMS) measurements and laboratory test results with reference to the emission concentration values (g/km) suggested by Ntziachristos et al. (2016). All NOx emission values i.e. Laboratory test results, on-road measurements and model estimated values were compared. This will give a clear idea about the significant difference between the actual and model estimated emission levels. Additionally, NOx emission levels from the defective Volkswagen models has been calculated to quantify the effect of the Volkswagen scandal on Ireland. The variations of NOx emissions over the period (2010-2015) with respect to number of vehicles have also been presented in this paper to see the change in emission trend with the vehicle number. The actual quantity of emission will be helpful in realising the severity of the situation and in studying effect of excess NOx emissions on health.

1. Introduction:

Air pollution is associated with 7 million premature deaths annually (WHO, 2014) and Nitrogen Oxides (NOx) are classic air pollutants which are responsible for a wide variety of environmental and health impacts. NOx pollution contributes to atmospheric levels of NOx, fine particulate matter, and ground-level ozone. Exposure to these pollutants has been linked with a range of serious health effects, including increased asthma attacks and other respiratory diseases (USEPA, 2016). Ireland has reasonably good air quality and meets the limits specified by the current EU directives (CAFÉ directive). However, while ambient NOx levels are within limit in Ireland at the monitoring locations, the 2013 emissions of NOx are above the 2010 limit as set out in the EU NEC Directive (EPA, 2014). It is expected that the ambient NOx concentration in Ireland will increase due to a significant increase in the number of diesel vehicles in the fleet since 2008 and due to the *dieselgate* scandal where many Volkswagen vehicles failed to meet the expected emission levels in real world driving conditions. These Euro 5 engines were originally planned to reduce the ambient NO_X concentration due to better vehicular technologies producing less NO_X emission than their predecessors which may not be the reality. The rise in the number of diesel passenger vehicles can be linked to the Irish Carbon-based vehicle tax system whereby vehicles purchased from 2008 onwards would be taxed based on their CO_2 emissions intensity rather than their engine capacity (the previous approach) (Giblin & McNabola, 2009). This resulted in a shift in new vehicle purchasing patterns from petrol to diesel.

In Volkswagen (VW) scandal, VW and Audi passenger cars have been found to be violating Euro 5 emission standards resulting in higher NOx emission levels from these vehicles than from vehicles with properly operating emission control systems. Reportedly, NOx emission levels from the VW 2.0 litre vehicles and 3.0 litre vehicles are higher than emission standards by 10-40 times and up to nine times respectively (USEPA, 2016). Transport and Environment (2016) has reported that Volkswagen Euro 5 LCVs produce cleanest vans when empty but exceeds the limit by 225% when full. Also, it has been suspected that total 21.4 million Euro 5 PCs and 2.2 million Euro 5 LCVs across Europe are faulty. It is important to investigate whether the discrepancy between the real world emission levels and the lab tested levels is adjusted in assessing the environmental impacts of NOx in Ireland.

COPERT4 is one of the most widely used models in Europe for calculating emissions from road transportation which are used for national inventories as well as for target setting for future. Thus it is important for the model to reflect the real world emissions well. COPERT4 is a recommended model by European Environmental Agency (EEA) to calculate emission for more than 30 European countries (EMISIA, 2014). COPERT4 to is developed based on a large database which includes information on vehicle fleet, speed related emission factors (EF), fuel related information, annual mileage and average speed for each vehicle category and capable of calculating a wide range of pollutants (Ong et al., 2011). COPERT is also used in Ireland to estimate emission levels of air pollutants (Caulfield, B, 2009; Brady and O'Mahony, 2011; Doorley et al., 2015; Alam et al., 2015). In recent studies, it has been identified that the model developed EFs do not comply well with the real world emission values and it is not only Volkswagen but all the other Euro 5 vehicles that might be emitting more NOx than the standard limit (Ntziachristos et al., 2016).

Achour et al. (2011) used a portable Gas Analyzer to validate COPERT4 EFs and found that COPERT4 underestimated the NO emissions. Berkowicz et al. (2006) used OSPM (Operational Street Pollution Model) and Kousoulidou et al. (2010) used PEMS to verify COPERT EFs and both have reported significant underestimation of NOx concentration by COPERT. From the aforementioned studies it can be concluded that COPERT always has a tendency to underestimate NOx and this might be because of COPERT considers average speed whereas in real driving scenario there are many other factors involved that affects the emission profile such as, driving behaviour, frequent speed changes which affect the emission levels.

In recent tests conducted by TNO (2016) on wide range of Euro 5 makes and models, it was observed that the NOx values obtained in real world conditions in lab or on the road are significantly higher than that obtained from the type approval test or Euro 5 limit. It has also been pointed out that earlier the model EFs could partially be linked to the real world emissions by the difference in them with respect to driving behaviour and conditions under real world condition. But now the difference in emissions are much higher even when the

vehicles are driven under such conditions that are comparable to the type approval test condition (TNO, 2016). Weiss et al. (2010) found the NOx values for diesel Euro 5 cars to be in the range 0.4-1 g/km which is 3-5 times more than the European driving cycle values.

This paper intends to study the environmental impact in terms of excess emission by Euro 5 light duty vehicles (LDV) i.e. PCs and LCVs in Ireland based on all the reported facts on *dieselgate*. The first objective of this paper is to study the NOx emission levels from all the Euro 5 PCs and LCVs in Ireland. This situation is considered and studied based on recent studies where it has been found that the real world EFs are lot higher than the euro standard limit. But exactly which models or if all the models are faulty or fitted with defeat device are not known. Thus the emission levels are tested considering all the Euro 5 PCs and LCVs to see the overall quantity of excess emission. Secondly, because of the VW scandal came in light, it has been identified which specific VW and Audi models (USEPA, 2016) are cheating the emission standard. Thus second objective of this study intends to see the effect of VW scandal in Ireland by quantifying the extra emission by reported VW and Audi models. Transport and Environment (2016) has reported that not only specific VW and Audi PCs but many other LDVs are suspected to be cheating the emission standards. The third objective has been designed to study the NOx emission levels resulted from all PC and LCV models of VW and Audi. This will give an idea how much a single brand of vehicle which has been proved to be cheating, is contributing.

The next section describes the methodology, followed by presentation and discussion of the results and a conclusion.

2. Methodology:

The potential effect of *dieselgate* in Ireland with respect to the under/over estimation of the emission inventory using COPERT4 has been explored in this study. The investigation was carried by designing different real and hypothetical scenarios. This section presents the methodology followed to find out the NOx emission levels for all diesel Euro 5 LDVs using COPERT4 (v11.3), lab test results, PEMS measurements and also based on euro standards. PEMS records the emissions when vehicle is driven on road and the measurements reflect the real-world emission levels. In order to achieve the objectives of the paper, different emission scenarios were designed and they are summarised below,

Scenario 0- Euro Standard Scenario: This section describes the expected emission levels following the Euro standard specifications for Euro 5 PCs and LCVs. The standard emission levels for all the vehicles were calculated using the following equation,

Standard emission (tonne)= No. of vehicles* average annual mileage (km)* euro standard emission factor (g/km)* 10^-6

Euro standard NOx concentration is taken as 0.18g/km for PCs (EEA, 2007) and 0.28g/km for LCVs (TNO, 2015).

Scenario 1A- COPERT Base Scenario: The COPERT base scenario describes the current situation of vehicular NOx emission levels for existing Euro 5 PC and LCV fleet in Ireland. Emissions in this scenario were calculated by COPERT4 (v11.3) using the default emission factors. Overall Euro 5 fleet data were obtained from Department of Transport, Tourism and Sport (DTTAS) by considering number of newly registered vehicle since the introduction of Euro 5 vehicles (i.e. over the period of 2011-2015, RSA). Average annual mileages were calculated for each year and mileage shares were assumed to be 15%, 9% and 76% for Urban, Rural and Highway driving respectively (Brady and O'Mahony, 2011). The NOx emissions were then calculated for each year separately (2011-2015) for PCs as well as LCVs and added up to obtain the overall NOx emissions from Euro 5 PCs and LCVs. The results obtained from this analysis are presented in different sections for PCs and LCVs.

Scenario 1B- Real-world Base Scenario: This section presents the actual quantity of the NOx emissions for Euro 5 vehicles to show the quantity of overestimated (for Euro 5 PC) and ignored (for Euro5 LCV) emissions by COPERT4. In order to do that emissions under urban, rural and highway driving conditions were calculated separately using COPERT and then modified to reflect the real-world NOx emissions. NOx emissions for Urban driving condition were found by keeping Urban driving share as 100% and the same for Rural and Highway as

zero. Speeds were also kept as zero for Rural and Highways while calculating emissions for urban driving condition. The similar approaches were followed while calculating emissions for Rural and Highway driving. Annual mileage values were disaggregated by their respective percentage of driving mode shares, e.g. in order to obtain mileage for Urban driving, overall mileage was multiplied by 15%. In order to get the real-world emission values, NOx concentrations (g/km) which are based on significant number of on-road and lab tests (Ntziachristos et al., 2016) have been taken as reference, the values have been presented in table1 and table 2 (Ntziachristos et al., 2016). EFs from real-world lab tests were found to be very close to that of COPERT4. But the differences between emission

Table 1: NOx values (g/km) for Urban, Rural and Highway for Passenger cars

Driving mode	Euro 5 Standard EFs	COPERT EFs	Real-world EFs	Percentage Difference (%)
Urban	0.18	0.76	0.88	14
Rural	0.18	0.49	0.22	123
Highway	0.18	0.61	0.35	74

values obtained from COPERT4 and on-road measurements are quite significant and both are much higher than the Euro 5 NOx limit. The percentage differences between the COPERT and PEMS estimated concentration values (g/km) were calculated. These percentage differences were used to estimate the on-road emission levels.

Table 2: NOx values from the graph (g/km) for Urban, Rural and Highway for Light Commercial Vehicles

Driving mode	Euro 5 Standard EFs*	COPERT EFs	Real-world EFs	Percentage Difference (%)	Lab test EFs	Percentage Difference (%)
Urban	0.28	0.78	1.55	50	0.90	13
Rural	0.28	0.64	1.52	58	0.72	11
Highway	0.28	1.25	1.64	24	1.16	8

*varies with respect to the weight, the highest among them is presented here.

Concentration values from real-world lab cycle tests were found to be higher than model estimated emission factors for Urban and Rural roads, but on-road measurements were even higher in all the driving conditions and all the estimated values were significantly higher than the standard Euro 5 NOx limit.

Real-world emission levels were calculated multiplying the separate emissions by a factor equal to the percentage differences (see table 1 and table 2) between COPERT EFs and PEMS EFs to access the real world NOx emission levels. These individual emission levels calculated under Urban, Rural and Highway driving conditions were then summed up to represent the total real-world NOx emission level. The same methodology was followed to acquire emission for every year from 2011-2015. Similarly, real world emission levels for Euro 5 LCVs were calculated.

Scenario 1C- Lab test Base Scenario: Lab test base scenario presents the quantity of Euro 5 NOx emissions based on lab test results. Similar procedure, as was followed to obtain NOx emissions based on PEMS measurements, was also followed to achieve lab test emissions from Euro 5 PCs and LCVs. In this case the percentage differences (see table 1 and table 2) found between COPERT 4 emission factors and lab test emission factors were used to modify emission values calculated by COPERT 4. It can be observed in Figure 1 that for Euro 5 PCs, the PEMS and lab test emission factors are very close. Thus it is considered that NOx emission levels estimated by COPERT 4 are consistent with those resulted from lab tests. Therefore, PC NOx emissions have not been calculated separately and lab test base scenario only presents results for Euro 5 LCVs.

Scenario 2A- VW COPERT Base Scenario: VW base scenario conveys the NOx emitted by the fleet of vehicles fitted with defeat devices as reported by USEPA. Table 3. presents

the VW and Audi passenger car models that have been found to be cheating the NOx emissions,

Table 3. Affected VW and Audi passenger car models (USEPA, 2016)

Affected 2.0 litre diesel models	Affected 3.0 litre diesel models
Jetta	Volkswagen Touareg
Jetta Sportswagen	Porsche Cayenne
Beetle	Audi A6 Quattro
Beetle Convertible	Audi A7 Quattro
Audi A3	Audi A8
Golf Sportwagen	Audi A8L
Golf	Audi Q5
Passat	Audi Q7

Specific reported models of Volkswagen and Audi passenger cars with 2.0L and 3.0 L were extracted from the overall database of Irish Motor Industry (SIMI, 2016) and NOx emissions were then calculated using COPERT4. Input parameters such as speed, mileage share, average annual mileage etc. were considered to be same as those in base scenario.

Scenario 2B- VW Real-world Base Scenario: This section presents the actual quantity of NOx discharged from USEPA reported VW and Audi models based on PEMS measurements. To access emissions measured by PEMS, similar approach was followed as Real-world base scenario i.e. emissions were calculated separately for different driving modes using COPERT and revised to calculate real-world emission levels.

Scenario 2C- VW Lab Test Base Scenario: This section presents the NOx emission levels exhausted by faulty VW and Audi models as per lab test results. The similar procedure, as followed in case of lab test base scenario to estimate emission for overall Euro 5 fleet, was also used to obtain NOx emission levels from VW and Audi PCs in lab tests.

Scenario 3A- VW PC Hypothetical Scenario: Hypothetical Scenarios are designed to access the effect of circumstances if all 59527 VW and Audi Euro 5 PCs (SIMI, 2016) and 12337 VW Euro 5 LCVs in Ireland are faulty. So, it would be worthy to assume that it's not only the USEPA reported VW and Audi models but all the VW Euro 5 PCs are equipped with defeat devices. Hence, the following hypothetical situations were tested to measure the excess amount of NOx. This section presents NOx emission levels of all the aforementioned VW scenarios i.e. VW COPERT base scenario, VW real-world base scenario and VW lab test base scenario, but for overall VW and Audi Euro 5 car fleet in Ireland. Total number of all VW and Audi models in Ireland were extracted from the overall dataset of Irish Motor Industry (SIMI, 2016). NOx emissions for all VW and Audi models were then accessed using the similar methodology as used to calculate the same for reported VW and Audi models.

Scenario 3B- VW LCV Hypothetical Scenario: In this section NOx emissions of all VW Euro 5 LCVs are presented. Number of VW LCVs present in Ireland were obtained from Irish Motor Industry (SIMI, 2016) database. Number of Audi LCVs are negligible, hence ignored. Emissions were calculated by all three methods, i.e. COPERT4, Lab test and PEMS following the similar approach as mentioned in real-world base scenario and lab test base scenario.

3. Data Description:

Major input data that were required to calculate emissions from COPERT were, meteorological data (e.g. mean monthly maximum and minimum temperature, humidity), engine size, fuel information, speed (kmph), mileage (km), travel share (%) and vehicle population. Table 4. shows the main input data and their respective sources. Speeds for Urban roads, Rural roads and Highways were taken as 50kmph, 80kmph and 100kmph respectively (RSA, 2013; RSA, 2015). The data availability on driving mode share in Ireland is very limited, therefore, the mileage shares assumed by Brady and O'Mahony (2011) for

Greater Dublin Area (GDA) have been extended to overall Ireland. Thus driving shares have been assumed to be 15%, 9% and 76% for Urban, rural and Highway respectively.

Table 4. Input data and their sources

Input data	Source of data
Meteorological data	MET Eireann: The Irish Meteorological Service Online
Fleet data	Department of Transport, Tourism and Sport
Speed	Road Safety Authority
Mileage data	Central statistics office (Kilometres travelled by road traffic)
Volkswagen Euro 5 cars and fleet configuration	Motorstats: The official statistics of the Irish Motor Industry

The total kilometre travelled by passenger cars were obtained from CSO (2014) and divided by total number of vehicles to get average annual mileage. Information on overall kilometres travelled were available till the year 2014, thus mileage for 2015 was calculated by extrapolation based on 2004-2014 data. Figure 1 and Figure 2 show the number of diesel Euro 5 LDVs and average annual mileage respectively. It is perceptible that there is a significant increase in vehicle numbers every year while the kilometre travelled per year is quite consistent.

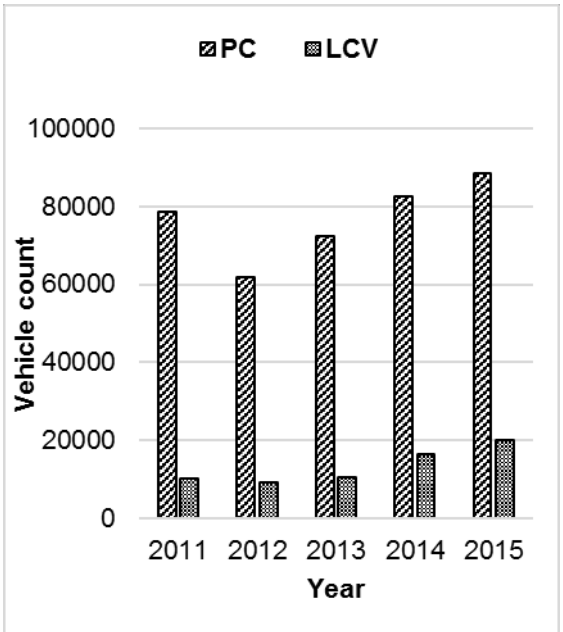

Figure 1: Total number of diesel Euro 5 LDVs

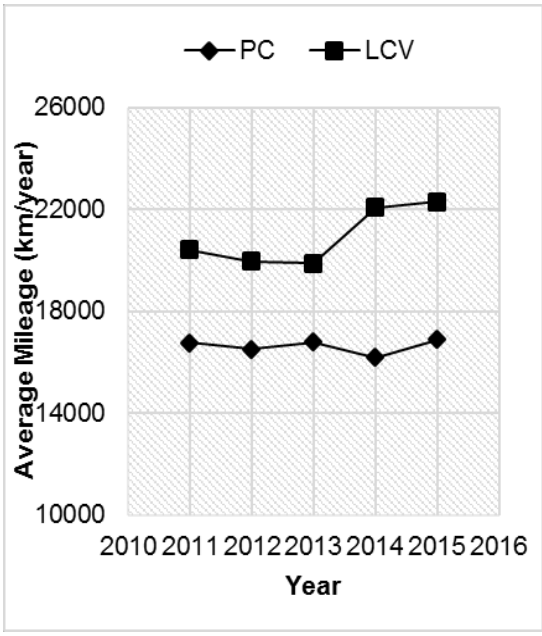

Figure 2: Annual average mileage (km/year)

The LCVs have increased at a higher rate with every year until 2014 while there is a sudden increase in average annual kilometre travelled after 2013. The number of affected diesel Euro 5 Volkswagen and Audi passenger cars those are present in Ireland are summarized in Table 5.

Table 5: Number of affected Volkswagen and Audi vehicles

Year	Volkswagen		Audi		Total	Percentage of total fleet
	<=2.0L	>2.0L	<=2.0L	>2.0L		
2011	3499	20	353	36	3908	5
2012	3543	21	351	38	3953	6
2013	3312	3	602	33	3950	5
2014	4088	2	1939	247	6276	8
2015	4455	18	2377	290	7140	8

It can be observed from table 5 that there is a significant increase in overall number after 2013.

4. Results and Discussion:

The methodology discussed in section 2 was followed to access the objectives of this paper and the results are presented and discussed in the following subsections.

4.1 Existing NOx emission levels in Ireland:

This section presents the emission levels for diesel Euro 5 LDVs in Ireland as calculated using COPERT 4 (v11.3) following the methodologies described in section 2 for scenario 1A, 1B and 1C. Table 6 presents the overall quantity of NOx emissions (tonnes) estimated by COPERT and PEMS and the last column in table 6 shows the desired NOx values in ideal case, i.e. NOx emissions if all the Euro 5 diesel passenger cars had followed the emission standard. A new version (11.4) of COPERT4 has recently been released with modified emission factors for Euro 5 LCVs and Euro 6 PCs. The emissions of Euro 5 LCVs have been calculated with the new version of COPERT 4 as well.

Table 6. Vehicle statistics and NOx emission values for Passenger cars

Year	Vehicle count	COPERT4 (v11.3/ v11.4)/ lab test	Real-world	Euro Standard
			In Tonnes	
2011	78710	738.14	485.38	237.45
2012	61910	571.65	376.09	183.97
2013	72558	679.53	447.26	219.04
2014	82777	745.84	490.94	241.18
2015	88485	835.38	549.69	268.71
Total	384440	3570.53	2349.36	1150.36

From table 6 it can be observed that the differences between the model estimated values and the real world emissions are significant (52%). The wrong estimation by the model might mislead the policymakers. There is huge gap between the desired and actual emissions. The emissions obtained via COPERT4 and on-road measurements are 100-220% in excess than the desired NOx emission levels from diesel Euro 5 PC fleet.

Table 7 summarizes the overall model estimated and real world emissions from Euro 5 LCVs along with the expected values, i.e. the total NOx emission from Euro 5 diesel LCVs if the standard emission specification was followed.

Table 7: COPERT, Real-world and Lab test emission values (in tonnes) for LCVs

Year	Vehicle count	COPERT4(v11.3)	COPERT4(v11.4)	Real-world	Lab test	Euro standard
			In Tonnes			
2011	10355	193.76	343.64	251.63	186.99	59.13

2012	9159	167.56	297.19	217.60	161.72	51.15
2013	10536	191.89	340.32	249.11	185.17	58.70
2014	16457	331.78	588.42	430.54	320.06	101.62
2015	19942	407.68	723.06	529.41	393.49	124.47
Total	66449	1292.68	2292.64	1678.29	1247.44	395.07

From Table 7 it can be noticed that the real world and model estimated emission quantities are about 200-500% higher than the anticipated values. Even though model estimated urban and rural NOx emission factors were observed to be more in lab test outcomes, combined emission amounts calculated by COPERT were estimated to be more than lab test results. On the other hand, the opposite pattern was observed when compared with on-road measurements. Emission values obtained from PEMS measurements were significantly higher than that estimated with COPERT. COPERT4 (v11.3) underestimates and COPERT4 (v11.4) overestimates the real-world emission by 23% and 37% respectively. The discrepancy between the actual NOx discharge and model estimates should soon be accounted, as it might affect many areas given COPERT's extensive application in air quality and impact assessments, projections (energy, CO_2, pollutants), urban/regional inventories, new road (road section) construction etc. (Kouridis et al., 2014).

NOx emission levels from affected VW-Audi vehicles:

In this subsection, the NOx emission levels calculated based on the methodology described in scenario 2A, 2B and 2C for the defective VW and Audi models in Ireland, are shown. NOx emissions were calculated for those PCs using COPERT4. Emissions in scenario 2B and scenario 2C were estimated in the similar way as estimated for overall fleet. The expected NOx emissions as per Euro specification were calculated as well. Figure 3 shows the amount of NOx discharged from the affected vehicles.

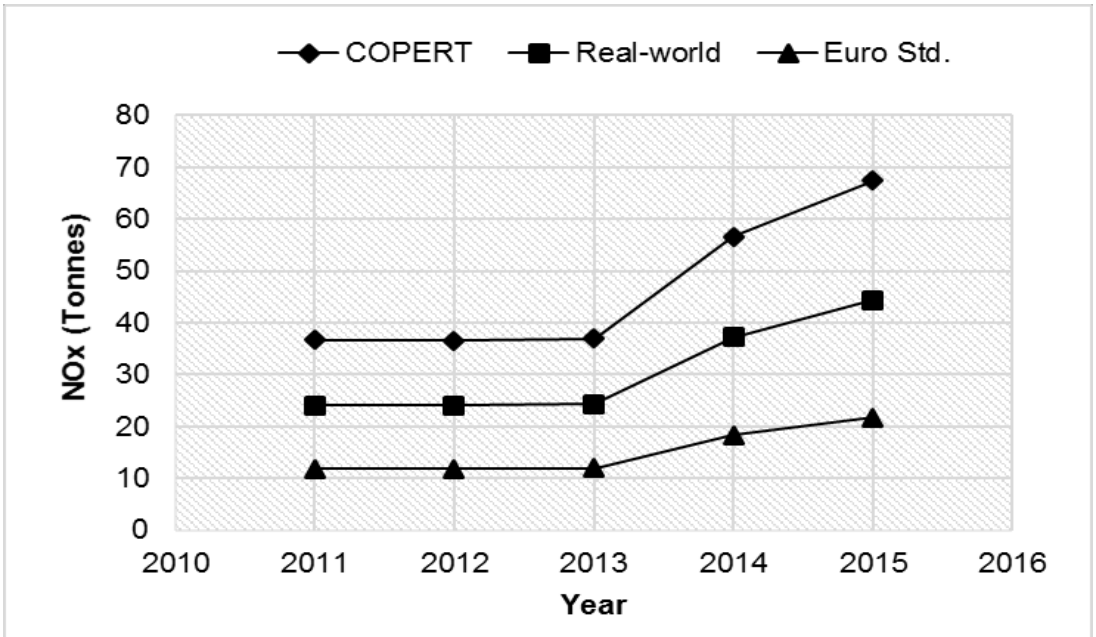

Figure 3. NOx emissions (Tonnes) from affected VW passenger car models in Ireland

It is observed from the results that the real-world emissions obtained from on-road measurements are almost double than the euro standard values. Only reported models constitute about 6% of the total excess NOx exhausted by overall diesel Euro 5 vehicles. Thus, it is not only these vehicles but also many other models which are emitting more than the legal limit.

4.2 Potential NOx emission levels:

This section presents the NOx levels from hypothetical scenario considerations i.e. NOx emission levels resulted from all VW and Audi Euro 5 LDVs. Table 8 shows the total number of Volkswagen and Audi Euro 5 (2011-2015) diesel cars in Ireland.

Table 8: Possible faulty VW-Audi (PC+LCV) vehicles in Ireland

Year	PC			Percentage of total PC fleet	LCV	Percentage of total LCV fleet
	VW	Audi	Total		VW	
2011	8299	3037	11336	14	1858	18
2012	7540	3373	10913	18	2326	25
2013	6792	3432	10224	14	2084	20
2014	8368	3967	12335	15	2852	17
2015	10284	4435	14719	17	3217	16
Total	41283	18244	59527	15	12337	19

Figure 4. shows the NOx emission levels for all 59527 VW and Audi Euro 5 PCs considering if all Euro 5 VW-Audi PCs in Ireland are faulty. The actual as well as modelled emission levels are significantly higher than that calculated by following the Euro standard emission

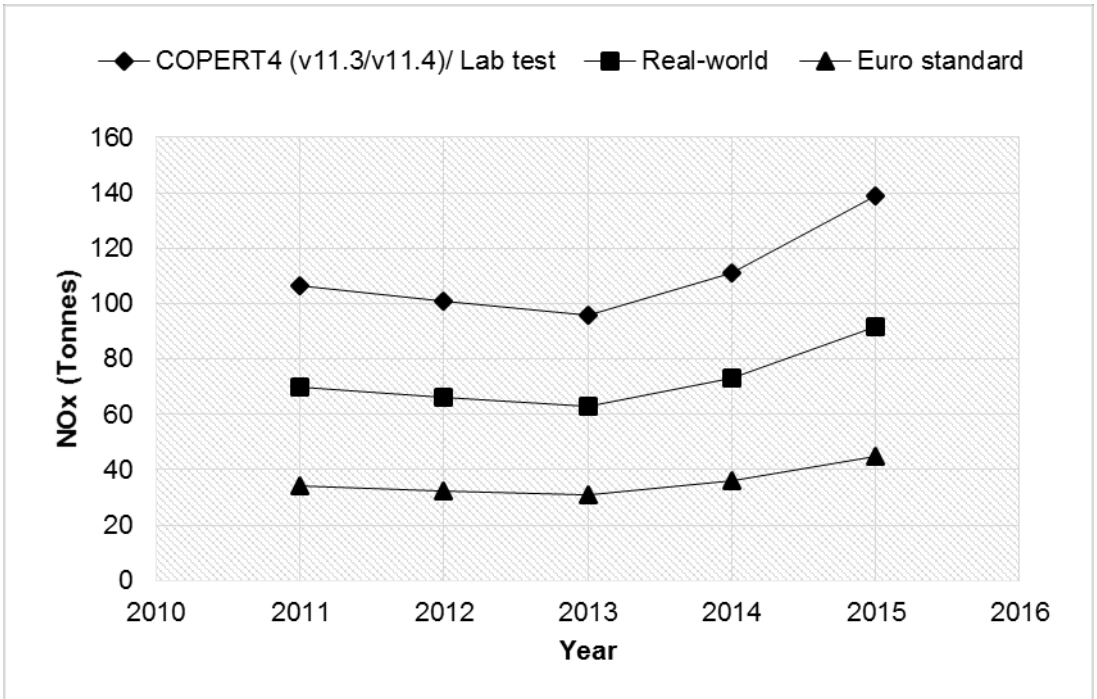

Figure 4: COPERT, Real-world and Euro standard emission values (in Tonnes) of VW and Audi PCs

factor for Euro 5 PC. It was observed that PCs of the brands VW and Audi alone produce 15% of overall extra NOx emissions from diesel Euro 5 PCs. Figure 5 presents the NOx

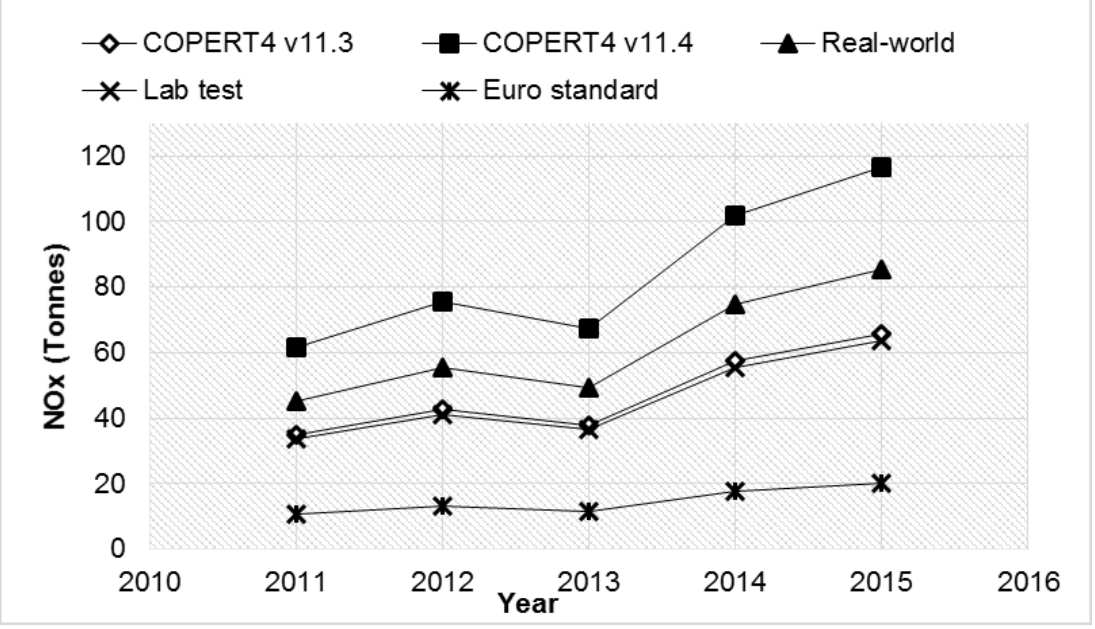

Figure 5. COPERT, Real-world, Lab tests and Euro standard emission values (in Tonnes) of VW LCVs

emission levels for all VW Euro 5 12337 LCVs in Ireland assuming if all Euro 5 VW LCVs in Ireland are faulty. It can be observed that VW LCVs solely contribute to significantly large amount of NOx emissions which is 18% of the excess emissions produced by overall LCV fleet.

Conclusion:

This paper aims to quantify the disparity between the expected, modelled and actual NOx emissions from diesel Euro 5 LDVs that are present in Ireland. It can be observed from the NOx emission levels that even though emission standards became tighter with every progressive euro standard (e.g. NOx limit is 0.25 g/km for Euro 4 and 0.18 g/km for Euro 5), the real-world as well as lab tested emissions are more than the expected emission levels. This clearly indicates that Euro 5 vehicles are not obeying the respective standards. The reason/s behind this excessive discharge of NOx should be examined and measures should be taken to make sure that vehicles follow the euro standard emission limits. Moreover, there is mismatch between COPERT4 estimated and actual emission levels and the differences are significantly high. COPERT4 (both v 11.3 and 11.4) overestimated PC NOx emission levels and in case of LCVs COPERT4 v11.3 underestimated and COPERT4 v11.4 overestimated the real-world NOx emissions by considerable amount. Provided COPERT's substantial applicability in many fields, this issue should also be focused on and suitable measures should be implemented accordingly so that COPERT reflects the real emission as accurately as possible.

Even though few Volkswagen and Audi PC models have been proved to be cheating the NOx emission, the results show that the amount of real-world NOx emissions for all diesel light duty vehicles are huge. If it is assumed that all VW and Audi vehicles may cause excess emission in real world driving conditions compared to the specified standard, then 422.50 tonnes of excess NOx is emitted in Ireland in last 5 years (2011-2015). This might have huge financial and health impacts. Consequently, extensive testing on different Euro 5 and Euro 6 vehicle of various makes and models are required to be carried out.

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