How To Reduce The Harmful Impacts Of Excessive Power Consumption In Our Transport Industry.

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1. Introduction

In recent years, there has been an increasing discussion on the impacts of the environment on social life. One element of this conversation has been the way in which pollution and a poor environment affects our health.

However, with recent events in the modern world, namely, the coronavirus pandemic, there has been a renewed importance on ensuring that we continue our battle against environmental pollution. This is to secure not only the safety of the environment but also the population.

Environmental concerns, scarcity and excessive cost of fossil fuels have obligated governments and industries to reduce the greenhouse gas emissions and deploy effective energy-saving strategies in various industrial sectors.

Power Consumption and Air Pollution

The transportation sector is one of the most energy-intensive industries which is responsible for a substantial portion of CO_2 emission footprint in the atmosphere. The industry consumes a huge amount of fuel. For example, in 2018, the transport industry in the United States consumed approximately 28% of the total energy (EIA,2020). In the UK in the same year, the transport industry amounted to 40% of the nation's energy consumption (UK Government, 2019).

With fossil fuels such as gasoline and diesel currently being the predominant source of energy used by the transport industry, there is a significant impact on the environment. Consumption and burning these fossil fuels can release greenhouse gases into the atmosphere. For example, road transport in the United States accounts for around 1.7 billion tonnes of greenhouse gas emissions each year.

Furthermore, the average vehicle emits between 6 and 9 tonnes of exhaust emission gases each year. A large proportion of these emissions is carbon dioxide.

These CO_2 emissions and other greenhouse gases can have far-ranging health effects. From the direct health implications that stem from air pollution, that will be discussed later in the report, to indirect health impacts such as the spread of infectious diseases as well as the aggravation of cardiovascular and respiratory problems (WHO,2020).

Consequently, immediate actions are required to reduce fuel consumption and associated greenhouse gas emissions in order to achieve a sustainable future.

Aerodynamics and Power Consumption

For road and rail transport, in particular, aerodynamics plays a fundamental part in fuel consumption. While at slower speeds, aerodynamic drag is not a significant factor, as soon as you increase the speed for rural roads and motorways above 60mph, aerodynamic drag can have a significant impact on the fuel consumption.

At speeds over 60mph, aerodynamic drag can account for more than 50% of the fuel consumption. What's more, the faster the speeds, the more fuel consumed as the vehicle pushes through the air. This is because aerodynamic drag is calculated in proportion to the speed.

Force of Drag = Frontal Area x Drag Coefficient (Cd) x Air Density x Speed squared.

With this in mind, even small changes to the force of drag on a vehicle can lead to significant fuel savings, limiting the impact on the environment. For example, a 10% reduction in drag force can improve the vehicle's fuel economy by as much as 5% at highway speeds.

By focusing on aerodynamics, it is not only possible to increase fuel efficiency, but also limit emissions, which can help to reduce the impact of air pollution. With this, it is then possible to reduce the health and environmental impacts of air pollution.

Finding Power Consumption Solutions

With the focus on sustainability, this report aims to discuss the effects of high-level fuel consumption on the environment and therefore, on health. To do this, it will first be necessary to analyse using statistical data, the environmental impacts of fuel consumption across the transport sector including cars, commercial vehicles and trains.

The report will then move on to use this analysis, to discuss the impacts that this data presents for various health conditions, including Coronavirus.

It will then conclude that excessive fuel consumption has a significant impact on air pollution and the worlds carbon footprint as a whole. Furthermore, we will look at the current options available such as hybrid or electric vehicles and systems for reducing aerodynamic drag.

It is vital that we continue to research into new technologies to improve the efficiency of fuel consumption, so that we may be able to continue our fight against environmental degradation and protect the future population from poor health. Ultimately, to improve the quality of life for much of the world's inhabitants.

2. Particulate Matter

In the context of this report, we must define what we mean by particulate matter so that we may better understand its damaging role in air pollution as a result of excessive fuel consumption. We will later discuss how this affects not only the environment but also its impact on our health.

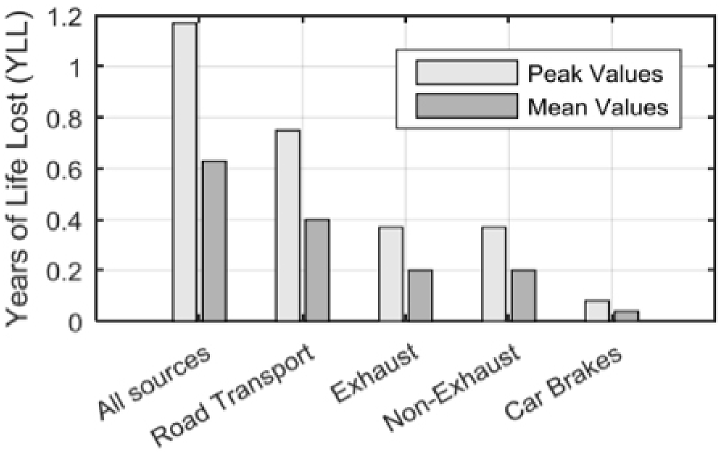
Particulate matter (PM): *Emissions consisting of particles suspended in the air, for example, sea salt, black carbon from combustion, dust, and condensed particles from certain chemicals. They are measured, according to the particle diameter size, as PM10 (diameter less than 10 micrometres), PM2.5 (less than 2.5 micrometres), and UFP (Ultra Fine Particles, less than 0.1 micrometres).*

Particles emitted as a result of excessive fuel consumption activity can also be distinguished as the following;-

- **exhaust traffic-related particles, which are emitted as a result of incomplete fuel combustion and lubricant volatilisation during the combustion procedure.**

It is vital to note, the emission of particulate matter can be translated to a reduction in life expectancy, due to health effects, such as cardiovascular and respiratory diseases and cancer. Alemanti (2017) estimated Years of Life Lost (YLL), an indicator to evaluate the reduction in life expectancy, due to PM emissions.

Figure 1 Years of Life Lost (YLL) in European urban areas due to different PM sources. Source: Alemani, 2017.



According to Alemani, the mean life expectancy in European urban areas is reduced by 0.63 years per person, with peaks of 1.2 years of life lost for each member of the continent's population due to PM emissions.

Now that we have defined the term particulate matter and the part it plays in air pollution, it becomes possible to have an in-depth look at the statistical data for the three mainland transportation sectors (cars, commercial vehicles and trains). By doing so, the report aims to provide an insight into the environmental impact of fuel consumption through its continued inefficiency in these three main modes of transport.

3. Environmental Impacts of Fuel Consumption in Road Vehicles

A vehicle's engine consumes fuel as it travels on the road, with engine power output contributing to five primary factors: drivetrain, inertia/braking/grade, rolling resistance, auxiliary loads and aerodynamics losses.

In an urban environment, the power dissipated through acceleration and braking of the vehicle is the dominant loss, whereas on the highway the aerodynamic losses are dominant. This is shown in the table below, which gives percentages based on the type of losses at various speeds. As you can see, at 70 mph, aerodynamic losses account for 70% of the power demand from the engine. They are, therefore, heavily responsible for the fuel consumption required to maintain that speed.

Table 1 Power losses at a range of vehicle speeds

Vehicle Speed	Aerodynamic	Rolling & Accessories
32 km/h (20 mph)	28%	72%
53 km/h (33 mph)	33%	66%
64 km (40 mph)	36%	64%
80 km/h (50 mph)	50%	50%
96 km/h (60 mph)	62%	38%
105 km/h (65 mph)	67%	33%
113 km/h (70 mph)	70%	30%

In table 2, fuel consumption from various vehicles is analysed.

Table 2 Fuel consumption per year and vehicle lifespan of various road vehicles. Source: Ministerio de Fomento, 2017

Type of vehicle	Yearly km considered	Vehicle lifespan (total km)	Average vehicle fuel consumption (litres/100 km)	Annual fuel consumption (litres)	Vehicle lifespan fuel consumption (litres)
Lorry. Articulated lorry	120,000	1,200,000	38.5	46,200	462,000
Lorry. 3 axle truck	95,000	950,000	30	28,500	285,000
Lorry. 3 axle truck	90,000	900,000	26	23,400	234,000
Average lorry	**101,667**	**1,016,667**	**31.5**	**32,025**	**320,250**
Van	50,000	400,000	12	6,000	48,000
Car	-	240,000	7	-	16,800

The related environmental impacts of current average fuel consumption per vehicle are presented below.

Table 3 Environmental impacts of fuel consumption (fuel production and combustion) during each vehicle lifespan.

Environmental impact category	Units	One vehicle lifespan		
		Average lorry	Van	Car
Climate change	kg CO_2 eq	982,882	145,467	49,874
Stratospheric ozone depletion	Kg CFC11 eq	0.53	0.09	0.02
Ionizing radiation	kBq Co-60 eq	7,279	1,062	366
Ozone formation, human health	kg NOx eq	4,665	683	91
Fine particulate matter formation	kg $PM_{2.5}$ eq	914	183	33
Ozone formation, terrestrial ecosystems	kg NOx eq	4,709	701	94
Terrestrial acidification	kg SO_2 eq	2,698	405	89
Freshwater eutrophication	kg P eq	1.05	0.17	0.07
Terrestrial ecotoxicity	kg 1.4-DBC e	228,091	512,409	38,666
Freshwater ecotoxicity	kg 1.4-DBC e	292	73	15
Marine ecotoxicity	kg 1.4-DBC e	579	330	41
Human carcinogenic toxicity	kg 1.4-DBC e	740	919	36
Human non-carcinogenic toxicity	kg 1.4-DBC e	39,415	4,979	1,977
Land use	m^2a crop eq	499	58	33
Mineral resources scarcity	kg Cu eq	7.0	2.6	1.9
Fossil resource scarcity	kg oil eq	327,199	48,507	16,485
Water consumption	m^3	1,438	211	75
Cumulative energy demand	MJ	14,195,199	2,100,882	716,678

For the worldwide vehicle fleet, 947 million cars, 279 million vans and 56 million lorries, the results for the significant carbon footprint and energy demand is shown.

Table 4 Carbon footprint and energy demand during worldwide vehicle's lifespan.

Impact category	Units per type of vehicle worldwide	Lorries	Vans	Cars
Climate change	tons CO_2eq	54,632,799,006	40,673,327,063	47,234,240,002
Cumulative energy demand	MWh	219,174,945,635	163,171,808,963	188,542,095,383

With the data above in mind and the severe impact it is causing to the environment and human health, there is a pressing argument to seek out a solution to reduce excessive power consumption across the transport sector.

In addition to the data highlighted in this section, we have also carried out further studies into the rail industry, found in section 4. This also provides significant data concerning the damaging impact excessive fuel consumption has on our planet.

4. Environmental Impacts of Fuel Consumption in Trains

In the UK during the 2018-19 financial year, passenger rail services consumed 3,976 million kWh of electricity and 469 million litres of diesel. Of the total 15,847 km of routes open for trains (31,091 km of tracks) 38% is electrified (ORR, 2019a). Consequently, Diesel Multiple Units (DMUs), trains powered with diesel, are used because sections of the lines are not electrified.

The Class 220 Voyager is a diesel-electric multiple-unit manufactured by Bombardier Transportation that operates in Cross Country network. All Cross Country trains are powered with diesel, and 34 trains of the total 92 train sets are Class 220 Voyager.

The main characteristics of this train related to fuel consumption are:

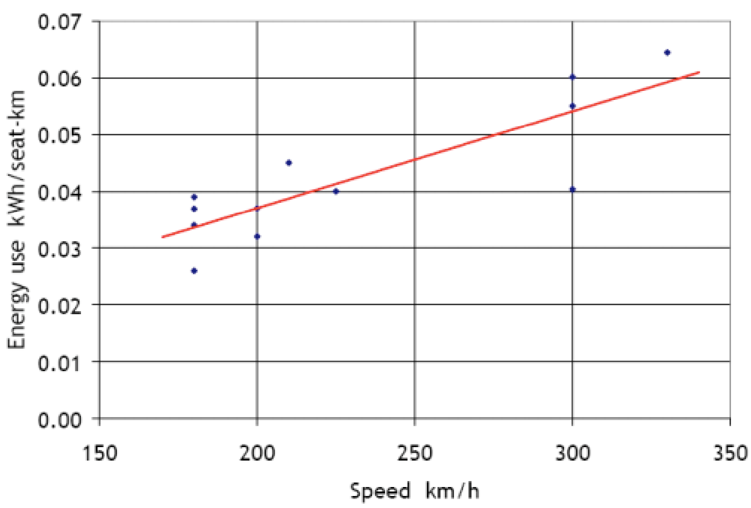
- Four cars per trainset
- Each car is equipped with a Cummins QSK19 diesel engine of 750 hp (560 kW) at 1800rpm
- Each car is equipped with a fuel tank of 1,300 litres of diesel
- The maximum range of approximately 1,350 miles (2,170 km) between each refuelling
- Class 220 operates at a top speed of 125 mph (200 km/h)
- It contains 200 seats.

In order to calculate fuel consumption of the Class 220, we used the amount of fuel that a train carries in the four cars and the maximum distance between each refuelling.

With this calculation, a Class 220 Voyager, consumes, on average, **3.85 litres of diesel per mile.**

It has to be considered that the consumption is directly dependent on the speed. Figure 2 presents the linear relationship between speed and energy used by trains, so at greater speed, more energy used. However, other factors will also determine the fuel consumption. This includes train weight, seat capacity and the number of stops during the route.

Figure 2 Relationship between energy usage and speed. Source: RSSB, 2007



In this section, the fuel consumption and its impact are analysed. The assumptions made, based on data from RSSB, are:

- A passenger train in the UK runs 330 days a year
- A Class 220/2201/222 runs an average 640 miles per day and power car
- A Class 220/2201/222 runs each day 15.1 hours.

In table 5, the assumed fuel consumption is presented.

Table 5 Fuel consumption per mile, 1 month, 1 year and 5 years.

	Diesel consumed per trainset (litres)
1 mile	3.85
1 month	67,793
1 year	813,511
5 years	4,067,556

The related environmental impacts of current average fuel consumption are presented below.

Table 6 Environmental impacts of fuel consumption (fuel production and combustion) per 1 mile, for 1 month, 1 year and 5 years.

Environmental impact category	Units	One Class 220 Voyager trainset			
		1 mile	1 month	1 year	5 years
Climate change	kg CO_2 eq	11.3	198,040	2,376,481	11,882,407
Stratospheric ozone depletion	kg CFC11 eq	5.97E-06	0.11	1.26	6.31
Ionising radiation	kBq Co-60 eq	0.077	1,364	16,368	81,840
Ozone formation, human health	kg NOx eq	0.18	3,239	38,864	194,319
Fine particulate matter formation	kg $PM_{2.5}$ eq	0.024	416	4,996	24,982
Ozone formation, terrestrial ecosystems	kg NOx eq	0.19	3,276	39,316	196,579
Terrestrial acidification	kg SO_2 eq	0.074	1,307	15,688	78,440
Freshwater eutrophication	kg P eq	4.28E-06	0.08	0.90	4.52
Terrestrial ecotoxicity	kg 1.4-DBC e	7.90	138,979	1,667,746	8,338,731
Freshwater ecotoxicity	kg 1.4-DBC e	3.14E-03	55	663	3,314
Marine ecotoxicity	kg 1.4-DBC e	8.06E-03	142	1,702	8,508
Human carcinogenic toxicity	kg 1.4-DBC e	1.20E-03	21	253	1,265
Human non-carcinogenic toxicity	kg 1.4-DBC e	0.17	2,929	35,146	175,732
Land use	m^2a crop eq	2.21E-03	39	468	2,339
Mineral resources scarcity	kg Cu eq	4.31E-05	0.76	9.11	46
Fossil resource scarcity	kg oil eq	3.5	60,868	730,418	3,652,089
Water consumption	m^3	0.015	258	3,097	15,486
Cumulative energy demand	MJ	153	2,691,906	32,302,868	161,514,339

According to the UK Department for Transport, the carbon dioxide emissions per type of routes in the UK are:

- Intercity: 14.48 kg CO_2eq/mile
- LSE (London and South East): 10.62 kg CO_2eq/mile
- Regional: 8.05 kg CO_2eq/mile.

The Class 220 Voyager is a Cross Country train and therefore has a consumption inside the average type of trains, this is due to it being classed as a regional model. The evidence shows that urban area trains not only have a more damaging impact, but they also operate in more densely populated areas where they also can have more of a direct impact on health. We discuss the health implications of fuel consumption for both road vehicles and trains in the next section.

5. Health Impacts of Fuel Consumption and Particulate Matter

Now that this report has discussed and analysed the environmental impact of fuel consumption and particulate matter. It now becomes possible to examine the impacts that this has on health.

It has been made clear through our study that fuel consumption has a significant impact on the release of particulate matter into the atmosphere. Various studies have discussed the impacts of this particulate matter on the respiratory tract, which, in turn, causes health problems.

It is also important to note that particle size affects particle deposition. Therefore, these different particulate matter sizes have wide-ranging impacts on health when they target different areas of the body. For example, coarse particles are mainly deposited in the upper respiratory tract (nose and throat). In contrast, ultrafine particles penetrate deep into the lungs, thus posing hazards related to oxidative stress and inflammation.

PM2.5 are emitted directly from processes such as fuel combustion and are also formed as a secondary pollutant. PM2.5 is one of the three major air pollutants that form part of the EC Ambient Air Quality Directive (2008/50/EC) and, as such, it is an important measure when reporting on health impacts, particularly Coronavirus.

Conticini et al. (2020) used ambient ground-level air pollution data from air quality monitoring sites in Italy to provide *"evidence that people living in an area with high levels of pollutant are more prone to develop chronic respiratory conditions and suitable to any infective agent."* This includes infective agents such as COVID-19.

PM2.5 has long been associated with adverse effects on respiratory and cardiovascular health. They are also linked to adverse outcomes in neurodevelopment, cognitive function and other chronic diseases such as diabetes.

"Air pollution kills 7 million people a year"

World Health Organisation 2020

This was further examined by the WHO and the World Economic Forum (2020). They report that an estimated 7 million premature deaths globally are linked to ambient air pollution (AAP), mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children.

More specifically, AAP contributed to 29% of all deaths and disease from lung cancer, 17% from acute lower respiratory infection, 24% of all deaths from stroke, 25% of all deaths and disease from ischaemic heart disease and 43% of all deaths and disease from chronic obstructive pulmonary disease (COPD).

Hospital visit rates for known comorbidities were calculated from NHS data from 2017 to 2018. These were split into cardiovascular and "other" comorbidities to also examine known relationships of air pollutants on cardiovascular diseases. The conditions included were:

Alzheimer's disease

Alzheimer's disease is an irreversible, progressive brain disorder that slowly destroys memory and thinking skills and, eventually, the ability to carry out the simplest tasks. In most people with the disease - those with the late-onset type, symptoms first appear in their mid-60s.

Asthma

Asthma is a condition in which your airways narrow and swell and may produce extra mucus. This can make breathing difficult and trigger coughing, a whistling sound (wheezing) when you breathe out and shortness of breath.

Influenza and pneumonia

Influenza (flu) is a highly contagious viral infection that is one of the most severe illnesses of the winter season. Influenza is spread easily from person to person, usually when an infected person coughs or sneezes. Pneumonia is a serious infection or inflammation of the lungs.

Other acute respiratory infections

Acute respiratory infection is an infection that may interfere with normal breathing. It can affect just your upper respiratory system, which starts at your sinuses and ends at your vocal cords, or just your lower respiratory system, which starts at your vocal cords and ends at your lungs.

Bronchiectasis

Bronchiectasis is a disease in which there is a permanent enlargement of parts of the airways of the lung. Symptoms typically include a chronic cough with mucus production. Other symptoms include shortness of breath, coughing up blood, and chest pain.

Cancer

Cancer is a condition where cells in a specific part of the body grow and reproduce uncontrollably. The cancerous cells can invade and destroy surrounding healthy tissue, including organs. Cancer sometimes begins in one part of the body before spreading to other areas. This process is known as metastasis. Cancer is the second leading cause of death globally, accounting for an estimated 9.6 million deaths, or one in six deaths, in 2018.

Cardiovascular conditions (all: current or recent) -- ischaemic heart disease, angina, myocardial infarction; heart failure; stroke; and atrial fibrillation

Cardiovascular disease (CVD) is a general term for conditions affecting the heart or blood vessels. It's usually associated with a build-up of fatty deposits inside the arteries (atherosclerosis) and an increased risk of blood clots.

Chronic kidney disease including renal failure

The term "chronic kidney disease" means lasting damage to the kidneys that can get worse over time. If the damage is very bad, your kidneys may stop working. This is called kidney failure or end-stage renal disease (ESRD). If your kidneys fail, you will need dialysis or a kidney transplant.

Chronic liver disease including liver failure

When you have cirrhosis, scar tissue slows the flow of blood through the liver. Over time, the liver can't work the way it should. In severe cases, the liver gets so badly damaged that it stops working. This is called liver failure.

Chronic obstructive pulmonary disease including respiratory failure

Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory lung disease that causes obstructed airflow from the lungs. Symptoms include breathing difficulty, cough, mucus (sputum) production and wheezing.

Dementia

Dementia is a syndrome in which there is deterioration in memory, thinking, behaviour and the ability to perform everyday activities. While dementia mainly affects older people, it is not a normal part of ageing. Worldwide, around 50 million people have dementia, and there are nearly 10 million new cases every year.

Diabetes

Diabetes is a disease that occurs when your blood glucose, also called blood sugar, is too high. Blood glucose is your primary source of energy and comes from the food you eat. Insulin, a hormone made by the pancreas, helps glucose from food get into your cells to be used for energy. Sometimes your body doesn't make enough - or any insulin or doesn't use insulin well.

Epilepsy

Epilepsy is a central nervous system (neurological) disorder in which brain activity becomes abnormal, causing seizures or periods of unusual behaviour, sensations, and sometimes loss of awareness. Anyone can develop epilepsy. Epilepsy affects both males and females of all races, ethnic backgrounds and ages.

Hypertension

Hypertension - or elevated blood pressure - is a serious medical condition that significantly increases the risks of heart, brain, kidney and other diseases.

HDP

Hypertensive disorders of pregnancy (HDP, including gestational hypertension, preeclampsia, and eclampsia) have a substantial public health impact. Maternal exposure to high levels of air pollution may trigger HDP.

Inflammatory bowel disease

Irritable bowel syndrome (IBS) is a common disorder that affects the large intestine. Signs and symptoms include cramping, abdominal pain, bloating, gas, and diarrhoea or constipation, or both.

Neurological conditions - motor neurone disease, Parkinson's disease and multiple sclerosis

Neurological conditions are disorders of the brain, spinal cord or nerves. They can have a range of causes including genetic factors, traumatic injury and infection. The causes of some of these conditions are still not well understood.

Osteoarthritis

Osteoarthritis is the most common form of arthritis, affecting millions of people worldwide. It occurs when the protective cartilage that cushions the ends of your bones wears down over time. Although osteoarthritis can damage any joint, the disorder most commonly affects joints in your hands, knees, hips and spine.

Osteoporosis

Osteoporosis is a health condition that weakens bones, making them fragile and more likely to break. It develops slowly over several years and is often only diagnosed when a fall or sudden impact causes a bone to break (fracture).

Rheumatoid arthritis

Rheumatoid arthritis is a long-term condition that causes pain, swelling and stiffness in the joints. The condition usually affects the hands, feet and wrists. There may be periods where symptoms become worse, known as flare-ups or flares.

Serious mental illness

Serious mental illness (SMI) is defined as a mental, behavioural, or emotional disorder resulting in serious functional impairment, which substantially interferes with or limits one or more major life activities.

Understanding the Health Conditions Associated with Air Pollution

The health conditions listed above come to affect the population's susceptibility to new threats such as COVID but also SARS. For example, the Office for National Statistics found that (without controlling for ethnicity), long-term exposure to fine particulate matter could increase the risk of contracting and dying from COVID-19 by up to 7%. (United Kingdom's Office for National Statistics, 2020).

Similarly, Wu et al. (2020) reported that *"long-term exposure to PM is positively associated with increased COVID-19 mortality".* Wu et al. specifically reported that a 1 µg m increase in average PM exposure would lead to an 8% increase in the -3 2.5 baseline death rate.

Particulate matter not only affects the health of the population, putting them at risk of contracting Coronavirus. Worryingly, particulate matter has also been seen to assist the spread of the virus itself.

For example, Setti et al. detected Coronavirus on particles of air pollution (University of Bologna, PREPRINT posted April 24, 2020). Setti et al. also found that higher levels of particle pollution could explain higher rates of infection in parts of northern Italy before a lockdown was imposed (University of Bologna, PREPRINT posted April 17, 2020).

Thus, it can be seen that particulate matter affects the environment not only through its air pollution. Research shows it also has a wide-ranging impact on various health conditions, including heart disease and respiratory illness. These health impacts, in particular, affect the risks presented by Coronavirus, as these conditions not only increase the risks of contracting the virus but also the mortality rate.

Moreover, while the research is new, it is increasingly suggestive that particulate matter has other impacts on the virus, such as affecting the way that it can be transported by air particles.

6. Solution

Ogab® Advanced TRS® (Turbulence Reduction System) for Road and Rail

At Ogab®, our goal is to innovate for a brighter future for all. This is by reducing air pollution and, therefore, the adverse impacts on the environment and human health. Our innovative patented Advanced Turbulence Reduction Systems (Advanced TRS®) demonstrates how we can achieve this goal. The Advanced TRS® shows benefits such as:

- Significantly reduced drag reduction
- Considerable reduction in fuel consumption
- Large reductions in CO_2 emissions
- Simple and cost-effective
- Easy to install and maintain
- No external design changes to the vehicle.

Most importantly of all, this is achieved whilst being powered by energy that would otherwise be lost.

6.1 Advanced TRS® for Commercial Vehicles

Test Case 1 – Mercedes-Benz Sprinter Van

The Advanced TRS® test results gave an impressive 41% reduction in drag coefficient, which would yield a massive 20% saving in fuel consumption.

The result of this reduction in drag coefficient offers a considerable fuel cost saving as well as increased performance and a significant reduction in CO_2 emissions.

The considerable reduction in drag also means that in a like-for-like journey scenario, a vehicle fitted with Advanced TRS would put less demand on the engine and therefore increase the vehicle's lifespan and reduce maintenance costs.

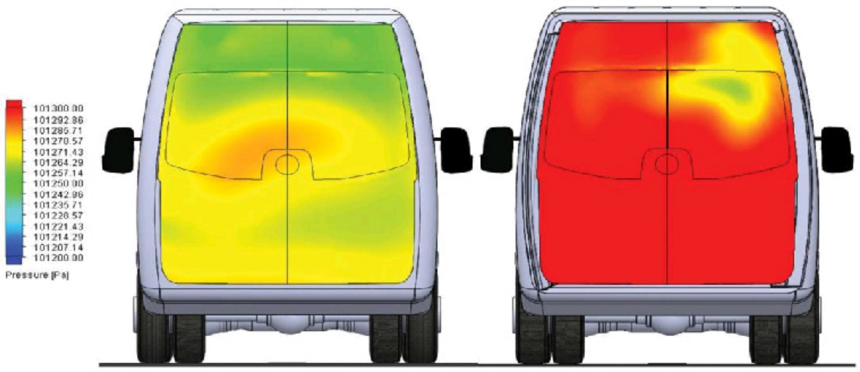
Commercial vehicle fleets can often be made up of hundreds of vehicles that cover many thousands of miles each year. The fuel consumption costs to run these commercial fleets is often the largest regular company expense for the fleet owner.

In addition to this, the environmental impact due to CO_2 emissions is also a significant concern in commercial vehicles due to the heavy fuel usage levels that take place.

Maintenance costs and the reliability of vehicles are equally a key issue for any fleet owner, with each individual vehicle having a significant cost attached to it in the case that it needs to be repaired or replaced.

Vehicle design teams and aerodynamics experts constantly look for innovative ways to reduce the effects of drag on commercial vehicles. These developments are carried out with the view to reducing the vehicle's level of fuel consumption and alleviate the issues caused by aerodynamic losses such as loss of performance.

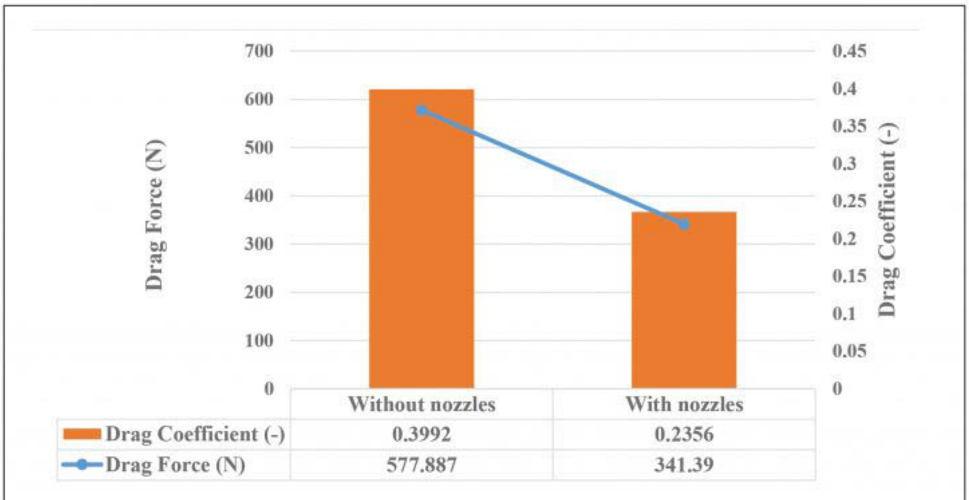
Ogab's Advanced TRS® has utilised patented Active Flow Control Technology which is powered only by the energy that would otherwise be lost. Through our research program, we have achieved unparalleled results in drag reduction, which combat these issues with ground-breaking results.Figure 3 Comparison of commercial vehicles with and without Advanced TRS



Comparison of static pressure on the key base surfaces of van without Advanced TRS® (left) and with Advanced TRS® (right).

The Advanced TRS research project gave results that achieved an unprecedented reduction in the drag coefficient of a Mercedes Sprinter Van from 0.4 to 0.24. This reduction means the vehicles drag coefficient value is altered from its original state to a value that is equal to a highly aerodynamic Tesla S without modifying the shape of the vehicle.

Figure 4 Graph to show the comparison of drag forces, with or without nozzles



Comparison for the key cases with and without nozzles on test vehicle - Mercedes-Benz Sprinter Van.

The 40.98% reduction in drag coefficient results in the considerable fuel consumption saving of 20.49%.

This gives every Sprinter Van an additional 214 miles for every tank of fuel at highway/motorway speeds.

Across a fleet of 100 commercial vehicles that travel 50,000 miles a year, this equates to 197,933 litres of fuel saved annually for the fleet.

The reduction in emissions with the above fuel saving in mind would prevent 600,000 kg of C02 being released into the atmosphere every year for each fleet of 100 vehicles.

Test Case 2 – Mercedes-Benz Tractor Trailer Lorry

DRAG COEFFICIENT = ~~0.612~~
WITH AdvancedTRS = 0.366
Turbulence Reduction System

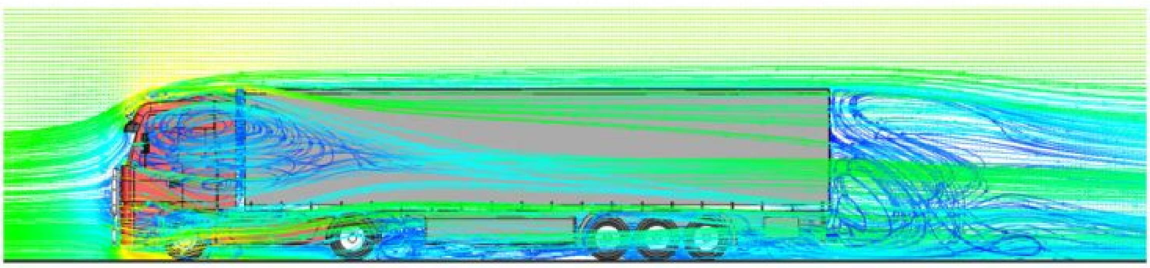
Our breakthrough Advanced TRS® technology was implemented on the test case vehicle –

a Mercedes-Benz Tractor Trailer Lorry.

The test results gave a 40% reduction in drag coefficient, which would yield a huge 20% saving in fuel consumption.

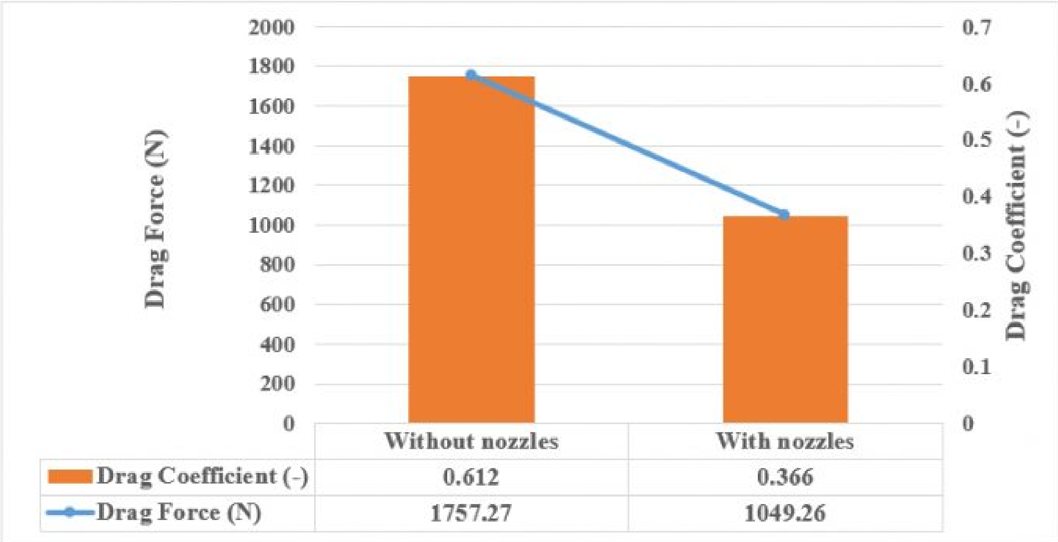
Commercial vehicle fleets of HGVs cover many thousands of miles each year at a huge cost to the fleet company in fuel consumption and the environmental impact due to the fleets considerable carbon footprint via C02 emissions.

Vehicle design teams and other research groups are continually looking for innovative ways to reduce these negative impacts, mainly through the reduction in drag on the vehicle.



Ogab's Advanced TRS® technology has achieved an unprecedented 40.19% reduction in drag coefficient by only using energy that would otherwise be lost.

Figure 5 Graph to show the comparison of drag forces, with or without nozzles



Comparison for the key cases with and without nozzles on test vehicle - Mercedes-Benz Tractor-Trailer Lorry.

For the current tractor-trailer style lorry, the average fuel consumption is about 6 miles per gallon. This value is equal to 39.22 litres per 100 kilometres.

Deploying the proposed active flow control strategy results in an additional 5.9 miles per gallon at highway/motorway speeds. This means that approximately 7.88 litres of fuel are saved per every 100 kilometres that is driven by the Mercedes tractor-trailer lorry.

6.2 Advanced TRS® for Rail

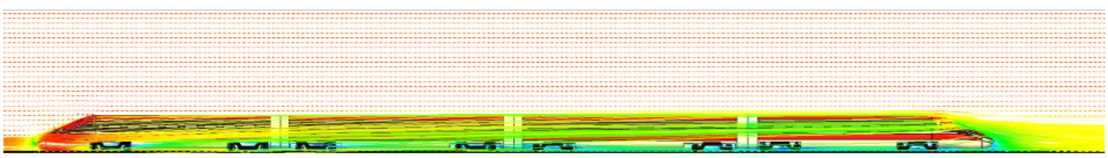
Ogab® has achieved a 22.34% reduction in drag force whilst making our trains kinder to the environment.

Powered by the energy that would otherwise be lost, our Advanced TRS® technology yields an 11% reduction in fuel consumption to cut C02 emissions and reduce running costs.

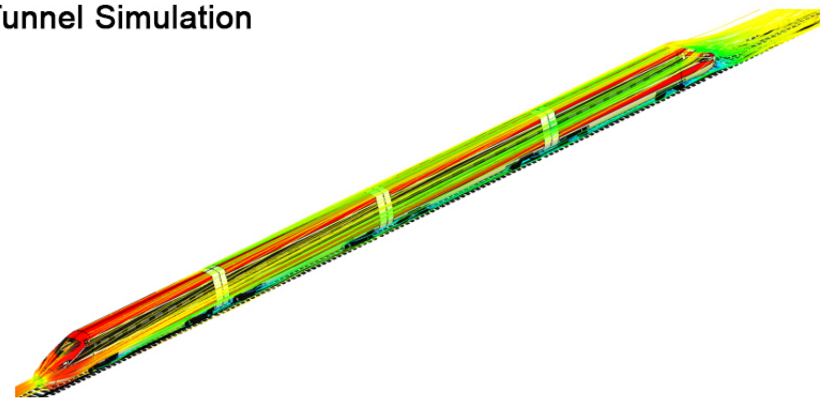
The majority of inter-city transportation of passengers are carried via train and are responsible for a significant portion of both fuel and electricity consumption as well as CO_2 emissions.

Class 220 Voyager trains which are used in large volumes across Britain's railways achieve speeds of 130 miles per hour as a result of their streamlined body.

The trains need to be as aerodynamic (minimal wind resistance) as possible. A 20% reduction in drag forces can see these trains achieve faster speeds, further reducing travel time of this transport.

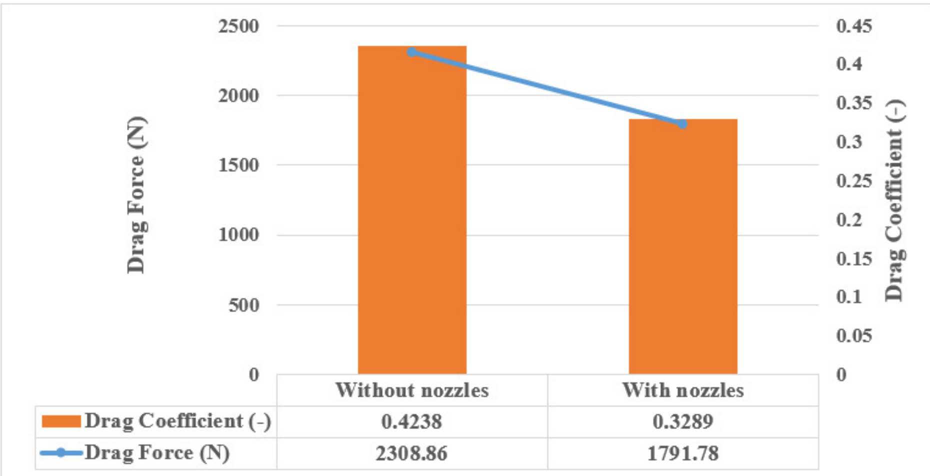


Wind Tunnel Simulation



This significant reduction in drag coefficient not only increases the speed of the train; it also achieves a fuel saving of over 10%. This results in a huge saving in cost as well as less fuel-related CO_2 emissions, heavily reducing the environmental impact of our rail networks.

Figure 6 Graph to show the comparison of drag forces, with or without nozzles



Comparison for the key results with and without nozzles.

The implementation of our Advanced TRS® system can make our train services run both more efficiently and at a lower cost.

This cost reduction could mean that Class 220 Voyager travel would be much more affordable for passenger tickets in a market where customers are feeling the financial impact of annual ticket price increases year on year.

Furthermore, the pressure field surrounding the train is significantly improved following the injection of hot and cold air. This improves the overall stability of the train and the comfort of travel.

7. Conclusion

This report has first examined the relationship between particulate matter and air pollution from excessive fuel consumption. It has utilised statistical data to give evidence of the environmental impact of fuel consumption through the three main modes of land transport: Road vehicles, commercial vehicles and trains.

Finally, this report discussed the impacts of particulate matter and ambient air pollution on the health of the population.

Through the information provided, it is clear to see that excessive fuel consumption has a significant impact on the production of particulate matter and other forms of pollution throughout a vehicle's life. This impact is not limited to the road network but rather the whole transport network.

This environmental impact, by extension, comes to affect world health in significant and life-changing ways. It is therefore crucial not just for the sake of the environment but also for the health of the global population that we continue to reduce our carbon footprint and pollution, especially air pollution and particulate matter.

Alternatives, not Solutions

In many cases, governments and businesses prioritise electric vehicles as the way to minimise pollution. In November 2020, the UK's Prime Minister, Boris Johnson, laid out plans to ban the sale of petrol and diesel cars by 2030. With this in mind, the UK government's plan focuses on making electric vehicles the priority.

However, it is essential to realise that electric vehicles are not zero-emissions or carbon neutral, and in the short-term future, this is not a realistic goal.

The mining and manufacturing involved in electric vehicle production generate a high level of emissions. Furthermore, fossil fuels are often in the energy mix when charging EVs. There is also the lifecycle of the vehicle, including new parts, brake wear particulates among others which all add to the emissions of the vehicle.

Consequently, the focus on EVs is side-stepping the issues of emissions, rather than solving some of the emission releasing problems first-hand.

Instead of focusing solely on electric vehicles as a solution, there is a huge value in solving the fundamental problem of aerodynamic drag and the related power consumption which can benefit all vehicles.

Why Aerodynamics Should be the Focus

One way in which this particulate matter and air pollution can be reduced is through investment and research into environmentally friendly technologies to reduce fuel consumption, such as aerodynamic solutions like Ogab's AdvancedTRS®.

Aerodynamic drag will continue to play a part in excessive power consumption, regardless of the energy type. Instead of a naïve assumption that electric vehicles offer zero-emissions, it is imperative to look at the significant problems affecting all road and rail vehicles such as aerodynamics.

With aerodynamic solutions such as AdvancedTRS®, it is possible to reduce the power requirements which can therefore cut fuel consumption. With this, limiting emissions is undoubtedly possible through the reduction of drag force in road vehicles and trains as described in the case studies presented. The developed technology discussed in this report helps meet this essential requirement across the transport sector to offer a cutting-edge solution to this issue.

Ogab's® focus on addressing the fundamental issues around excessive fuel consumption enables them to research and develop the innovative sustainable technology that supports the vital reduction of particulate matter and air pollution for a brighter and better future.

8. Recommendation

In light of the data provided in this report, it is highly recommended that the information relating to the harmful impacts of fuel consumption on human health and the global ecosystem as a whole needs to be recognised with immediate effect.

This recognition includes acknowledgement and action from government bodies, the transport industry and the wider global population. The technology described in the report offers a highly suitable solution to the issues raised and should be implemented as part of the action that needs to take place.

In addition to this, a greater focus on finding solutions to the issues we face with excessive power consumption due to aerodynamic drag needs to be recognised. Without addressing improvements, the problem with excessive power consumption will continue to impact energy usage, regardless of the energy source.

Therefore, it is essential to ensure we reduce emissions and air pollution for the sake of the environment and its inhabitants, which is only achievable by addressing the issues raised and implementing solutions such as those presented in this report.

"Together, we can create a better future; if we make the right decisions at this critical moment, we can safeguard our planets ecosystems, its extraordinary biodiversity and all its inhabitants. What happens next is up to every one of us."

Sir David Attenborough

Extinction: The Facts - BBC 2020

Report presented by Ogab® Limited – 2020

For further information contact info@ogab.co.uk

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