BrennerLEC

Brenner Lower Emissions Corridor

The BrennerLEC Project Team

The aim of the Brenner Low Emissions Corridor (BrennerLEC) was to make traffic along the Brenner axis more respectful of the local population's health and compatible with the geographical features of the land, to protect the particular Alpine environment crossed.

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In addition, the project also planned to tackle the wider challenge of increasing safety, increasing capacity and optimising traffic flow, reducing the environmental impact of the traffic and ensuring minimum inconvenience to road users.

A low emissions corridor (LEC) was implemented along a test stretch of the A22 motorway. The LEC used motorway traffic control measures to reduce emissions of air pollutants generated by transit traffic without restricting the circulation of vehicles.

Figure 1: The Brenner Motorway in Italy.

The five-year project started in September 2016 and concluded in September 2021

A total of nearly 5,500 hours of tests conducted during the project produced solid evidence showing the environmental, traffic flow and safety benefits of the control measures tested.

To ensure long-term benefits beyond the life of the project, the BrennerLEC results have become the basis for the low-emission Brenner Digital Corridor, which aims to extensively replicate the tested control measures (in conjunction with other measures) on the entire A22 motorway.

In free-flow conditions:

- Reduction of about 10% of roadside NO_2 concentrations with an average speed reduction of 14 km/h
- Reduction of about 8% of CO2 emissions and 16% of NO_2 emissions in case of higher traffic volumes determining more driving conditioning

In highly-congested traffic conditions:

- Reduction of about 10% of travel times with similar traffic volumes and reduction of traffic jams situation
- Significant improvement of traffic safety conditions (accident rate nearly zero with active variable speed limits).

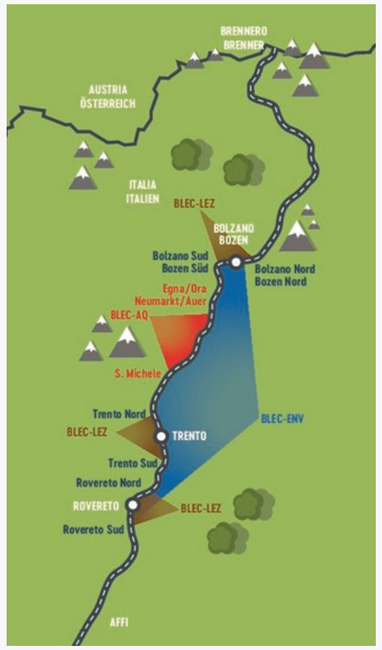


Figure 2: Areas of implementation of the BrennerLEC project.

Control measures and test areas

Location: A22 motorway stretch, 91 km long, between Bolzano North and Rovereto South (called "BLEC-ENV").

Aim: To act as a prototype for the extension of management techniques to the whole Alpine motorway section.

Three policies were tested during the project.

- **Dynamic road capacity management (BLEC-ENV)** to reduce speed limits according to levels of traffic flow and temporarily introduce an additional third lane during busy periods.
- **Dynamic speed limits management (BLEC-AQ)** to be applied to light vehicles according to current and forecast air quality conditions.
- **Dynamic integrated traffic management (BLEC-LEZ)** to improve coordination and management of travel information channels in urban areas to guide road users on recommended routes.

Actions had to be proportional to their potential to give positive results. For example, only when real-time and predicted traffic, weather, and air quality conditions indicate that **variable speed limits** are likely to achieve valuable benefits should they be used.

The Problem

Air pollution damages human health, costing the European economy between €427 and €790 billion per year.[1]

European city authorities are implementing low emission zones (LEZs) to reduce air pollutants produced by urban traffic. The most polluting vehicles are regulated within LEZs, where they may have to pay a fee to enter or may not be permitted to enter at all.

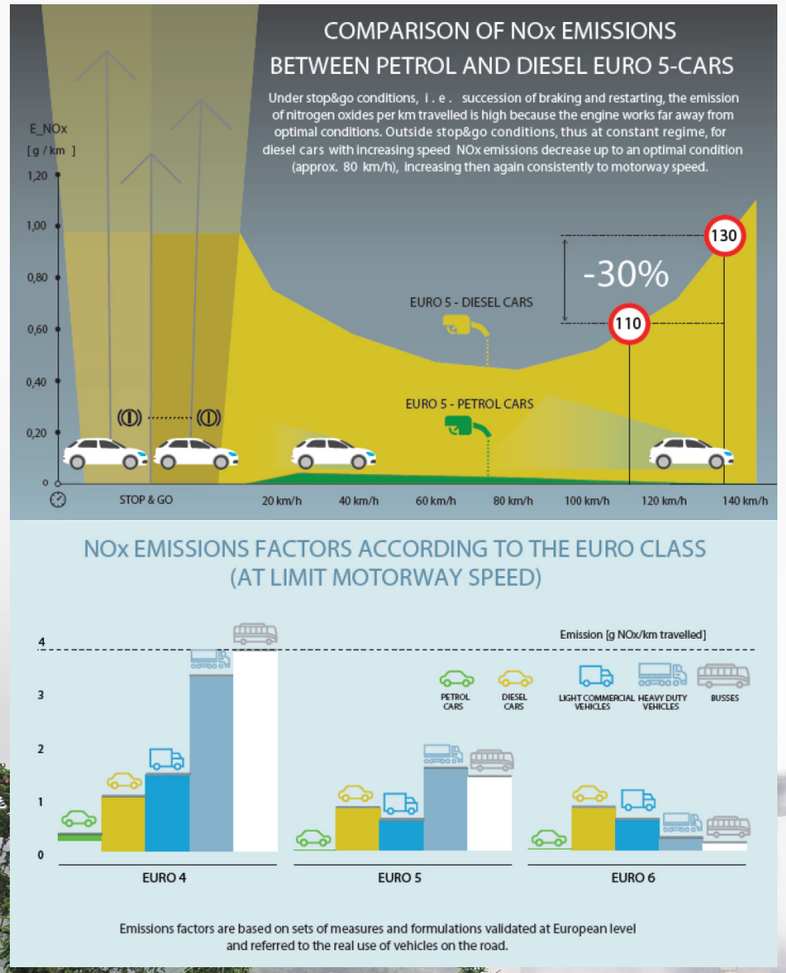
Smaller urban areas and mountainous regions like in the Alps need alternative or additional solutions.

1 CAFE Reference Documents. European Commission. [Online] https://ec.europa.eu/environment/archives/cafe/general/keydocs.htm.

Figure 3: View of Bolzano from above.

During the summer, the air at the bottom of valleys is generally clear. When the sun shines, and the wind blows, a continuous exchange of air keeps pollutant levels low. In winter, the situation is reversed. The air exchange is limited, and **pollutant levels are concentrated at the bottom of valleys.**

Along streets with heavy traffic flow, especially along motorways, it is possible for the level of nitrogen dioxide emissions and other air pollutants from traffic to exceed acceptable limits established by the European Union. Exceeding these limits indicates a potential risk for human health and **can cause acute and chronic pathologies of the respiratory and cardiovascular systems and increase rates of premature deaths.**



The A22 motorway crosses the towns of Bolzano and Bressanone in the South Tyrol region and the towns of Trento and Rovereto in Trentino in Italy. The traffic is estimated to be responsible for about 60 per cent of the overall NO_x (oxides of nitrogen) emissions generated in the region.

As a result and with the input of the environmental protection agencies of the autonomous provinces of Bolzano and Trento, a local public-private consortium decided in 2016 to implement the BrennerLEC project (co-funded by the European Commission under the LIFE programme).

Proposed solution: The Brenner Low Emission Corridor

The Brenner Low Emission Corridor (BrennerLEC) project aimed to **improve air quality, help protect the climate and reduce noise.**

The 'low emission corridor' (LEC) concept was created as part of the project. **The LEC uses motorway traffic control measures to reduce emissions of air pollutants generated by transit traffic without restricting the circulation of vehicles.**

The **control measures are primarily based on variable speed limits (VSLs). They mainly target diesel passenger cars** that typically travel at higher speeds and therefore produce higher NOx emissions than heavy trucks, which already travel at the optimal speed.

The project planned to define how to use traffic management measures to create the greatest environmental and transport benefits with **the least inconvenience to road users.**

Figure 4: Emissions and emission factors on the A22.

The technological system implemented

A complex, intelligent traffic system (ITS) was created to let the traffic management centre (TMC) of the A22 dynamically activate the VSLs.

The **forecasting** function uses data integration provided by the Open Data Hub2, an open platform developed by NOI Techpark, in which all relevant sensor measurements are collected. The so-called 'traffic state machine' determines the traffic conditions on a real-time basis and **suggests different VSLs according to the congestion levels.**

To determine **when VSLs are needed to tackle high NO_2 levels,** data on traffic-generated emissions, weather forecasts and atmospheric stability, and estimations of the nitrogen oxides concentrations are evaluated.

The system also supports the dynamic integrated management of traffic flow between the motorway and the main urban centres of the region, e.g. for **re-routing transit vehicles.**

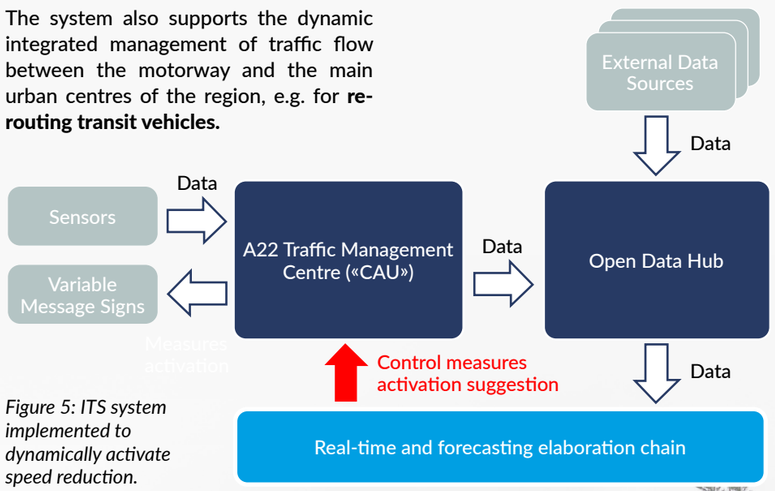


Figure 5: ITS system implemented to dynamically activate speed reduction.

Tests

Intensive testing took place over five years. Tests were mostly divided between VSLs triggered by poor air quality conditions (mainly characterised by the use of the recommended speed sign) and VSLs triggered by congestion.

Over 4,700 hours of testing was conducted on VSLs triggered by poor air quality, and over 750 hours of tests were carried out on congestion triggered VSLs. These tests happened less frequently because the necessary congestion is typically limited to the Christmas period and spring/summer weekends.

In Italy, **the activation of VSLs due solely to environmental reasons is not presently allowed.** This significantly limited the compliance rate of drivers with the VSLs and, therefore, the ability of the project to measure the impact of VSLs if they are adhered to.

'Gamification' was used to overcome this challenge. A mobile app was developed that automatically adds to or subtracts a driver's compliance points depending on their adherence to reduced speed limits on the motorway. Users with the highest number of points can win prizes. More than 100 users actively participated in the pilot, driving several times on the test stretch and collecting points; about a half managed to earn a positive score, i.e. respected on average the reference reduced speed of 100 km/h.

Results

Five years of intense testing of VSLs on the A22 motorway produced solid evidence on the benefits of this kind of measure.

Environmental

Data collected on **emission reductions associated with the average drivers' behaviour** (Table 1) show the effectiveness of VSLs in **reducing greenhouse gas emissions.**

During situations of more intense traffic volumes, that have been experienced in particular during the summer period of 2021, also the suggested speed scenario has produced interesting results with respect to the scenario BAU, in line with those of the binding speed limit scenario. However, this result is likely to be more influenced by traffic itself rather than by the proposed measure, even if vehicles respecting the suggested speed limit can have a remarkable impact on the driving patterns of the other surrounding vehicles.

Scenario	NO_x emissions scenario/BAU emissions scenario [%]	CO_2 emissions scenario/BAU emissions scenario [%]
Scenario BAU	100.0%	100.0%
Scenario suggested speed 100 km/h with low traffic volumes (real)	95.6% (-4.4%)	98.0% (-2.0%)
Scenario binding speed 100 km/h without section control (real)	83.5% (-16.5%)	91.6% (-8.4%)
Scenario binding speed 100 km/h with section control (simulated)	71.2% (-28.8%)	85.3% (-14.7%)

Table 1: Emissions' reduction associated with different reference scenarios. The reductions are compared to the reference Business-As-Usual (bau) scenario (no VSL).

Concerning roadside pollutant concentrations, **air quality measurements carried out by the environmental protection agencies have demonstrated a 10 per cent reduction of NO_2 concentrations with an average speed reduction of 14 km/h** (from 123 km/h without VSLs activated to 109 km/h).

Traffic flow

Compared to standard conditions, VSLs result in optimised traffic flow and therefore reduce traffic jams, stop&go situations and remarkable reductions in travel times. During times of or nearing congestion, the application of VSLs has the potential to increase the fluidity of traffic conditions. Estimates based from a comparison of reference days of high traffic volumes managed with and without VSLs, have shown on average **a reduction of about 10 per cent of the overall travel times** experienced by the drivers through the test stretch in comparable traffic volumes, and the possibility to let drivers experience **similar travel times also in a condition of increase of 10 per cent of traffic volumes.** What is also remarkable is the strong **reduction of the duration of traffic jams,** which has been reduced on average of **1-2 hours a day.**

Noise reduction

As far as the impacts on noise are concerned, the high presence of heavy vehicles in the driving lane has been found to be the dominating factor in the roadside noise levels. The contribution brought by this pilot measure is estimated to be under 2 dB(A).

Road safety

The activity has also **increased the already high road safety levels,** with almost no accidents during the test activities.

Conclusion

Five years of intense testing of VSLs on the A22 motorway produced **solid evidence showing the environmental, traffic flow and safety benefits.**

The work must now be replicated on a grander scale to gain maximum, long-term environmental benefit.

Results strongly depend on the level of driver compliance: **the more the drivers respect VSLs and demonstrate a smooth driving behaviour, the greater the benefits observed.**

The value of enforcement systems was also evaluated. However, the project experience has outlined the need to encourage drivers to observe proposed VSLs voluntarily. **A reward initiative based on a gamification app – probably the first attempt of its kind worldwide in the motorway domain – has demonstrated the enormous potential to encourage driver compliance.**

A method has been proposed to **determine the most suitable motorway stretches to be managed with the BrennerLEC measures** and optimise the balance between expected benefits and necessary roadside ITS investments such as variable message signs. The work will be carried out in cooperation with the Austrian and German motorway operators. Other relevant topics will be explored, such as controlling the entering/leaving traffic flows.

This work between the current motorway situation present in different member states is also **highlighting the need to upgrade/implement the reference EU regulation** so that drivers can get a uniform experience while driving on the entire Brenner Corridor.

Future forward

To ensure long-term environmental benefit, the BrennerLEC results are the basis for the low-emission Brenner Digital Corridor, which aims to replicate these and other measures on the entire **A22 motorway.** The corridor will benefit from a future C-ITS (cooperative intelligent transport system) hybrid infrastructure.

Future connected and automated vehicles (CAVs) will automatically receive the information of an active VSL and adapt their speed accordingly. Such cooperative scenarios are under research and development, and the first pilot tests have already been conducted on limited stretches of the A22.

Annual studies show that the renewal of the vehicles driving on the A22 motorway is happening fast in terms of EURO class, but without significant variations in the share of combustion engine type. The majority of transit vehicles are diesel light vehicles, with a share that increased from 75 per cent in 2017 to 82 per cent in 2019. **A remarkable increase in 'clean' vehicles** (e.g. newer EURO-6, hybrid or full-electric passenger cars) **is expected in the coming years.**

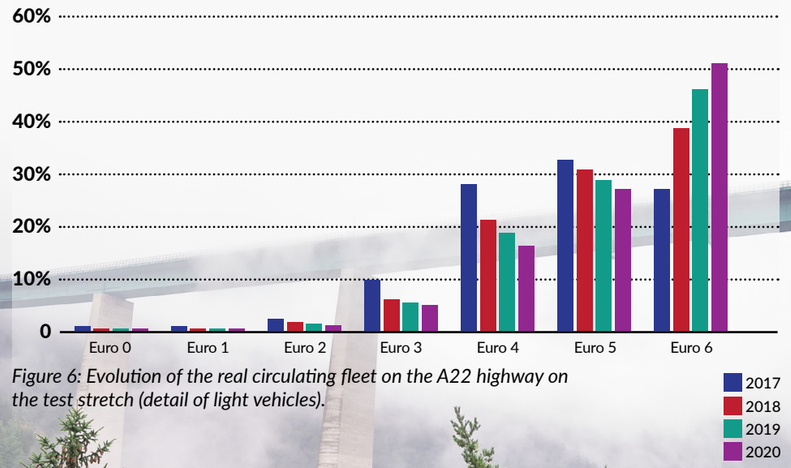


Figure 6: Evolution of the real circulating fleet on the A22 highway on the test stretch (detail of light vehicles).

The proposed plan for the extensive application of VSLs considers these challenges. It aims to ensure the best possible balance between expected impacts and the investments needed.

A method has been proposed to use VSLs for air quality purposes

- Calculate a detailed map of the average background pollutant concentrations, i.e. without the contribution produced by the traffic on the A22 motorway.
- Evaluate the average air quality conditions in correspondence of the motorway.

Applying this method will result in most VSLs being implemented within the most populated areas subject to the most significant air quality issues. As far as the VSLs in case of heavy congestion levels are concerned, the plan is firmly based on the ambition of the A22—to provide a hard shoulder running (HSR) on both carriageways between the toll gates of Bolzano South and Verona North (approx. 140 km) and variable message signs (VMS) at close distance.

Figure 7: New test stretches proposed.

Partners

Autostrada del Brennero has been the builder and manager of the A22 motorway since 1959 and has so experience in the management of a motorway in close contact with the Alpine environment. It also has to face daily problems related to the management of heavy goods and tourist traffic.

Agencies for the environment of Trento and Bolzano are provincial authorities for the control and management of air quality and responsible for the planning of the environmental protection policies.

The University of Trento provides scientific competence in environmental engineering, particularly in meteorology and the management of mathematical forecasting models.

CISMA are a local company specialising in environmental assessments and the development and use of complex calculation algorithms to implement decision support systems.

NOI Techpark is a technological innovation centre supporting the local industry with specific competencies in the 'smart mobility' field and with several experiences in the management of EU projects. NOI Techpark has substituted IDM Südtirol / Alto Adige in the consortium since 1.1.2019.

The project was also supported externally by observers with technical and strategic value. Among them, the **Environmental Ministry,** the **Transport Ministry,** the **Austrian motorway operator (ASFINAG)** and the **Agencies for the environment of the Lombardy, Emilia Romagna and Veneto regions.**

BRENNER LEC lower emissions corridor

PROJECT SUMMARY

The project is carried out with the aim of creating a concept of 'lower emissions corridor' (LEC) for the A22 motorway by implementing and validating a set of policies having the goal to provide clear environmental benefits in terms of air quality, climate protection and noise abatement, i.e. dynamic road capacity management, dynamic speed limits management and dynamic integrated traffic management.

PROJECT PARTNERS

The project coordinator is Autostrada del Brennero (Brenner motorway), based in Trento. The other partners are the agencies for the environmental protection of the autonomous provinces of Trento and Bolzano; the Department of Civil, Environmental and Mechanical Engineering of the University of Trento; NOI Techpark, South Tyrol's technology park; and CISMA, a company specialised in solutions to solve environmental issues. Both NOI and CISMA are based in Bolzano.

PROJECT LEAD PROFILE

Autostrada del Brennero is a public limited company operating under a public services scheme with the main aim of promoting, planning, constructing and operating tollways, including the A22 motorway.

It also promotes intermodal freight transport and railway transport and is sensible to environmental issues, fostering the construction of e-chargers and refuelling stations for alternative fuels (hydrogen, bio-LNG, CNG, LPG).

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