LIFE Project Number

LIFE15 ENV/IT/000281

Final Report

Covering the project activities from 01/09/2016 to 30/09/2021

Reporting Date

30/09/2021

LIFE PROJECT NAME or Acronym

BrennerLEC

Data Project

Project location:	Autonomous Provinces of Trento and Bolzano (Italy)
Project start date:	01.09.2016
Project end date:	30.04.2021 **Extension date:** 30.09.2021
Total budget:	€ 4.018.005
EU contribution:	€ 1.922.772
(%) of eligible costs:	58,07%

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2. List of key-words and abbreviations

AQ: Air Quality
ANPR: Automatic Number Plate Recognition
BAU: Business-as-Usual
C-ITS: Cooperative Intelligent Transportation Systems
DSS: Decision Support System
EC: European Commission
GUI: Graphical User Interface
HSR: Hard Shoulder Running
KPI: Key Performance Indicators
ITS: Intelligent Transportation Systems
MaaS: Mobility-as-a-Service
PM: Particulate Matter
PMT: Project Management Team
PCT: Project Core Team
TCC: Traffic Control Centre
TMC: Traffic Management Centre
ULP: Ultra Low Power
VMS: Variable Message Signs
VSL: Variable Speed Limits

3. Executive Summary

3.1. General progress

The long-term objective of the BrennerLEC project is the creation of a holistic concept of "**Low Emission Corridor**" (LEC) for the A22 highway, based on a set of different **dynamic traffic control measures** that have the goal to obtain a better compromise in terms **of better traffic fluidity** and **reduced environmental impact**. The measures cover primarily **dynamic VSL**, that are applied on one side to reduce air pollution caused by excessive NO_2 concentrations, and on the other side to reduce stop&go situations during heavy-congested traffic conditions. Another measure developed is the **dynamic integrated traffic management**, which aims to advance the management of highway traffic in correspondence of urban areas as a function of the current and predicted conditions covering both cities and highway.

The project successfully managed to **test and quantitatively assess** the impact of these measures developed in Actions B3, B4 and B5, technologically aided by the **complex ITS system** implemented within Action B2 (roadside equipment, back-end software components) and supported by the **forecasting tools** developed in Action B1. The results obtained are briefly summarized in Table 1.

Indicator	Expected Result	Achieved Result
Dynamic VSL driven by air quality conditions	• Reduction of NOx emissions of about 20% • Reduction of CO_2 emissions of about 10% • Reduction of NO_2 concentrations of about 10% • Improvement of state-of-art efficiency of existing measures	• Reduction of NOx emissions of about 10-15% (up to 25% possible) • Reduction of CO_2 emissions of about 5-10% (up to 13% possible) • Reduction of NO_2 concentrations of about 10% empirically confirmed • Maximal efficiency reachable through system configuration
Dynamic VSL driven by traffic conditions	Reduction of emissions of about 40%	Reduction of emissions in the order of 5%. Travel times reduced in the order of 10-15%
Dynamic integrated traffic management measures	Reduction of emissions of about 40%	Reduction of emissions in the order of 5%.
Development of a proactive system	Real-time traffic and air quality forecasting with DSS	Proactive system implemented as planned
Definition of an executive exploitation plan	Replication plan on the entire Brenner Corridor	Replication plan produced, with focus on the A22 highway
Preparation of a set of reports and guidelines	Including concrete recommendations on how to replicate the project measures	Recommendations include in particular the set-up of the dynamic VSL driven by air quality conditions
Level of information of local population	At least 50%	About 56%, measured through surveys
Level of acceptance by local population	At least 50% of the surveyed population	More than 55%, confirmed by the different surveys carried out
Level of acceptance by highway drivers	At least 70%	Between 55%-65%, according to the different surveys carried out

Table 1: Expected vs achieved project results.

The **application of VSL for environmental purposes** carried out in Action B4 is the measure that demonstrated the most tangible results in environmental terms, in particular during the first pilot phase in which the level of compliance registered the highest values. The empirical measurements confirmed the significant reductions' expectations in terms of emissions and NO_2 concentrations. Through properly calibrated simulation models it was also possible to quantify the improvement potential in case of "ideal" full compliance of VSL: in this case the reduction of NOx emissions is in the order of 25% and of CO_2 emissions in the order of 13%.

The **application of VSL driven by traffic conditions** carried out in Action B3 also confirmed its great potential to improve the traffic fluidity during nearly-saturated traffic congestion situations. Despite the testing sample was significantly smaller than those collected in Action B4, the measure clearly demonstrated a benefit in terms of reduction of travel times, estimated in the order of 10-15%. On the other side, the reduction of emissions per vehicle was estimated to be quite smaller than what expected, and limited to 5%. This result could however be underestimated, since the emissions' calculations tools used are not properly suited to exactly calculate emissions in correspondence of stop&go situations. The improvements associated to the **dynamic integrated traffic management measures** are estimated to be in the same order of magnitude.

A large set of **dissemination and networking activities**, much broader than what originally planned, was of strategic importance for ensuring a proper **acceptance by users and stakeholders** and for putting the basis for a replication after the project's end. All thh KPI related to the activities carried out in Actions D1 and D2 are therefore significantly overcome. **About 55% of the interviews** carried out during the last project survey revealed to be **informed about the project** and to **accept the proposed measures**, in line with the initial target. The project also demonstrated the great potential of a **stick & carrot approach** to properly obtain high compliance values of VSL. A **gamification APP that rewarded drivers** as a function of their average speed travelled was successfully tested, and despite it did not allow to reach significant usage numbers to get visible results in terms of speed compliance it clearly confirmed how such a measure could be proposed in the future together with enforcement measures to obtain the desired compliance and acceptance results.

All the empirical results and experience collected during the implementation of the project were the basis for the ambitious **replication strategies** identified in Action B6 and then converted in concrete activities in the **after-LIFE plan** produced in Action E1. Thanks to a scientific methodology the most sensible areas in terms of NO_2 pollution crossed by the A22 highway were identified for the application of the **dynamic VSL triggered by air quality conditions**, which revealed to be the areas near the cities of **Bolzano**, **Bressanone**, **Trento** and **Rovereto**, together with a small section in the **Bassa Atesina** area. As far as the **dynamic VSL triggered by traffic conditions** are concerned, this is linked with the planned extension of the stretch enabled to activate the HSR measure, i.e. **Bolzano South (km 85+327) -Verona North (km 225+372)**, for both directions of travel. The maintenance and further extension of the scope of **dynamic integrated traffic management measures** after the project's end is confirmed by the **agreement** signed with the reference **road operators in the Province of Bolzano.** The intention to immediately implement the after-LIFE plan is formally confirmed by a **new partnership agreement** signed by all project beneficiaries. Related **maintenance and investment costs** will be ensured by **Coordinating Beneficiary A22**, in absence of other co-financing sources. Finally, Action B6 produced **several recommendations** for the **improvement of current EU regulations and policies**.

3.2. Identified deviations, problems and corrective actions taken in the period

During the implementation of the project, the main following issues emerged and the corresponding deviations and recovery plans were put in place (listed in order of importance):

- **Impossibility to use speed limits since the second pilot phase of Action B4**. Due to strong pressure by the **Traffic Police**, the General Direction of Coordinating Beneficiary A22 decided to carry out the following pilot phases in the **"recommended speed" modality**, instead of using VSL. As a matter of fact, the **Italian Rules of the Road** do not allow a reduction of speed limits for environmental purposes. The grant originally received by the **Italian Ministry of Transportation** for implementing this pilot measure was put in to discussion due to changed boundary conditions, in particular at political level and in terms of contacts and relationship with the Ministry. Moreover, the Coordinating Beneficiary A22 is still currently involved through its shareholders in a negotiation with the Ministry for the **renewal of the motorway concession**, therefore the General Direction of Coordinating Beneficiary A22 at present is not in the condition to implement actions which are outside of the current legal framework. Despite this, the project put in place during the execution of the project several recovery actions to ensure on one side a **change in the current national regulation**, so to allow the application of VSL also for environmental purposes, and on the other side to **increase the compliance of the road users** to the recommended speed signal. All this was implemented in an **increase of the amount of dissemination and networking activities** and initiatives. A proposal for changing accordingly the Italian Rules of the Road is currently in consolidation phase, thanks to the commitment of the **Italian Ministry of Environment**. On the other side, the communication and awareness- raising measures implemented helped to obtain acceptable compliance values of VSL, even if clearly lower then those obtained in the first pilot phase.
- **Explosion of COVID-19 pandemic**. In March 2020 project beneficiaries started to immediately consolidate a **recovery plan** for properly manage the explosion of the COVID-19 pandemic, which had dramatic effects on the A22 highway traffic, in particular during the first months of lock-down. The nearly total absence of light vehicles determined the impossibility to carry out tests for many months. The plan agreed with the European Commission (**amendment nr. 3**) was mainly to **extend the project duration** up to September 2021, so to have the entire summer season 2021 to complete the final testing activities. The plan revealed to be successful, in particular for Action B3 where the trigger is given by nearly-congested traffic conditions. The COVID-19 pandemic determined also **additional implementation effort** for the ITS system, e.g. a new methodology to predict traffic was introduced, since it became much more unpredictable. On the other side, the COVID-19 pandemic gave the unique possibility to observe certain situations that otherwise could be impossible to observe, i.e. the level of pollution caused by a highway traffic characterized by only heavy vehicles. Thanks to this, a **much better calibration of the entire system** was possible.
- **Choice of a more efficient solution for the installation of the VMS for the final test sites setting**, which determined a remarkable deviation in the overall financial budget plan, in particular as far as durable goods' investments are concerned. The launch of the second test phase highlighted the need to install **some additional VMS** and to **extend the BLEC-AQ stretch** so to provide a more adequate information to road users and ensure a better compliance of applied VSL. This modification gave the possibility to **extend the scope of the overall pilot activities** originally foreseen and to have a **highway section in which a complete application of all VSL measures** (triggered by air quality / traffic) **can coexist**.

- **Safety issues related to the usage of HSR running**, which determined the impossibility to test this kind of measure, despite all the effort put in place, it has not been possible to test this measure in practice during the whole project period. The first issue that was encountered was related to the **involvement of the rescue teams**, who required further emergency procedures details. The **recovery plan** presented in the **Mid-Term Report** proposed to **postpone** the testing activities of these measure to the **following test phases**, while completing all the additional safety assessment analysis with the rescue teams. The kick-off of the testing of the HSR was planned for **December 8th 2019**, but unfortunately an accident in the wrong place just before the activation of the measure did not give the possibility to test it. The next occasions of testing the HSR would have been in the spring 2020 but unfortunately the explosion of the **COVID pandemics** determined the presence of traffic volumes which were not sufficient for its activation. Project beneficiaries decided therefore to **concentrate just on the VSL measure**, whose testing was also significantly jeopardized by the COVID emergency. Project beneficiaries committed to consider the testing of this measure in the **after-LIFE plan**, coupled with the activities of the extension of the VSL measure to a broader stretch of the A22 highway.

4. Introduction

4.1. Description of background, problems and objectives

The **Brenner motorway (A22)**, which runs through the Trentino-Alto Adige Region region, is of fundamental importance for the commercial relations between Italy and Northern Europe and is the transit axis of goods and passengers of great importance for the of the entire Alpine region. Recent studies carried out also an inter-regional level indicate the state of particular environmental suffering in the Alpine valleys. **Road transport** is responsible for **60% of regional emissions of NOx**; the major emission source is **highway traffic** with **41%**. That's the reason why as long as there is no appreciable reduction in the NOx emissions produced by highway traffic, the measures taken at local level are not sufficient to ensure compliance with the limit value in all parts of the territory by the date laid down in Directive 2008/50/EC. Regional road transport is also responsible for **more than 42% of CO_2 emissions** (**30%** if only **highway traffic** is considered). The hypothesis to be demonstrated / verified by the project is related to the **environmental assessment**, in the specific domain of interest, of the **impact of some pilot traffic control measures** that try to address these issues. The proposed measured cover in particular the application of **VSL** and **HSR running**, as well as a **better coordination of traffic control strategies** between different road operators. Such measures are extensively applied in whole Europe but not in Italy, and there is a wide evidence about not only their associated environmental contribution but also their improvement to the efficiency in the usage of the road network. State-of-art strategies identified for the solution of these challenges is mainly related to fuels and the technological progress of motors, but numerous studies and projects in the field of ITS have shown that a remarkable contribution can be also obtained with a reduction of vehicular speeds with an increased fluidity of traffic. The implementation of the project is based on the knowledge gained from experience in reducing motorway speed limits in other contexts (in particular in nearby Austria), but proposed to make a significant step forward, overcoming the **"reactive" approach** (measure activation when a problem has already occurred) and experimenting for the first time a real **"proactive" approach**, in which the activation of the measures are based on top of accurate forecasts.

4.2. Expected longer term results

The ambition of the project is to put the basis for a **full-scale application** of these pilot measures not only in the scope of the alpine stretch of the A22 highway, but ideally to the **whole alpine Brenner corridor Kuftstein – Affi** (so called "**Alpine BLEC**" stretch). This follow-up process was determined in the **exploitation plan** produced in the scope of Action B6.

The project, by virtue of its innovative character and its strategic relevance, aims to provide a **technical, operational and scientific contribution** to the **improvement of current state-of-art policies**, promoting measures that have a clear cost/benefit balance. Thanks to the relevant **networking** activities scheduled during the project, the project aims to prepare the basis not only for its **exploitation**, but also for its **replication** – in particular, at national level in which such measures are still little used and in some cases not admitted by current traffic laws.

In particular, the **replication in the Po basin area** where the problem of air quality due to traffic is very significant is of upmost importance, and will evaluated in strict contact with the **LIFE PREPAIR** integrated project.

The project is expected also to significantly contribute to the development of the **EUSALP policies**, according to the four principles that have been identified: (i) promotion of local economic development, innovation and research and development; (ii) increase in the connectivity of the macro-region, in a perspective of inter-modality (to be fully exploited when

the Brenner Basis Tunnel will enter into force); (iii) environment preservation, capable to efficiently address climate changes; and (iv) macro-regional governance. The objective is to foster a coordinated replication and further development of the pilot measures across the whole Alpine Region, with an increased involvement of local companies and competence centers that could bring to a further strengthening of the local know-how.

Last but not least, the results of the projects can lead to a **future improvement of the EU policies in different domains**, in particular the environmental (air quality and climate changes) and transportation ones. Such desirable effects are supported by the beneficiaries that are more directly involved in the work of policy-development, i.e. APPABZ and APPATN in the environmental sector and A22 for the transportation one (in limitation of its role of road operator).

5. Technical part

5.1. Action A1

Foreseen start date: 01/12/2016 **Actual start date:** 01/12/2016
Foreseen end date: 30/08/2017 **Actual end date:** 30/10/2017
Activities undertaken and quantifiable outputs achieved:
All scheduled preliminary **analysis** foreseen in sub-action A1.1 were successfully performed. All stakeholders' needs were properly investigated, use cases were jointly defined, the overall system architecture was designed and all relevant functional / non-functional requirements were identified. The output of this analysis is documented in deliverable D.A1.1.
Technical preparatory activities foreseen in sub-action A1.2 were completed. Associated Beneficiary IDM managed to prepare the **central data management system** to be then further implemented in Action B2. The prototype developed in the LIFE+10 ENV/IT/389 INTEGREEN project was transformed to a more reliable and scalable data management platform now called "**Open Data Hub**". Detailed analysis of all relevant ITS systems were performed, and the protocols and modalities for the automatic data transfer between all involved systems were selected and agreed, as documented in deliverable D.A1.1.
The **preliminary test areas preparation** of sub-action A1.3 was successfully completed, so to guarantee the execution of the first pilot tests foreseen in Actions B3, B4 and B5. In particular, **traffic and air quality monitoring stations** were installed along the roadside, and **first additional VMSs** as well as other relevant **road signage** were positioned (Figure 1). Air quality measurement **instruments** were purchased and installed, after proper inter-calibration activities organized in strict cooperation between APPABZ and APPATN. For more details on this please refer to Action C1.

Figure 1: Fixed road signage for the indication of the begin / end of test road stretches.

The **diagnostic and forecasting modelling chain** of the BrennerLEC system (sub-action A1.4) was defined and designed in all its different components. State-of-art forecasting models were evaluated so to understand their potential of applicability for the specific application scenario. Further details on this are highlighted in Action B1. Thanks to an intense networking work carried out by beneficiaries A22 and APPABZ in November 2016 the **Italian Ministry of**

Transportation granted the freedom to A22 to test dynamic speed limits triggered by air quality conditions (sub-action A1.5). Thanks to this **formal statement**, A22 had the possibility to internally define a decree which has officially launched the pilot tests on the A22 highway. The decree finally entered into force on January 26th 2017.

Comparison with planned output and time schedule:
The number of preparatory activities revealed in practice the need for two additional months with respect the original temporal plan for properly completing all scheduled tasks. All action milestones were achieved, as summarized in Table 2.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Autorizzazione ministeriale acquisita ed ordinanze predisposte	11/2016	01/2017	Achieved	An additional decree by A22 was needed to formally allow the tests' execution
Architettura di sistema definita, requisiti identificati, catena previsionale progettata, siti di test allestiti	08/2017	10/2017	Achieved	Pilot test areas were prepared with all essential elements needed for the tests. Installation of innovative air quality sensors postponed in Action B2.
Protocolli ed interfacce di scambio dati definiti	02/2017	10/2017	Achieved	-

Table 2: Planned and actual milestones' achievement for Action A1.

Deliverable	Submission	Status
D.A1.1 – Resoconto sulle attività di preparazione tecnico / amministrativo	1st Progress Report	Submitted to EC

Table 3: State of submission state of Action A1 deliverables.

Problems, deviations and recovery plans:
The main deviation was related to the **purchase and installation of innovative air quality sensors**. Initial project activities highlighted an increased need for initial investigation activities, in particular as far as the accuracy of the data collected by such sensors in comparison to reference air quality stations. This has led to the decision to establish a cooperation with CNR (Consiglio Nazionale delle Ricerche), which provided open monitoring units that can be completely configurable and controlled and a scientific support in such correlation assessments. The complexity of this matter and the willingness to use this technology also in a perspective of project exploitation encouraged project beneficiaries to devote additional time on this activity with respect to the original plan. A much deeper understanding about the functioning of these sensors was collected in 2018 thanks to first tests installations. The installation of the low-cost sensors was finally completed in the scope of Action B2 (sub-action B2.1) in the first months of 2019.

Synergies with complementary action outside LIFE:
The initial analysis completed in Action A1 also took into consideration the future use cases that could be implemented with the advent of **cooperative and autonomous driving** technologies into the market. The deployment of such technologies on the A22 highway side is currently undergoing in a certain number of EU projects co-financed by the CEF and H2020 programs of the European Union in which coordinating beneficiary A22 is involved, namely

C-Roads Italy, **5G-Carmen** and **ICT4CART**. In particular, the **direct transmission of in-vehicle signage and speed limits to the vehicles' on-board systems** is one of the so-called "Day 1" use cases identified by the EC and therefore concrete implementation synergies are already foreseen in the scope of the BrennerLEC project, as better described in Action B2.

Perspectives for continuing the action after the end of the project

Action A1 is functional for the B-implementation activities. Sub-action A1.1, A1.2 and A1.3 have a natural follow-up in Action B2, sub-action A1.4 in Action B1 and sub-action A1.5 in Action D2. In the replication plan of the project such activities will be further carried out, in particular:

- the blueprint development and requirements definition activities of sub-action A1.1 will be mainly continued in task 4.1 of the replication plan in order to extend the system architecture to the entire Brenner Corridor;
- the real-time data interfaces analysis activities of sub-action A1.2 will be continued mainly in task 2.4 of the replication plan (continuous expansion of the Open Data Hub platform);
- the test sites preparation of sub-action A1.3 will be continued mainly in WP3 of the replication plan, in which the new road stretches are going to be prepared;
- the evaluation and design of the forecasting system of sub-action A1.4 will be continued mainly in tasks 2.5, 2.6 and 2.7 of the replication plan, in which the forecasting tools will be continuously enhanced and improved in order to support the implementation of the different traffic control measures.

The request of the ministerial authorization (sub-action A1.5) is not going to be continued as such in light of the developments that have taken place during the project. Within task 6.3 of the replication plan a direct contact with the reference national authorities is going to be ensured in order on one side to guarantee an efficient implementation of the measures on the A22 highway, but also to support the upgrade of the current regulation.

5.2. Action B1

Foreseen start date: 01/12/2016 **Actual start date:** 01/12/2016
Foreseen end date: 31/12/2019 **Actual end date:** 31/12/2019

Activities undertaken and quantifiable outputs achieved:

The individual components of the traffic, emissions and air quality forecasting modelling chain (sub-action B1.1) were successfully implemented by CISMA and UNITN. The chain, initially used in **diagnostic** mode to carry out the analysis of the existing and the calibration of the individual components, is designed to operate in **prognostic** mode. The **traffic model** is based on the identification of typical traffic days in A22 (e.g. working / non-working day, presence / no presence of tourist flows), derived from the analysis of historical data, from which it is possible to obtain traffic composition and frequency distribution of vehicles speeds. The **emission model** estimates vehicular emissions based on traffic data and by applying the European COPERT methodology, after a detailed evaluation of the vehicle fleet traveling on the A22 highway (see Action C2.1 for details). The chosen **meteorological model** is WRF, which results can be downscaled by means of CALMET when a finer spatial resolution is required. The selected **air quality model** is R-line, which is deemed to better fit system requirements in comparison to other previously evaluated software like AUSTAL or AERMOD. The model calibration was performed by means of data collected by passive AQ sensors installed within the project in the BLEC-AQ stretch. The appropriate calibration coefficients were identified and adopted inside the modelling chain. Data collected during the first testing phase of Actions B3 and B4 allowed to identify an algorithm to evaluate the optimum **dynamic speed limit**, able to maximize traffic flow.

The final integration of the modelling chain with the entire system architecture (sub-action B1.2) was successfully completed. The modelling chain is fed up with real-time measurements collected by the different roadside monitoring systems and provides as output the proposed dynamic speed limit to be activated.

Comparison with planned output and time schedule:

Initial poor information about the emission characteristics of vehicles driving through the highway required an additional effort to properly calibrate the emission model. Moreover, the initial lack of homogeneity of traffic data collected by different inductive loops hindered the calibration of the components of the modelling chain. For this reason, the implementation of sub-action B1.1 took more effort than initially planned.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Componenti della catena modellistica sviluppate	05/2018	09/2018	Achieved	-
Catena modellistica integrata nella piattaforma centrale	12/2019	12/2019	Achieved	-

Table 4: Planned and actual milestones' achievement for Action B1.

Deliverable	Submission	Status
D.B1.1 – Il prototipo della catena modellistica del sistema BrennerLEC	Mid-Term Report	Submitted to EC

Table 5: State of submission state of Action B1 deliverables.

Problems, deviations and recovery plans:

European and national legislations establish health-based standards and objectives both for short and long term exposure to nitrogen dioxide. With regard to acute effects, the aim of 1-

hour standard is to protect **public health** by limiting people's exposures to short-term peak concentrations, which primarily occur near major roads. The analysis of measured data showed that the 1-hour threshold value is substantially never exceeded, not even at the air quality monitoring stations along the A22 highway. For this reason, for people living near the highway long-term exposure to high concentrations becomes more relevant than short-term peaks that this short-term forecasting system is able to predict. Therefore, it was decided not to go into detail on the application of dose-response relationships for short-term evaluation. Evaluations of the impact on the human health were limited to Action C2.

Synergies with complementary action outside LIFE:
The traffic and air quality forecasting models developed in this action are fully compatible with those used in local air quality plans and in particular in the NO_2 restoration plan of the Province of Bolzano. This allows a complete consistency between the pilot measures investigated in the scope of the BrennerLEC project and other measures that the Provinces of Bolzano and Trento have identified in order to tackle the excessive concentrations of nitrogen dioxide.

Perspectives for continuing the action after the end of the project
After the end of the project the correct functioning of the modelling chain requires a continuously update of the dataset needed for its calibration, mainly the emission factors update in the COPERT methodology and the vehicle fleet composition. A continuous implementation work of the components of the modelling chain is guaranteed by associated beneficiaries CISMA and UNITN, being this part of their core business / research activities. This activity is explicitly foreseen in the project replication plan (mainly task 2.5). Future developments include the possibility to real-time calibrate the modelling chain thanks to novel monitoring systems (e.g the ones investigated in the scope of the LIFE16 ENV/ES/000082 GySTRA project) and to further improve the accuracy and the efficiency of the algorithms for the recommendation of the dynamic speed limits.

5.3. Action B2

Foreseen start date: 01/03/2017 **Actual start date:** 01/01/2017
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
The installation of the **VMS network on the A22 highway** foreseen in sub-action B2.1 was successfully completed by Coordinating Beneficiary in May 2018. The initial activities highlighted a valuable alternative plan leading to minor costs, less environmental impact and minor inconveniences to highway traffic. Therefore, the choice was to install on the highway 9 **ULP VMS**, i.e. ultra low power VMS being powered through solar panels. Additional 3 VMS based on this technology were installed in 2020. For more details about this implementation choice please refer to the "Problems, deviations and recovery plans" section of this paragraph and to paragraph 8.1 of this report.

The installation of the **network of low-cost air quality sensors** along the A22 highway, postponed from Action A1, was successfully completed in March 2019 by Coordinating Beneficiary A22. Thirteen sensors were installed in different locations of the BLEC-ENV stretch: two of them in correspondence of reference air quality stations in order to continuously monitor the accuracy of the collected measurements, nine in correspondence of VMS, and two on poles powered with solar energy (Figure 2).

The installation of the **network of the Bluetooth sensors** on the extra-urban regional network by associated beneficiaries IDM / NOI and CISMA also suffered of delays, mainly caused by the regional road operators responsible of the infrastructure in which the sensors were intended to be installed. In 2019 the first installations were completed in the Municipality of Bolzano. The network of sensors in the area of Trento was completely deployed at the beginning of 2021, with additional sensors installed in cooperation with the Municipality of Trento in the last project months. Sensors in the regional network of the Province of Bolzano were been installed, in light of the decision of the regional authority to upgrade the existing traffic monitoring system with also this technology through a separate tender. The activity was therefore transformed in a data integration activity which is going to be completed in the after-LIFE period. By also considering these monitoring points, the project managed to install 30 sensors, on the entire axis Brennero – Rovereto, i.e. the reference alternative road to the A22 highway.

Figure 2: Low-cost air quality sensor (on the left) and Bluetooth sensor (on the right).

Based on the different data available a **web-application** with the **visualization of the real-time travel times** on the A22 highway and on the extra-urban regional network was also implemented in sub-action B2.2. The public launch of this tool will be particularly important in the after-LIFE activities, once the coverage of the road network will be further extended to almost all italian part of the alpine Brenner Corridor. Another significant development is the **central data management system** and the linked **DSS** (sub-action B2.3), which in the condition to display on a simple interface the real-time measurements collected by almost all monitoring systems.

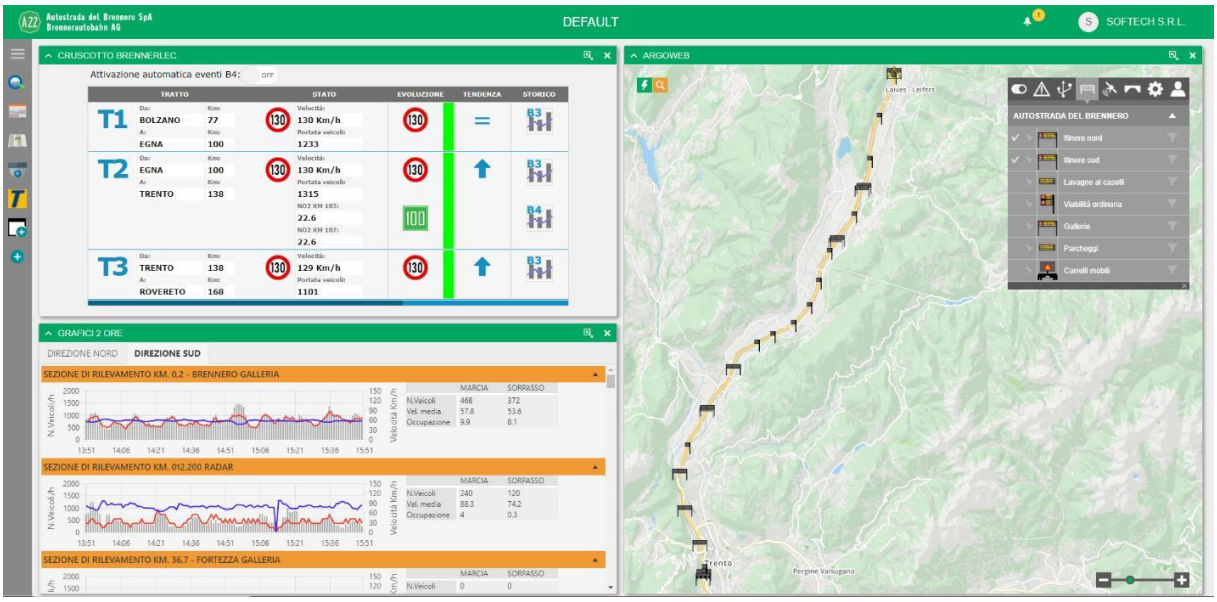

Figure 3: The DSS at disposal of the TCC operators of A22.

In the scope of the **final integration activities** of sub-actions B2.4, the DSS was integrated in the A22 dashboards that TCC assistants currently use, so to allow a smooth usage and acceptance of the new components developed. Because of the **COVID-19** pandemic, certain aspects of the forecasting chain needed to be adapted or implemented differently. In particular, a **data-driven method for the calculation of the traffic forecasts** was introduced in order to better cope with the much more unpredictable character of the traffic patterns on the A22. During the last project period several fine-tuning activities were also completed, mainly for further improving the **reliability** and the **efficiency** of the entire system chain caused by external factors associated to the COVID-19 pandemic; for example, automatic controls avoid activating VSL in case of unpredictable events such as very little light traffic measured on the highway. These efforts went even in the direction to implement a **higher level of automation** in the way VSL are activated by the TCC operators: this process is always **supervised**, but the approval was transformed in a simpler "check" of the recommendations provided by the system. This work also covered a continuous work of fine-tuning and improvement of the logics for the activation of the measures, e.g. the recommendation of speed limits in case of intense traffic volumes based on the state on the downstream section.

Comparison with planned output and time schedule:
The main deviation with the planned time schedule was mainly related to the delay in the implementation of the Bluetooth network and of the web-application with the visualization of the real-time travel times. Since the monitoring activities of Action C3 revealed no risk of traffic shift from the A22 highway to the regional network, such implementation activities was carried out differently from a temporal point of view so to guarantee a wide usage of these outputs in the after-LIFE replication phase. The final integration work were completed sooner than

expected mainly to guarantee a high acceptance in the usage of the system in particular by the operators of the TCC of the A22 highway.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Sistema di acquisizione e gestione dati implementato e sistema d'informazione all'utenza attivato	02/2018	01/2021	Achieved	The delay for the achievement of this milestone is associated to the delay in the implementation of the Bluetooth network and of the web-application with the visualization of the real-time travel times.
Sistema di supporto alle decisioni per l'operatore autostradale implementato e validazione del sistema BrennerLEC completata con successo	12/2019	12/2019	Achieved	A first consolidated DSS prototype was already available in June 2019. The validation of the BrennerLEC system was completed in 12/2019. Its empirical testing started with the kick-off of the phase 3 of the testing activities organized in Action B3.
Strategie finali di integrazione del sistema BrennerLEC definite	04/2021	12/2020	Achieved	Integration activities started earlier than expected in order to guarantee a high acceptance by TCC operators and a high potential for exploitation at the project's end.

Table 6: Planned and actual milestones' achievement for Action B2.

Deliverable	Submission	Status
D.B2.1 – Prototipo del sistema di acquisizione e di gestione dati e del sistema d'informazione all'utenza	Mid-Term Report / Final Report	Submitted to the EC. A second version including a description of the final monitoring network based on the Bluetooth sensors as well as the real-time travel times web application is submitted with the Final Report
D.B2.2 – Prototipo del sistema di supporto alle decisioni per l'operatore autostradale	Final Report	Submitted to the EC. The deliverable was already checked during the last monitoring visit in 2021.
D.B2.3 – Strategie informatiche di mantenimento ed integrazione del sistema BrennerLEC dopo il progetto	Final Report	Submitted to the EC.

Table 7: State of submission state of Action B2 deliverables.

Problems, deviations and recovery plans:
A major issue was empirically observed during the launch of the second test phase, in which **dynamic speed limits** were intended to be applied also in correspondence of the monitoring site placed **at km 107.** In this use case scenario, the first test sessions implemented in this new configuration evidenced in **direction north** only a **very low compliance rate** of the dynamic speed limits. This result was found to be correlated to the fact that due to the new VMS infrastructure configuration drivers don't see any "gantry VMS" ("*portale a cavalletto*") at the beginning of the stretch, but **only a "flag VMS"** ("*portale a bandiera*"). The publication of carefully designed text messages on the gantry VMS was found to be crucial in the compliance rate, since drivers can clearly understand that a different speed regime coupled with a speed monitoring activity is in action. The temporary expedient was to add a text message on the immediately previous "gantry VMS" placed at km 119+600, but being the advice too far away from the monitoring site the results obtained are still too poor. As a consequence, project partners took the important countermeasure to **extend the BLEC-AQ stretch** up to this "gantry VMS" and to add one further ULP VMS in the extension stretch (km 116+800, direction north). Two additional VMS installed at km 85+300 and km 127+550 were purchased as well in order to improve the information to road users traveling in direction south during situations of heavy traffic targeted by the Action B3 measures. It is important to point out that this modification gave also the possibility to **extend the scope of the overall pilot activities** originally foreseen in the proposal: in particular, it was possible to test the pilot measure tested in Action B3 (dynamic speed limits due to traffic) also in direction north and to have a **highway section in which a complete application of all dynamic speed limit measures** (triggered by air quality / traffic) **can coexist**. This has been an important empirical input for the consolidation of the exploitation plan defined in Action B6.

The implementation of the **network of the Bluetooth sensors** was hindered by several delays and external factors, mainly related to the road operators responsible for the roads in which the sensors needed to be installed. In particular, the connection with the available power supply network was the most complex activity to manage and required much more time than expected to be completed. It is important to underline that this activity is considered as of secondary importance in the economy of the project, since it does not put at risk the most important implementation activities foreseen in Actions B3, B4 and B5. Therefore, project partners managed the difficulties encountered in this implementation by considering them "non critical" and coordinating them according to this new time schedule.

Synergies with complementary action outside LIFE:
The implementation of the ICT solutions foreseen in BrennerLEC are complementary with the deployment that Coordinating Beneficiary A22 is carrying out in the scope of other EC-funded projects (see Action A1 for more details). In the scope of the **C-Roads Italy** project 58 roadside units capable of communicating data to and from vehicles were already installed based on the ITS-G5 protocol, and further 5 fixed and 15 mobile Road Side Units will be installed in the new co-funded project **C-Roads Italy 3**. Above all, A22 has started to adapt the back-end systems of its TMC in order to be able to communicate with vehicles with a short-range communication (through the ITS-G5 protocol, in case of safety-related messages) or long-term communication (through the mobile network, in case of non-safety-related messages). Since 2020 various joint demonstrations correlated with the BrennerLEC project have started. The most advanced one is the use case under implementation within the 5G-Carmen project, in which the cooperative control of vehicle emissions will be demonstrated. Since 2021 the first car makers have started to put into the market new vehicle models powered by these kinds of technologies and to enter in direct contact with A22 so to guarantee a proper reception and visualization on-board of this information. Once the vehicles will have an increased level of autonomy deployed, the

transmission of dynamic speed limits will be translated also in an automatic adaptation of the speed and as a consequence in a much higher level of compliance of such measure.

Perspectives for continuing the action after the end of the project

The activities of Action B2 are going to be a key element of the after-LIFE replication plan. In particular, the entire system implementation is going to be maintained and further enhanced in order to be able to ensure the productive application of all project measures in the new road stretches identified. This set of activities is organized within WP2 of the replication plan. The development of further C-ITS use cases will be further advanced in the scope of WP4, which deals with the harmonization of the digitalization developments with the Austrian and German highway operators.

5.4. Action B3

Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
The analysis, experimentation and calibration of the measures of dynamic regulation of road capacity and speed limits for the purpose of reducing emissions of greenhouse gases and atmospheric pollutants during periods of greater traffic flows according to the testing plan defined in the original project plan was successfully implemented. The reference VMS infrastructure is those implemented in Action B2. For a detailed overview of the position of the various VMS please refer to paragraph 8.1 of this report. An overview of the overall testing activities compared with the scheduled ones is provided in Table 8.

	Initial evaluation		**Extensive evaluation**		**Final evaluation**	
	Planned	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**
Period	09/2016 - 05/2018	Phase 1: 03/2017 - 09/2018	03/2018 - 12/2019	Phase 2: 01/2019 - 09/2019 + Phase 3: 12/2019 - 02/2020	10/2019 - 04/2021	Phase 4: 06/2021 - 09/2021
Road stretch	Trento South – Rovereto South (dir. South)	Trento South – Rovereto South (dir. South)	Bolzano North – Rovereto South (dir. South)	Phase 2: Trento South – Rovereto South (dir. South) + Phase 3: Bolzano North – Rovereto South (dir. South)	Bolzano North – Rovereto South (dir. South)	Bolzano North – Rovereto South (dir. South) + Trento South – Bolzano South (dir. North)
Support systems	Initial TCC systems	Initial TCC systems	First DSS prototype	Phase 2: Initial TCC systems (first DSS prototype since 08/2019) + Phase 3: First DSS prototype	Consolidated DSS prototype	Consolidated DSS prototype
Procedures	Non-standardized	Non-standardized + first standardized approach (since summer 2018)	First standardized approach	First standardized approach	Standardized	Standardized

	Initial evaluation		Extensive evaluation		Final evaluation	
	Planned	Actual	Planned	Actual	Planned	Actual
Nr. of test session days	12	61	40	Phase 2: 77 Phase 3: 13	Based on the system's triggers	44 (dir. South) + 26 (dir. North)
Overall test duration [hours]	-	414	-	Phase 2: 544 Phase 3: 65	-	322 (dir. South) + 167 (dir. North)

Table 8: Summary of test sessions carried out in the different testing phases of Action B3.

The **first pilot phase** (sub-action B3.1) concerned the reduction of speed limits in a limited section of the BLEC-ENV (between the Trento South toll gate and the Rovereto South toll gate, on the southbound carriageway) during days with high traffic flows. During this whole phase a much more extensive test effort than what originally planned was carried out, with reduction of speed up to 90 km/h. Most of the tests was carried out during the **summer period in years 2017 and 2018**, characterized by high volumes of tourist traffic. TCC operators started, from March to May 2017, by testing mainly a speed reduction up to 110 km/h; afterwards, from May 2017 to April 2018, speed reduction was tested up to 90 km/h. It was then agreed to carry out more tests in order to collect sufficient data to optimize the B3 measure before extending the test stretch to the 90 km foreseen by the second phase of the project. For this reason, the first test phase was extended up to **September 2018**. Since it was immediately clear that without a proper support system, the dynamic VSL activation was hard to be implemented with the tools that the TCC assistants had at disposal at the project start, project partners agreed to slightly **reorganize the following pilot phases**, as summarized in Table 9.

Pilot phase	Duration	Test characteristics
Phase 1	March 2017 – September 2018	First "non-standardized" application of VSL during days of intense traffic on reduced BLEC-ENV stretch, mainly based on the experience of TCC assistants
Phase 2	October 2018 - May 2019	First "standardized" application of VSL during days of intense traffic on reduced BLEC-ENV stretch, with initial empirical verification of procedures to be applied in the following test phases.
Phase 3	June 2019 - December 2019	Dynamic activation of VSL on full BLEC-ENV stretch based on a first prototype version of a DSS. Calibration of the modelling chain and of the organizational procedures.
Phase 4	January 2020 - April 2021	Dynamic activation of VSL on full BLEC-ENV stretch based on a consolidated DSS and consolidated procedures.

Table 9: New organization of pilot test phases in Action B3.

The main aspects to be underlined refer to the decision to **postpone the extension of the tests to the whole BLEC-ENV stretch** in the **new phase 3** by **anticipating the implementation of an early version of the DSS** to be directly integrated in the tools already in use in the A22 TCC. The first introduction of this tool for managing this type of test session is dated **August 2019**, at the **end of the second pilot test phase**. The tests carried out in August and September 2019 were fundamental to consolidate the first internal procedures for the activation of the VSL on the base of the recommendations provided by this new automated tool. This achievement was the base to extend the measure to the **full BLEC-ENV stretch**, which was started in **December 2019**. This stretch was divided into three sub-stretches (**T1**: from km 77 to km 100; **T2**: from km 100 to km 138; and **T3**: from km 138 to km 167), since they are typically characterized by heterogeneous traffic conditions. The control of the VMS in these sub-stretches is handled separately but in an integrated form so to avoid "jumps" in VSL displayed to road users.

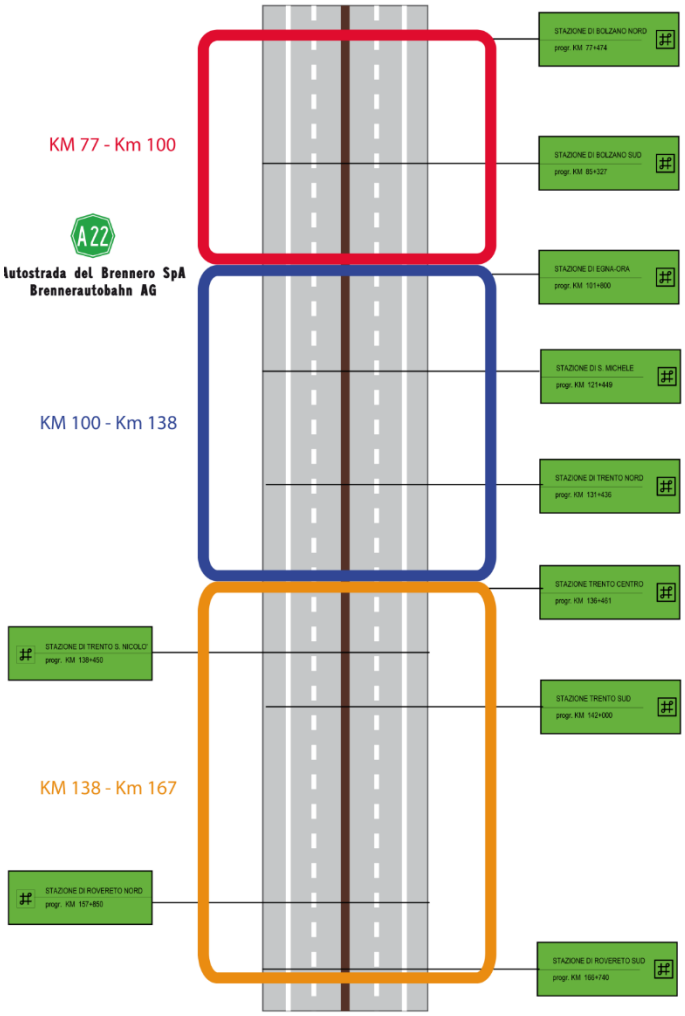

Figure 4: Sub-stretches of the full BLEC-ENV test stretch that will be separately controlled.

The duration of the third test phase was quite short since it was unexpectedly interrupted by the **explosion of the COVID-19 pandemic** in **March 2020**, which determined a significant reduction of traffic and in particular the complete disappearance of the heavy-congested traffic situations targeted by this action. In order to ensure a proper completion of the testing activities, project beneficiaries immediately defined a **recovery plan** that was accepted by the the EC through the **3rd amendment to the Grant Agreement**. The basic idea was to recover the test sessions scheduled for the summer 2020 mainly during the **summer 2021**, with the consequence

to **postpone the project's end** from April 2021 to **September 2021**. In the practice, the COVID-19 emergency unfortunately forced to restart the final testing phase only in **June 2021**. The overall period in which testing activities were not possible has ultimately been March 2020 – May 2021. The positive aspect of all this major issue has been to have an entire season (summer 2020) in which heavy traffic situations were managed without VSL, with the possibility to make more robust comparisons with the similar traffic situations experienced when the VSL were activated. The results of this analysis are presented in the summary of Action C2 activities.

During the **final testing phase** project beneficiaries also managed to start testing the measure **also in direction north**, in particular **from km 142 (Trento South) to km 85 (Bolzano South)**. In this way, it has been possible to **extensively test all the project measures dealing with VSL in both direction of travels**, namely the **BLEC-AQ stretch**.

The empirical results have suggested three main improvements to be further investigated in the after-LIFE period, namely (i) the possibility to **force the DSS to activate a VSL in an upstream sub-stretch based on the conditions of the downstream sub-stretch**. This functionality was consolidated and implemented, but never tested so far; (ii) the possibility to **further anticipate the first activation at all of the dynamic VSL**. Empirical results have shown that this is a fundamental aspect to be tackled in order to ensure an efficient stabilization of the traffic patterns, and the current logic has demonstrated that in some cases the activation recommendation is given too late; (iii) a **more visible presentation of VSL to road users even in presence of traffic events**. In case of a traffic event with higher priority, this is shown on the VMS instead of the information related to the VSL, and this has proofed to lead to inefficient stop&go situations during jams' situation. The solution that will be implemented is to always maintain the VSL pictogram displayed also in these conditions.

Comparison with planned output and time schedule:
The **objective** of **sub-actions B3.1 and B3.2** was to collect **up to the end of 2019** about **50 valid test sessions** to collect useful empirical indications for properly setting up and configure the automatic system for suggesting the optimal VSL to be displayed. **In practice**, it has been possible to carry out in this period (**up to February 2020**) **151 valid test sessions**, mainly thanks to an increased availability by the Coordinating Beneficiary in testing this pilot measure. Even if limited to a shorter period than what originally planned, the **final validation phase** with the overall system in place applied on the full BLEC-ENV stretch was considered **sufficient to consolidate the positive impacts and benefits** associated to this measure.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Prima fase sperimentale conclusa sul tratto BLEC-ENV	05/2018	09/2018	Achieved	-
Fase sperimentale estensiva conclusa sul tratto BLEC-ENV	12/2019	02/2020	Achieved	Pilot phase organized in two phases: the first one (up to September 2019) can be seen as an extension of the first pilot phase, the second one as an anticipation of the final pilot phase.
Fase sperimentale con politiche	04/2021	09/2021	Achieved	The final pilot phase could start only in June 2021 due to the

Milestone	Expected deadline	Actual Deadline	Status	Comment
ottimizzate conclusa sul tratto BLEC-ENV				changed traffic conditions caused by the COVID-19 pandemic

Table 10: Planned and actual milestones' achievement for Action B3.

Deliverable	Submission	Status
D.B3.1 – Definizione e valutazione delle politiche iniziali sul tratto BLEC- ENV limitato	Mid-Term Report	Submitted to EC
D.B3.2 – Definizione e valutazione delle politiche di applicazione estesa sul tratto BLEC- ENV	Final Report	Submitted to the EC. The deliverable was already checked during the last monitoring visit in 2021.
D.B3.3 – Definizione e valutazione delle politiche di applicazione del sistema previsionale sul tratto BLEC- ENV e considerazioni finali	Final Report	Submitted to EC

Table 11: State of submission state of Action B3 deliverables.

Problems, deviations and recovery plans:

Together with the testing of the VSL in the scope of this Action the project proposal also foresaw the **testing of the HSR**, even if in very limited way (3 test sessions during the initial phase, 6 test sessions during the intermediate phase). Despite all the effort put in place by the project beneficiaries and by the Coordinating Beneficiary A22 in particular, it has not been possible to test this measure in practice during the whole project period. The first issue that was encountered was related to the **involvement of the rescue teams** to be compulsorily involved in the implementation of this measure, who required **further emergency procedures** and additional procedures details on the communication interactions among all involved actors by considering as many as possible rescue scenarios. An active involvement of the prefect was also requested as well. The recovery plan presented in the Mid-Term Report proposed to postpone the testing activities of these measure to the following test phases, while completing all the additional safety assessment analysis with the rescue teams. The kick-off of the testing of the HSR was planned for **December 8th 2019**, which is historically a day of very intense traffic flows due to lot of Italian tourists coming back home after having visited the several Christmas markets in Trentino Alto Adige. Unfortunately, an accident in the wrong place just before the activation of the measure did not give the possibility to test it. The next occasions of testing the HSR would have been in the spring 2020 but unfortunately the explosion of the COVID pandemics determined the presence of traffic volumes which were very different (and in general much lower, in particular in the first months) from the pre-COVID period. The inability to precisely predict days with traffic volumes suitable for the activation of the HSR with a certain advance did not allow to organize any other further tests, and induced project beneficiaries to concentrate just on the VSL measure, whose testing was also significantly jeopardized by the COVID emergency. It is also to underline that after the explosion of the COVID pandemic the involvement of the rescue teams for such activity has been much more difficult because of their commitment in activities of higher priority. In order to tackle this issue, project beneficiaries have committed to consider the testing of this measure in the **after-LIFE plan**, coupled with the activities of the extension of the VSL measure to a broader stretch of the A22 highway.

Synergies with complementary action outside LIFE:
Please consider the information reported for Action B2 which apply for Action B3 as well.

Perspectives for continuing the action after the end of the project
The evaluation carried out in Action B6 has confirmed the potential to replicate the measure of VSL triggered by traffic conditions to a broader stretch of the A22 highway, in particular from the toll booth of **Bolzano South** (km 85) up to the **intersection with the A4 highway** (km 228), for about 143 km, in both direction of travels. This replication action is going to be implemented in the **WP3** of the **after-LIFE plan**. North to Bolzano, in the **stretch from Brennero (km 0)** characterized by a road infrastructure developed in a more challenging mountain environment, the impossibility to introduce a dense network of ITS equipment (VMS, traffic monitoring points, etc) an immediate replication of this measure is technically not possible. However, the deployment of **C-ITS** technologies expected in the mid-term period will allow its application also in this stretch, but with a different approach in the communication of the VSL to the road users (i.e. through a direct communication of this information directly on-board of the vehicles). Such scenarios will be in particular evaluated together with the cross-border stakeholders in the scope of the **WP4** of the **after-LIFE plan**.

5.5. Action B4

Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
The execution of the **phase 1 tests** scheduled in sub-action B4.1 lasted 17 months (**February 2017 – June 2018**) under the coordination of Coordinating Beneficiary A22 and Associated Beneficiary APPABZ and was successfully completed. Approximately **2.000 hours of tests with VSL equal to 100 km/h** were conducted from April 2017 to June 2018, a relevant data sample which was deemed to be statistically very robust in order to investigate the impact of this pilot measure on the environment. These initial tests were carried out according to the infrastructure setting illustrated in Figure 5. In this way, it was possible to observe in correspondence of the monitoring site at km 103+700 the effects with VSL, and at km 107+700 the effects without VSL, by considering the same quantity and typology of traffic.

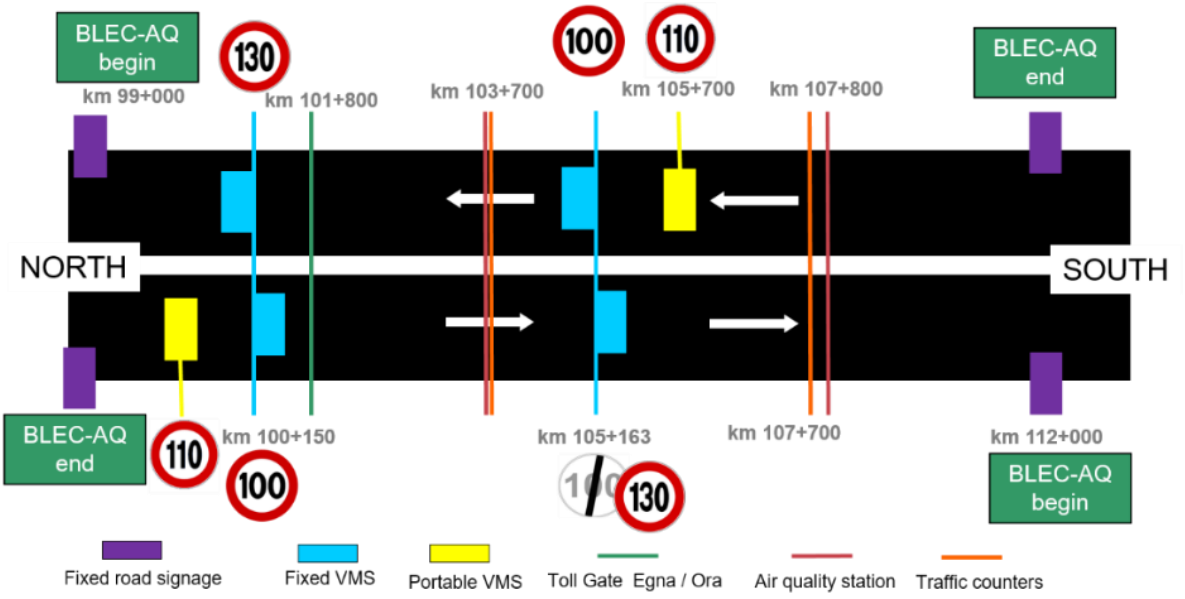

Figure 5: Road infrastructure setting used for the first tests in the BLEC-AQ stretch.

The tests were carried out in free traffic flow conditions and were distributed across all months of the year; furthermore, to obtain a comprehensive representation of the various conditions that are present throughout the year, these tests were conducted with different durations and during different hours of the day. Out of these tests, **1.367 hours were determined valid**, according to the following criteria: (i) speed reduction computed as the difference between the average speeds of two traffic counting stations located at km 103+700 (section with VSL in action) and 107+700 (section without VSL in action) greater than 10 km/h in each direction of travel; (ii) complete functioning of the test site equipment (VMS, monitoring systems); and (iii) absence of extraordinary events (e.g. accidents, weather events). The initial **compliance rate** of motorway users **was pretty satisfying**: on average **31%** of the car drivers respected the exposed VSL, with an **average speed of 109 km/h**. An **average speed difference** of **14 km/h** in relation to the normal motorway speed limit (130 km/h) was obtained, which guaranteed the possibility to make robust environmental assessment studies, reported in Action C2.

The **second pilot phase** organized in the scope of sub-action B4.2 began in **July 2018** and was completed in **September 2019**. The tests were carried out with a different modality: the application of the speed limits was substituted with the exposition of a **recommended speed** due to external factors that are described more in detail below in the section “problems”. The

set-up of the BLEC-AQ infrastructure was adapted as a function of the different testing purposes thanks to the new ULP VMS installed in Action B2, as illustrated in Figure 6.

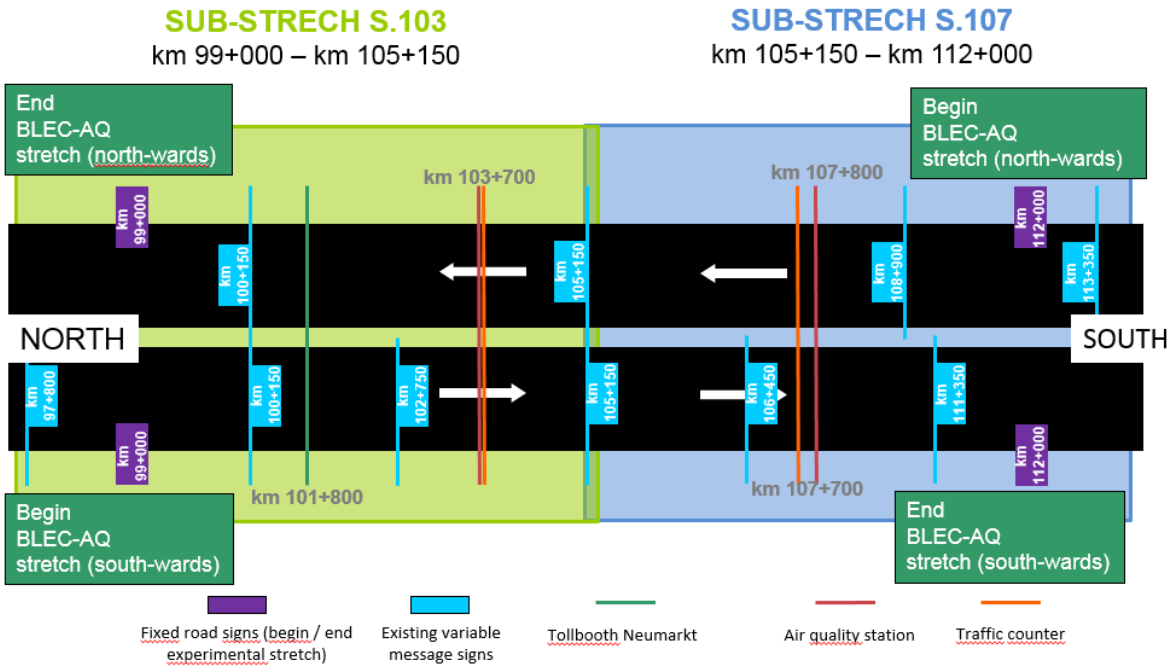

Figure 6: Road infrastructure setting used in the second pilot phase of Action B4.

In a first period, scheduled test sessions were carried out in only one subsection of the test stretches, **varying the recommended speed and the sub-stretch** in which it was applied. Unfortunately, no significant differences were noticed with different recommended speeds and it was difficult to observe remarkable speed differences in correspondence of the two monitoring points. For this reason, from **December 2018** onwards, the **recommended speed of 100 km/h** was **applied to the whole BLEC-AQ section**. During the Christmas season, in correspondence of heavier traffic flows, a couple of test sessions with recommended speed of 90 km/h were also carried out. In total, **1.836 valid hours** of tests were carried out, with an **average speed reduction** compared to undisturbed conditions of **around 5 km/h**. According to the data analysis performed in Action C2, this compliance result does not put in condition to highlight significant environmental improvements, even if measured effects are consistent with what was observed in the first pilot phase with situations of similar compliance rate. The tests also highlighted the **importance of the infrastructure used to signal the speed limit**. The presence of a gantry VMS (spanning the entire width of both carriageways) with a text and a space for two pictograms proved to be much more effective than a signal (pictogram) applied on a flag VMS placed on the side of the carriageway. Flag VMS are indeed useful for repeating the signal displayed at the start of the section but have revealed not sufficient to make clear that a different speed regime is in action.

The **third testing phase** successfully started in **October 2019** with a test set-up defined on top of the experience collected in the first two test phases (Figure 7). The same set-up was also used for the **final testing phase**, with the difference of the VMS positioned at km 116+800 (direction north) which allowed to **extend the BLEC-AQ stretch up to the gantry VMS placed at km 119+600**.

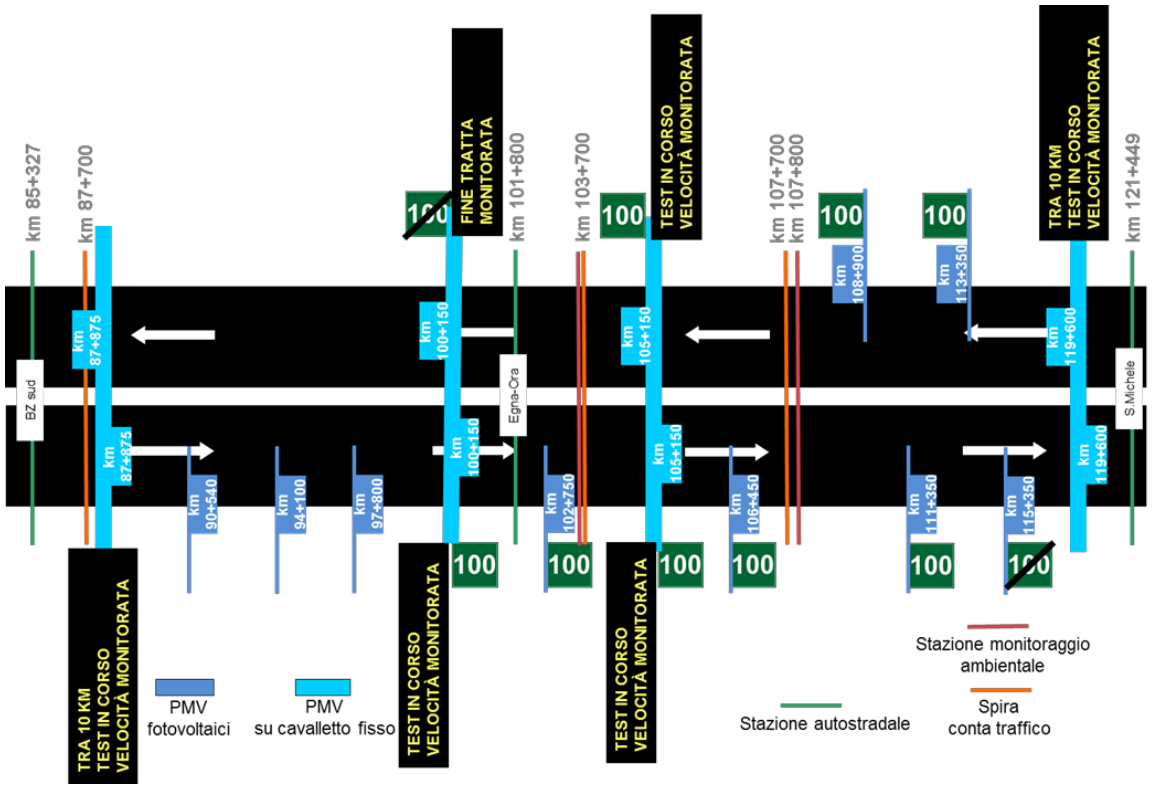

Figure 7: Road infrastructure setting used in the third and fourth pilot phase of Action B4.

During the **third testing phase** a **first version of the modeling chain** was introduced. The modeling chain was configured to be in a **"only-forecasting" mode**, without considering the real-time measurement provided by the on-field monitoring systems. The modeling chain was mainly used to predict from one day to the following one the more suitable situations for the dynamic activation of the VSL: sufficient traffic volumes and stable meteorological conditions. This testing phase was mainly used to consolidate the new testing procedures with the TCC operators, who were also trained to start using a first version of the DSS. The testing phase was stopped in **March 2020** due to the explosion of the **COVID-19 pandemic** which significantly reduced the traffic flows on the highways in the first weeks of generalized lockdown. It is worth underlining that in the last two months of this testing period different thresholds related to traffic and meteorology were considered for the activation of the tests; these modes were called "**hard**" and "**soft**", since they determined a different frequency in the appearance of the VSL on the BLEC-AQ stretch. During the **final testing phase**, which was finally started in **October 2020** up to **September 2021** – according to the new recovery plan shared with the EC - the **final version of the modeling chain** was introduced. In this case the activation of a VSL is automatically recommended as a function of a complex computation chain, which is based on the **achievement of a certain number of yearly hours of activation**. This objective determines a **reference quantitative threshold** which is calculated on top of the air quality (NO_2) conditions of the previous year. The system suggests a VSL activation if such threshold is lower than the **forecasted conditions** for the following day. The **real-time measurements** are also considered, but mainly to check if the forecasted traffic and air quality conditions are substantially confirmed. If not, suggested VSL activations are dynamically disabled. The execution of these two testing phases was successfully completed, despite the challenging conditions determined by the COVID-19 pandemics, which significantly altered the reference nature and variability of the target highway traffic.

During the execution of these tests sessions slight improvements on the modeling chain as well as in the procedures with the TCC operators were introduced; in particular, at the end of the project the entire system was configured so to allow a **semi-automatic dynamic activation of the VSL on the VMS**, with only a simple check by the TCC operators needed. In total, **1.310 hours** and **1.308 hours of tests** were respectively collected, which gave the possibility to understand the viability of the proposed measure to tackle the environmental impact of light vehicles travelling on the highway.

Comparison with planned output and time schedule:
A comparison between the actual test activities carried out and those planned in the project proposal is presented in Table 12.

	Initial evaluation		**Extensive evaluation**		**Policy testing**	
	Planned	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**
Period	09/2016 - 05/2018	04/2017 06/2018	03/2018 - 05/2019	07/2018 09/2019	*Reactive*: 03/2019 - 12/2019 *Proactive*: 10/2019 - 04/2021	*Phase 3*: 10/2019 - 03/2020 *Phase 4*: 10/2020 - 09/2021
Road stretch	BLEC-AQ (limited)	BLEC-AQ (limited)	BLEC-AQ	BLEC-AQ	BLEC-AQ	BLEC-AQ (extended)
Support systems	-	-	-	-	*Reactive*: only-based on real-time measurements *Proactive*: with full forecasting system	*Phase 3*: with simplified forecasting system only *Phase 4*: with full forecasting system
Procedures	Test days defined on a calendar basis	Test days defined on a calendar basis	Test days defined on a calendar basis	Test days defined on a calendar basis	Based on system inputs provided through a DSS	Based on system inputs provided through a DSS

	Initial evaluation		Extensive evaluation		Policy testing	
	Planned	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**
Nr. of test session days	Min. 50	87	Min. 75	144	-	*Phase 3*: 1.310 hours *Phase 4*: 1.308 hours
Overall test duration	Min 14% of a year time	1367 hours (about 15.6% of a year time)	Min 14% of a year time	1836 hours (about 21.0% of a year time)	-	

Table 12: Summary of test sessions carried out in the different testing phases of Action B4.

From a pure evaluation of the amount of testing activities carried out, the quantitative data demonstrate how all initial targets were achieved and significantly overcome. Please note, as summarized in Table 13, that the timing of different project phases was slightly updated, but without determining any negative effects. The recovery plan defined in order to tackle the COVID-19 emergency was effective to successfully complete the activities foreseen in this action. The reactive policy test phase was organized differently since it has been considered more beneficial for the final testing phase to test a first version of the forecasting system which implied a certain level of coordination with the TCC operators of the A22 highway. This choice revealed to be very appropriate since it gave the possibility to run the final testing phase in a much smoother way.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Prima fase sperimentale conclusa sul tratto BLEC-AQ	05/2018	06/2018	Achieved	-
Fase sperimentale estensiva conclusa sul tratto BLEC- AQ	05/2019	09/2019	Achieved	Tests carried out in the “recommended speed” modality
Fase sperimentale reattiva conclusa sul tratto BLEC- AQ	12/2019	03/2020	Achieved	Tests carried out on the extended BLEC-AQ stretch
Fase sperimentale proattiva conclusa sul tratto BLEC- AQ	04/2021	09/2021	Achieved	-

Table 13: Planned and actual milestones’ achievement for Action B4.

Deliverable	Submission	Status
D.B4.1 – Definizione e valutazione delle politiche iniziali sul tratto BLEC- AQ limitato	Mid-Term Report	Submitted to EC
D.B4.2 – Definizione e valutazione delle politiche di applicazione estesa sul tratto BLEC- AQ	Final Report	Submitted to the EC. The deliverable was already checked during the last monitoring visit in 2021.
D.B4.3 – Definizione e valutazione delle politiche di applicazione del sistema previsionale sul tratto BLEC- AQ e considerazioni finali	Final Report	Submitted to EC

Table 14: State of submission state of Action B4 deliverables.

Problems, deviations and recovery plans:
The execution of the first pilot phase was carried out in a very satisfactory way and the obtained results, in particular the initial assessment of the environmental impacts, confirmed the great potential associated to this measure. The problems were encountered at the beginning of the second pilot phase, when due to strong **pressure by the Traffic Police**, the General Direction of Coordinating Beneficiary A22 decided to carry out the following tests sessions in the **"recommended speed" modality**, instead of using mandatory VSL. As a matter of fact, the **Italian Rules of the Road** do not allow a reduction of speed limits for environmental purposes but only for the protection of human life, which is interpreted only in terms of road safety. It is worth underlining that during preparatory action A1 (in particular sub-action A1.5) beneficiaries A22 and APPABZ already received by the **Italian Ministry of Transportation** a grant for this pilot measure. Unfortunately, the boundary conditions have in meantime changed a lot at political level and in terms of contacts and relationship with the Ministry, and this initial grant was therefore put in discussion. Moreover, the Coordinating Beneficiary A22 is still currently involved through its shareholders in a negotiation with the Ministry for the renewal of the motorway concession, therefore the General Direction of Coordinating Beneficiary A22 at present is not in the condition to implement actions which are outside of the current legal framework. Despite this, project beneficiaries put in place during the execution of the project **several recovery actions** to ensure on one side a **change in the current national regulation**, so to allow the application of VSL also for environmental purposes, and on the other side to **increase the compliance of the road users to the recommended speed signal**. For this reason, the project team supported by its Steering Committee decided to tackle these major challenges by **extending the number of dissemination and networking activities and initiatives**. This choice has also had an important impact in the usage of available budget, as summarized in Table 15. For a detailed overview of the additional activities carried out in that regard, please refer to the summary of **Actions D1 and D2.**

Project action	Planned budget	Actual budget	Difference
A1 Technical and administrative preparation	€ 238.864	€ 237.840	- € 1.024
B1 Traffic and air quality forecasting models development	€ 230.101	€ 232.063	+ € 1.962
B2 ITS components development	€ 997.000	€ 761.822	- € 235.178
B3 Dynamic traffic-induced policies calibration	€ 150.315	€ 170.377	+ € 20.062
B4 Dynamic air pollution-induced policies calibration	€150.203	€ 182.991	+ € 32.788

Project action	Planned budget	Actual budget	Difference
B5 Integrated highway-urban policies calibration	€ 70.654	€ 55.531	- € 15.123
B6 Exploitation modalities evaluation	€ 96.468	€ 64.840	- € 31.628
C1 Air quality, noise and traffic monitoring	€ 1.041.427	€ 1.128.322	+ € 86.895
C2 Environmental improvements monitoring	€ 121.824	€ 252.666	+ € 130.842
C3 Socio-economic impact assessment	€ 90.590	€ 19.423	- € 71.167
C4 LIFE Project Performance Indicators monitoring	€ 24.936	€ 12.249	- € 12.687
D1 Large-scale dissemination	€ 122.697	€ 288.907	+ € 166.210
D2 Stakeholders involvement	€ 142.832	€ 114.156	- € 28.676
E1 Internal project management	€ 157.742	€ 201.007	+ € 43.265
E2 Coordination with LIFE authorities	€ 165.724	€ 89.441	- € 76.283
Overheads	€ 216.627	€ 225.105	+ € 8.478
TOTAL	€ 4.018.004	€ 4.036.741	+ € 18.737

Table 15: Planned and actual budget distribution per action.

Another recovery measure that was activated was to test the application of **dynamic VSL (with mandatory signage) in case of queues of heavy vehicles on the driving lane**. This situation is unfortunately quite often on the A22 highway and was activated in 2021 on one side to help the compliance rate of the tests in the BLEC-AQ section, and on the other side to further increase the road safety in these situations. The measure was applied on the entire **BLEC stretch (Brennero – Affi)** in both direction of travels with different speed limits (110 km/h in the stretch Affi – Bolzano South, 100 km/h in the stretch Bolzano South – Brennero).

Synergies with complementary action outside LIFE:
Please consider the information reported for Action B2 which apply for Action B4 as well. It is important to point out that the pilot measure performed in Action B4 is an important part of the **new programs for the reduction of the nitrogen dioxide pollution 2018 – 2023** defined by Associated Beneficiaries **APPABZ** and **APPATN**.

Perspectives for continuing the action after the end of the project:
The evaluation carried out in Action B6 confirmed the potential to replicate the measure of VSL triggered by air quality conditions to a broader stretch of the A22 highway, in particular in the **Bassa-Atesina** area (where the BLEC-AQ stretch is located) and near the towns of **Bolzano, Bressanone** (South Tyrol), **Trento** and **Rovereto** (Trentino). This replication action is going to be implemented in the **WP3** of the **after-LIFE plan.** The plan also contains the prosecution of the above-described efforts to change the current national regulation and to increase the compliance of the road users. The modalities of application of the measure will also depend on the **temporal evolution of the vehicular fleet** and in particular on the **level of penetration of (non-EURO 6d) light diesel vehicles** which will be regularly checked as stated for the replication of Action B1.

5.6. Action B5

Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
In the scope of this Action more efficient **procedures for the joint management of specific traffic situations and events between the highway, urban and inter-urban road operators** were introduced and initially tested. These procedures were defined and agreed with a participative approach, i.e. with an active involvement of other road operators involved in the scope of the **Working Group "Viabilità Urbana ed Extraurbana"** (Urban and Inter-Urban Traffic Management). For more details on this please refer to Action D2. The procedures cover (i) the definition of joint **temporary traffic management plans** during certain impacting **city events**; (ii) the joint planning of **roadworks**; and (iii) the real-time management of **traffic events**. The first major pilot activities were carried out under the coordination of A22 during the **Christmas market periods** in **2017** (sub-action B5.1) and in **2018** as well as in **2019** (sub-action B5.2) in the three **BLEC-LEZ** pilot areas of **Bolzano**, **Trento** and **Rovereto**. During a total of **35 test session days** (10 in 2017, 13 in 2018 and 12 in 2019) mobile VMS were used to recommend drivers on the highway a specific toll gate in order to better route traffic flows wanting to enter the different city centers. The **management in real-time of traffic events** was started in the intermediate pilot phase, in particular during **2019**, with a total of **36 situations** handled.

The explosion of the **COVID-19 pandemic** at the beginning of 2020 significantly influenced the expected pilot activities for the **final testing period**. In particular, the city authorities – the main beneficiaries of the proposed traffic control measures –obviously gave higher priority to the management of the emergency, and during the first months of the pandemics but also during the winter season 2020 pilot activities were suspended because of the near-zero traffic volumes caused by lock-down measures. For this reason, **no pilot activities** related to the management of tourist flows during the **Christmas Market 2020** period were carried out. At local level, one of the impacts generated by the COVID-19 pandemic was also an **increase of transit traffic volumes**, a phenomenon which started to appear strongly during the summer 2020. Situations of suffering were observed in particular in the **city of Bolzano**, which lacks of dedicated road transit infrastructures destined to the motorized traffic. The increased relevance of the congestion phenomena was a driver to boost again the different **traffic control measures** that were already identified during the previous testing phases and were **further detailed and adapted as a function of the changed traffic conditions**. The finalized measures deal mainly with the strategies of (i) **re-routing the transit traffic coming from a certain access gate to the city on the highway in order to cross the city**; and (ii) **optimally directing highway traffic willing to enter into the city to the recommended toll gate**. The real-time integrated management of **traffic events** was as a consequence **reactivated** during **2021**. Of all the **33 traffic events** managed, 21 (about **64%**) were related to **accidents** that needed highway traffic to be re-routed on the ordinary regional roads.

The city and regional authorities together with the main project partners involved also decided to sign an **agreement** for further **testing, improving and extending** such set of measures also in the **after-LIFE period**, according to the replication scenarios identified in the scope of Action B6. During the after-LIFE period it is also planned to start testing the **automated decision support tools** for the recommendation of a certain measure based on the real-time data available, such as the occupancy of the parking areas or traffic parameters like volumes or travel times. These tools will be further developed thanks to new ITS deployed by local stakeholders, e.g. the new 'real time' provincial traffic monitoring network, also equipped with Bluetooth sensors. This automation perspective could also lead to a **policy improvement** of the

Urban Pass scheme to facilitate the use of the A22 motorway in the city sections of **Trento** and **Rovereto** by local commuters, which was introduced and further incentivized by the local authorities during the project lifetime.

Figure 8: VMS messages for the re-routing strategies of highway traffic in the city of Bolzano defined in the scope of Action B5.

Comparison with planned output and time schedule:
Despite the explosion of the COVID-19 pandemics, the planned outputs of this action were successfully achieved, as summarized in Table 16.

	Planned	Actual
Sub-action B5.1	• First testing during Christmas Market 2017 (5-10 days)	• First testing during Christmas Market 2017 (10 days) • First identification of integrated traffic control measures set
Sub-action B5.2	• Testing activities extended to unpredictable events (e.g. accidents) • Introduction of automated decision support tools	• Testing activities extended to unpredictable events (36 situations in 2019) • Availability of automated decision support tools developed in Action B2
Sub-action B5.3	• Evaluation of new measures targeting the most polluting vehicles	• Detailed application of integrated traffic control measures with the Municipality and Province of Bolzano • Evaluation of new measures targeting the most polluting vehicles and signature of an agreement for the further testing, improvement and extension in the after-LIFE period

Table 16: Summary of test sessions carried out in the different testing phases of Action B5.

Also, from a temporal point of view it was possible to follow the original time plan. The additional months received were fundamental in particular for putting the basis of the replication scenarios identified in Action B6.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Prima fase sperimentale conclusa sui tratti BLEC-LEZ	05/2018	05/2018	Achieved	-
Fase sperimentale intermedia conclusa sui tratti BLEC-LEZ	12/2019	12/2019	Achieved	-
Fase sperimentale finale conclusa sui tratti BLEC-LEZ	04/2021	09/2021	Achieved	-

Table 17: Planned and actual milestones' achievement for Action B5.

Deliverable	Submission	Status
D.B5.1 – Definizione e valutazione delle politiche non automatiche sui tratti BLEC-LEZ	Mid-Term Report	Submitted to EC
D.B5.2 – Definizione e valutazione delle politiche automatiche sui tratti BLEC-LEZ	Final Report	Submitted to the EC. The deliverable was already checked during the last monitoring visit in 2021.
D.B5.3 – Definizione e valutazione delle politiche integrate sui tratti BLEC-LEZ e considerazioni finali	Final Report	Submitted to EC

Table 18: State of submission state of Action B5 deliverables.

Problems, deviations and recovery plans:
The explosion of the **COVID-19 emergency** initially created several challenges for the continuation of the pilot activities scheduled in the final project phase (sub-action B5.3). During the entire **year 2020** it was not possible to organize any test session related to any of the target situations identified. The **testing activities were therefore concentrated in year 2021** and adapted to the changed traffic conditions caused by pandemics. This period was used by the project partners in particular to **further consolidate the relationships with reference stakeholders**. By influencing the new mobility plans and other similar strategies that are currently under review, it was possible to guarantee perspectives of application and replication of these measures even after the project.

Synergies with complementary action outside LIFE:
Please consider the information reported for Action B2 which apply for Action B5 as well. The attention is in this case on scenarios dealing with the connection between the highway and the other regional and urban road network.

Perspectives for continuing the action after the end of the project
One of the most relevant outcomes achieved thanks to this was the **creation of a deeper knowledge, involvement and cooperation between all local road operators**, and also other players that are active in the mobility sector. The aforementioned **agreement**, together with the activities defined in the **after-LIFE plan** (i.e. tasks 2.7 and 3.3) not only ensures the perspectives for continuing the pilot activities even after the end of the project, but also opens the door for a much **more effective integration between the mobility, traffic and air quality domains in urban areas**, for example in direction **MaaS**. Such developments could also lead to new project initiatives, co-funded by the different funding programs made available by the EC.

5.7. Action B6

Foreseen start date: 01/01/2020 **Actual start date:** 01/01/2020
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
In the scope of this Action it was possible to put the foundations for transforming what had only been implemented on an experimental level during the project into stable measures for the efficient management of motorway traffic flows, with a particular attention to the protection of the sensitive environment through which they pass. The first step was to consolidate the way the measures proposed in the Actions B3, B4 and B5 could be extended on the overall alpine part of the A22 highway (sub-action B6.1).

As far as the **replication of the Action B3** is concerned, this is linked with the **planned extension of the stretch enabled to activate the HSR measure**, now limited to the stretch Trento South (km 142+850) - Rovereto South (km 166+739) only in direction South (approx. 28 km). The plan is to extend it to the stretch **Bolzano South (km 85+327) -Verona North (km 225+372)**, for both directions of travel. The work of infrastructure adaptations was already completed in the past years; the activity missing is in the complete set up of the ITS systems needed (i.e. VMS, traffic monitoring systems, etc.). **Detailed analysis of the historical traffic patterns** confirmed the **suitability to apply the dynamic application of the VSL triggered by the traffic conditions in the entire stretch enabled for the HSR**. Actually, the HSR can be seen as the last "stage" of the complex state machine developed in Action B2 for the automatic recommendation of the speed limits, to be activated in only very limited cases in combination of a speed limit reduced to 80 km/h (currently the last stage of the state machine). This relevant investment is already included in the **Financial Plan of Coordinating Beneficiary A22** and will be started once the reference national authorities will formally approve the **renewal of the concession for the management of the highway**.

As far as the **replication of the Action B4** is concerned, the **evaluation of the stretches** was carried out on the base of a **scientifical analysis** which has identified the **most critical areas** in terms of air quality conditions (Figure 9). This analysis combined the **annual average NO_2 concentrations**, derived from simulation models and that consider the whole emission sources present in the Trentino South-Tyrol region, with the **presence of buildings near the highway**. The entire A22 stretch was classified with a resolution of 2x2 km according to the following classes: (i) **red stretch**, in case the NO_2 concentration is higher than the reference threshold of 32 $\mu g/m^3$ (threshold for the protection of human health set by the Legislative Decree 13 August 2010); (ii) **orange stretch**, in case the NO_2 concentration is lower than the reference threshold of 32 $\mu g/m^3$ but there are buildings near the highway that experience a NO_2 concentration higher than 40 $\mu g/m^3$; (iii) **yellow stretch**, identified as the orange stretch but considering a threshold of 38 $\mu g/m^3$ instead of 40 $\mu g/m^3$ and (iv) **green stretch**, in case any of the above conditions are not satisfied (non-critical stretch). The concentrations experienced by buildings near the highway are derived from a spatialization model, which is a function of the typical traffic conditions observed and that was empirically validated through empirical measurements (passive samplers). This output was then further refined according to different criteria so to identify the effective stretches in which to apply the measure of VSL triggered by air quality conditions; these criteria include the fact to be part of a urban area and to be a residential building. The exact setting of the stretches was then finally finalized according the actual and planned presence of the ITS equipment needed (VMS, traffic and air quality monitoring systems) and trying to make small adjacent sections continuous, in order to give a continuity of signalling to road users. Five stretches were at the end obtained: the stretches in correspondence of the urban areas of **Bolzano**, **Bressanone**, **Trento** and **Rovereto** as well as a small section in the **Bassa Atesina** area, covered by the current BLEC-AQ stretch.

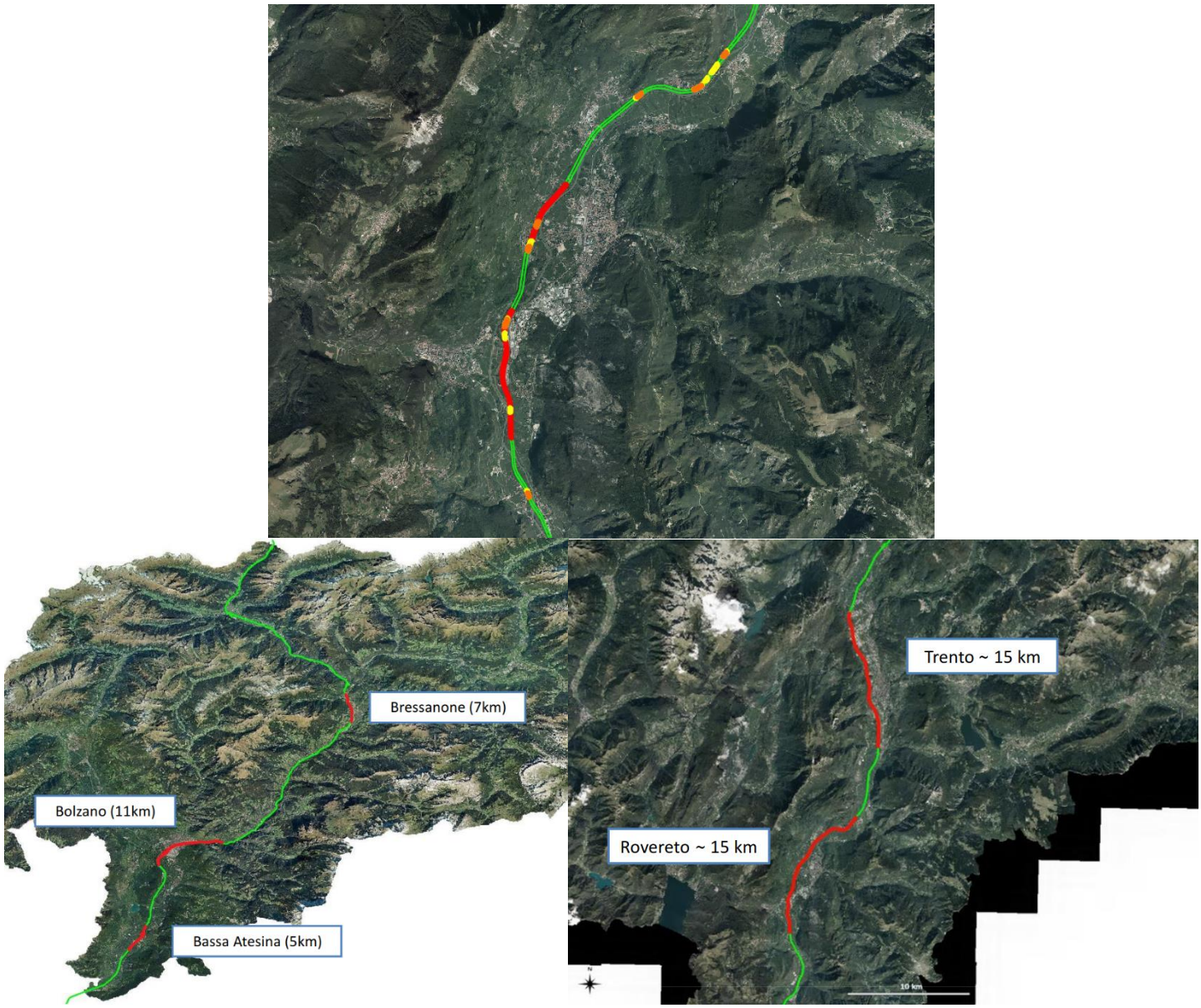

Figure 9: Identification of the replication stretches on the A22 highway of the measure of dynamic VSL for air quality purposes: potential stretch candidates (above) and final stretch setting (below).

As far as the **replication of the Action B5** is concerned, the plan is to extend all proposed integration measures on all reference **regional and urban roads in direction North – South** (i.e. mainly the SS12 road) and also considering **other important roads for the traffic circulation in the whole region** and that have an impact on the highway traffic as well. The goal is to fully **connect all ITS equipment** controlled by the different road operators, so to ensure a shared knowledge about the current situation and traffic control measures in action. This process, which already started within the project, will ensure the possibility to fully exploit the benefits associated to the development of future **C-ITS scenarios**. New and more challenging measures targeting additional needs and reference scenarios are going to be addressed, and cover (i) the **extension of the types of traffic events** that can be considered as trigger for the activation of certain measures, e.g. those appearing on the **regional road network** and on the **highway**; (ii) **extension of the set of triggers** that are at base of the activation of the measures: not only traffic will determine a re-routing of the transit traffic in order to manage a certain event, but also other types of triggers, e.g. **poor air quality conditions** or **other environmental needs** (e.g. necessity to reduce the greenhouse gases); (iii)

extension of the re-routing concept in the "temporal" or "transport mode" domain, so to pursue the strategy to promote a seamless exchange between the motorized individual mobility typical of the highway with the sustainable and shared services offered by the city / regional authorities. A comprehensive overview of all replication measures is provided in Figure 10.

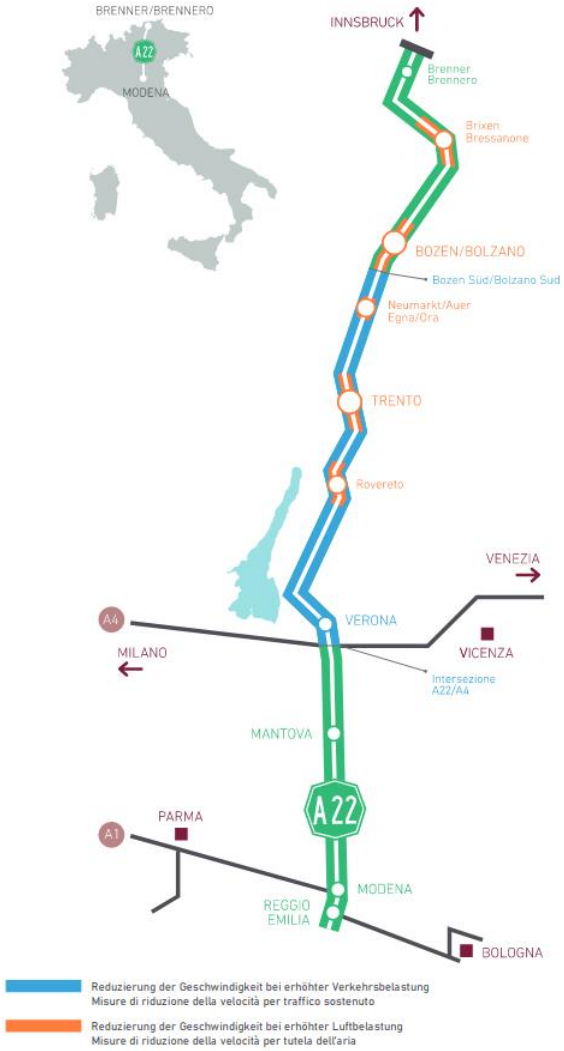

Figure 10: Comprehensive overview of the stretches on the A22 highway in which the dynamic VSL measures will be applied in the after-LIFE period.

Within sub-action B6.2 an effort was started so to align the project replication perspectives with the deployment strategies that are currently present for the entire Brenner Corridor (Alpine-BLEC stretch). A working group called "**Brenner Digital Green Corridor**", initiated by Coordinating Beneficiary A22 was initiated with the participation of the regional authorities of Trentino, South Tyrol, North Tyrol and Bavaria and the correspondent highway operators and Chambers of Commerce. A roadmap has been jointly defined in order to identify concrete measures to implement or, when already in place, to be aligned. These measures include the **dynamic VSL** and also cover other measures that are closed to the project, such as the (i) the **transit limitations to the most pollutant heavy vehicles**, (ii) the **joint management of traffic flows at the toll booths through ramp metering strategies**; (iii) the development of a set of **incentives for end-users adopting more sustainable mobility behaviour** (including more respectful driving style); and (iv) the promotion of **intermodality**, in particular as far as the transport of goods is concerned. As already identified in the replication of the B3 measures, a key aspect that will be promoted is the **digitalisation process** and the deployment of the **C-ITS**

technologies, which will make the proposed measures much more effective. In this perspective, the **real-time automatic exchange of relevant traffic data** as well as the **joint definition of processes to manage certain target situations** (similar to those defined in the Action B5) is going to be one of the first concrete activities that will be carried out.

The exploitation scenarios identified in the sub-actions B6.1 and B6.2 also highlighted certain improvement **proposals of the current EU policies**, that will further simplify and speed up the identified digital and green process of transformation. These recommendations, consolidated in the scope of sub-action B6.3, include (i) the **alignment at European level on how the emergency lane should be managed on a highway section**; (ii) the **full interoperability of the tolling systems according to the Directive 2019/520**, that will allow a much more efficient management of the traffic at the tolling stations, with significant reduction of the queues, stop & go and emissions' peaks phenomena; and (iii) **the rewarding mechanisms of end-users in the road / highway sector**, i.e. the possibility for users to receive mobility credits for their sustainable behaviour and convert them in money for the purchase of goods / services. In the scope of this sub-action Coordinating Beneficiary A22 started to share the consolidated replication plans as well as these recommendations proposals' in different EU networks, in particular those connected to the **Connecting Europe Facility (CEF) 2** programme.

Last but not least, in the scope of this Action also a **replication "procedure"** of the proposed project measures and in particular of the dynamic VSL activation for air quality purposes was produced **for other similar highway environments**. This procedure is mainly based on the methodologies applied for the replication on the A22 highway, but also consider other relevant aspects that need to be first investigated, such as a **detailed assessment of the environmental problem tackled**, a **characterization of the real vehicular fleet driving on the target road**, the evaluation of the **investments for the ITS equipment** needed (including back-end systems), the **calibration** needs for the **air quality monitoring systems**, as well as the **maintenance** and **benefits' assessment** aspects. Since the measure can be applied with different modalities and bring different reductions' results, a specific **tool** was produced that allows to compute and compare different **scenarios**. For example, it is possible to understand how the same environmental benefits can be achieved by considering a different type of signalling (recommended / mandatory speed limit) and a different maximum amount of yearly hours in which the measure is applied.

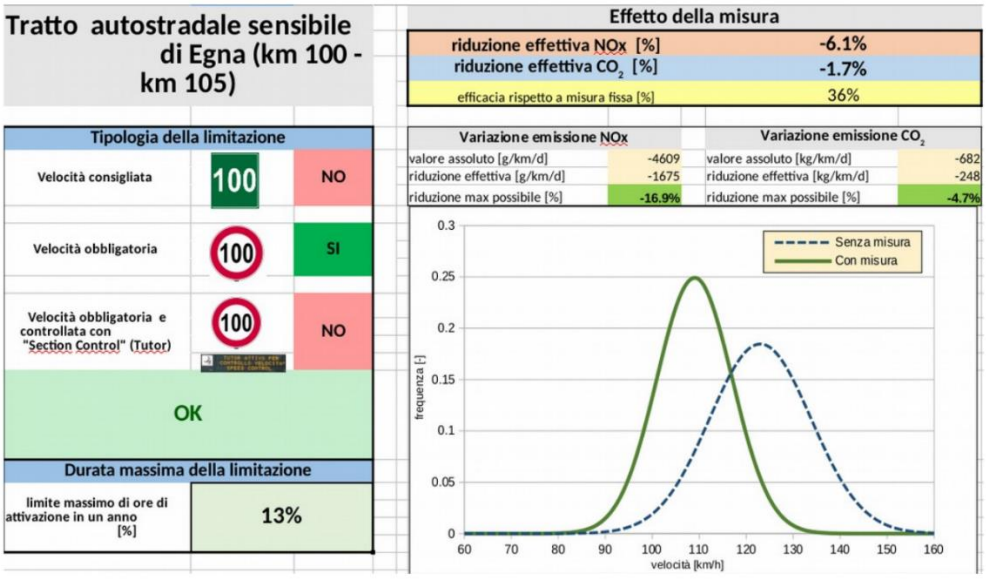

Figure 11: Tool for the assessment of different calibration scenarios of the dynamic VSL for air quality purposes measure.

Comparison with planned output and time schedule:

No significant deviations are to be mentioned here. The replication activities related to the A22 highway have taken some additional months due to the level of complexity of the proposed methodology of analysis.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Modalità di replicazione delle politiche sperimentali definite sul tratto BLEC	12/2020	06/2021	Achieved	-
Modalità di replicazione delle politiche sperimentali definite sul tratto Alpine-BLEC e raccomandazioni per lo sviluppo delle politiche EU in materia di trasporti disponibili	04/2021	09/2021	Achieved	-

Table 19: Planned and actual milestones' achievement for Action B6.

Deliverable	Submission	Status
D.B6.1 – Piano strategico per l'applicazione delle politiche sperimentali al tratto BLEC	Final Report	Submitted to EC
D.B6.2 – Piano strategico per l'applicazione delle politiche sperimentali al tratto Alpine-BLEC	Final Report	Submitted to EC
D.B6.3 – Raccomandazioni per lo sviluppo future delle politiche europee in materia di trasporto autostradale	Final Report	Submitted to EC

Table 20: State of submission state of Action B6 deliverables.

Problems, deviations and recovery plans: none.

Synergies with complementary action outside LIFE:
The exploitation plans are aligned to other project initiatives carried out by the Coordinating Beneficiary A22.

Perspectives for continuing the action after the end of the project:
The replication plan is an annex of the **after-LIFE plan** produced in Action E1. Its implementation is guaranteed by the signature of a **new partnership agreement** formalising the commitment of the project partners to implement this plan.

5.8. Action C1

Status of the action: in progress
Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
The installation of all monitoring equipment foreseen in the project proposal was completed already in the first months of the project. The latter instruments that were installed were the **ultrafine particle counter instrument** in February 2018, which completed the dotation of the monitoring station at km 164+400, and the **innovative air quality sensors** in March 2019.

Monitoring components	Responsibility	Ref. Sub-actions	Status
1 AQ station km 164+400	APPATN	C1.1	Active since March 2017. Ultrafine particle counter instrument installed in February 2018.
1 AQ station km 103+700	APPABZ	C1.1/2	Active since February 2017
13 innovative AQ sensors	A22	C1.1/2/3	Active since March 2019
2 noise monitoring sites	APPABZ	C1.1/2	Active since October 2017
2 sonic anemometers at different heights	UNITN	C1.1/2	Active since November 2017
8 inductive loops on the highway	A22	C1.1/2/3	Complete set active since March 2017
11 inductive loops outside the highway	Other road operators	C1.1/2/3	Active since before the project start.
1 AQ station km 107+800	APPABZ	C1.1/2	Active since January 2017
12 locations with passive AQ sensors	APPABZ	C1.2	Active since February 2017
10 reference background AQ stations	APPABZ, APPATN	C1.1/2/3	Active since before the project start.

Table 21: Summary of the activation of the BrennerLEC integrated monitoring system.

With the data collected starting from the beginning of 2017 by the three monitoring stations managed by APPATN (km 164+400) and APPABZ (km 103+700 and 107+800) a complete **meteorology and air quality characterization** (with a particular focus on NOx) was performed. A detailed **correlation with traffic** could be carried out thanks to the presence of inductive loops in correspondence of the same points. The installation of the **13 low-cost air quality sensors** along the A22 highway was anticipated by an **inter-calibration** activity in correspondence of an official air quality station, so to guarantee the proper comparability and reliability of the measurements. This activity was carried out in collaboration by APPATN and APPABZ with UNITN developing the calibration algorithms. Such developed algorithms ensure a very satisfactory data quality and confirm the basic project idea to use in the long-term period this low-cost network as a feedback channel for the DSS. This activity was then periodically repeated during the entire project lifetime in order to update the calibration coefficients and ensure a satisfactory behaviour of the sensors. In that regard APPABZ implemented a specific calibration site in correspondence of station at km 103+700 so to simplify these operations.

Figure 12: Roadside AQ stations: km 103 (link side), km 164 (right side).

Figure 13: Intercalibration of innovative air quality sensor at roadside AQ station at km 103.

The calibration of the meteorological models used in the modelling chain waseen carried out by Associated Beneficiary UNITN by also considering the measurements collected with **sonic anemometers**, which determine the atmospherical turbulence at different heights. The monitoring station located at km 103+700 was characterized by a specific **noise measurement campaign** carried out in 2018, whose results are reported in Action C2. **Traffic monitoring** is carried out by Coordinating Beneficiary A22 through the network of inductive loops placed along the entire BLEC-ENV section. This monitoring network was further improved during the project lifetime and now includes also reliable **radar sensors**. A **new travel times monitoring system** based on the **ANPR** technology was also successful trialled in the last project year and will substitute or integrate the current one based on a scanning of the Telepass OBU installed on the vehicles. Thanks to an automatic elaboration chain implemented by Associated Beneficiary CISMA, a daily report is produced for internal purposes so to provide synthetic indicators such as the frequency distribution of vehicles according to their speed.

Comparison with planned output and time schedule:
The main deviation with the planned time schedule is just related to the delay in the installation of the **network of low-cost air quality sensors** along the A22 highway, which had no effects in the timely execution of other project activities.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Sistema di monitoraggio attivo nella sua configurazione finale	08/2017	11/2017	Achieved	-
Tutti i dati di misura delle fasi iniziali nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ disponibili	05/2018	03/2019	Achieved	Innovative AQ sensors data will be used from the intermediate test phase starting in 06.2019.
Tutti i dati di misura delle fasi intermedie nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ disponibili	12/2019	12/2019	Achieved	-
Tutti i dati di misura delle fasi finali nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ disponibili	04/2021	09/2021	Achieved	-

Table 22: Planned and actual milestones' achievement for Action C1.

Deliverable	Submission	Status
D.C1.1 – Descrizione dettagliata dei sistemi di monitoraggio	1st Progress Report	Submitted to EC
D.C1.2 – Report iniziale sulle campagne di misura nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ	Mid-Term Report	Submitted to EC
D.C1.3 – Report intermedio sulle campagne di misura nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ	Final Report	Submitted to EC. The deliverable was already checked during the last monitoring visit in 2021.
D.C1.4 – Report finale sulle campagne di misura nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ	Final Report	Submitted to EC

Table 23: State of submission state of Action C1 deliverables.

Problems, deviations and recovery plans:
Most of the monitoring equipment was installed according to the planned timeline, except for the ultrafine particle counter instrument and the network of air quality sensors. This delay did not cause major problems for the evaluation of the impacts of the first pilot activities, thanks to the availability of other data collection instruments. On the other side, some issues were initially encountered with the **traffic monitoring system**. Since inductive loops are supplied by different companies, the collected data (in particular, the classification of the vehicles) was not immediately comparable, and advanced logics were developed by Associated Beneficiary CISMA in order to properly pre-process the data to be used for the analysis.

Synergies with complementary action outside LIFE:
The air quality and traffic monitoring system introduced for BrennerLEC has been implemented enriching the systems currently in use by A22, APPABZ and APPATN, becoming part of the ordinary monitoring network that guarantees a continuous data collection and assessments. .

Perspectives for continuing the action after the end of the project:
The monitoring activities will continue after the end of the project, even if with a different objective. While the project aimed to deepen and investigate certain correlations between the highway traffic and certain air quality pollutants' concentrations, the goal of the after-LIFE monitoring systems is to be **functional for the implementation and assessment of the measures in the replication stretches**. The environmental monitoring will be mainly carried out only by **low-cost innovative sensors**, which proofed to be sufficiently reliable for these specific applications. The only reference air quality station that will be kept in the short-term period will be the one place at km 103+700, in which the intercalibration activities will continue to take place. On the entire side, the entire **traffic monitoring system** will be clearly kept and where necessary further improved, since it is used by the Coordinating Beneficiary A22 also for other purposes.

5.9. Action C2

Status of the action: in progress
Foreseen start date: 01/09/2016 **Actual start date**: 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date**: 30/09/2021
Activities undertaken and quantifiable outputs achieved:
The Action was started with an **ex-ante analysis**, which characterised the environment of the study area in terms of air quality, noise, traffic, emissions, meteorology and estimated impacts on health (sub-action C2.1). The **estimation of emissions** of pollutants and CO_2 from traffic was the core of sub-action C2.2 and was performed starting from an **accurate characterisation of the vehicle fleet on the A22 highway**. The procedure adopted, that could advance reference state-of-art methodologies, uses data recorded by the **tolling system** of the A22 highway and data from the **inductive loops** which measure vehicles' type and velocity. The combination of these data and the use of the European procedure **COPERT V** allowed an accurate estimate of the emissions generated by the highway traffic. The analysis highlighted that on average **54% of NO_x emissions along the A22 highway are caused by vehicles (passenger cars and vans) with speed limit of 130 km/h**, suggesting that a significant decrease of the total emissions can be achieved with a reduction of the speed limits. CO_2 emissions have been estimated in a similar way, taking into account the fuel consumption associated to the vehicle fleet flowing along the highway. This activity was repeated every year from 2017 onwards and mainly highlighted two major aspects: (i) the **rapid renewal process of the motorization of the vehicles**. Since 2018 **EURO 6 light vehicles** represent the majority of transit vehicles and represent in 2020 **more than the 50%** of all light vehicles; (ii) **the dominance of diesel vehicles among light vehicles**, which remained fairly constant throughout the project at around **80%**. It is important to underline the introduction in the recent years of **EURO 6d and EURO 6d-temp engines** with significantly lower emission factors, which is already estimated at **around 20%** of all diesel vehicles.

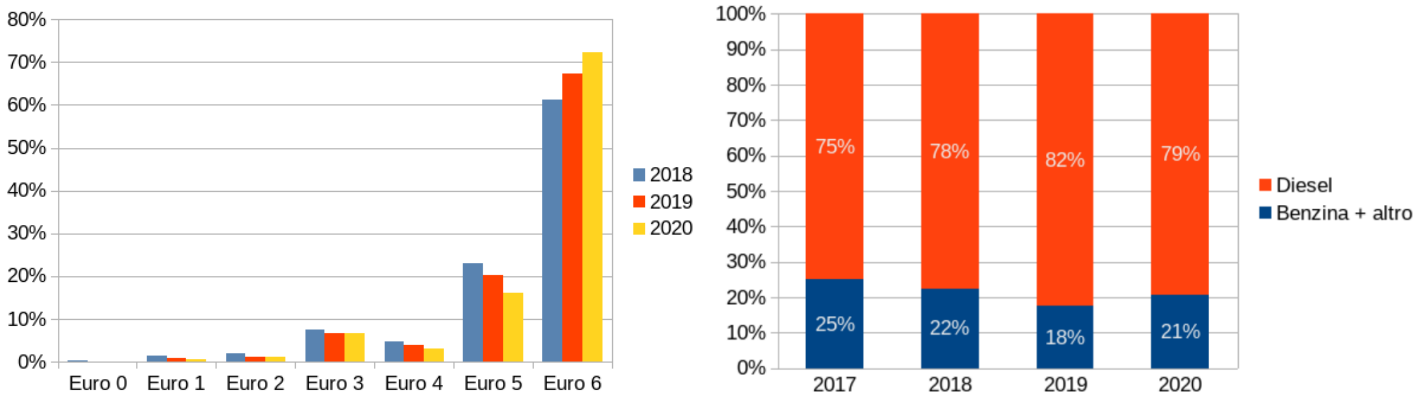

Figure 14: Vehicle fleet characterization on the A22 highway: classification per EURO class (on the left) and distribution per motorization type (on the right).

Sub-action C2.3 mainly dealt with the **characterization of the benefits associated with the pilot measures** tested in the scope of Actions B3, B4 and B5. The most robust results are those associated with the **dynamic VSL applied for air quality purposes** (Action B4). The setting of **phase 1** clearly demonstrated, supported by about one year of detailed measurements, that **nitrogen oxides roadside concentrations can be reduced of about 10%** in case of a reduction of the average speed of light vehicles of about 14 km/h, from 123 km/h to 109 km/h. The reductions are highest in conditions of intense traffic flows and of thermal inversion, which are the less favourable ones for the dispersion of the pollutants in the atmosphere. Similar correlation patterns were observed for the **roadside concentrations of black carbon**, while the measure does **not** have any **remarkable effect on the concentrations of PM**, confirming how

these are mostly dominating by other polluting sources. Thanks to the usage of **advanced modelling tools** calibrated on top of empirical measurements it was possible to evaluate the **impact of reference scenarios** associated to the application of the VSL measure, also those that were not possible to check in the reality due to the challenges associated to the compliance of the speed limits. These scenarios, evaluated in emissions' terms (emissions per vehicles), are summarized in Table 24 and refer to the reference speed profiles presented in Figure 15.

Scenario	NOx emissions (scenario / scenario BAU)	CO_2 emissions (scenario / scenario BAU)
BAU	100%	100%
Recommended speed (phases 2, 3, 4a)	95.8% (-4-2%)	98.1% (-1.9%)
Mandatory speed (phase 1)	88.0% (-12.0%)	93.9% (-6.1%)
Recommended speed (phase 4b)	83.5% (-16.5%)	91.6% (-8.4%)
Mandatory speed with section control system	74.6% (-25.4%)	87.1% (-12.9%)

Table 24: Emissions' reductions associated to different scenarios and testing phases related to the application of VSL for air quality purposes.

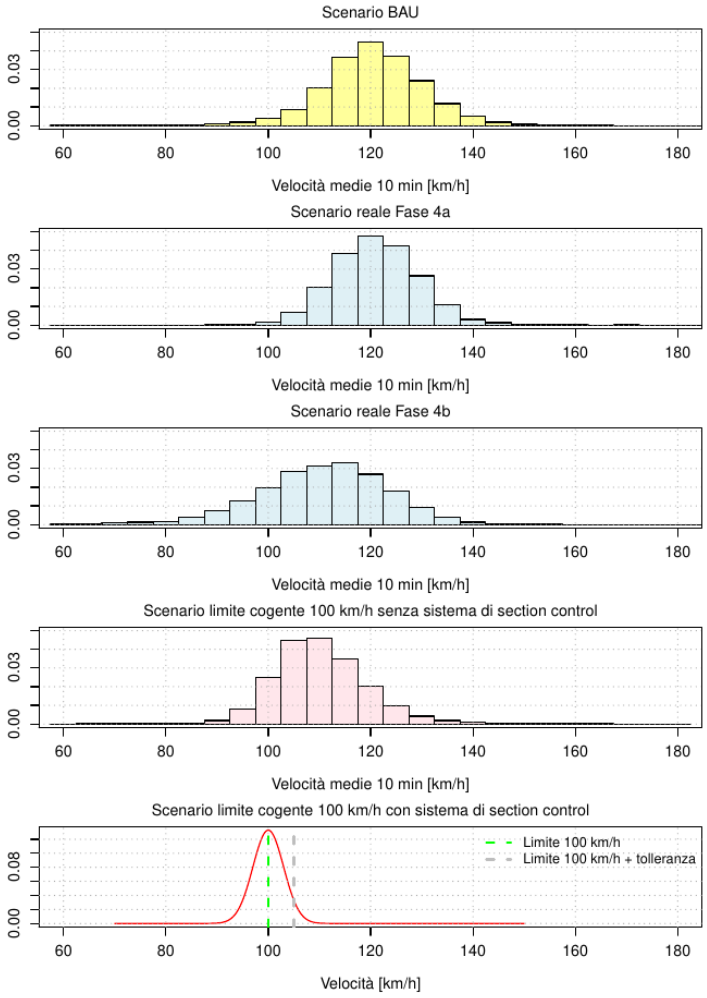

Figure 15: Reference light vehicles' speed patterns related to the scenarios considered for the emissions' reductions associated to the measure of dynamic VSL for air quality purposes.

Interestingly, in the last part of the final test phase the compliance of VSL (so-called "**phase 4b**") was much greater than in the previous period, determining reductions' results that are greater with those observed during phase 1, therefore has been evaluated separately from the other test phases. As graphically illustrated in Figure 26, this phenomenon is very likely to be associated to the **remarkable increase of traffic volumes** from May 2021 onwards. It is important to underline that while the emissions per vehicle were reduced, the overall amount of emissions produced was higher, due to the increased number of vehicles.

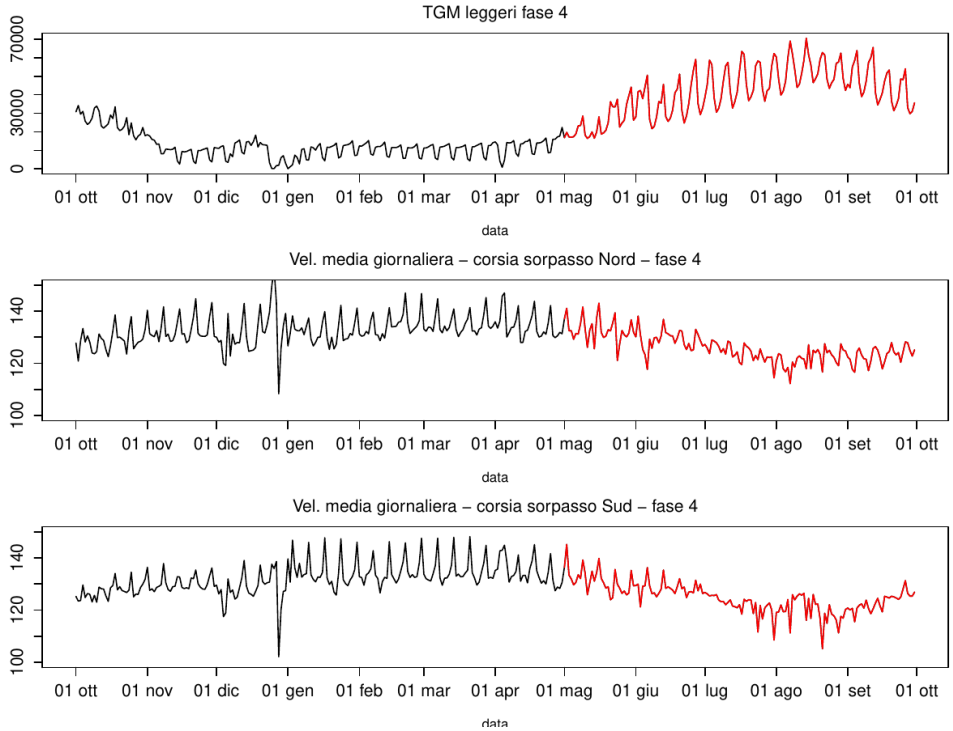

Figure 16: Traffic patterns change during the last part of the final test phase of the measure of dynamic VSL for air quality purposes.

As far as the impacts on **noise** are concerned, the **high presence of heavy vehicles** in the driving lane was found to be the **dominating factor** in the roadside noise concentrations. The contribution brought by this pilot measure is estimated to be **under 2 db(A)**, in line with the expected results.

Tests related to **Action B3** and **Action B5** are more focused on the improvements in the fluency of traffic, to be translated in pollutants and CO_2 emissions' reductions terms. The COVID-19 emergency and the recovery plan defined with the EC gave the unique possibility to collect during the **summer season 2020** several days of intense traffic flows which were **not managed through the pilot measure** of dynamic VSL, and to compare them with the associated traffic day patterns in **2019** (VSL applied with first version of DSS) and **2021** (VSL applied with consolidated version of DSS). The results in terms of traffic control efficiency are reported in Table 25, and refer to a total of 33 reference days in the years 2019-2020-2021 on the stretch **BLEC-ENV T3** (the only one which was used in all the testing periods). The empirical values obtained clearly demonstrate how it possible to reach a remarkable improvement related to the ability of the infrastructure to **reduce travel times** (**in the order of 10-15%**) also with an **increased volume of traffic** (**in the order of 30-40%**), which was particularly high during the summer 2021. The comparison between 2019 and 2021 also suggests the importance of a reliable DSS which is able to timely recommend the VSL to be activated.

Summer period	Traffic volume (8:00-20:00)	Average travel time (in minutes)
2020 (no tests)	28.586	33
2019 (tests with first DSS prototype)	+8%	-11%
2021 (tests with consolidated DSS prototype)	+37%	-14%

Table 25: Effects on traffic fluency associated to the measure of dynamic VS triggered by traffic conditions.

The quantification of the **vehicular emissions** produced during these day patterns is presented in Table 26. It is important to underline that the currently available models for the calculations of the emissions are not able to properly take into account the significant emissions' increase caused by stop & go situations, therefore the calculated benefits are likely to be underestimated. Results confirm that **despite an overall increase of the emissions**, caused by an increase of traffic, the measure was able to **reduce the emissions produced by each vehicle in the order of 5%**. The improvement associated to traffic events managed by the integrated traffic measures tested in the Action B5 are estimated to be in the same order of magnitude.

Summer period	Emissions of NOx (total, in g/km)	Emissions of CO_2 (total, in g/km)	Emissions of NOx (g/km per light vehicle)	Emissions of CO_2 (g/km per light vehicle)
2020 (no tests)	20.856	7.859	0.60	0.23
2019 (tests with first DSS prototype)	+1%	+3%	-3%	-2%
2021 (tests with consolidated DSS prototype)	+4%	+6%	-5%	-3%

Table 26: Dynamic VS triggered by traffic conditions and impacts on the generated emissions.

Comparison with planned output and time schedule:
The planned assessment activities were successfully completed and allowed to empirically evaluate the benefits to the associated pilot measures. A comparison between the expected environmental targets is summarized in Table 27.

Pilot measure	Expected target	Achieved target
Dynamic VSL induced by traffic conditions (Action B3)	Reduction of emissions of 10%-30%-40% during the different pilot phases	Reduction of emissions in the order of 5%* * underestimation due to the model used for the calculation of the emissions
Dynamic VSL for air-quality purposes (Action B4)	Reduction of NOx emissions of 20%, of CO2 emissions of 10%, of NO2 concentrations of 5%, of noise levels of 1-2 [dB]	Reduction of NOx emissions of 10-15%, of CO2 emissions of 5-10%, of NO2 concentrations of 10%, of noise levels of 1-2 [dB]
Integrated traffic management highway – city (Action B5)	Reduction of emissions of 10%-30%-40% during the different pilot phases	See achieved results for Action B3

Table 27: Comparison of expected and achieved environmental targets assessed by Action C2.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Valutazione ambientale ex-ante completata	08/2017	08/2017	Achieved	-
Analisi e valutazione dei risultati sperimentali iniziali terminata	05/2018	06/2018	Achieved	-
Analisi e valutazione dei risultati sperimentali intermedi terminata	12/2019	12/2019	Achieved	-
Analisi e valutazione dei risultati sperimentali finali terminata	04/2021	09/2021	Achieved	-

Table 28: Planned and actual milestones' achievement for Action C2.

Deliverable	Submission	Status
D.C2.1 – Valutazione della situazione ambientale ex-ante	1st Progress Report	Submitted to EC
D.C2.2 – Analisi e valutazione dei risultati sperimentali iniziali conseguiti nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ	Mid-Term Report	Submitted to EC
D.C2.3 – Analisi e valutazione dei risultati sperimentali intermedi conseguiti nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ	Final Report	Submitted to EC. The deliverable was already checked during the last monitoring visit in 2021.
D.C2.4 – Analisi e valutazione dei risultati sperimentali intermedi conseguiti nei tratti BLEC-ENV, BLEC-AQ e BLEC-LEZ	Final Report	Submitted to EC

Table 29: State of submission state of Action C2 deliverables.

Problems, deviations and recovery plans:
Unfortunately, several factors reduced the **compliance of road users** in relation to the certain test phases of the measure related to the **dynamic VSL for air quality conditions**, in particular the need to adopt a different road signage (recommended speed limits instead of mandatory speed limits) and the significant reduction of traffic flows during the phases 3 and 4a caused by the COVID-19 emergency. For this reason, empirical measurements did not allow a direct assessment of the benefits of the measure in terms of air pollutant concentrations, and other methodologies and approaches were explored. Traffic and air quality data collected on the field were as a consequence mainly used with another purpose, i.e. to feed advanced modelling tools (the same used also for the automatic elaboration chain developed in Action B2) for the evaluation of reference scenarios associated to the application of the VSL.

Moreover, the explosion of the **COVID-19 pandemics** and the deep change in the traffic volumes and patterns that this generated made any **ex-ante / ex-post analysis** quite **impracticable**, since the effects produced by this event were much more significant than those produced by the project measures. However, the monitoring system set-up in Action C1 gave an unprecedented possibility to **deeply analyse certain environmental aspects**, such as the **exact quantification of the background concentrations**, which were possible to observe in the strictest lock-down days with nearly no traffic on the highway. This analysis, carried out in the scope of sub-action C2.3 and reported in the final deliverable of Action C1, also significantly helped to improve the robustness and the accuracy of the entire modelling chain developed in the scope of the project (Action B2).

The **quantification of the environmental benefits** associated to the pilot measures tested in **Action B3** and **B5** were particularly challenging, due to the difficulty to have a comparison term to put in relationship with what was observed thanks to the application of the measure. The **recovery plan** defined for tackling the **COVID-19 emergency** allowed to use the **season 2020**, in which no test sessions were organized, as "reference baseline". Each significant test day was therefore put in comparison with the correspondent day of 2020 in terms of traffic volumes and demand. The exact quantification of the emissions' reductions per vehicle revealed to be extremely hard to achieve with the **currently available models for the calculations of the emissions**, since they are **not able to properly take into account the significant emissions' increase caused by stop & go situations**. The improvements observed are more likely to be associated only to the effect of the measure to maintain a longer period of traffic stability.

Synergies with complementary action outside LIFE: within the framework of the C-Roads Italy project (CEF), the ICT4CART and the 5G-CARMEN projects (Horizon2020) impacts assessment activities are on-going to evaluate how the new C-ITS technologies will impact on traffic efficiency, environment and safety.

Perspectives for continuing the action after the end of the project:
This impact assessment activities will continue even after the end of the project in order to monitor the benefits associated to the measures applied on the replication stretches. A specific WP (**WP5**) is foreseen for this in the **after-LIFE plan** and will also cover the **continuous improvement of the models** used for the **calculation of the emissions**, in particular as far as the characterization of **stop&go situations**. Linkages are also foreseen with the current **impact assessment studies of the C-ITS use cases** associated to the BrennerLEC pilot measures.

5.10. Action C3

Status of the action: in progress
Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:

All socio-economic monitoring activities were successfully completed according to the initial planning (i.e. ex-ante, initial, intermediate and ex-post monitoring) and covered all direct (sub-action C3.1) and indirect (sub-action C3.2) assessment observations, including the evaluation of the acceptance of project measures by the local stakeholders (sub-action C3.3).As far as the **direct assessment** activities are concerned, through the **four different public questionnaires** organized during the project lifetime it was possible to collect the feedback of **7.468 users**, classified in target groups according to their frequency of usage of the highway and their place of residence. A summary of the most relevant quantified KPIs is summarized in Table 30. The quantitative figures reported are an average of the KPIs measured for all different identified target groups. As expected, the **lowest levels of acceptance** are related to the **VSL measures**, in particular by the **users that frequently travel across the highway** (for this target group the acceptance rate reduces to 35-45%). While the acceptance for the dynamic VSL for air quality purposes remained pretty stable in all assessments, the acceptance for the other project measures saw a continuous increase along the entire project lifetime.

KPI	Ex-ante	Initial monitoring	Intermediate monitoring	Ex-post
Project knowledge	-	58%	58%	56%
Pilot measures acceptance (B3)	64%	49%	52%	61%
Pilot measures acceptance (B4)	55%	39%	55%	55%
Pilot measures acceptance (B5)	66%	75%	78%	86%

Table 30: Direct socio-economic monitoring indicators assessment.

As far as the **indirect assessment** activities are concerned, most of the effort was put on the continuous monitoring of the **compliance of the VSL** by road users. Table 31 provides an overview of the results related to the dynamic VSL measure for air quality conditions. The introduction of the **recommended speed signage** from phase 2 onwards significantly **reduced the efficacy of the test sessions**. It is worth to remark that the no-test speeds for phases 1 and 2 refer to the speeds measured during the test sessions in the part of the stretch in which the VSL were not applied while for phases 3 and 4 a comparison between different periods on the same entire stretch, with VSL activated or not activated, is considered.

KPI: *Speed limits compliance (B4)*			
Phase 1		No Test	118.6 km/h
		Test	-13.3 km/h
Phase 2		No Test	116.7 km/h
		Test	-6.3 km/h
Phase 3		No Test	121.8 km/h
		Test	-3.9 km/h
Phase 4a		No Test	125.1 km/h
		Test	-4.2 km/h
Phase 4b		No Test	123.3 km/h
		Test	-7.1 km/h

Table 31: Indirect socio-economic monitoring indicators assessment (speed limits compliance to pilot measure B4)

Not only the type of signage used and the different traffic volumes (particularly low during phases 3 and 4a due to the COVID-19 emergency) influenced these results, but also the **visibility of the VSL on the different types of VMS** in use in the pilot stretch. A detailed analysis carried out in phase 4 and summarized in Table 32 demonstrated the importance of having at the beginning and at the end of the stretch a gantry VMS, which can be used also for giving text messages; the flag VMS are on the other side more useful for repeating the current VSL along the stretch. These outputs were considered in the exploitation analysis of Action B6, in particular in the definition of the **VMS setting for the replication stretches**.

Test phase	No test	Test with only flag VMS active	Test with only gantry VMS active	Test with all VMS active
Phase 4a	125.1 km/h	-1.8 km/h	-6.2 km/h	-5.1 km/h
Phase 4b	123.3 km/h	-5.5 km/h	-8.4 km/h	-7.5 km/h

Table 32: Indirect socio-economic monitoring indicators assessment (speed limits compliance to pilot measure B4 as a function of different VMS types)

As far as the compliance to **dynamic VSL triggered by traffic conditions**, specific analysis carried out during the **first pilot phase** revealed how in these conditions the **compliance rate** is much higher, and in the order of **60%**. During the evolution of the testing activities the text messages on the gantry VMS were not used anymore to highlight a VSL in place, and only the pictograms were used together with other information related to the on-going traffic events (e.g. real-time travel times, accidents, queues, etc.). In general, however, this did not constitute a major problem since in these cases VSL are adapted as a function of the measured speeds of the vehicles.

The **good level of acceptance** observed, which was obtained mainly thanks to the wide set of dissemination and networking activities carried out in Actions D1 and D2, also **avoided the feared risk of shift of significant traffic volumes from the highway to the alternative ordinary roads**, as quantitively demonstrated by the traffic measurements on both road networks. Moreover, it was possible to guarantee a **neutral or positive acceptance of the project measures by all local environmental and socio-economic stakeholders**, also by those who were quite critical at the project's start towards the idea of testing VSL on the A22 highway. This allowed a smooth execution of all testing activities and a smooth acceptance and active support of the proposed after-LIFE plan.

Comparison with planned output and time schedule:
No significant deviation between the planned and actual execution of the activities is worth to be mentioned.

Milestone	Expected deadline	Actual Deadline	Status	Comment
Valutazione socio-economica ex-ante completata	08/2017	08/2017	Achieved	-
Ricadute socio-economiche iniziali analizzate	05/2018	05/2018	Achieved	-
Ricadute socio-economiche intermedie analizzate	12/2019	12/2019	Achieved	-
Ricadute socio-economiche finali analizzate	04/2021	09/2021	Achieved	-

Table 33: Planned and actual milestones'achievment for Action C3.

Deliverable	Submission	**Status**
D.C3.1 – Valutazione della situazione socio-economica ex-ante	1st Progress Report	Submitted to EC
D.C3.2 – Analisi e valutazione delle ricadute socio-economiche iniziali	Mid-Term Report	Submitted to EC
D.C3.3 – Analisi e valutazione delle ricadute socio-economiche intermedie	Final Report	Submitted to EC. The deliverable was already checked during the last monitoring visit in 2021.
D.C3.4 – Analisi e valutazione delle ricadute socio-economiche finali	Final Report	Submitted to EC

Table 34: State of submission state of Action C3 deliverables.

Problems, deviations and recovery plans:
The indirect monitoring activities mostly concentrated on the evaluation of **traffic data** (traffic volumes, speeds) due to the **late development of the Bluetooth monitoring network**, as described in Action B2. The absence of any phenomena of deviation of traffic flow between highway and ordinary roads did not however determine any negative effects to the completion of the proposed monitoring activities.

Synergies with complementary action outside LIFE:
Coordinating Beneficiary A22 has started to integrate the monitoring activities foreseen in this action with other internal monitoring evaluations carried out in order to evaluate the feedback of highway' users in more general terms

Perspectives for continuing the action after the end of the project
The monitoring activities of Action C3 will be **continued** with the same mix of direct / indirect assessments **in the after-LIFE period**, as they are foreseen in the **after-LIFE plan** (i.e. **task 5.4** and **WP6**). One of the main aspects to be particularly evaluated will be if and how the possible future introduction of the mandatory VSL signage for the air-quality measure will change the measured levels of acceptance of such measure, and if this could lead to negative externalities such as a shift of traffic from highway to ordinary roads.

5.11. Action C4

Status of the action: in progress
Foreseen start date: 01/09/2016 **Actual start date**: 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date**: 30/09/2021
Activities undertaken and quantifiable outputs achieved:

The quantitative evaluation of the reference indicators for the evaluation of the impact of the pilot activities as well as of all other project initiative, as indicated in the list of LIFE performance indicators was successfully completed. For more details about the outputs of this assessment, please refer to Chapter 7 of this Report.

Comparison with planned output and time schedule:

No significant deviation between the planned and actual execution of the activities is worth to be mentioned.

Deliverable	Submission	**Status**
D.C4.1 – Prima quantificazione dei LIFE Project Performance Indicators e degli indicatori per il monitoraggio dell'impatto	1st Progress Report	Submitted to EC
D.C4.2 – Seconda quantificazione dei LIFE Project Performance Indicators e degli indicatori per il monitoraggio dell'impatto	Mid-Term Report	Submitted to EC
D.C4.3 – Terza quantificazione dei LIFE Project Performance Indicators e degli indicatori per il monitoraggio dell'impatto	Final Report	Submitted to EC. The deliverable was already checked during the last monitoring visit in 2021.
D.C4.4 – Quarta quantificazione dei LIFE Project Performance Indicators e degli indicatori per il monitoraggio dell'impatto	Final Report	Submitted to EC

Table 35: State of submission state of Action C4 deliverables.

Problems, deviations and recovery plans: no significant issue is worth to be mentioned here.

Synergies with complementary action outside LIFE: not foreseen so far.

Perspectives for continuing the action after the end of the project: this monitoring activity is strictly related to the implementation of this LIFE project.

5.12. Action D1

Status of the action: in progress
Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
As already anticipated in the summary of Action B4 activities, a great amount of large-scale dissemination activities was carried out since the beginning of the project, much more than what originally planned. Indeed, first project pilot activities immediately showed the need to put an additional effort on communication and awareness-raising, in particular towards road users that frequently travel across the highway. A short summary about the highlights of the dissemination activities is provided in this report; for all the details please refer to the action deliverables.

Several **notice boards** consisting of **poster** and **flyers** were placed in the project area since the beginning of the project (sub-action D1.1). Main installations cover the **service areas of the highway**: 23 notice boards were installed in 19 of the 22 motorway service areas. Initial dissemination material was gradually substituted starting from 2018 by **new posters and graphics highlighting the first empirical results**, including relevant aspects such as the contribution to the whole pollution caused by diesel passenger cars. During two campaigns organized respectively in 2017 and 2018 by Associated Beneficiary APPABZ temporary notice boards were placed at the back side of the **urban buses** driving in the city of **Bolzano**. A similar campaign was organised in **Trento** by Associated Beneficiary APPATN with small boards hanging on board of the buses, even in **2019**. In 2019 APPABZ also organized a so-called **traveling exhibition** in which this dissemination material was made available for a certain amount of time to the public in correspondence of significant points of interest. Thanks to the cooperation with local stakeholders, additional information points were activated during the project lifetime. The most relevant case to be mentioned refer to all **104 libraries** in the **Autonomous Province of Trento**. In response to a comment received in occasion of the second monitoring visit of April 18th, 2018, **new fixed road signs** were also erected at the **entry of the highway**, in addition to the signs indicating the start and the end of the test stretches.

Figure 17: Notice boards in A22 service areas and on buses, fixed road signs at the entry of the A22 highway and traveling exhibition.

The **project web site** (http://brennerlec.life) was launched in the first project months and was regularly updated with news and information (sub-action D1.2). During the entire project lifetime, **more than more than 52.000 users** have visited the web site, with **more than 60.000 visits**. Furthermore, each project partner updated the project information published on its own institutional web site, as for example https://ambiente.provincia.bz.it/aria/brenner-lec.asp

The **presence of the project on the media** organized in sub-action D1.3 was significant since the project start. Apart from the media communication organized by the project staff, several articles appeared (on average, one every month) also in relation to beneficiaries or stakeholders citing the project also in relation to other topics. A relevant number of interviews, press releases and participation to different local awareness-raising public events therefore ensured a continuous project visibility on the media channels, thanks also to the active work of the members of the **Steering Committee**. The media highlights were the **three press conferences** organized at the A22 premises, the first one in 2016 aiming at presenting the project, the second one in 2018 with the goal of the results of the first pilot phase and the third one in 2019 for the launch of the gamification competition based on the APP Shelly which is later described.

Figure 18: Press conferences organized by the project.

Various **dissemination material** was produced (sub-action D1.4). The **initial set of outputs** (poster, flyer, video) were enriched by a series of **infographics** produced in 2018 reporting the first quantitative highlights of the project, used in particular for the aforementioned traveling exhibition. Specific dissemination material (poster, flyer, video) was also prepared and used for the promotion of the **gamification competition based on the APP Shelly**. The **final project results** were presented to the public through the **Layman's Report** and **eight small videos**,

each specific to one specific topic to be communicated, and **one longer video**. Of particular mention is the "**BrennerLEC game**", a boxed game conceived and prepared by Associated Beneficiary APPATN in cooperation with local students and mainly targeting **primary schools.**

Figure 19: Project dissemination material: final project video (on the left) and boxed game.

Traveller information channels managed by the Coordinating Beneficiary A22 were enriched with information on the tests ongoing along the motorway route (sub-action D1.5). In particular, special information was published all the time on the **A22 web site** during the days where tests took place. Such information was replicated through traffic bulletins published by local **radios**. Additionally, **radio spots** were prepared by beneficiaries APPABZ and A22 in 2017, 2018 and 2019 and distributed on local radios to amplify the knowledge about the motivations and proposed activities of BrennerLEC. Several **social media campaigns** were organized to improve visibility of the project activities towards occasional users, and several millions of users saw the BrennerLEC banners on different known web sites and search engines.

Aware of the difficulty to change users' behaviour along the motorway, in particular in a condition where mandatory speed limits could not be used (and therefore enforced) in all use cases, project's partners decided to develop an **APP** able to automatically monitor the driving behaviour of the road users in the BLEC-AQ stretch and rewarding those who observe reduced speed limits. This APP was implemented by a local company (**Top Evolution**) on the base of an existing APP called **Shelly**. The APP also implements an audio interface (so to avoid drivers' distraction), in order to inform the driver when he / she is entering or leaving the test area. The **competition** was **launched** in **November 2019** and was unfortunately then **stopped due to the COVID-19 emergency** in the spring 2020. The awareness-raising initiative was then reactivated in October 2020 up to the project's end. During the interruption break several improvements to the technical system and different simplifications for the participation to the competition were introduced. Despite the communication efforts to promote this competition, the situation of emergency did not allow to obtain critical masses of users using the system and favouring higher compliance rates of the VSL, as presented in the Action C3 results. A total of **255 users subscribed** to the competition, with **only 50 obtaining a positive score** (i.e. with a full compliance of the 100 km/h speed limit) necessary to win a reward, that were delivered during the **award ceremony** organized within the project final event (more details in the Action D2 summary). However, this experience was very useful to test this kind of incentive-based approach and to understand how the entire system and competition could be proposed in the future to really determine a change in the driving behaviour.

Figure 20: Award ceremony of the gamification competition based on the APP Shelly during the project final event.

Twelve technical reports destined to the project's stakeholders and professional target groups (sub-action D1.6) were finally prepared, providing details about the project and the quantitative results achieved. All these outputs are freely available on the project web-site.

Comparison with planned output and time schedule: The scope of the initial communication strategy defined at the project start underwent a revision, after having acknowledged the need to increase some communication activities. The volume of the activities of this project action was therefore quite significantly increased with what originally planned, as demonstrated by the number of dissemination outputs produced. This also had some implications on the budget, as already discussed in the summary of Action B4.

Milestone	Expected deadline	Actual deadline	Status	Comment
Conferenza stampa di inizio progetto realizzata	11/2016	11/2016	Achieved	The press conference took place on 28.11.2016
Prima versione del sito accessibile e poster e pannelli informativi posizionati ed installati nei luoghi identificati	02/2017	02/2017	Achieved	Further fixed notice boards activated during the project, also on the highway. Additional temporary exhibitions organized as well in high-visibility point of interests
Prima disseminazione completata: 1° pubblicazione tecnica, conferenza stampa inizio fase intermedia	03/2018	05/2018	Achieved	The second press conference took place on 30.05.2018. Several dissemination outputs (infographics) prepared to

Milestone	Expected deadline	Actual deadline	Status	Comment
sperimentale, 1° evento di sensibilizzazione, video, canali informativi aggiornati, flyer				communicate the first project results
Seconda disseminazione completata: 2° pubblicazione tecnica, conferenza stampa inizio fase conclusiva sperimentale, 2° evento di sensibilizzazione	01/2020	12/2019	Achieved	The third press conference took place on 15.11.2019. Additional communication material and activities organized to promote the gamification competition based on the APP Shelly
Attività conclusive di disseminazione completate: 3° pubblicazione tecnica, conferenza stampa di fine progetto e Layman's Report	04/2021	09/2021	Achieved	The award of the winners of the gamification competition took place during the project final event on 25.11.2021. Several dissemination outputs (videos, Layman's Report) prepared to disseminate the project results

Table 36: Actual and planned milestones' achievement for Action D1.

Deliverable	Submission	**Status**
D.D1.1 – Sito web di progetto e pannelli informativi	1st Progress Report	Submitted to the EC
D.D1.2 – Primo report di avanzamento sulle attività di disseminazione	1st Progress Report	Submitted to the EC
D.D1.3 – Secondo report di avanzamento sulle attività di disseminazione	Mid-Term Report	Submitted to the EC
D.D1.4 – Terzo report di avanzamento sulle attività di disseminazione	Final Report	Submitted to EC. The deliverable was already checked during the last monitoring visit in 2021.
D.D1.5 – Quarto report di avanzamento sulle attività di disseminazione	Final Report	Submitted to the EC
D.D1.6 – Layman's Report	Final Report	Submitted to the EC

Table 37: State of submission state of Action D1 deliverables.

Problems, deviations and recovery plans:
No significant issue is worth to be mentioned here, except for the need highlighted during the project implementation to carry out an increased number of dissemination activities in order to maximize the acceptance of the pilot measures by road users.

Synergies with complementary action outside LIFE:
Communication activities related to the project were strictly correlated not only with institutional communication activities performed by all project partners, but also with the wide range of stakeholders with which the project is in contact.

Perspectives for continuing the action after the end of the project
A dedicated work package (WP6) is included in the after-LIFE plan in relation to the after-LIFE dissemination activities, which include (i) the **upgrade and further development of the network of notice boards**; (ii) the **maintenance and continuous update of the project web site** and of the **web pages on the institutional web sites**; (iii) the organization of a **follow-up awareness raising initiative** that can exploit the experience collected through the gamification action organized in the project (iv) the **execution of an awareness-raising campaign in the schools** on the base of the boxed game and (v) the organization of all **media activities** as well as the **preparation of all dissemination products** that are needed for communicating the project replication on the A22 highway.

5.13. Action D2

Status of the action: in progress
Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
A relevant work of local stakeholders' involvement was performed, in particular during the first project phase in order to ensure a large acceptance of the pilot measures trialled in the project. This process started already in **December 2016** with a **plenary meeting** of all stakeholders identified and was then continued in the form of different working groups, according to the interests of all different invited organizations. Concerning local municipalities and road operators (sub-action D2.1) two working groups were created: one involving local road operators (working group "*Viabilità Urbana ed Extra urbana*" - **"Urban and extra-urban traffic management"**) and one involving the traffic police competent on the A22 motorway stretch (working group **"Enforcement"**), with which the cooperation was continuous along the entire project execution. Within the first working group the traffic management procedures proposed in Action B5 were proposed and the correspondent pilot activities were organized. The activities of this working group were particularly intense during the first and last project phase, in relation to the pilot activities related to the city of Bolzano. A total of **15 meetings** was organized and carried out.

Two further working groups were created in order to involve all reference environmental and economic stakeholders: the working groups "*Sostenibilità Ambientale*" (**Environmental Sustainability**) and "*Osservatorio Socio-Economico*" (**Socio-Economic Observatory**) (sub-action D2.2). **Four plenary meetings** with each group were organized in correspondence of the major project's milestones; during the last meeting the proposed **replication plan** was presented and agreed with all local stakeholders. Through the organization of additional networking meetings organized by some of the most active stakeholders it was possible to improve the number of contact people involved in this open networking process.

Figure 21: Networking meetings with local stakeholders.

Networking activities organized in the scope of sub-actions D2.3 / D2.4 / D2.5 targeted also non-local stakeholders. Two meetings with the **Austrian motorway operator ASFINAG** were

organized in 2017 and 2018 in order to deepen the Austrian experience of dynamic speed reduction. Also based on the inputs of some local socio-economic stakeholders, in particular the Chamber of Commerce of Bolzano and Trento, a working group called "**Brenner Digital Corridor**" was launched in 2020 in collaboration of the highway operators and public administrations along the Brenner Corridor in order to co-develop a roadmap for the joint digitalization of highway traffic, also in light of the sustainability targets that projects like BrennerLEC are contributing to address. An active cooperation was also established with the **EUSALP** working group led by the Tyrol region for integrating BrennerLEC pilot measures within the macro-regional strategic policies of the Alpine region in the field of transportation. **Four networking meetings** with **national stakeholders** (including reference people from the Italian Ministries of Environment and Transportation) were carried out, with the intention to promote a replication of this best-practice in other Italian regions and support the improvement of the current legislative limitations. The cooperation with other **highway operators** was at the beginning quite difficult, while at the project's end a high appreciation and interest in the replication of the project on the highways they manage was observed.

Networking activities with other **LIFE** projects were also carried out (sub-action D2.7): in particular, BrennerLEC was presented during technical events organized in the scope of the LIFE projects **"MONZA", "DYNAMAP"** and **"PREPAIR**, with which a strict cooperation was ensured, thanks to the presence of APPATN in both consortia. The entire list of connected projects is available at the web page https://brennerlec.life/en/other-eu-projects

As far as the international and scientific networking is concerned (sub-action D2.6 and sub-action D2.8), the project actively participated to two networking meetings in the field of air quality and environmental sustainability, i.e. the **LIFE Platform Meeting on Air Quality** held in Barcelona in September 2017 and to the **21st European Forum on Eco-innovation** held in Sofia in February 2018. Apart from several small events on local scale, project presentations were organized in **fifteen international congresses** and **scientific conferences**, the most relevant being in the field of meteorology, pollutants' emissions and intelligent transport systems. **Two scientific papers** were produced respectively in relation to the calibration of the low-cost air quality sensors and the effects of the COVID-19 lockdown measures. The project also actively contributed to the production of the annual environmental report produced by SNPA (*Sistema nazionale a rete per la protezione dell'ambiente)*, the local association of environmental agencies in Italy. **Three project workshops** open to all interested organizations (including private companies) were organized in April 2017, May 2019 and February 2021 (in the form a webinar), respectively. Last but not least, **two high-policy events** were organized with the active participation of the **EC**, one in February 2020 and one in November 2021, the latter one representing the **final project event**. A comprehensive summary of all networking meetings organized by the project is given in Table 38.

Figure 22: Networking activities with national and international stakeholders.

Meeting	Date	Location	Nr. of stakeholders	Nr. of participants
Kick-off with local stakeholders	05.12.2016	Trento, A22	15	26
1st meeting working group "Enforcement"	12.01.2017	Trento, A22	1	1
1st meeting working group "Viabilità Urbana ed Extra urbana"	23.01.2017	Trento, A22	6	14
1st meeting working group "Alpine-BLEC"	27.01.2017	Innsbruck, ASFINAG	1	2
1st meeting working group "Osservatorio Socio-Economico"	22.02.2017	Bolzano, IDM	8	8
1st meeting working group "Sostenibilità Ambientale"	22.02.2017	Bolzano, APPABZ	10	12
2nd meeting working group "Viabilità Urbana ed Extra urbana"	18.04.2017	Trento, A22	4	6
1st project workshop	20.04.2017	Bolzano, Klimamobility Fair	40	46
1st networking meeting with national stakeholders	21.04.2017	Trento, Province Trento	7	10
3rd meeting working group "Viabilità Urbana ed Extra urbana"	15.11.2017	Trento, A22	5	10
2nd meeting working groups "Osservatorio Socio-	30.05.2018	Trento A22,	9	9

Meeting	Date	Location	Nr. of stakeholders	Nr. of participants
Economico" and "Sostenibilità Ambientale"				
4th meeting working group "Viabilità Urbana ed Extra urbana"	27.06.2018	Trento, A22	2	4
2nd meeting working group "Enforcement"	04.09.2018	Trento, A22	1	3
5th meeting working group "Viabilità Urbana ed Extra urbana"	13.09.2018	Bolzano, IDM	2	3
6th meeting working group "Viabilità Urbana ed Extra urbana"	26.11.2018	Trento, A22	4	7
2nd networking meeting with national stakeholders	28.11.2018	Bologna, Emilia-Romagna Region	5	12
2nd meeting working group "Alpine-BLEC"	05.12.2018	Trento, A22	1	1
2nd project workshop	14.05.2019	Bolzano, NOI	56	89
7th meeting working group "Viabilità Urbana ed Extra urbana"	14.11.2019	Trento, A22	5	11
3rd meeting working groups "Osservatorio Socio-Economico" and "Sostenibilità Ambientale"	21.11.2019	Bolzano, Province BZ	11	13
1st High-Policy Event	06.02.2020	Bolzano, Province BZ	37	107
1st meeting working group called "Brenner Digital Corridor"	08.09.2020	Trento, A22 and online	9	16
2nd meeting working group called "Brenner Digital Corridor"	03.11.2020	Online	10	20
8th meeting working group "Viabilità Urbana ed Extra urbana" (focus Bolzano)	10.12.2020	Online	2	10
3rd networking meeting with national stakeholders	17.12.2020	Online	6	14
9th meeting working group "Viabilità Urbana ed Extra urbana" (focus Bolzano)	17.02.2021	Online	2	4
3rd project workshop	05.02.2021	Online	49	94
3rd meeting working group called "Brenner Digital Corridor"	24.02.2021	Online	9	21

Meeting	Date	Location	Nr. of stakeholders	Nr. of participants
10th meeting working group "Viabilità Urbana ed Extra urbana" (focus Bolzano)	10.03.2021	Online	2	4
11th meeting working group "Viabilità Urbana ed Extra urbana" (focus Bolzano)	31.03.2021	Online	2	2
12th meeting working group "Viabilità Urbana ed Extra urbana" (focus Bolzano)	07.04.2021	Online	2	4
13th meeting working group "Viabilità Urbana ed Extra urbana" (focus Bolzano)	05.05.2021	Online	2	3
14th meeting working group "Viabilità Urbana ed Extra urbana" (focus Bolzano)	22.06.2021	Online	2	2
4th meeting working groups "Osservatorio Socio-Economico" and "Sostenibilità Ambientale" (BZ stakeholders)	30.09.2021	Bolzano, Province BZ	16	27
4th meeting working groups "Osservatorio Socio-Economico" and "Sostenibilità Ambientale" (TN stakeholders)	04.10.2021	Trento, A22	11	20
15th meeting working group "Viabilità Urbana ed Extra urbana" (focus Bolzano)	21.10.2021	Bolzano, NOI	2	1
4th networking meeting with national stakeholders	28.10.2021	Online	6	18
2nd High-Policy Event (final event)	25.11.2021	Online	54	116

Table 38: Details of networking meetings organized by the project.

Comparison with planned output and time schedule:

The amount of networking sessions was significantly higher than what originally planned, mainly for two reasons. On the one hand, this was a direct consequence of the high interest in the project by stakeholders at various levels and the need to obtain and maintain a widespread acceptance / support from all of them. On the other hand, networking activities were recognized as the right measure to address with the support of the stakeholders the Italian Ministry of Transportation, so to promote the upgrade of the Traffic Rules of the Road and allow the application of VSL not only for road safety reasons.

Milestone	Expected deadline	Actual deadline	Status	Comment
Tavolo di lavoro con le amministrazioni comunali e i gestori stradali aperti	02/2017	12/2016	Achieved	-
Tavoli di lavoro con le associazioni di categoria e le imprese locali aperti, tavolo di confronto con stakeholder austriaci avviato	08/2017	01/2017	Achieved	-
Prima serie di presentazioni del progetto a conferenze scientifiche ad eventi internazionali di networking effettuate, primo workshop di progetto realizzato	12/2017	09/2017	Achieved	-
Primo evento di alto profilo politico realizzato e prima serie di incontri coi gruppi di lavoro col Ministero dei Trasporti e con il Ministero dell'Ambiente svolta	12/2018	02/2020	Achieved	1st High Policy Event (06.02.2020)
Secondo workshop di progetto realizzato	12/2019	05/2019	Achieved	Event taken place on (15.05.2019)
Secondo evento di alto profilo politico realizzato	12/2020	11/2021	Achieved	Final project event (25.11.2021)
Serie finali di presentazioni del progetto a conferenze scientifiche ed eventi internazionali di networking completate, evento finale di progetto completato	04/2021	09/2021	Achieved	-

Table 39: Actual and planned milestones' achievement for Action D2.

Deliverable	Submission	Status
D.D2.1 – Primo report di avanzamento sulle attività di coinvolgimento degli stakeholder	1st Progress Report	Submitted to the EC
D.D2.2 – Secondo report di avanzamento sulle attività di coinvolgimento degli stakeholder	Mid-Term Report	Submitted to the EC
D.D2.3 – Terzo report di avanzamento sulle attività di coinvolgimento degli stakeholder	Final Report	Submitted to the EC. The deliverable was already checked during the last monitoring visit in 2021
D.D2.4 – Quarto report di avanzamento sulle attività di coinvolgimento degli stakeholder e piano di coinvolgimento after-LIFE	Final Report	Submitted to the EC

Table 40: State of submission state of Action D2 deliverables.

Problems, deviations and recovery plans:
The main issue was related to the relationship that project partners had at various levels with the **Italian Ministry of Transportation**, which did not actively support the implementation of the project as promised in the letter of interns signed at the project's start despite the several efforts and action carried out at different levels. This issue will be further tackled in the **after-LIFE period** in particular by beneficiaries A22, APPABZ and APPATN, also thanks to the active support of other stakeholder, primarily the I**talian Ministry for the Environment**. The cooperation will likely be improved once the Italian Ministry of Transportation will formalise the **concession** to A22 to manage the highway for the next 30 years.

Synergies with complementary action outside LIFE:
Project networking activities were organized in cooperation with other CEF and H2020 projects that the Coordinating Beneficiary A22 has been carrying out, namely C-Roads Italy, ICT4Cart and 5G-Carmen. Institutional partners A22, APPABZ and APPATN have been managing the relationships with most of the local stakeholders in synergy with the networking work carried out in BrennerLEC.

Perspectives for continuing the action after the end of the project
Most of the local, national and international networking activities will continue even after the project's end, as defined in the **after-LIFE plan** (**tasks 6.2 and 6.3**), with workshops and periodic update meetings with the stakeholders already involved (on average, once a year). The involvement of some stakeholders, such as municipalities and other road operators will be much more intense since they will be more actively involved in the design and implementation of the replication measure.

5.14. Action E1

Status of the action: in progress
Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
The internal project management activities were successfully completed. The coordination modalities demonstrated to be appropriate for managing the complexity of this project, also thanks to the strict and profitable cooperation established inside the **PMT** and the **PCT** and the support of the **Steering Committee.**

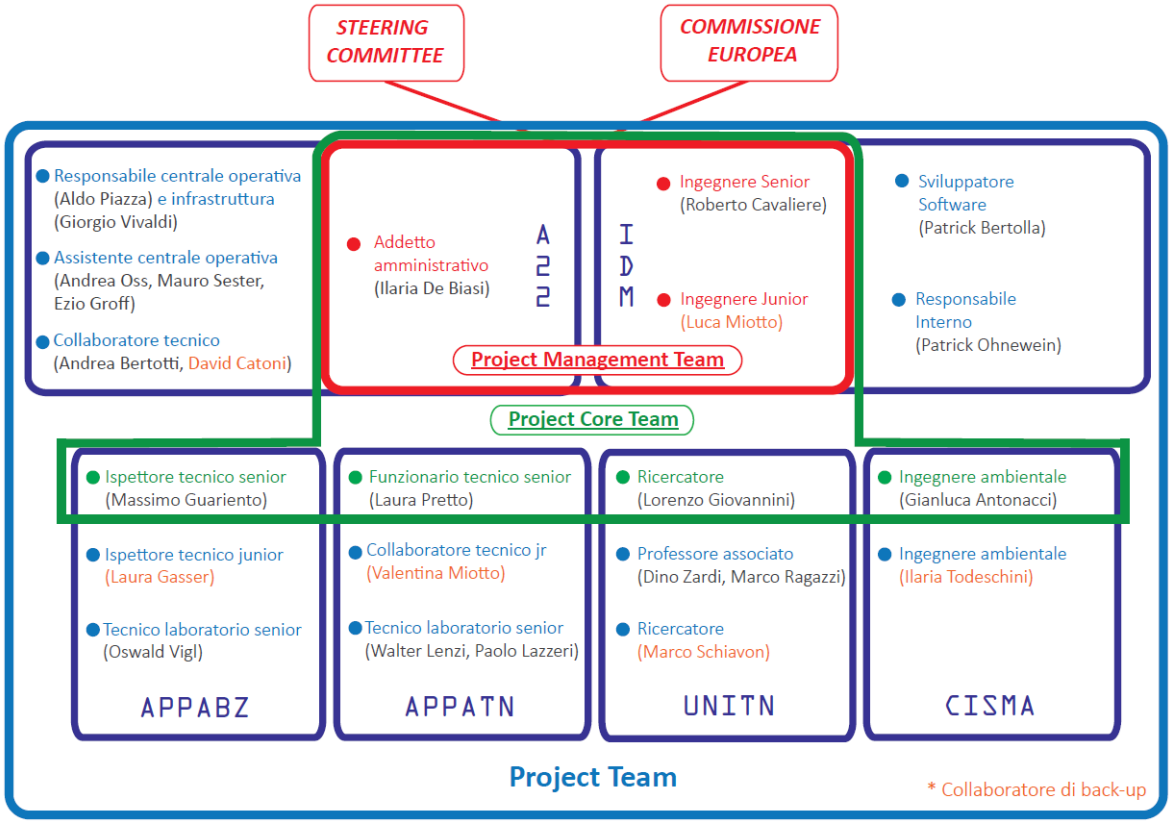

Figure 23: Project organization and staff.

After a successful **project kick-off**, completed already by the end of **2016**, a regular project coordination was put in place with all partners. Beside the technical meetings which involved only part of the beneficiaries and the project staff, 58 plenary meetings and just as many conference calls were completed, covering both technical and financial matters. All this project management work is properly documented and can be made available to the European Commission if needed. The involvement of the **Steering Committee** was successfully organized in correspondence of the major project milestones and for handling with a commonly shared approach the most critical challenges. The managers of the boards and in particular the **General Technical Direction of Coordinating Beneficiary A22** had a key role to strengthen the position of the project at high-policy levels and to ensure its smooth execution for the assessment of the demonstrative VSL-based pilot measures. This commitment was also key for elaborating an ambitious **after-LIFE plan**, which not only aims to **replicate the measures along all the alpine stretch of the A22 highway** and to ensure the continuity of certain activities initiated through the BrennerLEC project, but is also fully integrated with the development and investments' plans of the Coordinating Beneficiary A22 and policy partners

APPABZ and APPATN. Project partners formally committed to implement this plan through a **specific after-LIFE partnership agreement** signed in correspondence of the project's end.

Comparison with planned output and time schedule:
All project milestones were successfully achieved within the scheduled deadlines and all relevant outputs (i.e. signed Partnership Agreement) were already transmitted to the European Commission together with the first Progress Report. The after-LIFE partnership agreement is annexed to the Final Report. In light of the first project amendment dated September 21st 2018, no audit report was produced.

Milestone	Expected deadline	Actual deadline	Status	Comment
Kick-off meeting realizzato	09/2016	09/2016	Achieved	-
Partnership Agreement sottoscritto e procedure interne di gestione amministrative del progetto avviate	12/2016	12/2016	Achieved	-

Table 41: Actual and planned milestones' achievement for Action E1.

Deliverable	Submission	Status
D.E1.1 – After-LIFE Plan	Final Report	Submitted to the EC
D.E1.2 – Audit Report	Final Report	Won't be submitted in light of Amendment nr.1 to the Grant Agreement

Table 42: State of submission state of Action E1 deliverables.

Problems, deviations and recovery plans: the explosion of the COVID-19 emergency determined the necessity to transform the physical plenary meeting in virtual ones. Despite this was not optimal for the team building, this change did not have particular impacts on the execution of the project management activities.

Synergies with complementary action outside LIFE: not foreseen so far.

Perspectives for continuing the action after the end of the project: the entire project management structure will be kept after the end of the project and is part of the **after-LIFE plan (WP1)**.

5.15. Action E2

Status of the action: in progress
Foreseen start date: 01/09/2016 **Actual start date:** 01/09/2016
Foreseen end date: 30/04/2021 **Actual end date:** 30/09/2021
Activities undertaken and quantifiable outputs achieved:
The coordination with the LIFE authorities was successfully carried out in a positive and constructive way, in particular during the most critical phases of the project, e.g. the explosion of the COVID-19 pandemics and the need to identify a recovery plan in order to tackle the changed situation. LIFE authorities were always regularly updated through the monitoring team about the project progress, in a periodic way (monthly / every three months) or in case of significant notices or deviations with the project plan. In that regard the **annual monitoring visits** were important checkpoints, also to clarify detailed aspects associated to the accounting of financial expenditures. The monitoring visits took place on April 5th 2017, April 18th 2018, May 17th 2019 (physically), and on June 19th 2020, April 30th and May 17th 2021 (virtually). The third monitoring visit in 2019 was enriched by the presence of Desk Officer Lionetti and of LIFE national contact point Stefania Betti.

The activities of this action also included the **project reporting** towards the EC, which was a shared work of all PCT coordinated by the PMT, as a function of the responsibilities of the different project actions set in the proposal. The peer review work mainly carried out by the PMT ensured harmonized and high-quality reporting outputs.

Comparison with planned output and time schedule:
The project management activities foreseen in this Action were completed without any significant deviation from the planned project plan.

Milestone	Expected deadline	Actual deadline	Status	Comment
Prima visita di monitoraggio completata	08/2017	04/2017	Achieved	-
Seconda visita di monitoraggio completata	08/2018	04/2018	Achieved	-
Terza visita di monitoraggio completata	08/2019	05/2019	Achieved	-
Quarta visita di monitoraggio completata	08/2020	06/2020	Achieved	-
Quinta visita di monitoraggio completata	04/2021	05/2021	Achieved	-

Table 43: Actual and planned milestones' achievement for Action E2.

Problems, deviations and recovery plans: no significant issue is worth to be mentioned here.

Synergies with complementary action outside LIFE: not foreseen so far.

Perspectives for continuing the action after the end of the project: this activity is strictly related to the implementation of this LIFE project.

5.16. Main deviations, problems and corrective actions implemented

The main issues, deviations and recovery plans that the project faced are summarized in the executive summary and in the action details of this chapter. A summarized overview is reported in Table 44.

Issue / deviation	Severity and description	Recovery plan
Impossibility to use speed limits since the second pilot phase of Action B4	**Major**. Initial grant applied in phase 1 put into discussion. Support by the Italian Ministry of Transportation in discussion due to changed boundary conditions.	Solution searched at **political level** through the **Steering Committee** and the **involvement of key stakeholders**. Improvement of the Italian Rules of Road on-going thanks to the Italian Ministry of Transportation. Road users' compliance sought through alternative measures, i.e. broader awareness-raising campaign, incentives and gamification solutions.
Explosion of the COVID-19 pandemics	**Major**. Impossibility to carry out pilot activities for several months, in particular during the heavy lock-down period of spring 2020.	**Extension of the project duration** up to **September 2021**, so to have the entire summer season 2021 to complete the final testing activities (amendment to the Grant Agreement nr.3). Additional implementation effort needed on the ITS system, e.g. a new methodology to predict traffic was introduced.
Change in the proposed technical solution for the VMS infrastructure	**Medium**. More efficient solution adopted (solar flag VMS) with remarkable effects on budget plan.	**New VMS infrastructure** successfully implemented and used during the pilot activities.
Extension of the BLEC-AQ stretch	**Medium**. Extension of the stretch in order to ensure a better visualization of VSL on VMS. Additional VMS installations needed.	**Slight re-organization of the pilot phases** foreseen in Actions B3 and B4
Delay in the tests related to the usage of HSR running.	**Medium**. Delay due to the need of additional effort with the reference **traffic police** and **rescue forces** for determining the safety procedures in case of accidents. Impossibility to test the measure after the COVID-19 pandemics explosion.	Decision to **concentrate just on the VSL measure**, whose testing was also significantly jeopardized by the COVID emergency

Issue / deviation	Severity and description	Recovery plan
Delay in the installation of the low-cost air quality monitoring network	**Low**. Delay due to the need to better investigate the functioning of these sensors and make the best use of the available data.	Monitoring activities limited in the first phase to the usage of reference air quality stations.
Delay in the installation of the low-cost Bluetooth monitoring network	**Low**. Delay due to technical issues associated to the road operators.	Associated monitoring activities and end-users applications covered by other systems. Activity labelled as "non-critical" and organized according to a **new time schedule**
Modelling chain without public health module	**Low**. Deviation due to practical utility of the module.	Public health considerations limited to ex-ante assessment studies.
Unforeseen additional costs for initial monitoring sites installation	**Low**. Issues related to practical needs empirically found during the installation phase.	All necessary activities were financially covered, determining slight budget variations.
Increased amount of expenditures for dissemination and networking	**Low**. Functional to the achievement of expected project results.	One of the major countermeasure to the above major issue.

Table 44: Main deviations, problems and corrective actions implemented.

5.17. Evaluation of Project Implementation

The **methodology** proposed for the implementation of the project, characterized by a strong **mix of technical developments** and an **active involvement of road users and stakeholders**, can with no doubt evaluated as very successful. This was also the feedback shared by many stakeholders, including those who have expressed a negative evaluation of the proposed pilot measures. The results also confirm the suitability of the proposed actions, including the pilot implementation but also the monitoring, dissemination and networking ones.

A **comparison between achieved and expected results** associated to each project action is already exhaustively presented in the summary of each project action. Apart of some minor variations in the organization of the activities scheduled in the different actions, mainly caused by external factors, a complete alignment with the initial proposal of work organization was successfully achieved.

The **measure tested in Action B4** already brought to **remarkable quantitative results** in terms of emissions reductions and NO_2 concentrations. The application of the "recommended speed limit" mode unfortunately reduced this environmental improvement. On the other side, the **measures developed in Actions B3 and B5** already showed **clear quantitative improvements in terms of traffic fluency** during nearly-congested traffic conditions. The environmental associated benefits were estimated to be limited and currently not clearly visible in terms of pollutions' concentrations, even because the targeted traffic situations are non frequent. The **amendment nr. 3** that allowed to extend the project duration up to September 2021 was fundamental for the final assessment of all pilot measures; without it the results would have been partial and probably not so solid from a scientific point of view.

A significant work was also carried out as far the **replication efforts** are concerned. The application of VSL is a measure that other organizations **at national level**, in particular in the northern area (Lombardia and Emilia-Romagna), are starting to investigate, at least in terms of feasibility check. Not only **environmental agencies** but also **highway operators** demonstrated a strong interest to replicate the project measures. In that regard, the expected review of the Italian Rules of Road is fundamental to give a framework for their application without uncertainties. The networking work at **EUSALP** level and with relevant stakeholders in **North-Tyrol** and **Bavaria** created the right pre-conditions for consolidating the **exploitation plan** not only on the **A22 highway** but also on the **entire Brenner Corridor** and more generally speaking on the **entire alpine region**.

As far as the **effectiveness of the dissemination activities** are concerned, project beneficiaries soon understood that the initial amount of dissemination activities and budget would have been insufficient to cope with the communication needs of this project. Therefore a particular and **greater attention and effort** were put on these kind of activities, in particular after the necessity to introduce the "recommended" speed limits in Action B4 since the second pilot phase. The level of acceptance obtained was pretty satisfactory, and great negative reactions by the target audience – something that was somehow expected at the project's start – were not observed. On the other hand, the absence of mandatory measures demonstrated the impossibility to obtain high compliance values. A **stick & carrot approach** is probably the best approach at all in order to obtain both high acceptance and high compliance values for the targeted measures, as empirically suggested by the awareness-raising action organized in the form of a **gamification app** awarding users that drive in conformity with VSL (the first experience ever worldwide.

In terms of **policy impact**, the main achievement that the project tried with all its own forces to accomplish during its duration is the review of the **Italian Rules of the Road**, so to allow the possibility to apply all proposed pilot measures, in particular VSL for environmental purposes, also in a non-experimental way. Unfortunately, this process has not been concluded yet but the project managed to activate all necessary steps for achieving this goal in a near future, thanks in particular to the cooperation of the **Italian Ministry of Environment**, which is currently following this topic at national level. It is important to underline that recently both **APPABZ** and **APPATN** published their **new programs for the reduction of the nitrogen dioxide pollution**. The actions carried out in BrennerLEC are an essential element of the measures identified for the achievement of the target environmental goals in the Provinces of Trento and Bolzano. Finally, the **recommendations for the improvements of the current EU policies and regulations** provided in the scope of Action B6 represent concrete inputs for ensuring that European framework in the field of environment and transportation could further improve so to allow the implementation of further measures to improve the traffic control of the highway. For example, a better **management of tolling systems** can ensure a smoother and more controlled flow of traffic in or from the highway.

5.18. Analysis of benefits

A qualitative evaluation of the project as a function of the results achieved is briefly reported in Table 45. For a more quantitative analysis, please refer to chapter 7.

Type of benefit	Evaluation
Environmental benefits	- **Benefits associated to the pilot measure B4**: reductions of NOx emissions and concentrations in line with initial targets. Similar effects also confirmed for black carbons, while the impacts on particular matter are nearly negligible. Reductions

Type of benefit	Evaluation
	in noise level are quite limited due to the remarkable presence of heavy vehicles driving on the A22 highway. - **Benefits associated to the pilot measure B3 and B5**: empirical measurements demonstrated a remarkable improvement of traffic fluency, while the reduction of emissions was calculated to be lower than what ambitiously expected, even if this can be underestimated due to the complexity to calculate emissions related to stop&go situations.
Economic benefits	- **Direct effects**: development of know-how by project beneficiaries with opportunities of creating new qualified jobs; involvement of local companies as suppliers. - **Indirect effects**: reduced cost externalities due to higher level of service of highway (minor delay and minor accidents) during intense traffic conditions; reduced fuel costs due to more cost-effective driving behaviour
Social benefits	- Improved quality of life in the pilot areas near the highway - Increased awareness of environmental concerns. - Contribution in the improvement of sustainable mobility habits
Replicability, transferability, cooperation	- Replication on the **A22 highway** - Medium replication potential in the **EUSALP region** - Medium replication potential on other **national highways** - Cooperation with EC-funded projects in the field of **cooperative and autonomous driving** in which A22 is involved, with applications on the **Brenner Corridor**
Best-practice lessons	- Participation in events organized by third parties - Project events (e.g. workshops) - Networking with other projects, in particular LIFE ones
Innovation and demonstration value	- **"Proactive" approach** - **Calibration** of **emission model** thanks to detailed characterization of **vehicular fleet** - **Calibration** of **low-cost air quality sensors** - **Open ICT infrastructure** suitable for future smart mobility developments - **Open innovation approach** for the involvement of interested 3rd parties
Policy implications	- Enhancement of **Italian Rules of the Road** - Enhancement of **local policies** in the field of sustainable transportation and environment - Enhancement of **EUSALP policies** in the field of transportation - Enhancement of **EU policies** in the field of sustainable transportation and environment

Table 45: Benefits assessment related to the project.

6. Key Project-level Indicators

A quantitative evaluation of the project is summarized in Table 46, which provides a summarized view of the quantification of the project KPIs. The summary includes also a comparison between the final KPIs estimation with those made at the project start. The indicators related to the climate change adaptation (indicators set nr.9 in the online tool) were deleted since the project is to be intended just as a climate change mitigation project. The initial values for the CO_2 emissions are not reported since they referred to a different test stretch. For more details related to the quantification of the KPI, please refer to deliverable D.C4.4 and to the online tool, in which all the necessary clarifications are reported.

KPI	Initial snapshot			Final snapshot		
	Start-of-play	State-of-lay at project's end	Expected state-of-lay after 5 years	Start-of-play	State-of-lay at project's end	Expected state-of-lay after 5 years
1.5 Project extent [km^2]	0	480	1400	0	450	1720
1.6 Humans influenced by the project [nr.]	0	350.000	600.000	0	350.000	600.000
5.2.1 Noise [db Lden]	60	58	57	60	59	57
6.1 NOx emissions [tons / year]	140	100	85	140	119	105
6.2 PM10 concentrations [µg/m^3]	16	15	14	19	16	16
6.2 PM10 exceedances [nr / year]	3	3	3	3	0	0
6.2 NO_2 concentrations [µg/m^3]	58	39	36	45	37	32
6.2 NO_2 exceedances [nr / year]	6	0	0	6	0	0
8.1.1 CO_2 emissions [kg/km per kg]	-	-	-	3.36	3.12	2.90
8.1.1 CO_2 emissions [t/year]	-	-	-	46.629	43.365	40.567
9.1 Adaptation area	0	360	1000	-	-	-
9.2 Infrastructures targeted	0	1	2	-	-	-
10.1.1 Duty holders covered (public entities)	4	7	30	0	23	49
10.1.2 Duty holders covered (large enterprises)	-	-	-	0	4	16
10.1.2 Enforcement bodies	0	1	1	0	1	1
10.1.3 Enforcement systems	3	3	6	0	4	6
10.2.1 Involvement of stakeholders (public)	0	6	10	0	45	75
10.2.1 Involvement of stakeholders (private)	-	-	-	0	12	29
11.1 Website accesses [nr.]	0	20.000	50.000	0	60.859	100.000
11.2 Nr of different publications (journal / conferences)	0	3	5	0	30	55

KPI	Initial snapshot			Final snapshot		
	Start-of-play	State-of-lay at project's end	Expected state-of-lay after 5 years	Start-of-play	State-of-lay at project's end	Expected state-of-lay after 5 years
11.2 Nr of articles in print media	0	3	5	0	28	53
11.2 Nr of other distinct media products	0	3	5	0	33	48
11.2 Nr of hotline / information centers created	0	3	5	0	3	5
11.2 Nr of events / exhibitions organised	0	15	20	0	10	15
11.2 Nr of different displayed information (info boards)	0	40	60	0	156	171
11.2 Number of discrete Project Reports drafted	-	-	-	0	13	18
11.3 People surveyed [nr.]	0	3.000	5.000	0	7.468	12.468
12.1 Contacts with representatives of other EU project	-	-	-	0	25	50
12.1 International professionals involved [nr.]	0	500	750	0	149	349
12.1 Local professionals involved [nr.]	0	360	600	0	303	653
12.2 Local professionals trained [nr.]	0	10	20	0	10	20
13 FTE project staff [nr.]	0	7	10	0	7	7
14.1 Running / operating costs	0	€ 380.000	€ 500.000	0	€ 4.500.000	€ 5.660.900
14.2.1 Capital expenditure after the project end	-	-	€ 1.000.000	-	-	€ 940.000
14.3 Future funding	-	-	€ 1.000.000	-	-	€ 2.100.900

Table 46: Summary of quantified KPI.

7. Comments on the financial report

This section of the Final Report provides an insight of the costs incurred from the project's start (September 1st 2016) up to the project's end (September 30th 2021).

7.1 Summary of Costs Incurred

Table 47 illustrates the overall costs incurred by the BrennerLEC project for each cost category. In total, **€ 4.036.740,73** (total costs with overheads) has been spent, i.e. € 18.736,73 more than the total project budget as defined in the Grant Agreement.

PROJECT COSTS INCURRED				
	Cost category	Budget according to the grant agreement in €	Final costs incurred in €	%
1.	Personnel	€ 2.034.703,00	€ 2.134.631,05	104.9%
2.	Travel and subsistence	€ 39.430,00	€ 20.092,09	51.0%
3.	External assistance	€ 517.709,00	€ 650.880,58	125.7%
4.	Durables goods: total non-depreciated cost			
	- *Infrastructure sub-tot.*	€ 556.000,00	€ 233.429,00	42.0%
	- *Equipment sub-tot.*	€ 564.280,00	€ 628.151.59	111.3%
	- *Prototype sub-tot.*	€ 0,00	€ 0,00	-
5.	Consumables	€ 52.905,00	€ 80.839,48	152.8%
6.	Other costs	€ 36.350,00	€ 63.611,95	175.0%
7.	Overheads	€ 216.627,00	€ 225.105,00	103.9%
	TOTAL	**€ 4.018.004,00**	**€ 4.036.740,73**	**100.5%**

Table 47: Final cost expenditures of the BrennerLEC project per cost category.

The main budget deviation is related to a **remarkable deviation** in the way the **infrastructure of VMS** needed for the pilot tests was implemented. The original plan was to install two gantry VMS and three flag VMS, with a significant investment for bringing the power supply in correspondence of the positions in which such VMS need to be installed (Figure 24). The new proposed solution that has been successfully implemented, as reported in the technical chapter (Action B2), foresees only the use of 9 of a new generation of flag VMS (without gantry VMS and the need of infrastructure goods for the power supply), more visible to the road users and most interestingly energy-sufficient, being powered by solar energy and back-up batteries (Figure 26). This alternative plan was implemented due to clear better cost / benefit compromise, and due to the possibility to ensure a smoother and quicker implementation of the required VMS infrastructure, with reduced impacts on the normal traffic flows. From a financial point, the adoption of this alternative plan determined the variations summarized in Table 48. Please note that the difference between the infrastructure and equipment costs is related to different part of the VMS (only the electronic display is considered equipment, see Figure 25).

In 2020 Coordinating Beneficiary A22 made a second investment of three additional solar-powered VMS that were used to further increase the readability of the dynamic speed limits in the south carriageway and to allow the possibility to start testing the B3 measure (dynamic speed limits driven by traffic conditions) also in the north carriageway. These additional VMS

were installed at km 116+800 (direction north), km 85+300 (direction south) and km 127+550 (direction south).

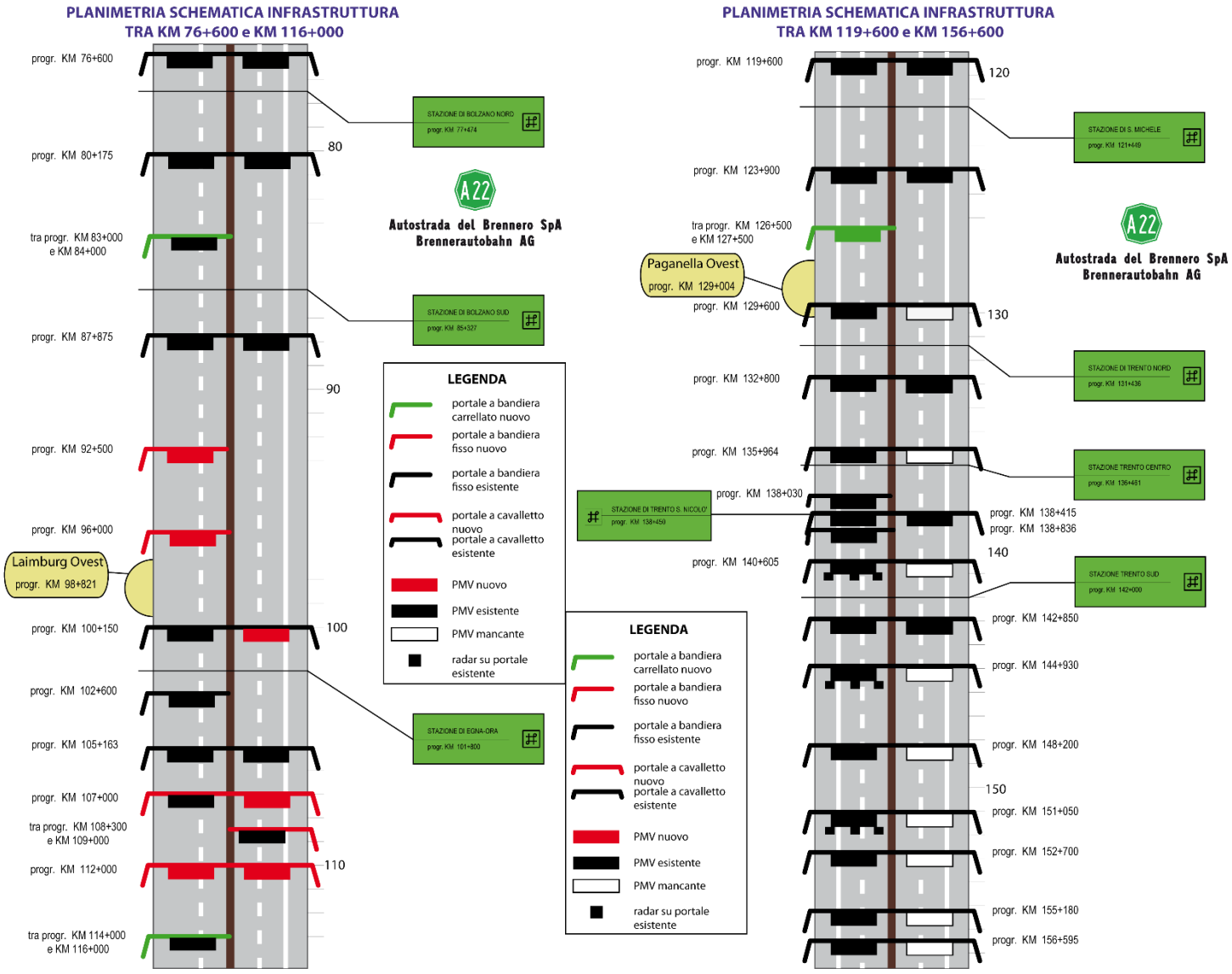

Figure 24: VMS infrastructure as in the original upgrade plan (in red and green the new proposed installations, with "portale a bandiera" and "portale a cavalletto"meaning meaning "flag VMS" and "gantry VMS", respectively).

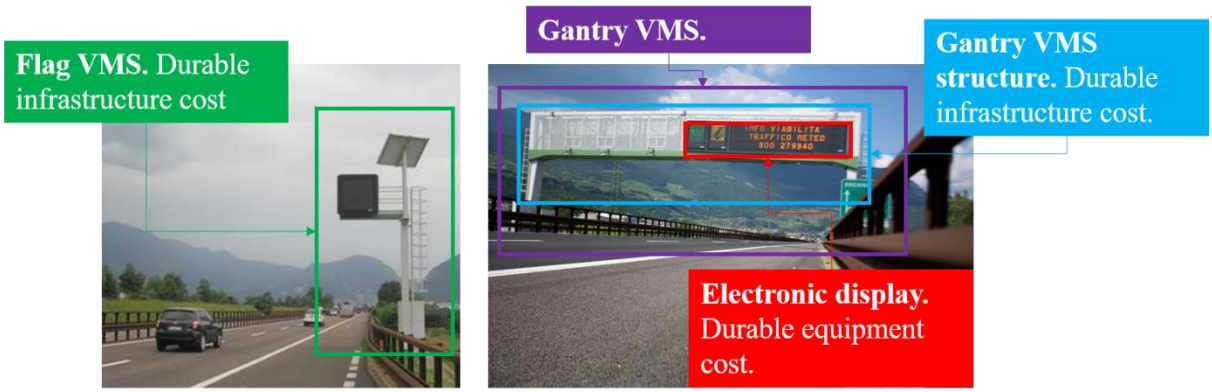

Figure 25: Gantry vs flag VMS: durable infrastructure and equipment costs.

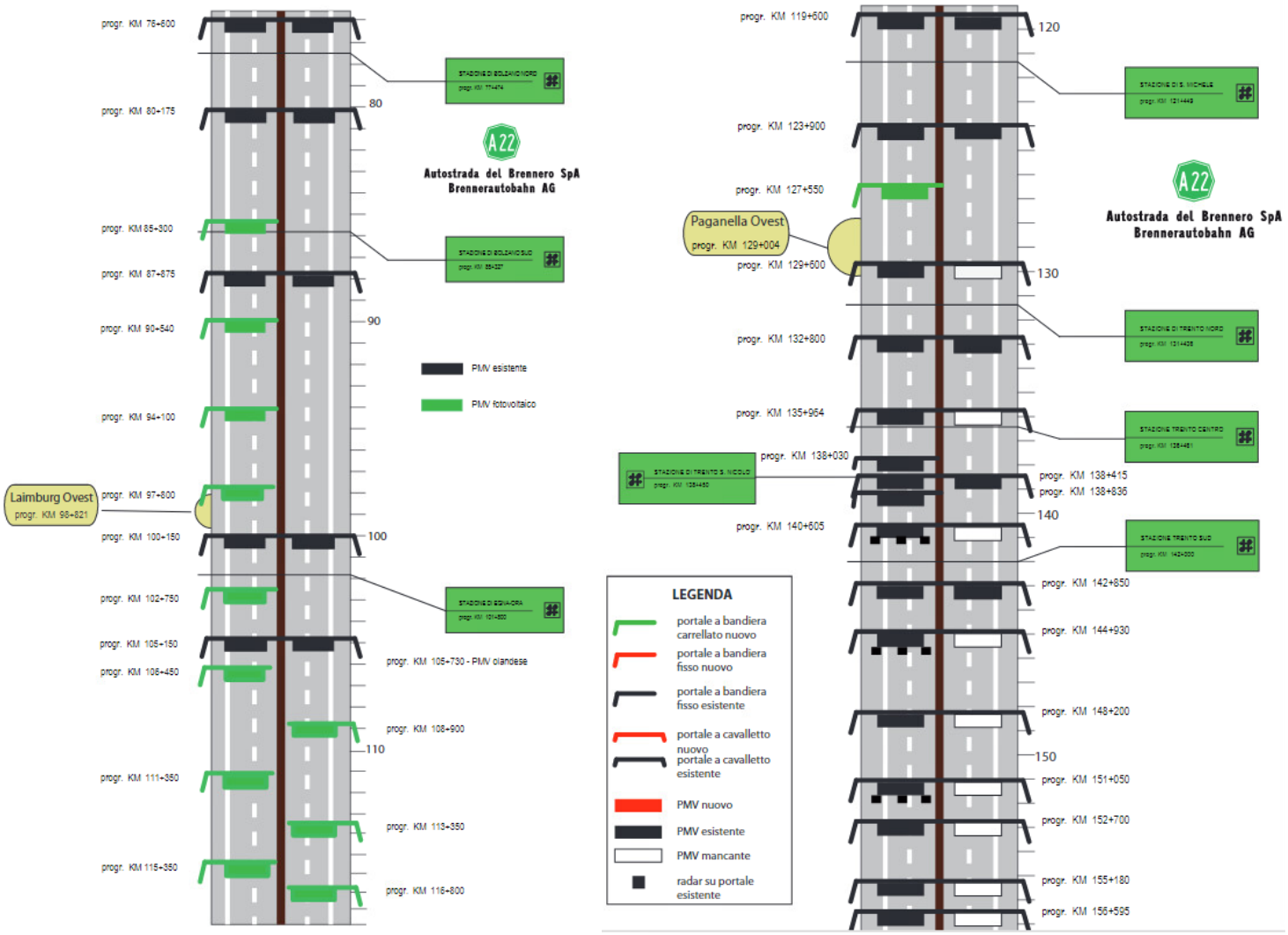

Figure 26: VMS infrastructure implemented plan (in green the new VMS installed).

Cost item	Original budget		Revised budget	
	Actual (€)	Depreciation (€)	Actual (€)	Depreciation (€)
Durable goods - infrastructure				
Trencher for 1,5 km electrification	€ 195.000,00	€ 48.750,00	€ 0,00	€ 0,00
N.2 Gantry VMS	€ 168.000,00	€ 42.000,00	€ 0,00	€ 0,00
N.3 Flag VMS	€ 177.000,00	€ 44.250,00	€ 233.429,00	€ 58.357,25
Durable goods - equipment				
N.6 Electronic displays for gantry VMS	€ 75.000,00	€ 30.000,00	€ 161.111,60	€ 80.555,80
TOTAL	€ 615.000,00	€ 165.000,00	€ 394.540,60	€ 138.913,05

Table 48: Financial deviations associated to the implementation of the additional VMS.

The increase in the equipment costs is also motivated by the need to complement the basic VMS infrastructure with a mobile VMS, that has been used in a flexible way in the road stretch according to the varying needs that emerged during the different pilot test sessions. For completeness's sake, it is important to underline that this budget review is completed by some unforeseen consumable costs (€ 8.100,74) for the purchase of plinths needed for the installation of the gantry VMS. Please note that only 6 of the total 12 gantry VMS are accounted to the project; other 6 gantry VMS required by the technical implementation were covered by the

internal financial resources of the Coordinating Beneficiary, as already highlighted in the cover letter of the 1st Progress Report (point 7). The motivation for this is related to the compliance with Art. II.9.1 of the Grant Agreement, i.e. the obligation for all beneficiaries to organize an open tendering procedure for contracts exceeding € 130,000. Coordinating Beneficiary decided to not organize a public tender since it has already in place a large-scale system managing all the VMS on the A22 highway. This system was initially purchased through a public tender organized according to public evidence rules defined by law, and then step-by-step extended in strict cooperation with the chosen supplier (Aesys S.p.A.) through successive direct contracts. Even for this specific implementation it was decided to work in strict cooperation with this supplier. This represented for sure the best value for money, since any integration of fixed VMS from any other 3rd party supplier would have had bigger costs due to the necessity to implement software adapters allowing to connect the hardware devices with the software back-end system of Aesys. The internal investment of the Coordinating Beneficiary was equal to € 388.566,71 (€ 364.264,50 for the gantry VMS and € 24.302,21 for the plinths). Together with the costs accounted for the project, the total costs needed to improve the VMS network were € 783.107,31. Please note that despite an increase of € 168.107,31 with respect to the budgeted costs, it was possible to equip a larger portion of the A22 highway (in both direction of travel), with installation activities that were completed in a shorter time and with much more reduced impacts for drivers.

7.2 Estimation of person-days used per action

An estimation of the person-days worked for the different project actions is given in Table 49 and reflect which type of actions were carried out internally by the project staff. It is to underline the significant effort put on the monitoring activities, and in particular in the assessment of the pilot measures.

Action type	Budgeted person-days	Actual person-days
Action A: Preparatory actions	875	707
Action B: Implementation actions	3277	2786
Action C: Monitoring actions	1992	2956
Action D: Public awareness/ communication and dissemination of results	752	682
Action E: Project management	1167	907
TOTAL	8063	8037

Table 49: Comparison of budgeted vs actual person-days used per action.

7.3 High-level overview of external costs expenditures

An overall high-level summary of the external costs expenditures is provided in Table 50. Costs accounted on different cost categories but related to the same type of activity have been grouped together, so to provide an overall glance of the costs incurred for all main type of activities carried out. Please note that the presented costs are presented in terms of invoiced amounts without VAT.

Type of activity	Cost expenditures
Reference air quality stations (incl. infrastructure works, stations maintenance, back-end systems upgrade, consumable material)	€ 601.759,77
Low-cost air quality sensors (incl. back-end system, installation, sensors, consumables)	€ 64.195,74
Back-end ITS tools (incl. external traffic modelling experts involvement, enhancement of TMC systems, modelling chain and data platforms development)	€ 157.424,73
ITS equipment (incl. VMS, traffic monitoring systems)	€ 474.766,61
TOTAL	€ 1.480.130,59

Table 50: High-level overview of external costs expenditures.