

0 Executive Summary

Aalborg has implemented an environmental zone (low emission zone, LEZ) in the city centre, bounded by the ring road and by the fjord (see the following map on Figure 3). This project developed in the framework of Danish National legislation, wants to reduce emissions and pollution derived from goods distribution and buses within the city centre.

Only HGV and buses (>3.5 tonnes) that comply with the following standards are allowed to drive in the zone:

- Particulate filter or EURO III from February 2009 onwards
- Particulate filter or EURO IV from July 2010 onwards
- Since autumn 2011 also foreign buses and lorries have had to comply with these requirements

Information campaigns for freight companies and citizens have been organized for each of the three stages of introduction.

The pollution level has been evaluated through air quality indicators such as CO levels, NOx levels and particulate levels. The City of Aalborg has used a framework for air quality modelling developed by DMU (National Environmental Research Institute), organisation that also carried out the modelling.

Also vehicle emissions are indicators for knowing the effects of this measure. The emissions from vehicles have been modelled based on a licence plate registration carried out after the implementation of the Environmental Zone and compared with data from before the implementation.

The results from the modelling show a reduction in emissions as an impact from the introduction of the environmental zone.

The share of trucks with Euro IV or better increased from 28% in 2008 to 54% in 2010. The trucks with engine standard Euro II or earlier have been reduced from 26% to 15%. There has been a replacement of both Euro II and Euro III vehicles. Euro II vehicles are having an age where they are normally replaced rather soon. The registered trucks are on average 6 years old. According to Statistics Denmark, the average age for the entire car park in Denmark in 2010, is 8.2 year for trucks.

The overall conclusion from the Cost Benefit analysis is that the value of the capitalised benefits is enough to yield a satisfactory return on this measure's capital costs. The Environmental Zone project has an NPV of approximately €123,000.

Finally, it can be argued that Aalborg's image as an environmental conscious city is improved. And furthermore it might increase, or be a prerequisite for, the migration of people, companies and students to Aalborg. These impacts are not easily quantified, but should, none the less, be taken into account when evaluating the success of the measure. The same goes for the documented decrease in NO₂ reductions.

The overall conclusion from the process evaluation is that LEZs are realistic, when they are introduced according to national policy. If national policy allows a LEZ installation and if the city has the required stakeholder support then a consideration of a LEZ makes sense.

A Introduction

A1.1 Objectives

The measure objectives are:

- (A) High level / longer term:
 - To reduce pollution in the city centre.
- (B) Strategic level:
 - To continue the good cooperation with freight companies and federations
- (C) Measure level:
 - (1) To reduce HGV emissions of CO, HC and NO_x by about 25% by restricting polluting vehicles of more than 3.5 tonnes from the city centre.
 - (2) To reduce HGV Particular Matter emissions by 20% by restricting polluting vehicles of more than 3.5 tonnes from the city centre.

A1.2 Target groups

- People living and staying within the boundaries of the Environmental Zone¹. Improved air quality and lower emissions in the environmental zone should influence people living and staying within the boundaries of the Environmental Zone in a positive way.
- Freight companies and federations are involved in the Environmental zone, since their trucks and buses with a weight of more than 3.5 tonnes have to fulfil the regulations of the Environmental Zone. Every freight company with trucks or buses of more than 3.5 tonnes is therefore in this target group.

A2 Description

In December 2006 the Danish Parliament adopted the law concerning low emission zones (LEZ) in Denmark.

Five municipalities were given the possibility of establishing a LEZ. These five are: Copenhagen, Frederiksberg, Århus, Odense and Aalborg. Copenhagen and Frederiksberg implemented their Environmental Zone in September 2008.

Aalborg was the third city to establish the Environmental Zone by February 2009. Århus and Odense have both implemented these zones afterwards.

The requirements within the Environmental Zone are exactly the same in all environmental zones in Denmark. Issues concerning geography and transit roads are individual.

Aalborg has implemented an environmental zone bounded by the ring road around the centre of Aalborg and north of the centre by the fjord (see Figure 3). Only HGV (>3.5 tonnes) that comply with the following standards are allowed to drive in the zone:

- Particulate filter or EURO III (2000) from February 2009 onwards
- Particulate filter or EURO IV (2005) from July 2010 onwards

¹ In this report, the following terms are used to describe the same concept: Environmental zone, low emission zone, LEZ



Figure 1: Inauguration of the Environmental Zone, February 2009

At each entrance to the Low emission zone, there is a sign informing about the requirements in the zone. The signs are the same in cities with an environmental zone. The signs were changed in July 2010 when the requirements were changed.

The vehicles entering the zone have to have a sticker in the front window that shows that the vehicle is fulfilling the requirements of the zone:

The sticker is put in the front window and vehicles without a sticker are not allowed to drive in the zone even though they fulfil the requirements.

Vehicles not fulfilling the requirements or not equipped with a sticker are subjects for fining. The police is in charge of this process.



Figure 2: Environmental Zone sticker



Figure 3: Map shows the 3.5 km² Environmental Zone. The green area is the Environmental Zone. The red road segments are transit routes made available for crossing the environmental zone without entering it. Large loads such as windmills cannot go through the tunnel and need an alternative, hence the transit routes.

A3 Person in charge for evaluation of this measure

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B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure are:

- **New conceptual approach** – The opportunity of implementing an Environmental Zone as the one implemented in Aalborg, has been given by law on December 15th 2006, being effective since January 2007. The law makes it possible for the bigger cities in Denmark to implement an environmental zone. Copenhagen, capital of Denmark inaugurated the first Environmental Zone in September 2008. Aalborg inaugurated the Environmental Zone in February 2009 as the second in Denmark.
- **New policy instrument** – The City of Aalborg decided to use the opportunity of implementing an environmental zone. The process of the environmental zone was ongoing from 2006 until it was finally decided by the City Council the 26th of November 2007. In 2008 efforts have been made to inform involved people about the regulations.
- **New organisational arrangements or relationships** – Due to previous successful projects on urban HGV traffic Aalborg has a unique cooperation with freight operators that has led to a positive attitude towards environmental zones. ARCHIMEDES has built on this.

B2 Planning of Research and Technology Development Tasks

Not relevant.

B3 Situation before CIVITAS

In December 2006, the Danish Parliament adopted the law concerning environmental zones (also called low emission zones) in Denmark. The legislation for environmental zones in the major cities in Denmark was approved in January 2007. Five municipalities (Copenhagen, Frederiksberg, Aarhus, Odense and Aalborg) were given the possibility of establishing such a zone and they all implemented the low emission zones. The conditions within the environmental zone are the same in all environmental zones in Denmark. However, there are differences concerning geography and transit roads.

In order to implement, a number of practical problems had to be solved before the environmental zones could be in operation and weak relations to freight operators was a real problem in more cities.

B4 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Planning of the environmental zone (*September 2008 – February 2009*): *For the planning of the environmental zone, the relevant actors from the City of Aalborg, the police and the freight operators were involved. This stage also included information to stakeholders and a campaign to inform residents of the environmental zone. Furthermore, an information meeting with freight operators was held on September 16, 2008.*

Stage 2: Baseline evaluation (*December 2008*): *Before the environmental zone was inaugurated, a license plate registration of vehicles beyond 3.5 tonnes was carried out on all access roads to the environmental zone. The objective of the registration was to determine the share of lorries not fulfilling the requirements of the environmental zone. The registration of vehicles will be explained thoroughly later in this report.*

Stage 3: Implementation of the environmental zone (*February 2009*): *Aalborg implemented the environmental zone in the city centre. Only heavy goods vehicles and buses (>3.5 tonnes) that comply with the required Euro 3 standards were from now on allowed to drive in the zone. In January 2009, signs were mounted at the entrances and exits of the zone. Promotion material such as leaflet, posters and the website informed involved target groups. The inauguration with the Alderman for the Technical and Environmental Department took place February 2 at one of the main entrances of the environmental zone.*

Stage 4: New Euro 4 requirements for the environmental zone (*July 2010*): *From July 2010 heavy goods vehicles and buses had to fulfil the Euro 4 standards to drive in the zone. To communicate these changes, an information campaign for the freight operators took place in spring and summer.*

Stage 5: After evaluation (*March – December 2010*): *In March, a learning history workshop was held with participation from various stakeholders of the steering group. In October 2010, a license plate registration took place on all access roads to the environmental zone. From November 2010 until January 2011 the city of Aalborg provided data (traffic counts and traffic data) for air quality modelling for the National Environmental Research Institute.*

Stage 6: New requirements for foreign freight and bus transport (*October 2011*): *Lorries and buses from other countries were not yet required to have an environmental zone sticker. This has been introduced as a new requirement from autumn 2011. A campaign for these new requirements was started in August 2011.*

B5 Inter-relationships with other measures

The measure is related to other measures as follows:

Measure AAL 01– Measure 63, implementing an environmental zone in Aalborg, is closely linked to the bio fuel trials in measure 01.

Across cities, Aalborg's positive experiences in previous work with stakeholders in city distribution traffic have been used in the development of initiatives in this field in other ARCHIMEDES sites in measures BH 64 and UNL-67.

C Planning of Impact evaluation

C1 Measurement methodology

C1.1 Impacts and indicators

C1.1.0 Scope of the impact

The high level / long term objective is to reduce pollution in the city of Aalborg. The pollution level is modelled through air quality indicators such as CO levels, NO_x levels and particulate levels. The City of Aalborg has used a framework for air quality modelling developed by DMU (National Environmental Research Institute) and this organization also carried out the modelling. By using an existing framework, the emission levels can be compared with the situation before the implementation of the Environmental Zone.

Also vehicle emissions are indicators for this measure. The emissions from vehicles have been modelled based on a licence plate registration carried out after the implementation of the Environmental Zone and compared with data from before the implementation. Through the licence plate registration, the share of vehicles fulfilling different EURO-norms has been determined and based on this split the emission from HGVs were modelled. This was then linked to the evaluation of emissions from the HGVs, vans and buses running on bio-diesel within Measure 1.

Measure title:

Measure 63 – Efficient goods distribution in Aalborg

City: Aalborg

Project: ARCHIMEDES

Measure number: 63

C1.1.1 Selection of indicators

NO.	EVALUATION CATEGORY	EVALUATION SUB-CATEGORY	IMPACT	INDICATOR	DESCRIPTION	DATA /UNITS
	ECONOMY					
2b		Costs	Capital Costs	Capital costs	Project costs	Euros, quantitative, derived or measurement
2c			Maintenance costs	Maintenance costs	Costs for maintenance in project period	Euros, quantitative, derived or measurement
	ENERGY					
	ENVIRONMENT					
5		Pollution/Nuisance	Air Quality	CO levels ²	CO concentration	Ppm or g/m3, quantitative, measurement
6				NOx levels	NOx concentration	Ppm or g/m3, quantitative, measurement
7				Particulate levels	Particulate PM ₁₀ and/or PM _{2.5} concentration	Ppm or g/m3, quantitative, measurement
9			Emissions	CO emissions	CO per vkm by type	
10				NOx emissions	NOx per vkm by type	
				HC emissions	HC per vkm by type	Ppm or g/m3, quantitative, measurement
11				Particulate emissions	PM ₁₀ and/or PM _{2.5} per vkm by type	g/vkm, quantitative, derived
	SOCIETY					
14			Acceptance	Acceptance level	Attitude survey of current acceptance of the measure ³	Index (%), qualitative, collected, survey

² The CO level is only modelled for Copenhagen, however the level can be transferred to Aalborg. CO is measured using a regression analysis over a three year period (2008-2010) on H.C. Andersen Boulevard in Copenhagen. The result of the analysis shows a 9% reduction of the street contribution of CO. However, since fuel driven cars are the primary CO source, CO is not expected to be reduced significantly as a result of the low emission zone.

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NO.	EVALUATION CATEGORY	EVALUATION SUB-CATEGORY	IMPACT	INDICATOR	DESCRIPTION	DATA /UNITS
			Compliance	Number of violations	Number of violations recorded in the police statistics	No, quantitative, measured
	TRANSPORT					
25			Freight Movements	Goods vehicles moving in demo areas	Daily number of goods vehicles moving in area	No, Quantitative, derived or measurement

C1.1.2 Methods for evaluation of indicators

No.	INDICATOR	TARGET VALUE	Source of data and methods	Frequency of Data Collection
2b	Capital costs		Investments made to set up the environmental zone, primarily design and procurement.	Annually
2c	Maintenance costs		Maintenance of the signs to the Environmental Zone	Annually
5	CO levels		<p>Measurements of level in the city centre. The City of Aalborg co-operates with the Danish Environmental Protection Agency and National Environmental Research Institute regarding measurements of pollution levels in the city centre.</p> <p>Air quality calculations have been carried out with an inter-linked model system consisting of a regional long-range transport model (DEHM), an urban background model (JBM) and a street air quality model (OSPM) and associated meteorological and emission data. The AirGIS system has been used to automatically generate street geometry and traffic input to the OSPM model based on digital maps for roads and buildings, enabling efficient calculations for many locations.</p> <p>The model is based on traffic level data and measurements of levels at one measurement station in the city. Hence, the model comprises 31 different roads in the zone.</p> <p>CO is measured using a regression analysis over a three year period (2008-2010) on H.C. Andersen Boulevard in Copenhagen. However, since fuel driven cars are the primary source for CO, CO is not expected to be reduced significantly as a</p>	Pollution level measurements in the city

³ No. 14 (Acceptance level) was conducted as a part of the process evaluation, making the survey more qualitative, but including the most significant stakeholders of the measure.

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No.	INDICATOR	TARGET VALUE	Source of data and methods	Frequency of Data Collection
			result of the low emission zone. For a full explanation of this please refer to the annex of this report.	
6	NOx levels		Measurements of level in the city centre. The City of Aalborg co-operates with the Danish Environmental Protection Agency and National Environmental Research Institute regarding measurements of pollution levels in the city centre During the project a model for the levels in the city is made by the National Environmental Research Institute, The model is based on traffic level data and measurements of levels at one measurement station in the city. Hence, the model comprises 31 different roads in the zone. For a full explanation of this please refer to the annex of this report.	Pollution level measurements in the city
7	Particulate levels		Measurements of level in the city centre. The City of Aalborg co-operates with the Danish Environmental Protection Agency and National Environmental Research Institute regarding measurements of pollution levels in the city centre During the project a model for the levels in the city is made by the National Environmental Research Institute, The model is based on traffic level data and measurements of levels at one measurement station in the city. Hence, the model comprises 31 different roads in the zone. For a full explanation of this please refer to the annex of this report.	Pollution level measurements in the city
8	CO emissions	Reduce HGV emissions of CO, HC and NOx by about 25%	Modelling of emissions using the maximum emissions from the different EURO norms and applying them to the licence plate count. The method for the modelling will be explained	One model covering before and after situation
9	NOx emissions	Reduce HGV emissions of CO, HC and NOx by about 25%	Modelling of emissions using the maximum emissions from the different EURO norms and applying them to the licence plate count.	One model covering before and after situation
	HC emissions	Reduce HGV emissions of CO, HC and NOx by about 25%	Modelling of emissions using the maximum emissions from the different EURO norms and applying them to the licence plate count.	One model covering before and after situation
11	Particulate emissions	Reduce PM emissions by 20%.	Modelling of emissions using the maximum emissions from the different EURO norms and applying them to the licence plate count.	One model covering before and after situation
14	Acceptance level		Interviews with freight operators. The interviews included the various freight operators/federations that have been included in the planning process. In total 8 of the largest operators/federations within the area are included. It has been qualitative interviews focussing on acceptance and compliance.	Twice

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No.	INDICATOR	TARGET VALUE	Source of data and methods	Frequency of Data Collection
	Number of violations		Police statistics concerning violations of the regulations of the environmental zone	Continuously
25	Goods vehicles moving in demo areas		Licence plate registration in the city centre (both inside the environmental zone and on main routes outside the zone)	One before and one after the implementation of the environmental zone.

C1.1.3 Planning of before and after data collection

EVALUATION TASK	INDICATORS INVOLVED	COMPLETED BY (DATE)	RESPONSIBLE ORGANISATION AND PERSON
Interviews with a sample of freight operators operating in the Environmental Zone for process evaluation	14	M18 and M30	Aalborg, Gustav Friis
Measurements of level in the city centre. The City of Aalborg will cooperate with the Danish Environmental Protection Agency and National Environmental Research Institute regarding measurements of pollution levels in the city centre During the project a model for the levels in the city is made by the National Environmental Research Institute, The model is based on traffic level data and measurements of pollution levels at one measurement station in the city. Hence the model will comprise 31 different roads in the LEZ in Aalborg. For the results of this analysis please refer to the annex of this MERT.	5, 6, 7	M24	Aalborg, Gustav Friis
Licence plate registration in M3 and M25 will be the basis of modelling emissions.	8, 9, 11, 25	M3 and M25	Aalborg, Gustav Friis
Police statistics concerning violations of the regulations of the environmental zone will be collected in co-operation with the police. There is no before data.		Continuously until M32	Aalborg, Gustav Friis
D12.2 Baseline and first results from data collection	All indicators	Month 34	
D12.3 Draft results template available	All indicators	Month 36	
D12.4 Final version of results template available	All indicators	Month 49	

C1.2 Establishing a baseline

In order to measure and evaluate the effect of environmental zone, emission levels from 2005 and 2008 were established as a baseline. These emission levels from before the LEZ was introduced are then compared to emission levels in 2010, when the LEZ was established.

For the evaluation of changes in emission levels as an effect of the low emission zone, registrations of license plates coupled to the Motor Registry were conducted in 2005 and 2008. These registrations allow the establishment of a baseline, since the environmental zone was implemented in Aalborg in 2009, and the same registrations were conducted in 2010.

Manual recordings of license plates of heavy good vehicles entering and leaving the environmental zone in Aalborg were carried out, and these license plate data was coupled to the Motor Registry. The Motor Registry includes data to determine the emission category (Euro emission standard) of each vehicle.

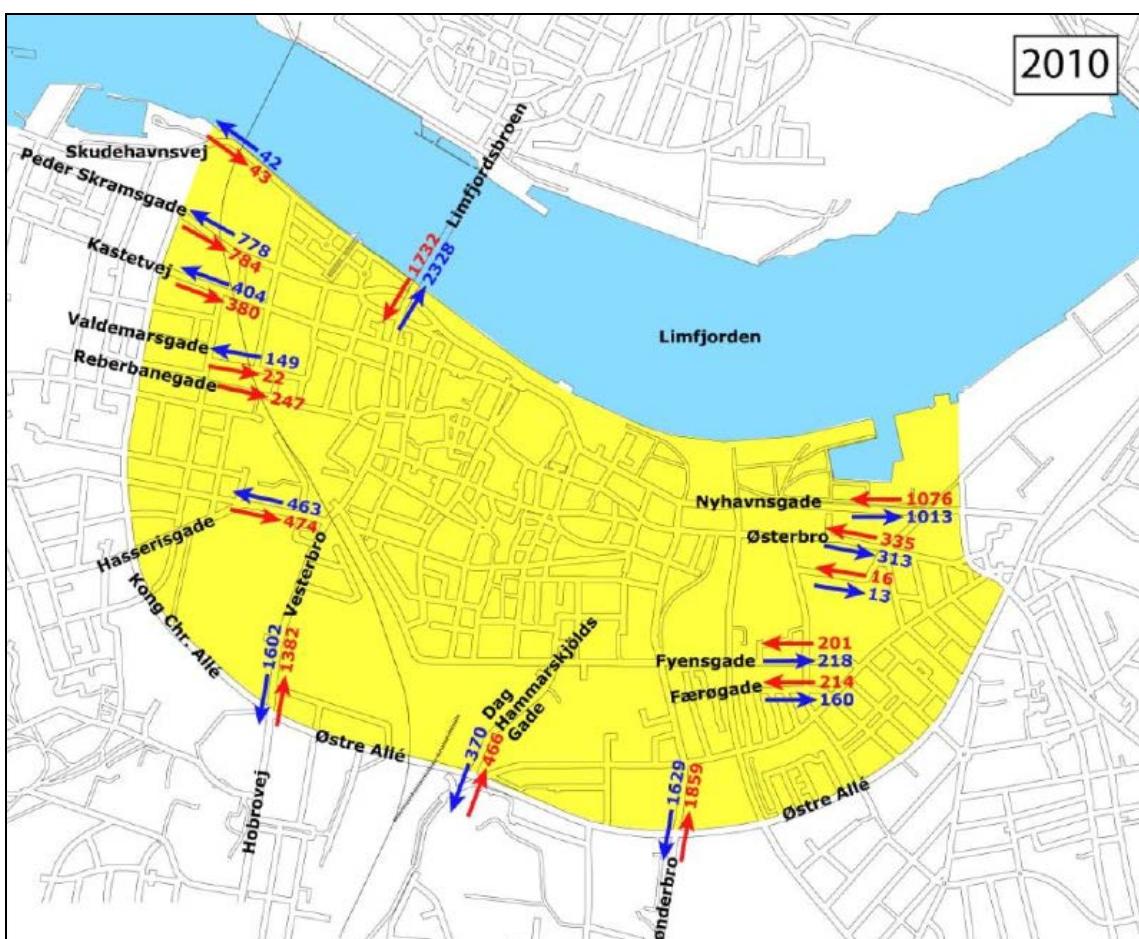


Figure 4: Registration of vehicles entering (red) and leaving (blue) the environmental zone. This figure shows the registration in 2010.

The 2010 manual registration was carried out Wednesday the 6th of October 2010 from 06:00 – 18:00 at the locations shown on the map above. The time period correspond with previous registrations (2005, 2008) which were also carried out on autumn weekdays between 06:00 and 18:00. The hired registrators registered the incoming and outgoing vehicle licence plates. The licence plates were then coupled to the Motor Registry to know the age and EURO Norm of the vehicle. However, it proved difficult to get information about the Euro Norm and the age of the vehicle has formed the main evidence of the Euro Norm then.

For the evaluation of changes in air quality, a baseline is not applicable. Even though the National Environmental Research Institute (NERI) conducted air quality models previous to the introduction of LEZ, the models changed so much in the meantime, that the previous models are not directly comparable to the ones in the last evaluation report by NERI.

C1.3 Method for Business as usual scenario

There are two kinds of business as usual scenarios for this measure – one related to changes in emission levels and one describing changes in air quality.

- The license plate registrations from 2005 and 2008 are used to model the business as usual scenario for the emission levels in Aalborg. Based on the licence plate registration conducted in 2005 and 2008 a linear regression model for the fleet of vehicles in the zone in 2012 is developed and compared to the actual fleet (registration from 2010). The licence plate registration showed a number of vehicles fulfilling different EURO norms. EURO norms for new vehicles continuously change, and in 2012 the fleet operation in the city would look different only because of this. The model therefore gives a picture of the cleaner fleet in 2012 based on the licence plate registration. In this way it is investigated whether the environmental zone has a positive impact on the norms that the fleet is fulfilling. The rate of renewal on the national level has been compared to the actual renewal of trucks and busses in Aalborg in order to evaluate the impacts of the LEZ.
- Air quality changes related to heavy goods transport are difficult to determine in the middle of the city, since air quality is influenced by many factors that are not related to traffic. Therefore, it is difficult to measure air quality changes related to the environmental zone as such. A business as usual was chosen based on air quality modelling conducted by the National Environmental Research Institute (NERI). The data source for these models included traffic sources from the environmental zone in Aalborg and air quality measurements conducted in the environmental zone in Copenhagen. These models show scenarios for the air quality without the LEZ in 2010, 2015 and 2020 – in other words the business as usual scenario. These scenarios can then be compared to the air quality models with the LEZ in the same years.

C1.4 Cost Benefit Analysis

Appraisal case, relevant alternatives and base line case

The project includes as described in B4 a 3.5 square kilometre environmental zone that has been introduced in Aalborg. The zone requires HGVs and busses to fulfil at least EURO 3 or be fitted with a particulate filter until July 2010, when the requirements for the same vehicles were updated to EURO 4 standard or fitted with a particulate filter.

Project life

Project life time will depend on the technology development in terms of vehicle performance and emissions. EURO 6 standard is planned to come in effect from September 2014, which therefore could require replacement of the signs. In this respect project life can be said to be 9 years (until 2020).

However, the replacement of the signs for the newest EURO standard could also be seen as a maintenance cost in the project period, and therefore the project life time can be argued to be as long as the longest time span recommended; 60 years.

Key impacts of the project

The key impacts of the project are:

- Capital costs of the zone

- Maintenance costs of the zone
- Benefits from reduced air pollution

The extra costs for the companies for retrofitting and purchasing of new vehicles are not included in this analysis, since these costs only constitute a redistribution of costs between freight operators and sellers of retrofitting/new vehicles. In the perspective of a cost benefit analysis focusing on the cost of the society, in this case The City of Aalborg, these costs are not part of the analysis.

Main parties affected by the measure

It is expected that the implementation of this measure will affect the following stakeholders:

Table 1.4.1: Agents and implication for them

Agent	Implications
Local Authority	The local authority faces costs in implementing and maintaining the environmental zone (signs, information, web-pages, maintenance of signs, etc.) These costs will be included in the cost benefit analysis.
Society	The citizens of Aalborg, especially those living in the environmental zone, benefit from an improvement on air quality due to the reduced emissions (air pollutants). Also, the overall society benefits from a reduction in green-house gasses emissions (reduced global warming)

Key impacts of the measure

The main impacts of the measure are synthesized in the following table in the form of cost and benefits affecting the above referred parties. No impacts on movements on older trucks outside the environmental zone are foreseen, however, a potential impact will be indicated through a counting of the share of older trucks on the main roads outside the environmental zone. Data from these counts will be supplemented with the qualitative data from the interviews with freight operators/federations on acceptance level.

Quantification and monetization of impacts

Table 1.4.2: Quantification and monetization of impacts

Pollutant	Factor costs in € (2000 prices), Unit: €/t of pollutant								
	NO _x	NM VOC	SO ₂	PM _{2.5} (exhaust)			PM ₁₀ (non-exhaust)		
Local environment				Urban Metropo litan	Urban	Outside built-up areas	Urban metropoli tan	Urban	Urban Outside built-up areas
Denmark	4,400	700	5,200	386,800	124,700	45,400	154,700	49,900	18,200

Source: CBA Recommendations for CIVITAS Evaluation, J. Piao and J. Preston, Transportation Research Group, Southampton University, UK

For the quantification and monetization of impacts, the CBA Recommendations for CIVITAS Evaluation were included. These recommendations allow the accounting of the impact in monetary terms. However, at this point some of the factors are still missing, i.e. to allow the accounting of the volume of the environmental zone.

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Main parties affected by the project

Agents	Costs	Benefits
Society		Better air quality Less carbon emissions Health benefits
Local Authority	Capital Costs Maintenance Costs	

C2 Measure results

C2.1 Economy

For the introduction of the environmental zones, project costs were related to the signs and their construction in the beginning of 2009. Then, in 2010, the requirements changed and thus the stickers on the signs were changed, leading to smaller maintenance cost.



Figure 5: Part of the signs was changed with the new requirements. The white and green sticker that had allowed Euro III vehicles in the zone until July 2010 is not valid anymore.

Table 2.1.1: Economy indicators

2b	Costs	Capital Costs	Project costs	74.100 € (552.300 DKK) in the year 2009/2010
2c		Maintenance costs	Costs for maintenance in project period	7.170 € (53.400 DKK) in the year 2010/2011

C2.2 Environment

C2.2.1 Air Quality

The National Environmental Research Institute (NERI), Aarhus University has been responsible for conduction an evaluation of the effects on air quality of the low emission zones in Denmark financed by the Danish Environmental Protection Agency.

A Mid-term report has been published in 2010 (Jensen et al. 2010), which focused on assessing the effect on air quality of the low emission zones in Copenhagen and Frederiksberg, that were the first municipalities to implement the low emission zone requirements.

In the final report presented in July 2011, the effects on air quality are re-evaluated for Copenhagen in the light of an updated vehicle fleet and traffic information and emission assumptions, and new assessments were carried out for Aarhus, Odense and Aalborg.

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The methodologies, main conclusions and project results are all described in the annex of this report which is the English Summary of the NERI report on the effects of low emission zones in Denmark. Below, the result tables for Aalborg are shown.

Table 2.2.1: Number of exceedances of the limit value of NO₂, and average, maximum and minimum modelled NO₂ concentrations in 2010, 2015 and 2020 in Aalborg without and with the low emission zone (LEZ)

	NO ₂ ave. ($\mu\text{g}/\text{m}^3$)	NO ₂ max. ($\mu\text{g}/\text{m}^3$)	NO ₂ min. ($\mu\text{g}/\text{m}^3$)	Number of exceedances ⁴
Without LEZ 2010	31	39	19	0
With LEZ 2010	30	37	18	0
Without LEZ 2015	24	30	15	0
With LEZ 2015	24	30	15	0
Without LEZ 2020	16	20	11	0
With LEZ 2020	16	20	11	0

There are not calculated any exceedances of the air quality limit values for PM_{2.5} (25 $\mu\text{g}/\text{m}^3$ in 2015) and PM₁₀ (40 $\mu\text{g}/\text{m}^3$ in 2005), see the next table.

Table 2.2.2: Modelled concentrations of PM_{2.5} and PM₁₀ in 2010, 2015, and 2020 without and with low emission zones (LEZ) in Aalborg

	PM _{2.5} ave. ($\mu\text{g}/\text{m}^3$)	PM _{2.5} max. ($\mu\text{g}/\text{m}^3$)	PM ₁₀ ave. ($\mu\text{g}/\text{m}^3$)	PM ₁₀ max. ($\mu\text{g}/\text{m}^3$)
Without LEZ 2010	13.3	14.3	22.4	24.6
With LEZ 2010	13.0	14.0	22.1	24.3
Without LEZ 2015	12.9	13.8	22.1	24.1
With LEZ 2015	12.8	13.7	22.0	24.0
Without LEZ 2020	12.7	13.4	21.8	23.7
With LEZ 2020	12.7	13.4	21.8	23.7

⁴ Number of exceedances of NO₂ limit value of 40 $\mu\text{g}/\text{m}^3$ counted as exceedances of the value 40.5 $\mu\text{g}/\text{m}^3$.

Table 2.2.3: Air quality summary for the LEZ in Aalborg

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After – Before	Difference: After – B-a-U
No.6: Average NO ₂ level (µg/m ³)	n.a.	31 (2010) 24 (2015) 16 (2020)	30 (2010) 24 (2015) 16 (2020)	n.a.	- 1 0 0
No.7: Average PM _{2.5} concentration (µg/m ³)	n.a.	13.3 (2010) 12.9 (2015) 12.7 (2020)	13.0 (2010) 12.8 (2015) 12.7 (2020)	n.a.	- 0.3 - 0.1 0.0
No.7: Average PM ₁₀ concentration (µg/m ³)	n.a.	22.4 (2010) 22.1 (2015) 21.8 (2020)	22.1 (2010) 22.0 (2015) 21.8 (2020)	n.a.	- 0.3 - 0.1 0.0

As described in section C1.3, the business as usual scenario for air quality modelling is the development in air pollution without introduction of the low emission zone. The model show the long term effects of the low emission zone, in 2015 and 2020. As seen above, the effects of the low emission zone in terms of concentrations are eliminated in 2020.

This indicates that the low emission zone has an effect now, because it pushes forward the replacement of old cars or they are retrofitted with particle filters, whereas the effects in 2020 will not be existing because the replacement of the cars will happen no matter what. If the requirements of the zone are not changed over time, it is obvious that it will lose the effect.

C2.2.2 Emissions

License plate registration

The registrations of license plates coupled to the Motor Registry were conducted in 2005, 2008 and 2010, after the introduction of the new requirements. The Motor Registry includes data to determine the emission category (Euro emission standard) of each vehicle.

The purpose of the license plate registration in December 2010 was to investigate and analyze vehicle composition 1.5 years after the environmental zone in Aalborg was introduced and the new requirements in the environmental zone has been a reality for 4 months.

The analysis is then compared with a similar analysis conducted in autumn 2008, shortly before the introduction of the LEZ as well a feasibility study from 2005.

The next step was to link the license plate data to the Central Motor Registry (CMR). This showed that between 82% and 93% of the entering vehicles are diesel driven and thus subject for the LEZ. The share of diesel vehicles is very similar to the share in 2008.

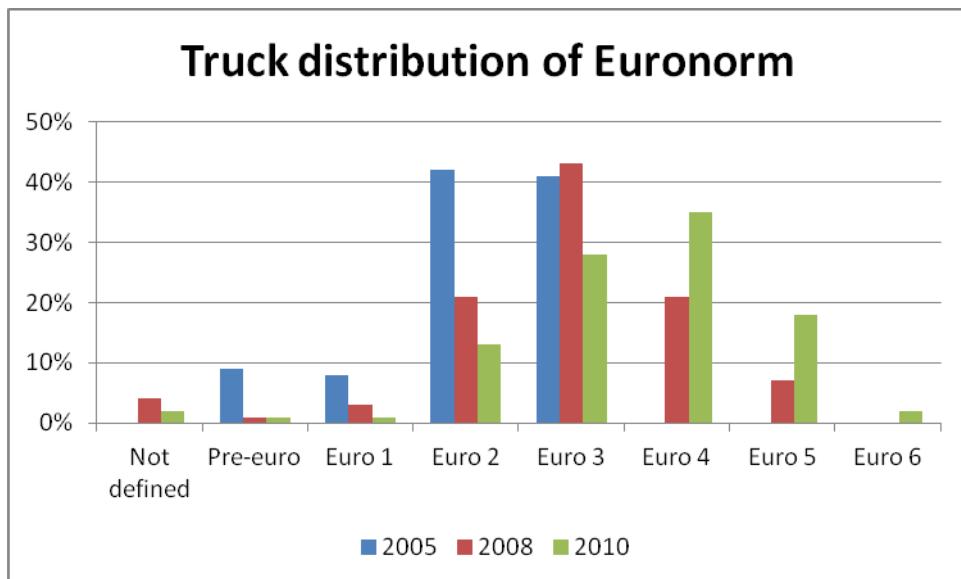


Figure 6: Truck distribution of EURO Norms for Aalborg

Figure 6 above shows the percentage distribution of the Euro-norm, and thus reflects trends in vehicle age from 2005, 2008 and 2010.

A total of 215 trucks representing 45% of the trucks that were registered in the environmental zone do not comply with Euro IV standard in 2010. This does not mean with the vehicles do not comply with the requirements of the environmental zone, as vehicles with retrofitted with particulate traps also are compliant. It is not possible to get information on whether the vehicle has a particulate filter from the CMR.

The share of trucks with Euro IV or better increased from 28% in 2008 to 54% in 2010. The trucks with engine standard Euro II or earlier have been reduced from 26% to 15%. There has been a replacement of both Euro II and Euro III vehicles. Euro II vehicles are having an age where they are normally replaced rather soon. The registered trucks are on average 6 years old. According to Statistics Denmark, the average age for the entire car park in Denmark in 2010, is 8.2 year for trucks. The average age of the Danish fleet in recent years remained fairly stable.

Age composition of vehicles operating in the environmental zone in Aalborg is significantly lower than the composition of Denmark as a whole. We also see that special trucks and buses are considerably younger than the national level. This supports the conclusions that the LEZ requirements have helped to stimulate a trend towards the purchase of newer vehicles.

However, vehicles can also meet the LEZ requirements by having mounted particle filters, which are not registered in the CMR. There is at the moment no other way to count the number of filters.

Whereas for passenger cars, the standards are defined by vehicle driving distance, g/km, for lorries (trucks) they are defined by engine energy output, g/kWh, and are therefore in no way comparable.

The official category name is heavy-duty diesel engines, which generally includes lorries and buses.

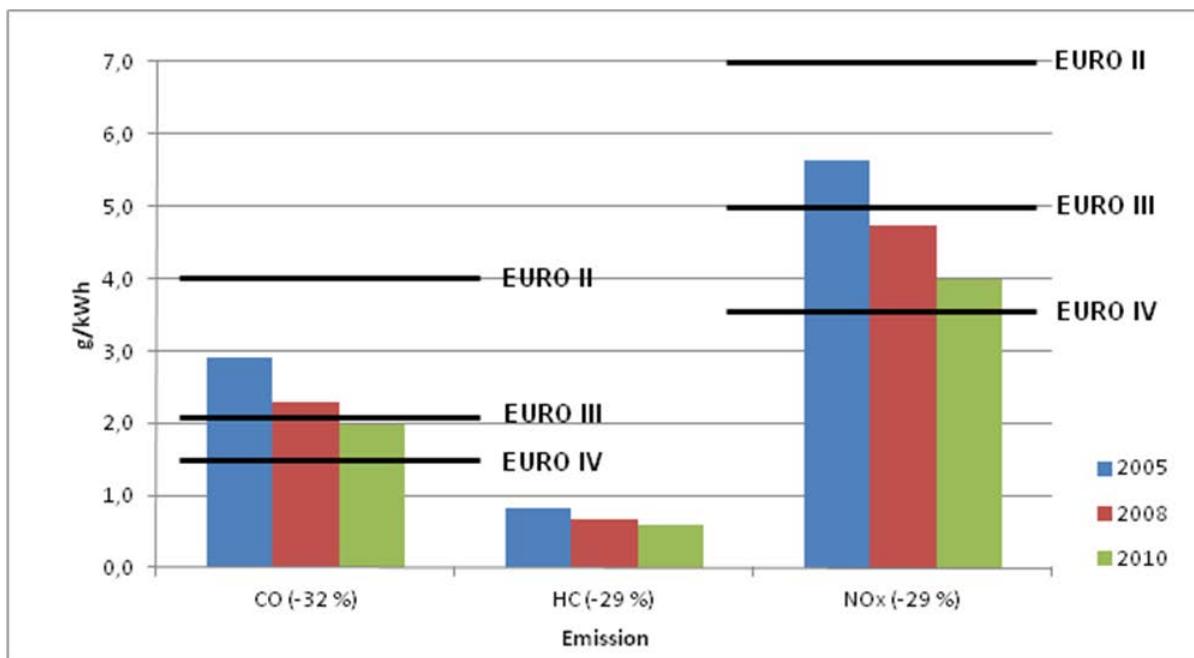


Figure 7: Average emissions from HGVs in 2005, 2008 and 2010 based on the distribution of EURO norms in the Environmental Zone.

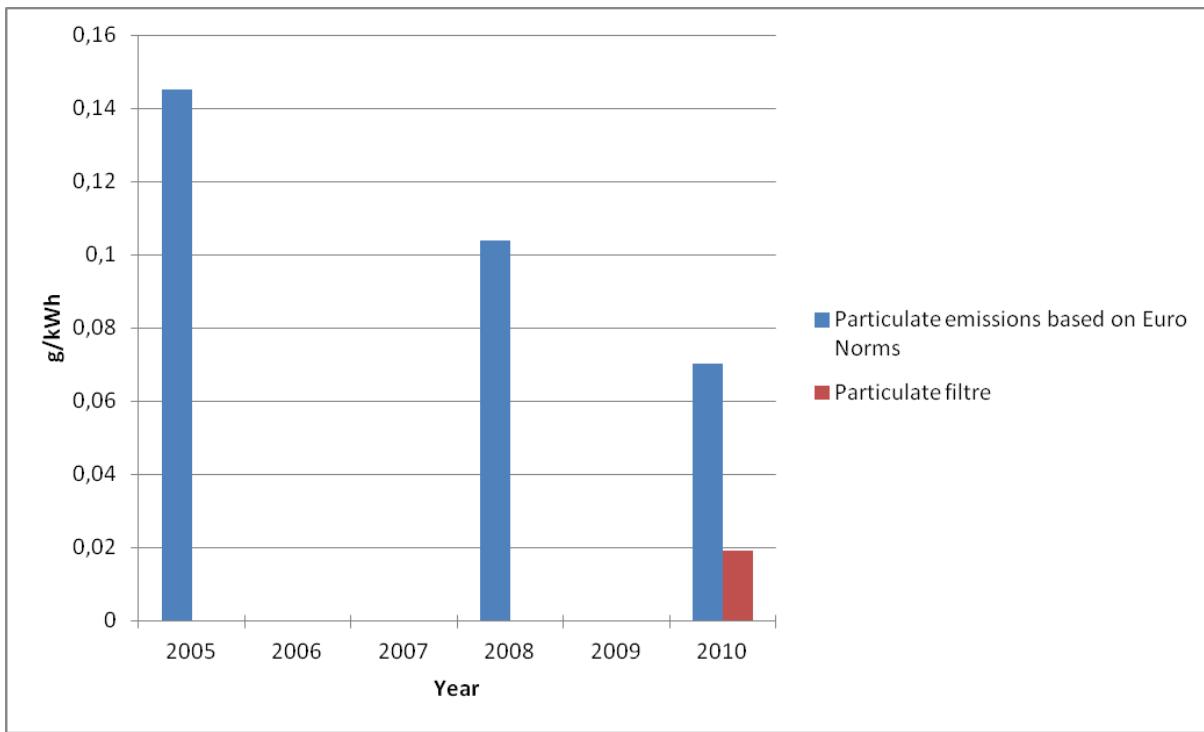


Figure 8: Particulate emissions. The 2010 results show the expected emissions of particles based on the distribution of EURO Norms, and the expected emission of particles based on EURO Norms and the assumption that all vehicles older than EURO IV are retrofitted with a particle filter.

The used assumptions for the emission modelling, is as follows: The maximum value of emissions for each EURO norm has been checked. Then the maximum value has been applied to the distribution of vehicles for each registration (2005, 2008, 2010). The distribution used can be seen in figure 7. Hence, the emission value for each year is an average emission for the vehicles entering the zone the

respective year. As shown in figure 7, the average emissions are beyond EURO III before the introduction of the zone, and beyond EURO IV after the implementation of the zone. The reason why the average is still beyond EURO IV is because the retrofitting of particulate filters does not imply (significantly) other emissions than particles. And, as described above, vehicles are still allowed in the zone if they are either fulfilling the EURO IV norm OR have a retrofitted particulate filter. A EURO III truck is in this way still allowed in the zone if it has a retrofitted particulate filter.

As described in the business as usual scenario (C1.3), vehicles would be newer even though the environmental zone was not implemented. The effect from 2005 to 2010 is in that way not only affected by the implementation of the environmental zone, but also other factors.

That the low emission zone does have an effect and do push forward the renewal of vehicles, is indicated by the fact that the registered trucks are on average 6 years old in 2010. According to Statistics Denmark, the average age for the entire car park in Denmark in 2010, is 8.2 year for trucks. However, it is impossible to quantify a business of usual scenario for the development for more reasons.

The first reason is that the renewal of vehicles cannot be seen as linear or close to linear. It is considered to be in steps following the introduction of the EURO norms. The second reason is, that the count in autumn 2008 was close to the implementation of the environmental zone in Aalborg (February 2009). Even though only EURO III or particulate filter was required in 2009, the renewal of vehicles to EURO IV can have begun in 2008 to ensure compliance with the zone also after the EURO IV requirements in the zone in 2010. Hence, trucks and buses in 2008 can already be newer or have a retrofitted particle filter than actually expected.

A third reason that gives reason to believe that the low emission zone has a larger effect on the renewal of the fleets compared to previous development, is based on feedback from freight companies who state that the low emission zone has forced them to renew the fleet even though the financial situation in Europe (leading to less transport) would normally have had the opposite impact on the companies. It is therefore likely to believe that trucks would not have been replaced due to the financial crisis alone, but that the low emission zone requirements have helped to the development.

Table 2.2.4: Emissions summary for the LEZ in Aalborg

Indicator	Before (2005)	B-a-U (date)	After (2010)	Difference: After – Before	Difference: After – B-a-U
No.9: CO emissions (g/kWh)	2,9 (2005)	n.a.	2,0 (2010)	- 32 %	n.a.
No.10: NOx emissions (g/kWh)	5,6 (2005)	n.a.	4,0 (2010)	- 29 %	n.a
HC emission (g/kWh)	0,8 (2005)	n.a.	0,59 (2010)	- 29%	n.a.
No.11: Particulate emissions: Average (g/kWh)	0,15 (2005)	n.a.	0,02 (2010)	- 86 %	n.a.

C2.3 Transport

The 12 hour registrations of license plates in 2005, 2008 and 2010 registered the goods vehicles:

- In 2005, 9,810 vehicles were registered entering and 8,963 leaving the area of the planned LEZ.
- In 2008, 11,338 vehicles were registered entering and 10,894 leaving the planned LEZ area.
- In 2010, 9,231 vehicles were registered entering and 9,482 leaving the LEZ.

Table 2.3.1: Vehicle movement in and out of the Environmental Zone

Indicator	Before 2005	B-a-U 2008	After 2010	Difference: After - Before	Difference: After - B-a-U
No.25: Freight Movements, entering/leaving	9,810/8,963	11,338/10,894	9,231/9,482	- 5,9 % / 5,8 %	-18,6 % / -13,4%

There is a decrease in entering goods vehicles from 2005 to 2010, but a small increase in goods vehicles leaving the zone area. The change, however, is considered so low that it is not significant taking into account the method for collecting data. From 2008 and to 2010 there is a large decrease in transport entering and leaving the zone area.

This could be explained by the environmental zone, but the main explanation is estimated to be the financial crisis that Europe has experienced since 2008/2009. The impression given by the freight operators at stakeholder meetings is that the amount of goods has decreased as part of the crisis and hence also the freight movements.

Transit traffic

As part of the LEZ, transit routes are defined for the traffic crossing the fjord. These routes are exempt from the LEZ requirements. For this analysis, transit traffic is defined as the traffic between entering and leaving ports on a transit route where the time period between entrance and exit was less than 10 minutes.

Approximately 20% of the entering traffic from Hobrovej drives over the Limfjord Bridge. In 2008, this was on the same stretch 10%, while it in 2005 was 21%. The average travel time for transit traffic to the north on Vesterbro is 5 minutes.

Between the Limfjord Bridge and the west part of the City there is a relatively large share of transit traffic with 24%. In the opposite direction, only approx. 1% can be described as transit traffic. The average travel time for transit traffic on this stretch is 2 min. in both directions. In 2008, there was registered 25% transit traffic on the corresponding stretch from Strandvejen to the Limfjord Bridge, and 4% in the opposite direction and travel time is approximately the same.

Table 5 shows the vehicle distribution in relation to the Euro standard for diesel vehicles in, where the transit traffic between the Limfjord Bridge and Vesterbro respectively Strandvejen are excluded because the transit traffic are exempt from the LEZ requirements.

Table 2.3.2: Vehicle distribution in relation to the Euro standard for diesel vehicles based on CRM, where transit traffic between Limfjord Bridge and Vesterbro respectively Strandvejen is excluded (2010)

	Not registered	Pre EURO	EURO I	EURO II	EURO III	EURO IV	EURO V	EEV	Total
Trucks	30	9	3	40	122	154	92	7	447

Vans	4.610	-	-	-	6	34	1	-	4.651
Large cars	41	2	1	2	17	26	4	7	100
Cars	141	-	-	-	8	13	-	-	162
Utility vehicles	6	-	-	-	-	-	-	-	6

Table 2.3.3: Distribution of diesel vehicles in 2010, with the exclusion of transit traffic between Limfjord Bridge and Vesterbro respectively Strandvejen, under the assumption that vehicles without a registered Euro standard meet the emission requirements that were applicable at the time of initial registration

	Not registered	Pre EURO	EURO I	EURO II	EURO III	EURO IV	EURO V	EEV	Total
Trucks	11	5	5	54	126	157	82	7	447
Vans	91	78	154	653	2.006	1.495	174	-	4.651
Large cars	8	4	5	11	30	31	4	7	100
Cars	1	-	2	6	56	75	22	-	162
Utility vehicles	-	-	1	2	1	2	-	-	6

A total of 201 trucks representing 45% of registered vehicles do not comply Euro IV standard and thus do not comply with environmental zone, regarding only the requirements for engine standard. The Central Motor Registry does not register whether a vehicle has an after-mounted particulate filter, so the study cannot provide a precise answer on whether the requirements of the environmental zone in Aalborg are respected.

Vans are not subject to requirements in the LEZ, but 2,982 vans corresponding to 64% would not comply with a demand for Euro IV standard, if such were introduced for vans.

We cannot compare the registered EURO norms with national figures, but have to depend on the age of the vehicles as the indicator for the EURO norms. Please refer to the explanation of the renewal of trucks and busses in Aalborg compared to national figures above.

The “not registered” category above stands for vehicles where data is missing either due to the fact that the license plate numbers don’t match the CMR database, because the registration was filled out wrong, or because they are foreign license plates.

C2.4 Society

Acceptance

In general there is a good knowledge of the rules on environmental zone in Aalborg. The police states that the rules are mostly respected. Most of the compliances were registered in the first LEZ year.

Acceptance is further described in section D in relation to the process evaluation.

Non-compliance

Non-compliances per year, which were registered by the police:

- In 2009, 15 non-compliances were registered
- In 2010, data missing.
- In 2011, 8 non-compliance was registered
- In 2012 (first half of the year), 6 non-compliance was registered

The non-compliances are not equal to the vehicles that do not reach the required EURO-standard, due to the fact that the police is not controlling the requirements at all times.

C2.5 Cost benefit analysis

The following conducts a cost benefit analysis (CBA) of the project Efficient Goods Distribution in Aalborg as it is described above. The overall objective of this CBA is to evaluate whether the investment that is made into this project results in satisfactory returns.

C2.5.1 Evaluation period for CBA

In order to evaluate the project, its key impacts will be compared to a "business-as-usual" scenario, since no baseline is available for comparison of the project Efficient goods distribution.

Project life time will depend on the technology development in terms of vehicle performance and emissions. Euro 6 standard is planned to come in effect from September 2014, which therefore could require replacement of the signs. Based on this the project life time is set to 9 years.

The European Commission (EC) suggests that non-cohesion countries apply a social discount rate (SDR) of 3.5 %. Furthermore the base year for discounting, and the price base, will be set to 2008. Finally, an exchange rate of 750 DKK/EUR is applied when relevant, all externalities are discounted using a GDP deflator and all other prices are discounted using the consumer price index (CPI).

C2.5.2 Method and values for monetarisation

As described above the key impacts of the project are:

1. Capital costs of the zone
2. Benefits from reduced air pollution

With regards to bullet 2, the reduction in air pollution has been measured on NO₂, PM_{2.5} og PM₁₀, but as values for monetarisation of NO₂ is not readily available, only benefits from reductions in PM_{2.5} and PM₁₀ will be directly included in the CBA. The value of reductions in NO₂ should, though, none the less be considered in the final evaluation.

C2.5.3 Life time cost and benefit

Table C2.5.1 illustrates the timing of capital costs of the project:

Table 2.5.1: Capital cost in the evaluation period (not discounted)

	Cases for comparison	Cost
2009	CIVITAS measure	-€74,100
	Reference case (or BAU)	€0
2010	CIVITAS measure	-€7,170

	Reference case (or BAU)	€0
2011	CIVITAS measure	€0
	Reference case (or BAU)	€0
2012	CIVITAS measure	€0
	Reference case (or BAU)	€0
2013	CIVITAS measure	€0
	Reference case (or BAU)	€0
2014	CIVITAS measure	€0
	Reference case (or BAU)	€0
2015	CIVITAS measure	€0
	Reference case (or BAU)	€0
2016	CIVITAS measure	€0
	Reference case (or BAU)	€0
2017	CIVITAS measure	€0
	Reference case (or BAU)	€0

As it is seen from the table above the capital costs that are directly linked to the project Efficient goods distribution in Aalborg accumulate to €81,270. These costs cover the following:

1. Construction and deployment of signs
2. Changing of signs due to changes in requirements (see Figure 5).

Table C2.5.2 in the following shows timing of the realisation of the monetarised value of reducing air pollution through the project Efficient goods distribution:

Table 2.5.2 Value of pollution reductions in the evaluation period (not discounted)

	Cases for comparison	Values
2009	CIVITAS measure	€0
	Reference case (or BAU)	€0
2010	CIVITAS measure	€52,380
	Reference case (or BAU)	€0
2011	CIVITAS measure	€45,396
	Reference case (or BAU)	€0
2012	CIVITAS measure	€38,412
	Reference case (or BAU)	€0
2013	CIVITAS measure	€31,428
	Reference case (or BAU)	€0
2014	CIVITAS measure	€24,444
	Reference case (or BAU)	€0
2015	CIVITAS measure	€17,460
	Reference case (or BAU)	€0
2016	CIVITAS measure	€13,968
	Reference case (or BAU)	€0
2017	CIVITAS measure	€10,476
	Reference case (or BAU)	€0

The project Efficient goods distribution results in a reduction in PM_{2.5}- and PM₁₀ levels of 0.3 tonnes in 2010 compared to the business-as-usual case. This is assumed to decline linearly to 0 tonnes in 2020. The result is a monetarised benefit of reduced air pollution of €52,380 in 2010, which decreases linearly to €10,476 in 2017.

C2.5.4 Compare the lifetime costs and benefits

There are two measurable key impacts from the project Efficient goods distribution in Aalborg; capital costs and value of reduced air pollution. Capital costs are incurred in the project's first two years, whereas the benefits and operation costs are incurred in every year of the project; excluding 2010. The capital costs appear to be in a good relationship with the benefits.

Table 2.5.3 Lifetime cost/benefit of CIVITAS measure (discounted)

	Capital cost	Benefits	Total cost	Total Benefit	Cumulated cost
2009	-€71,594	€0	-€71,594	€0	

Measure title:

Efficient goods distribution in AalborgCity: **Aalborg**Project: **ARCHIMEDES**Measure number: **63**

2010	-€6,928	€48,897	-€6,928	€48,897	-€71,594
2011	€0	€40,945	€0	€40,945	-€29,624
2012	€0	€33,474	€0	€33,474	€11,320
2013	€0	€26,462	€0	€26,462	€44,794
2014	€0	€19,885	€0	€19,885	€71,256
2015	€0	€13,723	€0	€13,723	€11,141
2016	€0	€10,607	€0	€10,607	€104,864
2017	€0	€7,687	€0	€7,687	€15,472
Total	-€78,522	€201,680	-€78,522	€201,680	€123,158

Table 2.5.4 Lifetime cost/benefit of the reference measure/case (discounted)

	Capital cost	Benefits	Total cost	Total Benefit	Cumulated cost
2009	€0	€0	€0	€0	€0
2010	€0	€0	€0	€0	€0
2011	€0	€0	€0	€0	€0
2012	€0	€0	€0	€0	€0
2013	€0	€0	€0	€0	€0
2014	€0	€0	€0	€0	€0
2015	€0	€0	€0	€0	€0
2016	€0	€0	€0	€0	€0
2017	€0	€0	€0	€0	€0
Total	€0	€0	€0	€0	€0

C2.5.5 Summary of CBA results

The overall conclusion is that the value of the capitalised benefits is enough to yield a satisfactory return on the Efficient goods distribution project's capital costs. The project has an NPV of approximately €123,000.

Finally it can be argued that Aalborg's image as an environmental conscious city is improved which might increase its population's feeling of pride and its satisfaction with its local government. And furthermore, it might increase, or be a prerequisite for, the migration of people, companies and students to the Aalborg. These impacts are not easily quantified, but should none the less be taken into account when evaluating the success of the measure. The same goes for the documented decrease in NO₂ reductions.

C2.6.5.1 Sensitivity analysis

In order to test the robustness of the conclusion a sensitivity analysis on select key impacts has been carried out. If any one of the following bullets were to be realised, the NPV of the project will turn negative:

1. There are yearly maintenance costs of above approximately €17,000.
2. The value of reduced air pollution is reduced by 61 %.
3. The sum of capital costs are increased to approximately €210,000.
4. The applied SDR is increased to 47.8 %.

Based on this sensitivity analysis it is argued that the overall conclusion, as laid out above, is robust.

C3 Achievement of quantifiable targets and objectives

All of the targets have based on the licence plate registrations been achieved. In terms of air quality, the environmental zone has a small effect.

No.	Target	Rating
8	Reduce HGV emissions of CO by about 25%	***
9	Reduce HGV emissions of HC by about 25%	***
	Reduce HGV emissions of NOx by about 25%	***
11	Reduce PM emissions by 20%	***
NA = Not Assessed O = Not Achieved * = Substantially achieved (at least 50%)		
** = Achieved in full *** = Exceeded		

C4 Upscaling of results

The following scenarios are up scaling:

- **The environmental zone is to cover a larger area.** The measurements and models of air quality and emissions from the involved vehicles could be upscaled using the National Environmental Research Institute's model for Air Quality Monitoring and the TEMA2000 model.

- **The requirements in the environmental zone would be EURO V.** This scenario indicates lower emissions from the involved vehicles. The TEMA2000 model could be used for up scaling the emission reduction by the use of the licence plate registration. The number of violations could be taken into account to strengthen the model—
- **Vans would be included in the environmental zone.** Reduced emissions as a result of including vans in the environmental zone could be modelled with the TEMA2000 model. Vans are included in the licence plate registration and will be taken into considerations. However, the sample might not be sufficient to create a strong model, since the euro norms fulfilled by the van are often not registered. In that case, it might be necessary to use the whole fleet of vans in Denmark to obtain a fulfilling sample, assuming that the fleet operating in the environmental zone is similar to the Danish fleet when it comes to euro norms.

C5 Appraisal of evaluation approach

In general it is to be said that air quality and emission measurements and modelling are not easy to carry out quickly, with a satisfying result. It is a rather difficult matter and requires a lot of resources.

For this evaluation, seen in retrospect, the creation of a baseline for air quality before 2008 would have been helpful. For this evaluation, such a baseline was not possible, because the air quality models changed and made it impossible to compare the newer models with the older ones.

C6 Summary of evaluation results

The registrations of license plates coupled to the Motor Registry were conducted in 2005, 2008 and 2010. The Motor Registry includes data to determine the emission category (Euro emission standard) of each vehicle.

The share of trucks with Euro IV or better increased from 28% in 2008 to 54% in 2010. The trucks with engine standard Euro II or earlier have been reduced from 26% to 15%. There has been a replacement of both Euro II and Euro III vehicles. Euro II vehicles are having an age where they are normally replaced rather soon. The registered trucks are on average 6 years old. According to Statistics Denmark, the average age for the entire car park in Denmark in 2010, is 8.2 year for trucks. The average age of the Danish fleet is in recent years remained fairly stable.

An impact assessment of the low emission zone on air quality has been carried out based on model calculations for 138 busy streets in the cities of Copenhagen and Frederiksberg, 55 streets in Aarhus, 40 streets in Odense, and 31 streets in Aalborg. The assessment showed that the environmental zone in Aalborg has a small effect on air quality compared to doing nothing, and that the effect of the environmental zone will decrease over time.

The environmental zone is helping to push forward the replacement of older cars, hence the effect of the zone both in terms of vehicle improvements and air quality is decreasing over time if the requirements are not updated.

C7 Future activities relating to the measure

There are no future activities related to the measure. In general the LEZ requirements will develop according to the Danish law. The municipality is following the development of Clean-Air-Zones which is being elaborated by the Ministry of the Environment to see if this can be implemented to benefit the environment in the city.

D Process Evaluation Findings

D.0 Focused measure

0	No focussed measure
1	Most important reason: <i>The measure fits into the city policy towards sustainable urban transport and / or towards sustainability in general.</i>
2	Second most important reason: <i>Participation of a range of different actors</i>
3	Third most important reason: <i>The measure fits into the EU policy towards clean urban transport and it is possible to make a Cost-Benefit analysis on the experiences in Aalborg.</i>

D.1 Deviations from the original plan

The implementation timeline as described in the DoW was followed. There are no deviations from the original plan.

D.2 Barriers and drivers

D.2.1 Barriers

Preparation phase

- **Barrier 1** - (organizational) A possible barrier of this measure is related to creating the right working group from the beginning of the working process. This was important, in order to avoid that people changed during the process.
- **Barrier 2** – (organizational) Secondly, stakeholders involved in process should be consigners on material in regards to city logistics and the environmental zone, since they use time on the process.

Implementation phase

- No barriers identified

Operation phase

- No barriers identified

D.2.2 Drivers

Drivers have been similar in all the phases.

Preparation phase

- **Driver 1** – (organizational) A driver for this measure was the good co-operation between stakeholders, including frequent meetings built on a process beyond this measure. Before starting up this measure, the working group has worked for many years with city logistics in Aalborg.
 - Frequent and well organised meeting with the right people is a driver for the process.
 - Fewer complaints from freight operators etc in spite of it is (in Denmark) a new way of regulating city logistics, and very few freight operators are not fulfilling the requirements due to good information.

- **Driver 2** – (organizational) Also, the city of Aalborg has benefited from the involvement of a broad range of stakeholders in the process, in addressing problems and challenges towards the Danish Ministry of Environment and the implementation of the measure has been eased by the process when decisions were made in the City Council.

Implementation phase

- **Driver 1** – (organizational) A driver for this measure was the good co-operation between stakeholders, including frequent meetings built on a process beyond this measure. Before starting up this measure, the working group has worked for many years with city logistics in Aalborg. The meetings continued into the implementation phase.
 - Frequent and well organised meeting with the right people is a driver for the process.
 - Fewer complaints from freight operators etc in spite of it is (in Denmark) a new way of regulating city logistics, and very few freight operators are not fulfilling the requirements due to good information.

Operation phase

- **Driver 1** – (organizational) A driver for this measure was the good co-operation between stakeholders, including frequent meetings built on a process beyond this measure. Before starting up this measure, the working group has worked for many years with city logistics in Aalborg. The meetings continued into the operation phase.

D.2.3 Activities

Activities have been the same in the three development phases

Preparation phase

- **Activities 1** – (organizational) co-operation between stakeholders, including frequent meetings built on a process beyond this measure. Before starting up this measure, the working group has worked for many years with city logistics in Aalborg. The meetings continued into the implementation phase.

Implementation phase

- **Activities 1** – (organizational) co-operation between stakeholders, including frequent meetings built on a process beyond this measure. Before starting up this measure, the working group has worked for many years with city logistics in Aalborg. The meetings continued into the implementation phase.

Operation phase

- **Activities 1** – (organizational) co-operation between stakeholders, including frequent meetings built on a process beyond this measure. Before starting up this measure, the working group has worked for many years with city logistics in Aalborg. The meetings continued into the implementation phase.

D.3 Participation

D.3.1. Measure Partners

- **Measure partner 1** – ARCHIMEDES partners involved in this project is The City of Aalborg as leader of the steering committee group of stakeholders. The Alderman for the technical and environmental department has been the chair of the committee.

D.3.2 Stakeholders

- **The Police in North Jutland** – Participant in the working group for implementation of the low emission zone and efficient freight solutions in Aalborg.
- **DTL (The Danish Transport and Logistics Association)** – Participant in the working group for implementation of the low emission zone and efficient freight solutions in Aalborg.
- **Danske Fragtmænd (Freight Company)** – Participant in the working group for implementation of the low emission zone and efficient freight solutions in Aalborg.
- **Post Danmark (National Postal Service)** – Participant in the working group for implementation of the low emission zone and efficient freight solutions in Aalborg.
- **Port of Aalborg** – Participant in the working group for implementation of the low emission zone and efficient freight solutions in Aalborg.
- **DHL (Freight Operator)** – Participant in the working group for implementation of the low emission zone and efficient freight solutions in Aalborg.
- **Aalborg City (The trade Association in Aalborg)** – Participant in the working group for implementation of the low emission zone and efficient freight solutions in Aalborg.
- **HTS / DI Transport (Employer's Associoation)** – Participant in the working group for implementation of the low emission zone and efficient freight solutions in Aalborg.

D.4 Recommendations

D.4.1 Recommendations: measure replication

- In Denmark, national legislation made implementation of an environmental zone possible in the five largest cities including Aalborg. Before this, the City of Aalborg had tried to set up a low emission scheme with out carrying it out until the legislation was ready. Using the same requirements in more city makes operation easier.
- LEZ are realistic, when they are introduced according to national policy. If the national policy allows for a LEZ and if the city has the required stakeholder support, then a consideration of a LEZ makes sense.
- The measure is fairly easy to replicate. No advanced technology is required, but signs and stickers for the HGVs and buses.
- In Denmark, the Environmental Protection Agency is the responsible authority for the low emission zones in the five cities. The local police units in the city are controlling the vehicles. In this respect, the city's role in operating the zone is very little.

D.4.2 Recommendations: process (related to barrier-, driver- and action fields)

- **Recommendation Working group including central freight operators/federation:** In order to secure good co-operation with freight operations/federations these should be included in the planning process. The identification of central freight stakeholders of the freight operations/federation is central in the preparation phase of a LEZ. This allows for the creation of a working group with the right people in the whole process period.
- **Recommendation 2: Secure engagement and fulfil requirements:** Frequent meetings with freight operators and information are ways to secure engagement and fulfilment of requirements.