EGCA 2018, Umeå, Sweden

5. Ambient air quality

It is very pleasing to point out that the annual mean EC limit value of nitrogen dioxide (NO_2) has been undercut for three consecutive years. Implicating that long-term strategic efforts and implemented actions have begun to pay off. Still, a need to improve the air quality persists.

Today Umeå has 120,000 inhabitants and since the 60s the city has been growing twice as fast compared to the national average. The rapid growth rate creates several challenges linked to urban development such as a deteriorated air quality. To address the air quality situation, and to achieve a sustainable growth, a comprehensive plan (*see City introduction*) was adopted in 2011. A Sustainable Urban Mobility Plan (SUMP) is integrated within the comprehensive plan which aims to reduce car use in favour of sustainable transport. The majority of urban growth should take place within a 5 kilometres radius from the public transport system main lines, hence providing favourable conditions to pedestians, cyclists or public transport users through proximity to public transport and accessible walking and bicyckle paths. Thus, car traffic can be reduced in central Umeå, enabling a transformation of the old traffic arteries into city streets where sustainable transport and urban development are prioritized. The strategic development plans of Umeå is visualized in *Figure 5A1*.

Furthermore, the political level stresses the importance of an unpolluted air environment which has led to adaptation of a national environmental target which advocates a lower threshold value on air pollution than the EU standards (annual mean of 20 µg/m^3 NO_2 and an annual mean of 15 µg/m^3 for particles (PM_{10})). In addition, one of the City Council strategic long term objectives is: Sweden's best public health by 2020.

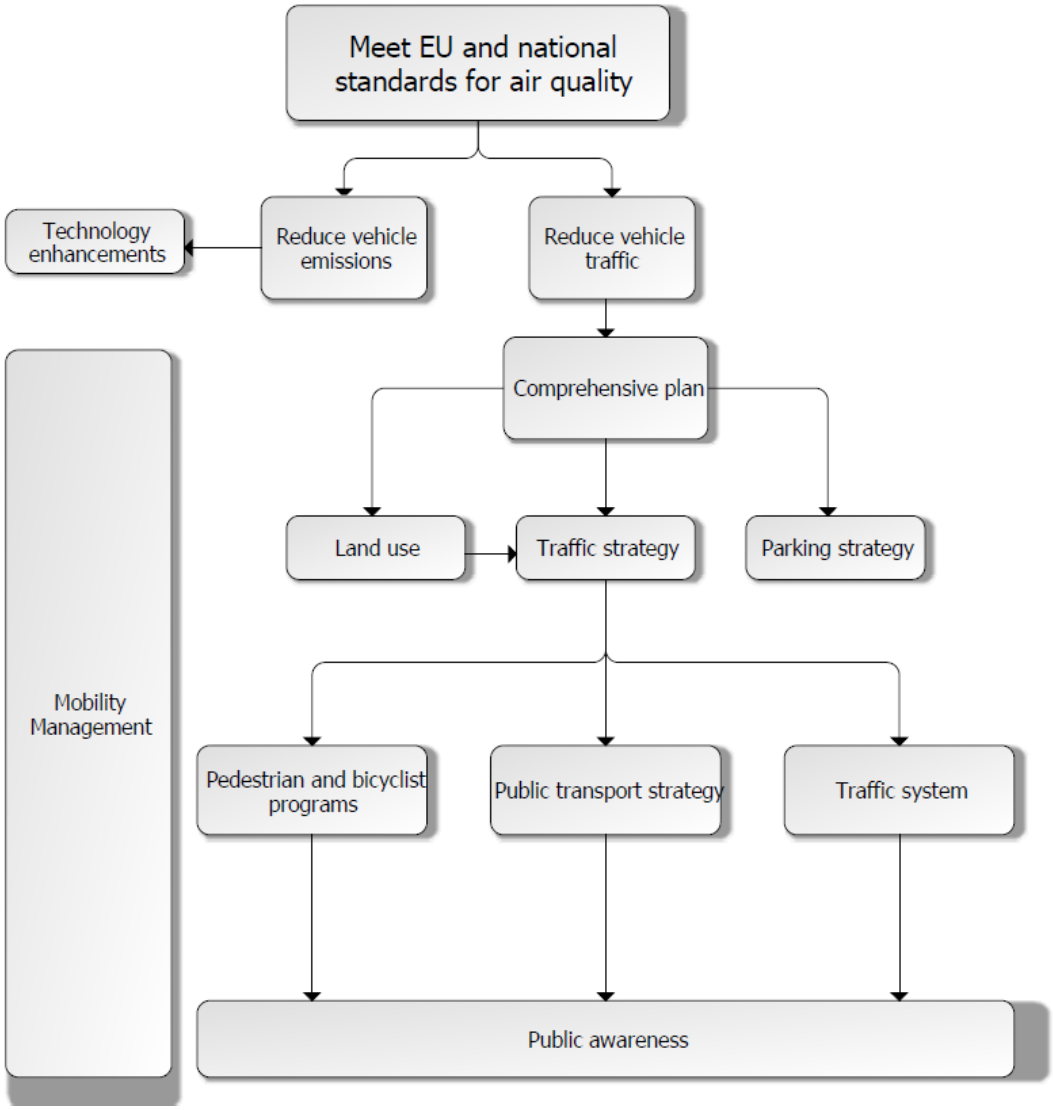

Figure 5A1. Flow chart showing an overall picture of how Umeå addresses the air environment situation based on a long-term strategic perspective. A densification of the city and sustainable transports (described more fully in 2. Local Transport) are key ingredients.

5A Present situation

Umeå started addressing air quality issues at a strategic level early. Measurements of sulfur dioxide and black smoke began in 1969 and today measurements of NO_2, PM_{10} and $PM_{2.5}$ are performed. Health effects of air pollution have been closely monitored by world leading scientists at Umeå University and are described in several studies[1].

[1] Specific studies for Umeå:
http://www.umea.se/download/18.232bb3eb132b9e0c2ca800069914/1361888402500/H%C3%A4lsoriskbed%C3%B6mning+F%C3%B6rskolor_nov2011.pdf
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Air quality problems in Umeå are in particular linked to high measured values of NO_2 and PM_{10}, mainly originating from traffic. The air quality problems are most severe in the city centre where two heavily trafficked highways intersect in the vicinity to densely populated areas.

The highest levels of NO_2 are measured at the street Västra Esplanaden, which is a part of highway 503 running north/south bound directly through central Umeå and also one of two natural river crossings. The combination of a closed street area, cold winters and the meteorological phenomenon stable stratification or inversion, keeps emissions at street level and hence causes poor conditions for a good air environment. A higher grade of cold starts during winter and subsequent non-optimal combustion adds to the problem. Thus, the air pollution level at Västra Esplanaden is highly correlated to temperature and seasonal variation.

During winter a large part of motorists use studded tires because of slippery and icy road conditions. High levels of particles are typically measured at early autumn or late spring when studded tires tear up the exposed road surface.

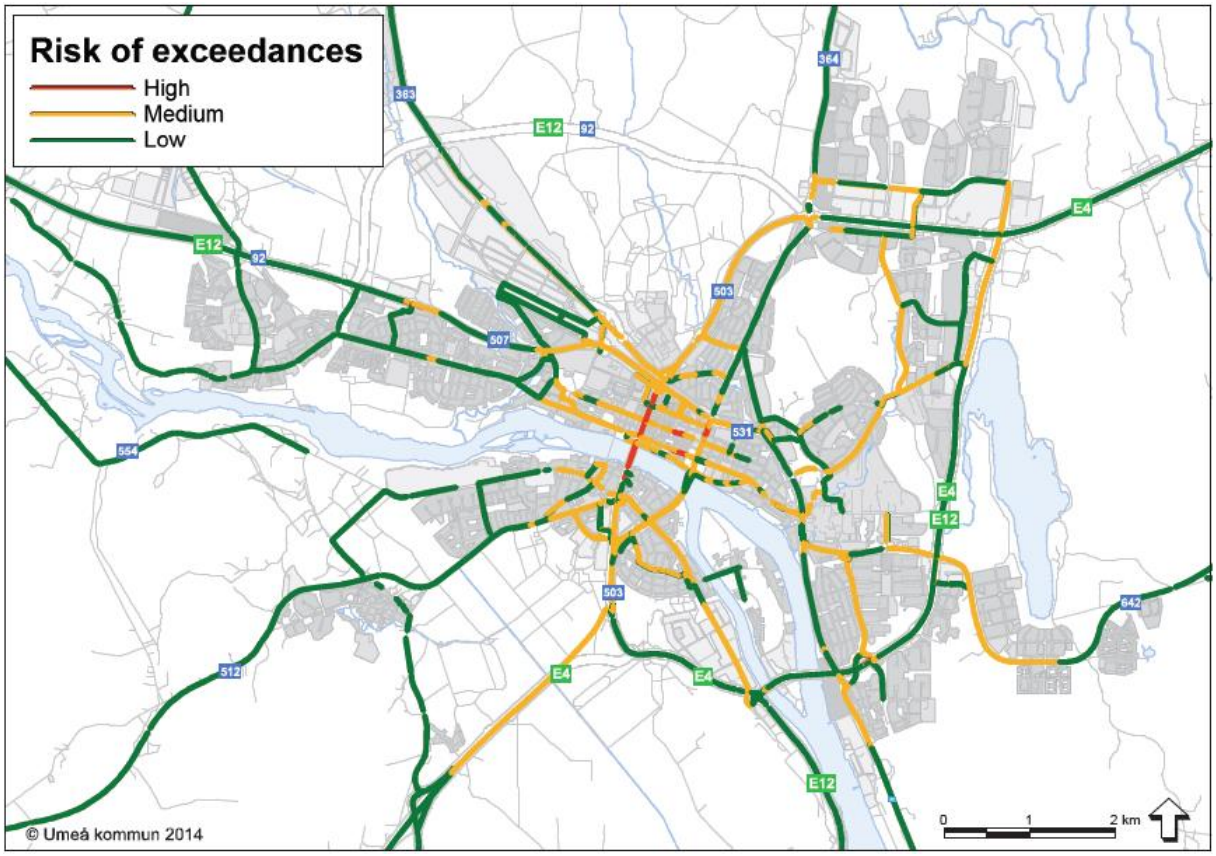

Figure 5A2. The road network in Umeå and estimated risk of exceeding annual EU NO_2 limit value (40 µg/m^3). Red indicates a high risk of exceeding the limit value. Västra Esplanaden is located along highway 503 at the red line in the centre of the map, north of the river crossing.

Number of days per year where EU target value for ozone was exceeded (8h mean)

Ozone levels in northern Sweden are in general low. Measured days above the EU target limit value as 8 hour mean varies between 0–3 per year between 2010–2014. Ozone concentration is measured as regional background level at Vindeln 55 kilometers outside Umeå.

The limit values for NO_2.

Road transport is the dominant source of NO_2 emissions and several measures implemented have been aimed at reducing traffic. *Figure 3* shows a strong downward trend in traffic development at Västra Esplanaden 2007–2014. In 2014 the traffic volume was 21,040 out of which 8,6% was heavy traffic. Since 2011, total traffic flows at Västra Esplanaden have decreased by 9,6% and heavy traffic by 26,7%. Lowering traffic flows plays a key role in reducing NO_2 levels, but existing meteorology and technology factors are also crucial ingredients, where the two latter are hard to affect.

Air pollution at Västra Esplanaden directly affects 350 residents. Indirectly, vastly more people passing through the street area are exposed.

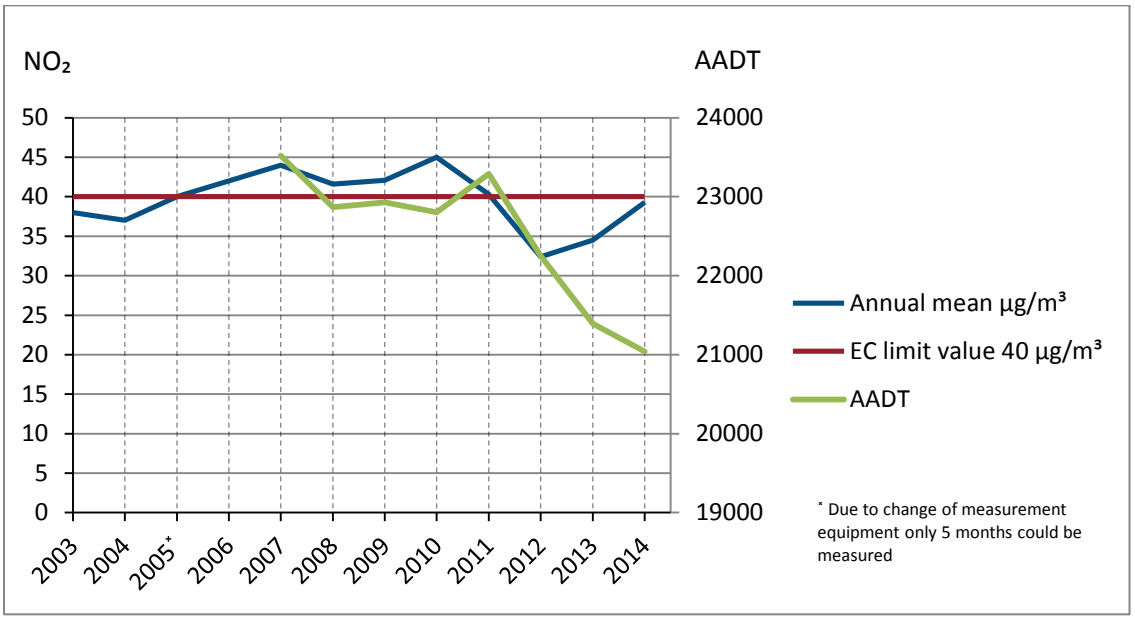

Figure 5A3. Annual mean concentrations of NO_2 (2003–2014), EU limit value and AADT (Average Annual Daily Traffic 2007–2014).

The EU limit of hourly mean of NO_2 was exceeded twice during 2007–2014. Exceedances of hourly mean in Umeå are in general strongly linked to meteorological conditions and inversion from late autumn to spring. In 2011 the meteorological conditions were particularly unfavorable.

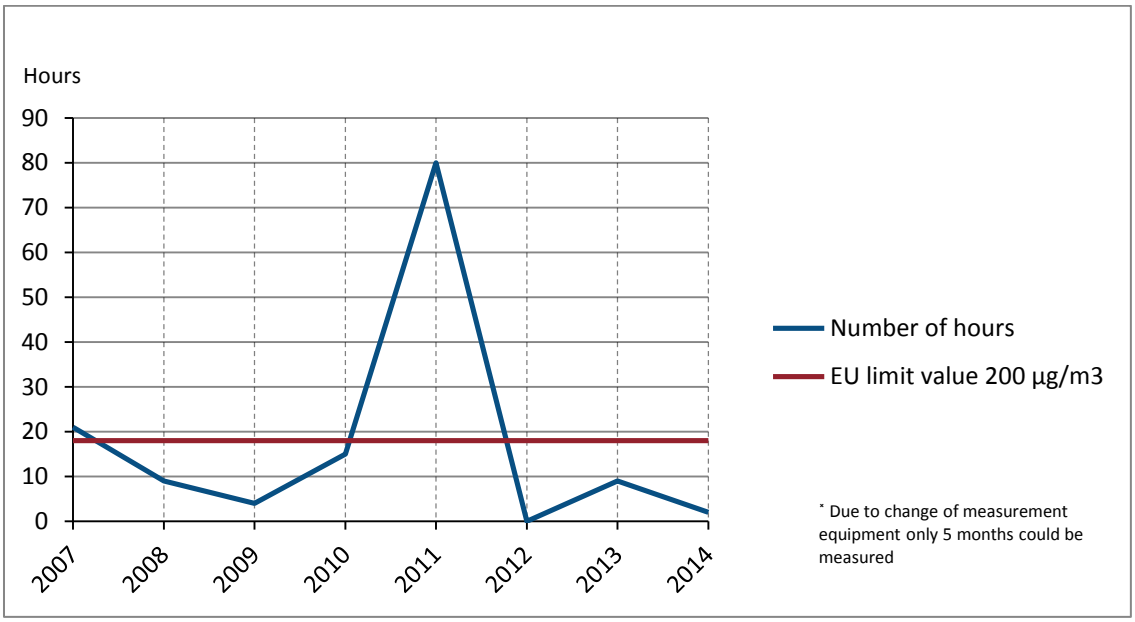

Figure 5A4. Number of hours where the EU limit for NO_2 was exceeded during 2007–2014 (limit value 18 hours/year). Trends from continuous monitoring at Västra Esplananden, Umeå.

As a basis for spatial planning, dealing with complaints and evaluating the air quality situation, Umeå uses forecasting tools linked to GIS-systems to evaluate the impact on air quality of different actions.

Forecasts show that regional background constitutes around 1–3 µg/m^3 of annual mean and relates mainly to traffic outside Umeå. In total, regional background accounts for 4%, urban background 24 % and local contribution 72% of the NO_2 level. The contribution from abroad is small.

The limit value for PM_{10}

In 2013 the daily mean limit was exceeded for the first time, as shown in *Table 5A1*. Out of 39 exceedances, 36 occurred during January to August. A late spring and unusually low precipitation together with elevated particle levels due to a construction site close to the monitoring station might have contributed to this exceeding.

The exceeding took place although dirty snow was transported away and streets were cleaned in order to reduce PM_{10}. In the autumn of 2013 dust-binding actions were launched to reduce PM_{10} levels. Dust-binding actions were performed 33 times during 2014, resulting in just 3 exceedances. Simultaneously an environmental zone and passage prohibition for heavy traffic through the city center was introduced.

Table 1 shows the annual mean level of PM_{10} originates to 25–30% to regional background, 45–50% to urban background and 25–30% to local level.

PM_{10}	2006	2007	2008	2009	2010	2011	2012	2013	2014
Annual mean EU limit 40 µg/m3 (Västra Esplanaden)	28,7	26,6	25,4	22,2	19,3	21,2	21,2	22,4	18,6
Number of days above 50 µg/m3 (max 35)	34	25	28	33	17	26	28	39	3
Urban background µg/m3 (City library)	12,6	13,7	11,4	-	-	-	-	-	-
Regional background µg/m3 (Vindeln 55km outside Umeå)	8,6	6,6	6,4	-	-	-	-	-	-
$PM_{2.5}$	2006	2007	2008	2009	2010	2011	2012	2013	2014
Annual mean EU limit 25 µg/m3 (Västra Esplanaden)	-	7,9	7,3	6,4	7,5	8,2	-	-	-
Urban background µg/m3 (City library)	-	4,7	4,1	4,1	4,9	5,1	-	-	-
Urban background µg/m3 (Preschool Mården)	-	-	-	-	-	4,8	4,5	4,3	-

Table 5A1. PM_{10} (VCM corrected data from 2014) and $PM_{2.5}$, Annual means, daily means, urban- and regional background contribution 2006–2014.

The target value for $PM_{2.5}$

Umeå has not exceeded the EU limit value and measured levels are far below the limit as shown in *Table 5A1*. Most $PM_{2,5}$ originates from long-distance sources.

Indicator	Number	Unit	Year of data
Max number of days per year on which EU target value for ozone was exceeded (8h mean);	1	Days	2014
Number of ozone monitoring stations	1	No of monitoring stations	Regional background in Vindeln
Max number of days per year on which EU target value for PM_{10} was exceeded (daily mean);	3	Days	2014
Number of PM_{10} monitoring stations	1	No of monitoring stations	Traffic
PM_{10} Max concentration recorded	73 204 288	ug/m3	2014 2013 2008
Number of NO_2 monitoring stations	2	No of monitoring stations	Traffic
NO_2 Max concentration recorded	462 229	ug/m3	2010 2014
NO_2 Annual Average concentration	39,3	ug/m3	2014
Number of $PM_{2.5}$ monitoring stations	1	No of monitoring stations	Urban background
$PM_{2.5}$ Max concentration recorded	21,8	ug/m3	2014
$PM_{2.5}$ Annual average concentration	4,3	ug/m3	2013

Table 5A2. Summary of measured values.

5B Past performance

Since air quality standards set by the EU and the Swedish government have been exceeded in Umeå, a vast work has been conducted to improve the air quality. Umeå adopted its first air quality management plan in 2009, focused at reducing NO_2 emissions. The plan has been adopted and carried out. A new air quality management plan was adopted in 2015 (see 5C).

The actions of the old air quality management plan were divided into four subgroups:

Measures in the street/road network

The most important infrastructural improvement linked to the air quality management plan is the ring road project. The eastern and northern parts of the ring road have already been built and are open for traffic. The western and final part of the road is planned to be finished in 2021. When the ring road is completed the part of highway 503 passing through the city centre will be rebuilt into a city street, enabling a densification of the urban environment as visualized in *Figure 5B1*. Accompanied by traffic decreasing measures, the aim is to radically lower traffic flows in central Umeå by a change in transport behavior and a redistribution of traffic to the ring road. These measures are crucial in order to improve air quality.

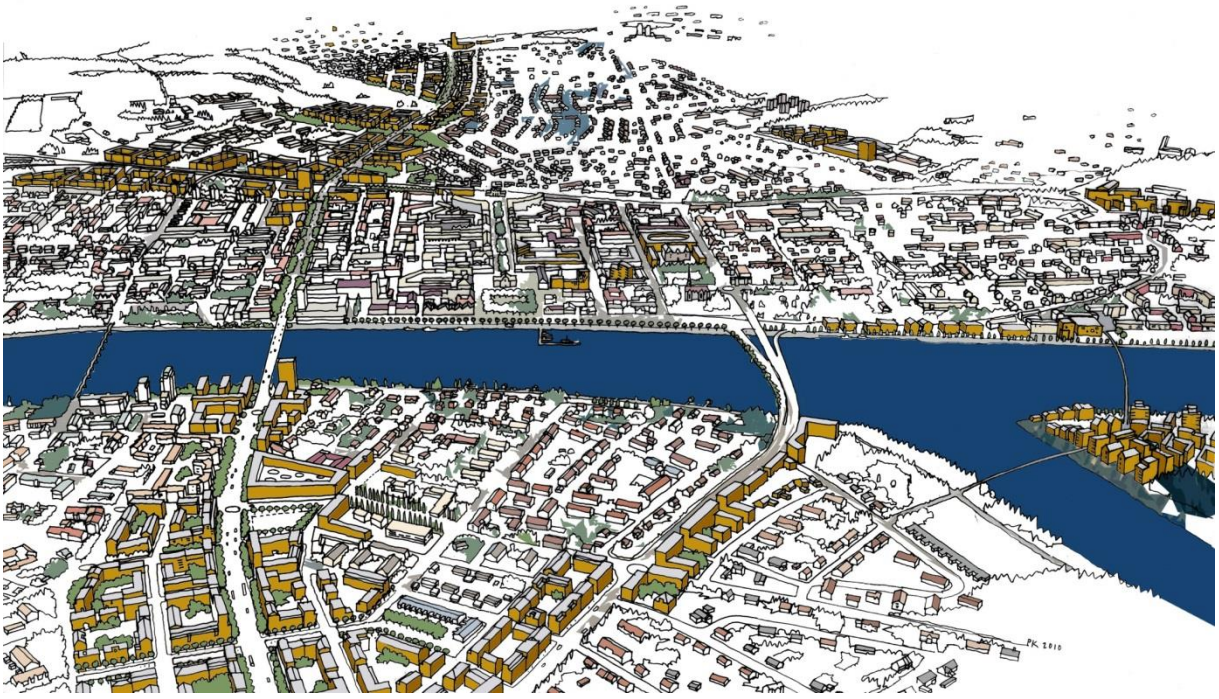

Figure 5B1. An illustration of how the former highways areas can be transformed to housing and commercial zones, thus enabling a densification of Umeå as visualized in the comprehensive plan. Yellow structures representing additional buildings. Shorter travel relationships and proximity to services creates favorable conditions for increasing the share of sustainable travel.

Figure 5B2. A view of Västra Esplanaden (highway 503) and central Umeå during peak-hour traffic. Finalization of the ring road system plays an important role in order to redistribute traffic from the city center and create an improved air quality.

This subgroup also includes measures concerning traffic management, such as the project ITS Umeå (see 5C Future plans) and a passage prohibition of large goods vehicles through the city centre. The latter is in effect since October 2013 and have contributed to a 25% decline in heavy traffic at Västra Esplanaden since 2012.

Influence/control road user behaviour

In the air quality management plan, one important measure is to increase public transport travels by 25%. Since 2005, public transport journeys have increased by 55% in Umeå. To influence transport behavior among the local residents, a municipal mobility management office has been ongoing since 2008. Key ingredients are information and campaigns aiming to enhance walking, cycling and public transportation.

The availability of parking space is an important tool in order to control traffic flows. In Umeå, a parking strategy is part of the comprehensive plan. The strategy focuses on reducing parking space for car commuters in the city centre meanwhile promoting public transportation and cycling.

Measures at the source of emissions

A low-emission zone for heavy vehicles was implemented April 2014 in the central parts of Umeå which prohibits passage of vehicles with emissions above a limit value. Within the municipal organization, car pools have been established and environmental requirements are imposed in procurements, an example being the electric buses (see *5C Future plans*).

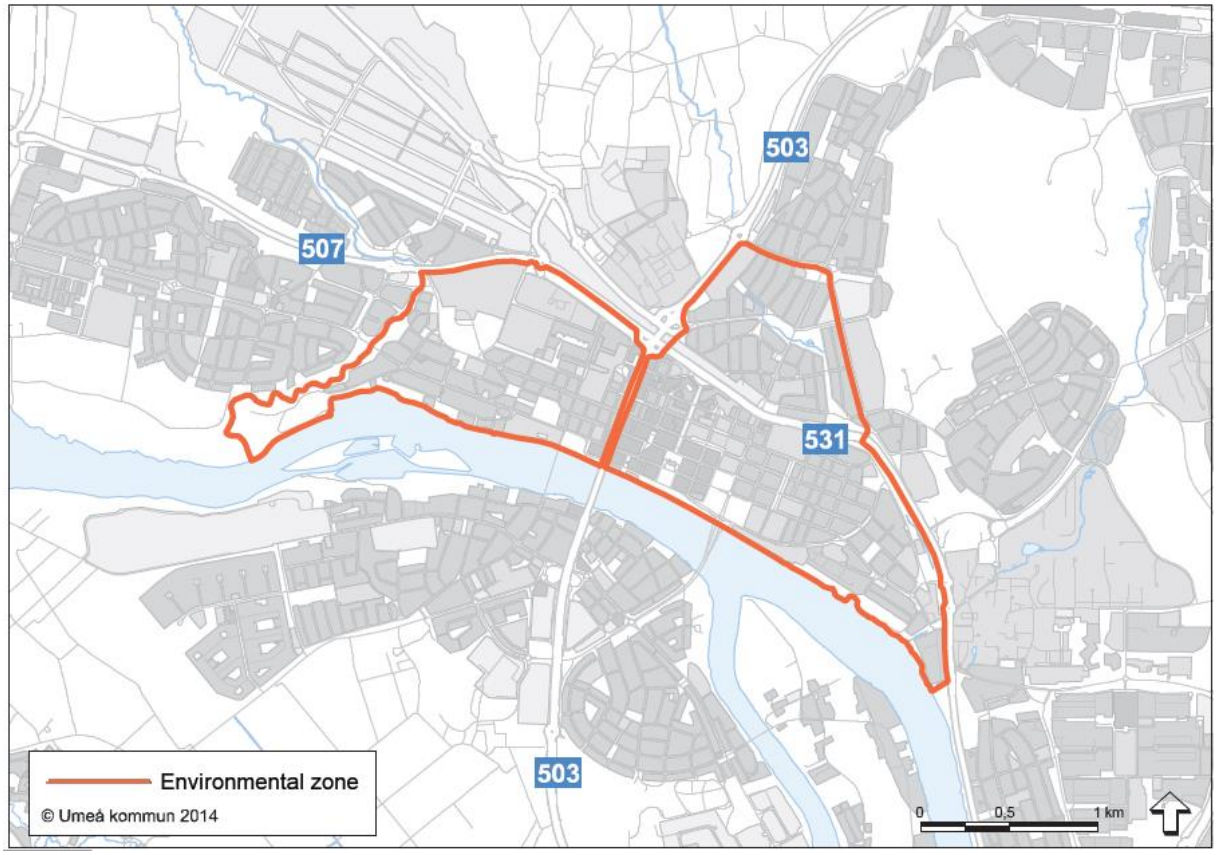

Figure 5B3. The low-emission zone in central Umeå was introduced 1 April 2014. Since the heavy traffic is a major contributor of NO_2 emissions, the low emission zone is considered as an effective measure.

Land use and planning measures

Measures in this category are based on the comprehensive plan and the six development strategies (see City introduction). Typically it is difficult to isolate the effect of a single measure, because effectiveness of a certain measure is often dependent on other measures in order to produce the desired effect. The main idea of the air quality management plan is a holistic approach, where all the actions work together in concert towards the same goal. To monitoring the progress the development strategies are monitored and evaluated including GIS visualisation. In this work Umeå has been involved in pioneering the development of the EU RFSC, Reference framework for sustainable cities.

The importance to keep the public informed about the air quality situation cannot be stressed enough, since it affects public health and since all inhabitants have a responsibility to lower emissions. In Umeå, information about the air quality is continuously updated at the municipality website, where the air quality can be observed at any given moment. All measurement data is avalible for the public, businesses and universities as opendata.

Figure 5B4 shows an air quality demonstrator located in the city centre next to a busy road that informs about present air quality. At the same time it functions as an interactive screen where people can play a video game that teaches them about how sustainable transportation can improve the air quality.

Figure 5B4. The air quality demonstrator. Right now the demonstrator informs that "The air is alright".

As a part of the Intelligent Traffic System (ITS) Umeå project, Virtual Message Signs have been placed alongside the major city entrances. The signs receive air quality data continuously from the measurement station in the city centre and proposes more sustainable transport routes along the ring road when air quality is poor in the city centre. For both local and regional buses ITS is used to minimize waiting time through GPS-based real-time information.

Umeå is well known in Sweden for its many birch tree alleys lining the street space as depictured in *Figure 5B5*. Originally they were planted to prevent fire from spreading across

the street space, but now they serve as air purifiers while also counteracting heating of the street areas, thus reducing the urban heat island effect.

Figure 5B5. The birches along the inner city streets are an important green urban structure. Simultaneously they improve the air quality, help drain and cooling the city.

5C Future plans

New air quality management plan

A revised air quality management plan was adopted in 2015. The plan includes future measures such as electric powered buses, charging infrastructure for electric vehicles, reducing mileage at snow removal and a walking and cycling bridge crossing the river. Other proposed measures within the former plan, such as the parking program, enter an implementation phase in the revised plan. The long term objective is to reduce the concentration of NO_2 emissions and create a healthy air environment. Since the current plan was adopted, the measures for land use and planning have been implemented in the comprehensive plan.

In the process of constructing the new air quality management plan, a need arose to adapt the national air pollution simulation tool SIMAIR to the prevailing meteorological conditions in Umeå to increase estimation accuracy. This task was appointed to the Swedish Meteorological and Hydrological Institute (SMHI) which later drew attention to this development process effort at their website.

Rebuilding highways to city streets

The completion of the ring road is a prerequisite to manage the air environment. When finalized, Umeå will take ownership of the state owned part of highway 503 passing through central Umeå, which will be rebuilt into a city street. A densification of Umeå alongside traffic reducing measures, intends to reduce car use and to redistribute traffic to the ring road, while enhancing the possibilities to walk, cycle or to use public transportation. Thus reducing traffic flows through central Umeå and relieving polluted street areas.

Green parking pay off and adaptive parking requirements

Parking is a key component in creating a more sustainable transport system. Umeå is developing an adaptive parking model where property owners can receive reduced parking requirements for residential buildings, thus saving money on fewer costly parking spaces while freeing land for more housing.

Another voluntary pilot called Green parking pay off is currently active. Based on an agreement between the city, the city parking company and real estate owners, the number of employee parking places on commercial properties can be reduced. Forecasts show that the full potential of the Green parking pay off project is a 41% shift from car to more sustainable transport modes at real estate level. The aim of the project is to create a clear win-win situation for Umeå, the real estate owner and the air environment. So far the

project has been a success and it has been extended to incorporate more property developers.

In both examples property developers provide sustainable mobility services in return, such as providing bicycle facilities, connecting the property to a carpool or allocating resources to mobility management funds. The allocation of funds for mobility management has allowed the city parking company to hire two full time employees designated to support property developers to implement measures. For the initial part of the project Umeå will commit €22 000.

Mobility management

The project Be Green Umeå expired 2015 and mobility management is now an integrated part of the ordinary operation at the municipality and the municipality parking company. This is consistent with the concept Umeå uses where development funds are used in co-financed projects. Therafter desirable results are integrated into regular operations while future development efforts are carried out in project form. Up until 2015 Umeå have committed about €71 600 annually.

Car pools and electric buses

Umeå has established a car pool that can be utilized by employees as well as citizens. The plan is to expand this project by supplying electric powered vehicles and establish new car pools based on demand. Umeå has a well-developed cooperation with a company developing ultra-fast charged electric buses with hybrid back-up. Today two electric buses are operational and by 2016 there will be 9 buses in traffic . The vision is to add another 24 buses by 2020. Umeå is thereby facing up to the climate challenge by committing to investments in green innovation that will increase the share of electric buses in the city transport system from 0% to 70% from 2010 to 2020. The rest of the bus-fleet will comply to the Euro 6 standard.

Figure 5C1. An image of an electric bus developed by Hybricon.

The transport system

Umeå will continue planning sustainable infrastructure for goods transportation, based on the transport route concepts of the Bothnian Green Logistic Corridor from north to south, and the Nordic Logistic Corridor (NLC) from east to west. The port of Umeå shown in *Figure 5C3* togheter with the NLC railway terminal are important multimodal nodes. North of Umeå, a new coastal railroad is proposed. It will connect Umeå with its neighboring city Skellefteå and the rest of northern Sweden, thus reducing the need to use road transport. The eastward connections to Finland and the neighboring city of Vasa is planned to be improved with a new liquid natural gas driven ferry shown in *Figure 5C2*, meeting the standards of the EU sulphur directive active from 1 january 2015 (Directive 2012/33/EU).

Figure 5C2. A prototype image of a LNG-driven ferry. A well-functional ferry link between Umeå and Vasa (Finland), across the gulf och Bothnia, shortens east-west transport distances radically compared to land solutions.

Figure 5C3. An overview picture of the port of Umeå located in Holmsund. Today the railway connection is fully electrified providing sustainable multimodal transport solutions. Midway Alignment of the Bothnian corridor is an EU-financed project aiming at promoting relations between the strong and fast-growing regions around Umeå through a LNG-powered ferry.

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