METHODOLOGY TO ESTIMATE THE CARBON MITIGATED BY A TRANSPORTATION POLICY IMPLEMENTED BY CITY COUNCIL

- It was intended to develop a carbon model that would estimate the carbon mitigation due to various interventions proposed by the city council. Model is generic in nature to some extent but it was designed keeping in mind the public policies of Aberdeen city council.
- Carbon Model was based on the emission factor of the vehicle published by Department for environment food and rural affairs (DEFRA). These emission factors were calculated by repetitive experiments on vehicles across different specification. Specification of the vehicle varied based on euro standard, engine size an tonnage.
- Union Street and Market Street were the potential intervention areas for Aberdeen city council. Hence road counters were activated to take the vehicle counts on theses two busy streets. The vehicle counts for April 2009 were provided by Andrew Smith and Nathan of traffic department of Aberdeen city council. This data was extrapolated to a years count.
- Model input requires number of vehicles moving in the street under study, classification of the vehicles, speed at which it is moving in the street. The outcome of the model is quantity of CO_2 emission in tonnes. This is eventually monetised to compare it with the investment cost and to make a cost benefit analysis.
- Carbon emissions were estimated for Union Street and Market Street based on limited data available.
- It was observed that major emitter of carbon in Union Street was cars and in Market Street it was heavy vehicle due to its proximity to harbour.

  Description attached below.

INTRODUCTION:

The following paper describes a generic methodology that can be applied- to estimate the potential of a public policy for carbon mitigation. Such a methodology may be used as one of the decision making factors along with public acceptability and political factor. This methodology uses emission factor as a basis for estimating future carbon emission reduction. The major emissions from vehicles are considered in this report and these greenhouse gases are CO_2, CO, NO_x, and PM.

Air quality of UK is governed by UK National Air Quality Archive which sets the air quality limits for all air quality pollutants. Some of the gases identified as potential threat to air quality are SO_2, NO, NO_2, PM, O_3, C_6H_6, 1,3 Butadiene, CO & lead[1]. But of these not all are derivative of transportation emission. NO by it self do not have any health hazard, but soon it oxidises to NO_2 which is harmful for human lungs. Apart from NO_x PM, Benzene, 1, 3 Butadiene and CO are the major transportation emission which affects the air quality directly. Hence curbing these gases from vehicular emission may compliment the other air quality improvement initiative.

METHODOLOGY

Boulter, P,G, et al identifies three major source of vehicle emissions and those are hot emission, cold emission and evaporation[2]. Haan M and keller M[3] highlights the importance of real time vehicle speed influencing the emission from the vehicle. Ericsson came out with a consolidated model summarising all the drivers influencing the final emission for road transport vehicle.

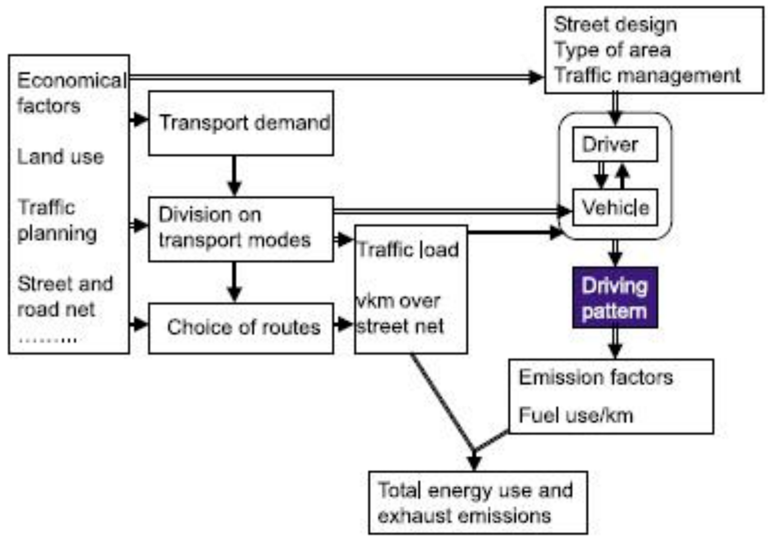
---

[1] http://www.airquality.co.uk/

[2] http://www.dft.gov.uk/pgr/roads/environment/emissions/summaryreport.pdf

[3] http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6VH3-41360PK-7-T&_cdi=6055&_user=138221&_pii=S1352231000002338&_orig=search&_coverDate=12%2F31%2F2000&_sk=999659972&view=c&wchp=dGLzVtb-zSkzV&md5=5a1fa8f20647fafcdf046a670708e395&ie=/sdarticle.pdf

E. Ericsson / Transportation Research Part D 6 (2001) 325–345



Overall emission of a vehicle depends on multiple factors like

1. Engine specification of vehicle (also type of fuel used)
2. Distance travelled.
3. Cold start and hot start.
4. Euro standard
5. Speed variation while driving which in turn is related to drivers behaviour while driving.

There are other macro factors such as economy, future development in infrastructure, policies to influence drivers behaviour which are not considered in this study. Factors those directly affect the emissions are considered. Hence it can be represented as

$E \alpha \; d * s$ ……………………… (1)

Hence

$E = A * d * s$ ……………………… (2)

Where E is the total emission by a vehicle in g (grams)

d is distance travelled by the vehicle in Km

s speed of the vehicle in Km/hr

A is a constant expressed in g Hr / Km

Constant A is derived by series of experiment done on vehicle by department of transport. Based on the experimental results the final emission factor formula equation 2 becomes

E= (a + bx + cx2 + dx3 + ex4 + fx5 + gx6) x * d …………………(3)

Where a, b, c, d, e, f, g are coefficient derived experimentally

These coefficient depends on engine size, fuel and euro standard. Hence experiment was conducted on all possible types and combination of vehicle engine size, fuel and euro standard. Based on the above mentioned classification we have following set of vehicles.

Table: 1

Vehicle type	Fuel	Engine capacity	Euro classification
Car <2.5 t	Petrol	<1400 cc	Pre-Euro 1
Car <2.5 t	Petrol	<1400 cc	Euro 1
Car <2.5 t	Petrol	<1400 cc	Euro 2
Car <2.5 t	Petrol	<1400 cc	Euro 3
Car <2.5 t	Petrol	<1400 cc	Euro 4
Car <2.5 t	Petrol	<1400 cc	Euro 5
Car <2.5 t	Petrol	<1400 cc	Euro 6
Car <2.5 t	Petrol	1400-2000 cc	Pre-Euro 1
Car <2.5 t	Petrol	1400-2000 cc	Euro 1
Car <2.5 t	Petrol	1400-2000 cc	Euro 2
Car <2.5 t	Petrol	1400-2000 cc	Euro 3
Car <2.5 t	Petrol	1400-2000 cc	Euro 4
Car <2.5 t	Petrol	1400-2000 cc	Euro 5
Car <2.5 t	Petrol	1400-2000 cc	Euro 6
Car <2.5 t	Petrol	>2000 cc	Pre-Euro 1
Car <2.5 t	Petrol	>2000 cc	Euro 1
Car <2.5 t	Petrol	>2000 cc	Euro 2
Car <2.5 t	Petrol	>2000 cc	Euro 3
Car <2.5 t	Petrol	>2000 cc	Euro 4
Car <2.5 t	Petrol	>2000 cc	Euro 5
Car <2.5 t	Petrol	>2000 cc	Euro 6
Car <2.5 t	Diesel	<1400 cc	Pre-Euro 1
Car <2.5 t	Diesel	<1400 cc	Euro 1
Car <2.5 t	Diesel	<1400 cc	Euro 2
Car <2.5 t	Diesel	<1400 cc	Euro 3
Car <2.5 t	Diesel	<1400 cc	Euro 4
Car <2.5 t	Diesel	<1400 cc	Euro 5
Car <2.5 t	Diesel	<1400 cc	Euro 6
Car <2.5 t	Diesel	1400-2000 cc	Pre-Euro 1
Car <2.5 t	Diesel	1400-2000 cc	Euro 1
Car <2.5 t	Diesel	1400-2000 cc	Euro 2
Car <2.5 t	Diesel	1400-2000 cc	Euro 3
Car <2.5 t	Diesel	1400-2000 cc	Euro 4

Car <2.5 t	Diesel	1400-2000 cc	Euro 5
Car <2.5 t	Diesel	1400-2000 cc	Euro 6
Car <2.5 t	Diesel	>2000 cc	Pre-Euro 1
Car <2.5 t	Diesel	>2000 cc	Euro 1
Car <2.5 t	Diesel	>2000 cc	Euro 2
Car <2.5 t	Diesel	>2000 cc	Euro 3
Car <2.5 t	Diesel	>2000 cc	Euro 4
Car <2.5 t	Diesel	>2000 cc	Euro 5
Car <2.5 t	Diesel	>2000 cc	Euro 6
Car <2.5 t	LPG	All	Euro 1
Car <2.5 t	LPG	All	Euro 2
Car <2.5 t	LPG	All	Euro 3
Car <2.5 t	LPG	All	Euro 4
Car <2.5 t	LPG	All	Euro 5
Car <2.5 t	LPG	All	Euro 6
Car 2.5-3.5 t	Petrol	All	Pre-Euro 1
Car 2.5-3.5 t	Petrol	All	Euro 1
Car 2.5-3.5 t	Petrol	All	Euro 2
Car 2.5-3.5 t	Petrol	All	Euro 3
Car 2.5-3.5 t	Petrol	All	Euro 4
Car 2.5-3.5 t	Petrol	All	Euro 5
Car 2.5-3.5 t	Petrol	All	Euro 6
Car 2.5-3.5 t	Diesel	All	Pre-Euro 1
Car 2.5-3.5 t	Diesel	All	Euro 1
Car 2.5-3.5 t	Diesel	All	Euro 2
Car 2.5-3.5 t	Diesel	All	Euro 3
Car 2.5-3.5 t	Diesel	All	Euro 4
Car 2.5-3.5 t	Diesel	All	Euro 5
Car 2.5-3.5 t	Diesel	All	Euro 6
Car (taxi)	Diesel	All	Pre-Euro 1
Car (taxi)	Diesel	All	Euro 1
Car (taxi)	Diesel	All	Euro 2
Car (taxi)	Diesel	All	Euro 3
Car (taxi)	Diesel	All	Euro 4
Car (taxi)	Diesel	All	Euro 5
Car (taxi)	Diesel	All	Euro 6
LGV N1(I)	Petrol	All	Pre-Euro 1
LGV N1(I)	Petrol	All	Euro 1
LGV N1(I)	Petrol	All	Euro 2
LGV N1(I)	Petrol	All	Euro 3
LGV N1(I)	Petrol	All	Euro 4
LGV N1(I)	Petrol	All	Euro 5
LGV N1(I)	Petrol	All	Euro 6
LGV N1(I)	Diesel	All	Pre-Euro 1
LGV N1(I)	Diesel	All	Euro 1
LGV N1(I)	Diesel	All	Euro 2
LGV N1(I)	Diesel	All	Euro 3
LGV N1(I)	Diesel	All	Euro 4
LGV N1(I)	Diesel	All	Euro 5
LGV N1(I)	Diesel	All	Euro 6
LGV N1(II)	Petrol	All	Pre-Euro 1
LGV N1(II)	Petrol	All	Euro 1

LGV N1(II)	Petrol	All	Euro 2
LGV N1(II)	Petrol	All	Euro 3
LGV N1(II)	Petrol	All	Euro 4
LGV N1(II)	Petrol	All	Euro 5
LGV N1(II)	Petrol	All	Euro 6
LGV N1(II)	Diesel	All	Pre-Euro 1
LGV N1(II)	Diesel	All	Euro 1
LGV N1(II)	Diesel	All	Euro 2
LGV N1(II)	Diesel	All	Euro 3
LGV N1(II)	Diesel	All	Euro 4
LGV N1(II)	Diesel	All	Euro 5
LGV N1(II)	Diesel	All	Euro 6
LGV N1(III)	Petrol	All	Pre-Euro 1
LGV N1(III)	Petrol	All	Euro 1
LGV N1(III)	Petrol	All	Euro 2
LGV N1(III)	Petrol	All	Euro 3
LGV N1(III)	Petrol	All	Euro 4
LGV N1(III)	Petrol	All	Euro 5
LGV N1(III)	Petrol	All	Euro 6
LGV N1(III)	Diesel	All	Pre-Euro 1
LGV N1(III)	Diesel	All	Euro 1
LGV N1(III)	Diesel	All	Euro 2
LGV N1(III)	Diesel	All	Euro 3
LGV N1(III)	Diesel	All	Euro 4
LGV N1(III)	Diesel	All	Euro 5
LGV N1(III)	Diesel	All	Euro 6
HGV - rigid	Diesel	3.5-7.5 t	Pre-Euro I
HGV - rigid	Diesel	3.5-7.5 t	Euro I
HGV - rigid	Diesel	3.5-7.5 t	Euro II
HGV - rigid	Diesel	3.5-7.5 t	Euro III
HGV - rigid	Diesel	3.5-7.5 t	Euro IV
HGV - rigid	Diesel	3.5-7.5 t	Euro V
HGV - rigid	Diesel	3.5-7.5 t	Euro VI
HGV - rigid	Diesel	7.5-12 t	Pre-Euro I
HGV - rigid	Diesel	7.5-12 t	Euro I
HGV - rigid	Diesel	7.5-12 t	Euro II
HGV - rigid	Diesel	7.5-12 t	Euro III
HGV - rigid	Diesel	7.5-12 t	Euro IV
HGV - rigid	Diesel	7.5-12 t	Euro V
HGV - rigid	Diesel	7.5-12 t	Euro VI
HGV - rigid	Diesel	12-14 t	Pre-Euro I
HGV - rigid	Diesel	12-14 t	Euro I
HGV - rigid	Diesel	12-14 t	Euro II
HGV - rigid	Diesel	12-14 t	Euro III
HGV - rigid	Diesel	12-14 t	Euro IV
HGV - rigid	Diesel	12-14 t	Euro V
HGV - rigid	Diesel	12-14 t	Euro VI
HGV - rigid	Diesel	14-20 t	Pre-Euro I
HGV - rigid	Diesel	14-20 t	Euro I
HGV - rigid	Diesel	14-20 t	Euro II
HGV - rigid	Diesel	14-20 t	Euro III
HGV - rigid	Diesel	14-20 t	Euro IV

HGV - rigid	Diesel	14-20 t	Euro V
HGV - rigid	Diesel	14-20 t	Euro VI
HGV - rigid	Diesel	20-26 t	Pre-Euro I
HGV - rigid	Diesel	20-26 t	Euro I
HGV - rigid	Diesel	20-26 t	Euro II
HGV - rigid	Diesel	20-26 t	Euro III
HGV - rigid	Diesel	20-26 t	Euro IV
HGV - rigid	Diesel	20-26 t	Euro V
HGV - rigid	Diesel	20-26 t	Euro VI
HGV - rigid	Diesel	26-28 t	Pre-Euro I
HGV - rigid	Diesel	26-28 t	Euro I
HGV - rigid	Diesel	26-28 t	Euro II
HGV - rigid	Diesel	26-28 t	Euro III
HGV - rigid	Diesel	26-28 t	Euro IV
HGV - rigid	Diesel	26-28 t	Euro V
HGV - rigid	Diesel	26-28 t	Euro VI
HGV - rigid	Diesel	28-32 t	Pre-Euro I
HGV - rigid	Diesel	28-32 t	Euro I
HGV - rigid	Diesel	28-32 t	Euro II
HGV - rigid	Diesel	28-32 t	Euro III
HGV - rigid	Diesel	28-32 t	Euro IV
HGV - rigid	Diesel	28-32 t	Euro V
HGV - rigid	Diesel	28-32 t	Euro VI
HGV - rigid	Diesel	>32 t	Pre-Euro I
HGV - rigid	Diesel	>32 t	Euro I
HGV - rigid	Diesel	>32 t	Euro II
HGV - rigid	Diesel	>32 t	Euro III
HGV - rigid	Diesel	>32 t	Euro IV
HGV - rigid	Diesel	>32 t	Euro V
HGV - rigid	Diesel	>32 t	Euro VI
HGV - artic	Diesel	14-20 t	Pre-Euro I
HGV - artic	Diesel	14-20 t	Euro I
HGV - artic	Diesel	14-20 t	Euro II
HGV - artic	Diesel	14-20 t	Euro III
HGV - artic	Diesel	14-20 t	Euro IV
HGV - artic	Diesel	14-20 t	Euro V
HGV - artic	Diesel	14-20 t	Euro VI
HGV - artic	Diesel	20-28 t	Pre-Euro I
HGV - artic	Diesel	20-28 t	Euro I
HGV - artic	Diesel	20-28 t	Euro II
HGV - artic	Diesel	20-28 t	Euro III
HGV - artic	Diesel	20-28 t	Euro IV
HGV - artic	Diesel	20-28 t	Euro V
HGV - artic	Diesel	20-28 t	Euro VI
HGV - artic	Diesel	28-34 t	Pre-Euro I
HGV - artic	Diesel	28-34 t	Euro I
HGV - artic	Diesel	28-34 t	Euro II
HGV - artic	Diesel	28-34 t	Euro III
HGV - artic	Diesel	28-34 t	Euro IV
HGV - artic	Diesel	28-34 t	Euro V
HGV - artic	Diesel	28-34 t	Euro VI
HGV - artic	Diesel	34-40 t	Pre-Euro I

HGV - artic	Diesel	34-40 t	Euro I
HGV - artic	Diesel	34-40 t	Euro II
HGV - artic	Diesel	34-40 t	Euro III
HGV - artic	Diesel	34-40 t	Euro IV
HGV - artic	Diesel	34-40 t	Euro V
HGV - artic	Diesel	34-40 t	Euro VI
HGV - artic	Diesel	40-50 t	Pre-Euro I
HGV - artic	Diesel	40-50 t	Euro I
HGV - artic	Diesel	40-50 t	Euro II
HGV - artic	Diesel	40-50 t	Euro III
HGV - artic	Diesel	40-50 t	Euro IV
HGV - artic	Diesel	40-50 t	Euro V
HGV - artic	Diesel	40-50 t	Euro VI
Bus	Diesel	<15 t	Pre-Euro I
Bus	Diesel	<15 t	Euro I
Bus	Diesel	<15 t	Euro II
Bus	Diesel	<15 t	Euro III
Bus	Diesel	<15 t	Euro IV
Bus	Diesel	<15 t	Euro V
Bus	Diesel	<15 t	Euro VI
Bus	Diesel	15-18 t	Pre-Euro I
Bus	Diesel	15-18 t	Euro I
Bus	Diesel	15-18 t	Euro II
Bus	Diesel	15-18 t	Euro III
Bus	Diesel	15-18 t	Euro IV
Bus	Diesel	15-18 t	Euro V
Bus	Diesel	15-18 t	Euro VI
Bus	Diesel	>18 t	Pre-Euro I
Bus	Diesel	>18 t	Euro I
Bus	Diesel	>18 t	Euro II
Bus	Diesel	>18 t	Euro III
Bus	Diesel	>18 t	Euro IV
Bus	Diesel	>18 t	Euro V
Bus	Diesel	>18 t	Euro VI
Coach	Diesel	15-18 t	Pre-Euro I
Coach	Diesel	15-18 t	Euro I
Coach	Diesel	15-18 t	Euro II
Coach	Diesel	15-18 t	Euro III
Coach	Diesel	15-18 t	Euro IV
Coach	Diesel	15-18 t	Euro V
Coach	Diesel	15-18 t	Euro VI
Coach	Diesel	>18 t	Pre-Euro I
Coach	Diesel	>18 t	Euro I
Coach	Diesel	>18 t	Euro II
Coach	Diesel	>18 t	Euro III
Coach	Diesel	>18 t	Euro IV
Coach	Diesel	>18 t	Euro V
Coach	Diesel	>18 t	Euro VI
Moped	Petrol	< 50 cc	Pre-Euro 1
Moped	Petrol	< 50 cc	Euro 1
Moped	Petrol	< 50 cc	Euro 2
Moped	Petrol	< 50 cc	Euro 3

M/cycle, 2-stroke	Petrol	<=150	Pre-Euro 1
M/cycle, 2-stroke	Petrol	<=150	Euro 1
M/cycle, 2-stroke	Petrol	<=150	Euro 2
M/cycle, 2-stroke	Petrol	<=150	Euro 3
M/cycle, 2-stroke	Petrol	150-250	Pre-Euro 1
M/cycle, 2-stroke	Petrol	150-250	Euro 1
M/cycle, 2-stroke	Petrol	150-250	Euro 2
M/cycle, 2-stroke	Petrol	150-250	Euro 3
M/cycle, 4-stroke	Petrol	<=150	Pre-Euro 1
M/cycle, 4-stroke	Petrol	<=150	Euro 1
M/cycle, 4-stroke	Petrol	<=150	Euro 2
M/cycle, 4-stroke	Petrol	<=150	Euro 3
M/cycle, 4-stroke	Petrol	150-250	Pre-Euro 1
M/cycle, 4-stroke	Petrol	150-250	Euro 1
M/cycle, 4-stroke	Petrol	150-250	Euro 2
M/cycle, 4-stroke	Petrol	150-250	Euro 3
M/cycle, 4-stroke	Petrol	250-750	Pre-Euro 1
M/cycle, 4-stroke	Petrol	250-750	Euro 1
M/cycle, 4-stroke	Petrol	250-750	Euro 2
M/cycle, 4-stroke	Petrol	250-750	Euro 3
M/cycle, 4-stroke	Petrol	>750	Pre-Euro 1
M/cycle, 4-stroke	Petrol	>750	Euro 1
M/cycle, 4-stroke	Petrol	>750	Euro 2
M/cycle, 4-stroke	Petrol	>750	Euro 3

Emission for each of the vehicle category is calculated based on the derived equation 3. Distance travelled by each vehicle is different and emission may vary for every discrete distance travelled. Hence neglecting the distance d from the equation, what obtained is emission factor for a particular speed. Taking this into consideration, emission factor for 4 different speeds, 24 Km/hr, 32Km/hr, 40 Km/Hr and 48 Km/hr, was calculated for all category of vehicle. It was observed that in most cases as the speed increases the emission decreases. Speed limit for Aberdeen is Union Street is 20 miles per hour (32 Km/hr) and emission factor for 24 Km/hr, 32Km/hr, 40 Km/Hr and 48 Km/hr was calculated with highest emission at 24 Km/hr and lowest emission at 48Km/hr with some exceptions.

For example (exception)

Car < 2.5 t, Petrol, >2000 cc Euro 2 has following emission factor for above mentioned 4 different speeds

24 Km/ Hr --------- 0.174833 g/Km

32 Km/ Hr --------- 0.166225 g/Km

40 Km/ Hr --------- 0.16586 g/Km

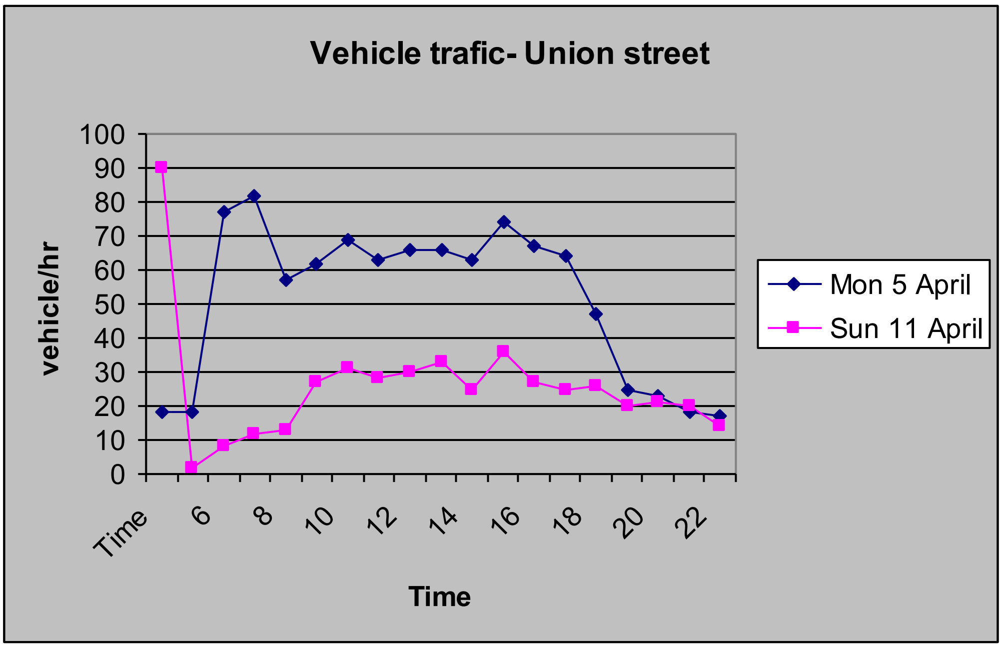
48 Km/ Hr --------- 0.169617 g/Km

Except for few of the above mentioned case most of the emission factors reduces as the speed increases and hence it is advisable for vehicle to move at a greater speed than existing one but at the same time that would increase health and safety hazards due to congestion and vehicle density.

Emission factors are different for different types of vehicle pollutants like CO2, CO, CO2, PM and NOx. Hence based on the different value of coefficient emission factor for each of the vehicle classification is calculated.

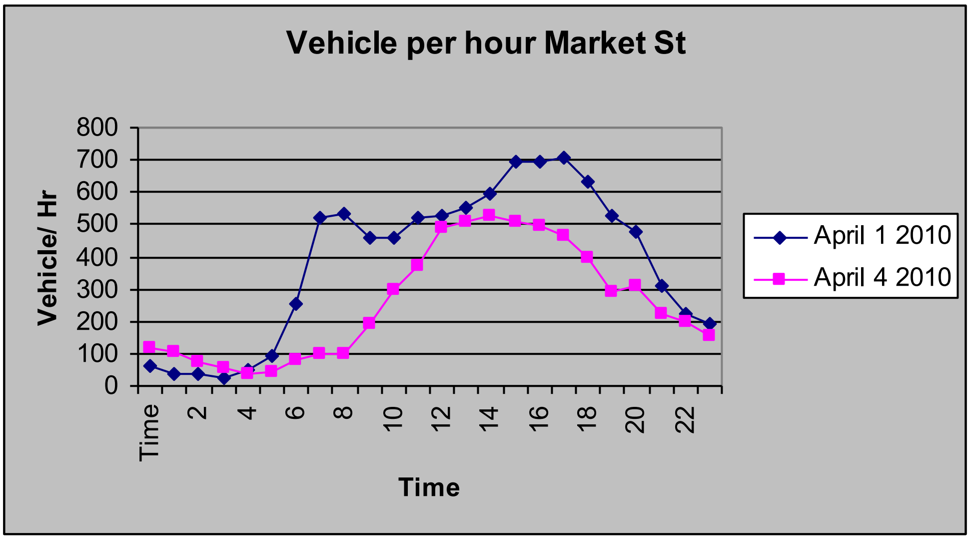
Aberdeen Model for Union Street and Market Street

The following study is conducted on Union Street and Market Street of Aberdeen city. Union Street is the city centre and most travelling across the city is done through Union street. Hence it follows a usual traffic pattern of two peaks in morning rush hour and evening rush hour as shown in the graph.



Where as Sunday traffic is relatively low and follows a different pattern than that on other week days. During week days traffic rate begins to rise just after 6 am in the morning, dips marginally after 9 am and follows a consistent trend till 2 am. After 2 am vehicle traffic rises marginally and finally start dipping from 6 pm. Two major traffic peaks identified are at 8 am and at 4 pm. These peak timing would play a decisive factor in implementing peak hour restriction on high emission vehicle. Nevertheless, while considering peak hour restriction on Sunday, other factors like investment in establishing such a restriction and air quality target needs to be considered.

Week days traffic pattern of Market Street is almost similar to that of Union street with two peaks in a day but Sunday traffic is somewhat a normal curve. And gap between the traffic on Sunday and week day may be considered fairly uniform as shown in the graph. Hence any peak hour restriction may be followed uniformly over the week. Apart from that the proportion of traffic or the classification of the vehicle that comprises the given traffic in the two streets is also fairly different. HGV have relatively higher emission factor as compared to other form of vehicle like LGV's, cars and buses (apart from Motorcycle, which has highest emission factor). HGV moving in Market street is five times more than that moves in Union street and hence inspite of being just 0.8 Km as compared to 1.6 km of Union street, there is more emissions in Market street.



Additional factor that adds to the traffic of Market Street is Aberdeen harbour and its connection supply chain.

Traffic composition of Union Street and Market street

Vehicle classification	Union street	Market Street
Cars	525917	818074
LGV’s	43059	26495
HGV’s	7098	37445
Buses	6711	380
Motorcycles	29267	91884

Based on the vehicle classification, road length and emission factor equation 3, emission factor is calculated for each of the vehicle pollutants, CO, CO2, PM, HC and NOx. The calculated value of the emission for each of pollutant is shown in the excel sheet Aberdeen Model-1. Since the data was available for a month, the obtained value is calculated for a Year. Now we have the total emission of each kind of pollutant for a year.

Each pollutant has a different potential for global warming and harm the environment. Hence it is necessary to benchmark all the emissions in one norm so that it becomes more expressible and convenient in analysis. USA uses carbon equivalent as a benchmark for all the emissions, which means all emission are multiplied by a factors that would make it to carbon equivalent. Whereas IPCC converts all emission into Carbon dioxide equivalent by multiplying a factors which is known as global warming potential. In this study objective is to improve air quality of Aberdeen by reducing vehicle emissions. Hence air quality improvement potential for different gases may be different from global warming potential. Here we are taking global warming potential as a factor to convert all the gas emission into Carbon dioxide and global warming potential factors are taken from the guideline laid down by IPCC. The Global warming potential for major emissions are as follows.

Species	Chemical formula	Life time (yrs)	Global warming Potential (Time Horizon)		
			20 Years	100 years	500 Years
CO_2	CO_2	Variable	1	1	1
Methane	CH_4	12±3	56	21	6.5
Nitrous Oxide	N_2O	120	280	310	170

Even though NOx and HC emissions are less, its impact on environment is quite high and hence when converted to carbon dioxide equivalent, the value becomes significant.

The outcome of the CO_2 equivalent is monetised based on market value of carbon. This gives the basis for comparing the investment and its potential outcomes.

Course material

Course material for two module of Transport management and Transport and environment were prepared and it was funded by CARE North. The carbon model developed for CARE North was given to the students as case study. Each module has 10 topics.

Video Conferencing

Provisional Title: The potential to mitigate carbon from business travel using by setting a videoconferencing target

Authors: David Gray and Amar Nayak

- This paper will reflect on research aimed at mitigating carbon through substituting staff travel with videoconferencing at a UK University.
- In the first part of the paper, results from an analysis of staff travel authorisation forms and a travel diary survey will be used to estimate the benefits of replacing 15% of journeys made by RGU staff by videoconferencing. Benefits are defined as:
  - direct financial savings associated with the cost of travel;
  - tonnes of carbon saved;
  - and the opportunity cost associated with unproductive time spent travelling by car, bus, train or aeroplane.
- The findings will be analysed by staff cost quintile, journey type, and ease of journey substitution
- The paper will highlight the business case for substituting 15% of unnecessary journeys with videoconferencing and teleconferencing; by comparing the annual cost savings (both direct and opportunity) with the cost of buying and running the videoconferencing technology (which the University is committed to purchasing anyway as part its Estates master plan).
- In contrast to the clear business and environmental case for pursuing a video-conferencing strategy, the second part of the paper will explore the practical tensions and 'institutional scepticism' encountered in trying to pursue the research; the difficulties encountered in trying to engage staff and obtain buy-in from senior management (for a project that is externally funded and will save the University money and obtain better productively at a time when it under sever cost pressures and looking to shed jobs); and limitations placed on the methodology in order to address privacy and data protection concerns.
- Such tensions raise some interesting questions about Universities and their constituent academics, their progressive role in promoting the climate change agenda, and whether we are actually very good at practicing what we preach.
- The paper will conclude by

- reflecting on the potential of video conferencing to mitigate carbon emissions from transport across different kind of organisations
- identifying the practical/ institutional/ cultural barriers to doing do
- considering whether Universities should be setting an example; whether our travel and journey making are more vital or deserving than those from other industries or sectors; and if we do not have the institutional will to change administrative and managerial structures in order to mitigate our carbon emissions, whether we have the right to demand that other organisations, institutions or societies do so?