OVERVIEW OF WORK AND RESULTS OF PROJECT

The LCE4ROADS project arose from the necessity for a new, green, holistic and EU-harmonised certification system integrating a Life Cycle Engineering (LCE) approach: environmental indicators along with the economic, technical and social aspects, for the assessment of future and existing road infrastructures, as well as their construction materials such as asphalt mixtures and cement-based materials. This methodology, together with a guide for road certification and a multi-criteria software tool, define criteria and provide recommendations, supporting and motivating relevant stakeholders and industry to include greener, more cost-effective and safer technologies in their road construction, maintenance and renewal projects. In order to achieve the expected results, a complete work plan has been put together that moves from the definition of the new certification/rating methodology considering existing relevant labelling approaches, plus the analysis of road products, to the development of guidelines and a software tool that will motivate future EU-harmonised certification approaches for roads that would grant the implementation of the LCE4ROADS results. The project has considered European standards both as an input for information and as an output, developing a CEN document within the CEN Workshop Agreement Sustinroads.

The LCE4ROADS project has contributed to the implementation of European policies and strategies, boosting the integration of transport in sustainable development promoting technologies and materials that reduce pollutant emissions and the use of natural and financial resources. Here we outline the results of the main work carried out within the six technical Work Packages (WPs). More information can be found at www.lce4roads.eu or by contacting the Project Coordinator Aquilino Alvarez-Castro of ACCIONA at aquilinoantonio.alvarez.castro@acciona.com.

WP1: SETTING THE SCENE: LABELLING APPROACHES AND KEY PERFORMANCE INDICATORS

This WP aimed to provide an overview of the existing labelling approaches related to road infrastructures and products, through Europe. To reach this goal, an extensive state-of-the-art dealing with road performances, labelling or certification methods and related indicators as well as regulations, standards and constraints, has been realised. An analysis of European and national standards related with road materials and sustainability was assessed in D7.6, together with relevant regulatory documents like the Construction Products Regulation (CPR). Some 14 sustainability rating systems, 15 software and online tools, 15 EU projects and eight national projects considered as labelling approaches or their support (in the case of the tools) were analysed. The regulatory aspects related to four major domains (technical, environmental, social and economic) of sustainable development were also checked.

The LCE4ROADS methodology was then developed. The consortium decided that a certification was more convenient than a label. This certification would be applied to all phases of infrastructure life cycle as a whole (planning, design, construction, operation, maintenance and end of life (EOL). Two levels of LCE analysis were covered in the methodology: road products and road infrastructure as a composition of road products and processes needed to transform group of road products into road infrastructure. The design phase was considered only once the itinerary is chosen, and both preliminary certification and final certification provided. The certification concerns both new and existing projects. An initial set of Key Performances Indicators (KPIs) with a definition of their limits, was proposed for each domain.

A benchmarking based on a reduced set of projects (France, the Netherlands and Spain) was performed to check the applicability of the assessment method in the four domains and of the associated KPIs. It was also decided that the ranges of indicators should be considered country by country. Moreover, ranges should be provided to meet an applicable certification, because many KPIs are country dependent (i.e. environmental

KPIs are fully concerned as far as they include energy mix in the systems of assessment). Thus, the list of KPIs has been completed as regards KPIs applicability and needs.

In the last part of the work, a preliminary study on the implementation strategies and market analysis was carried out. The objective was to define how supporting a wide deployment around EU and neighbouring countries of the LCE4ROADS methodology (voluntary/mandatory certification, incremental implementation routes, business models to apply, etc.). In the meantime, input gained from stakeholders meetings (e.g. EU and national workshops), and work done in other WPs were taken into account. For more information, contact Veronique Cerezo of IFSTTAR at veronique.cerezo@ifsttar.fr.

WP2: SUSTAINABILITY CERTIFICATION METHODOLOGY FOR ROAD PRODUCTS AND INFRASTRUCTURES

This WP was aimed for developing the certification system and the associated methodology. This WP is core for the project, as the other WP were built upon its outcomes.

There are many initiatives in the market capable to assess sustainability aspects for roads, although many lack of a holistic view of sustainability as the focus is, by default, put on its environmental side. Systems like Greenroads, Envision and Invest certification systems in US, Ceequal, in the UK, CO2 Performance Ladder in the Netherlands have been already implemented; however, a complete evaluation of sustainability has not been implemented yet because some of the current approaches do not cover all life cycle phases or all sustainability pillars (environment, social and economic). Therefore, the LCE4ROADS methodology was built taking into account the limits that the other methodologies analysed have

The LCE4ROADS methodology integrates a Life Cycle Engineering (LCE) approach: it includes the all the sustainability pillars - Environmental, Economic and Social -, plus a Technical domain as the technical performance of the road must be ensured. The methodology also was developed flexible enough in order to make it applicable in different countries, with specific technical requirements and ad hoc LCA methods; flexible enough to make possible to assess the sustainable performance of the road in all road life cycle stages (from design, to construction and maintenance). The methodology took also into consideration current EN and ISO standards such as the one for sustainability in construction (EN15804), for LCA/LCC analysis (ISO 14040-44 and ISO15686) and previous developments from other research projects like MIRAVEC, EVITA, COST 354 among others.

Other key aspects at European level like the adaptation and resilience to Climate Change and the implementation of freight corridors (the so called TEN-T: Trans European Transport Network) were considered to create this new certification system.

The assessment of the sustainable performance of the road done with the methodology is proposed to be done in three stages of the road life cycle: design, construction and operation. This is linked to the three stages where the LCE4ROADS certificate can be awarded: during the planning and design stage (1), after construction (2), to validate that all what was defined in the project has been fulfilled and during the operation phase (3) to check the real performance.

In order to refine the methodology, the certification system, methodology and key performance indicators were presented to key sectorial stakeholders such as:

- National and Regional Road Authorities in six EU countries (France, The Netherlands, Spain, Germany, Sweden, Poland) and Turkey (The Turkish Ministry of Transport is partner of the FP7 Project).
- The European Commission (DG Research, DG Environment, DG JRC, and DG Move-Transport)
- Sectorial Platforms and Associations like the European Committee for Standardization (CEN), The European Road Federation (ERF), the Spanish Construction Technology Platform (mirror of the European ECTP) among others.

Thanks to the stakeholders feedback, the scope of the certification system and the applicability of the methodology was improved and released for validation to the associated work packages.

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WP3: ASSESSMENT AGAINST THE LCE4ROADS METHODOLOGY OF ROAD PRODUCTS AND INFRASTRUCTURES

The assessment was carried out on asphalt and cement based products.

In the recent years new techniques, additives and mixing processes were developed for asphalt, which allow paving and mixing at lower temperatures than usual while maintaining the workability of the mixture. Theoretically, a reduction of mixing and paving temperature should lead to a reduction of the heat and energy demands, however, there are still some open questions about the field performance of the new so-called "warm mix asphalts". Furthermore, the large amounts of energy required to manufacture some WMA additives have to been taken into account due to their potentially high contribution to the overall LCA analysis. While all industry efforts have been in the field of temperature reduction, results show, that a reduction of aggregate moisture content or proper isolation of the asphalt plant component leads to big gains in terms of fuel and energy saving. Fuel choice is another area which can help to achieve better emissions.

A large source of discomfort for the population is noise pollution due to traffic and road noise. Rolling noise due to tire-pavement interaction is the main source of noise for speeds of more than 30 km/h in passenger cars and 60 km/h in trucks. Proper pavement design and choice can help to reduce noise levels in "classical" asphalt courses such as Asphalt Concrete. In the last decades, the most efficient noise-reducing course has been Porous Asphalt, albeit it has lower durability and limitations such as pore clogging in low-rainfall areas or low speed roads. As a summary, a catalogue of best practices, which follows the LCE4ROADS "Key Performance Indicators", has been included to help relevant stakeholders in their decision–making process.

It was identified from the analysis that cracking is one of the key factors influencing the long term performance of cement-based pavement products. Fibre reinforced concrete is an innovative solution to improve the resistance of concrete pavement to cracking. The results from the assessment against LCE4ROADS methodology show that with fibre reinforced concrete the pavement thickness can be reduced and, as a consequence, less material will be used in the FRC pavement and also less maintenance will be needed, leading to a higher cost-effectiveness. Therefore, FRC pavements should be a very sound technology in terms of three LCE4ROADS KPIs. On the other hand, the use of low CO2 binders can significantly reduce the emission of CO2 through the reduced use of Portland cement. Under a cost-effectiveness perspective blended cements have a strong position in the potential reduction of environmental effect but in the economic, social and technical domains the effect is considerably low. As a summary, the combination of FRC with low CO2 binder would lead to a solution for safer, greener and climate resilient roads.

The construction, maintenance and rehabilitation of road pavements was evaluated against the LCE4ROARDS methodology. The methodology and KPIs identified for road infrastructures in WP1 and WP2 were used for the assessment of road case studies in order to illustrate the implementation of LCE4ROADS for the LCE assessment for road infrastructures taking into account all sustainability domains: environmental, technical, social and economic.

One small road case in The Netherlands and one big road case in Turkey have been selected to apply the LCE assessment for construction, maintenance and rehabilitation. Based on these case studies improvements were suggested both on the methodology as on the suggested KPI formulation and calculation.

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WP4: DEVELOPMENT OF THE LCE4ROADS SOFTWARE TOOL

WP4 has developed and implemented an innovative software tool that integrates the LCE4ROADS certification methodology developed for road products and infrastructures alongside the project. This tool allows the evaluation of the global performance of a road project according to the Key Performance Indicators (KPIs) selected. To this end, the tool is able to model and calculate the impact of the materials and activities involved in all phases of a road life cycle (design, construction, maintenance and final disposal) under a holistic multi-domain (environmental, economic, social and technical) perspective, providing results and recommendations to obtain the LCE4ROADS certification. This assessment can be developed considering three different stages of the road, during the planning and design stage, after construction and along the road operation. In case the road project does not match the requirement criteria established by the methodology, the tool indicates which KPIs are out of range and provides recommendations to improve the performance and the LCE4Road certification.

The tool aims to boost and facilitate the implementation of the LCE4ROADS methodology in all EU State Members and other countries, supporting decision making of relevant stakeholders and groups of interest in TEN-T (Trans-European Transport Networks) roads and motorway projects.

Apart from public bodies and policy makers who may award the certification, the tool may also be used by road contractors and operators or consultancy and engineering companies in order to evaluate and compare different road projects, by selecting the most proper combination of materials, activities and scenarios according to their particular requirements. The tool creates a certificate with the KPIs values applying the LCE4ROADS methodology. However, the procurer would be the one responsible for taking the final decision about giving or not the certification, which may be supported by additional criteria (such as scoring, limits, or penalties or bonus depending on the KPIs).

The software is fed by a full comprehensive in-house developed database of materials, processes for road construction, maintenance and disposal stages, and other relevant information, such as technical and social country-specific legal requirements. In addition, the user can also create new elements into the database by completing all the required fields and assuming the entire responsibility on the reliability and accuracy of the data. The information inserted by the users into the tool, combined with this in-house database and the implemented algorithms based on the LCE4ROADS methodology, will enable them to determine the status of their respective projects to obtain the LCE4Roads certification.

Although the tool has been created as desktop installation software, the interface of the tool is based on html format, to ensure a friendly and up-to-now look. The tool can be installed in Windows 7 or newer and has been developed using standard open source projects.

During today's final conference, CIRCE Foundation will show how the tool operates giving a practical demonstration of the LCE4ROADS software and its application in two demo case studies: a new construction and a rehabilitation project considering concreate and asphalt pavement roads, respectively. For more information, contact Ana María López (amlopezs@fcirce.es) from CIRCE Foundation www.fcirce.es

WP5: VALIDATION OF THE LCE4ROADS METHODOLOGY AND THE ASSOCIATED SOFTWARE TOOL

WP5 aimed to validate the methodology and associated software tool by cross-checking it with data from real cases provided from National Road Administrations, analysing the LCE4ROADS achieved and the recommendations the software suggested for the purpose of improving the achieved label in terms of innovation, green profile, cost-effectiveness and long-term behaviour.

The LCE4ROADS methodology was analysed in accordance with ISO standards on LCA in terms of the realisation of goals set by the Description Of Work (DoW) and the project consortium. Additionally, a framework for the goal and scope definition was provided, together with an example of life cycle inventory analysis (LCI), life cycle impact assessment (LCIA) and life cycle interpretation. Part of the methodology validation process covered some problematic issues related with LCE analysis of road projects: the idea of EOL scenario; the problem of including impacts related with traffic and issues related with technical KPIs.

The LCE4ROADS software tool is based on the earlier defined methodology, therefore was analysed if all issues addressed by the methodology are incorporated into the tool. Proper functioning of the tool is mainly related

with the databases used for the analysis, therefore the databases were validated by comparing them with other data sets commonly accepted in Europe and used in programs as ECORCE M and SimaPro. It was concluded that the LCE4ROADS software tool fits its purpose and if further developed and improved, in the future it could be a commonly used tool for green public procurement in the EU countries.

LCE4ROADS methodology and software tool provide a platform for the sustainability evaluation of road infrastructure projects by recognising and analysing their performance in terms of economic, social and environmental. For more information, contact Besim Hoxha (besim.hoxha@investeko.pl) from Investeko.

WP6: LCE4ROADS GUIDE AND IMPLEMENTATION STRATEGIES

WP6 represents the latest phase of the project before its market deployment. Concretely, it develops the LCE4ROADS Guidelines for the implementation of the new road certification system. It also develops the most suitable strategies to facilitate the business deployment including the new Public Procurement Directive and other innovative initiatives as the Green Public Procurement Criteria for pavements developed by the Joint Research Centre of the European Commission.

LCE4ROADS Guidelines

Guidelines set the framework for the deployment of the LCE4ROADS the road certification system during the planning and design, construction and operation phases after assessing performance of environmental, social, economic and technical indicators in future and existing road infrastructures, as well as their construction materials such as asphalt mixtures and cement-based materials.

Guidelines offer a description of the final list of KPIs, including the measurement methods (i.e. data requirement, performance calculation), level of achievements (i.e. light and complete certificate) and as well evaluation criteria and documentation to be presented during the tendering processes by those parties interested to receive the certificate.

The reliability of the LCE4ROADS methodology relies on the completion of various initial tests for asphalt and concrete materials in small scales. Outcomes of these tests have been used by the consortium to optimise the Guidelines and the associated software (i.e. functioning, requirements, layout) together with the results of its validation in three real projects in Turkey, Poland and Spain for both concrete and asphalt pavements.

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Implementation strategy

An implementation plan was developed to include identified barriers and opportunities. There are several key issues in the implementation strategy.
First, the practices and interests in sustainability assessment are drivers across Europe. Simultaneous implementation of LCE4ROADS is therefore unlikely and an incremental approach is preferred (focussing on certain countries first). This does require an EU-wide platform to coordinate activities and to safeguard harmonization.
Secondly, broad use of LCE4ROADS will require pilot projects in each country to increase interest and gain experience, and to further validate the value of LCE4ROADS.
Thirdly, adding a LCE4ROADS certificate including sustainability assessment will generate additional costs in infrastructure projects. Such additional cost may be minimal, especially considering the value gained through improving the sustainability of road infrastructures. Nonetheless, actors and policy makers will need to decide if the benefits are worth the investment.
The implementation plan of LCE4ROADS describes eight activity groups.

- **EU-wide LCE4ROADS platform/committee;** these activities are aimed at preparing the European wide implementation process, and to coordinate and harmonise European initiatives and developments related to LCE4ROADS.
- **Sector & market analyses**; activities aimed at further understanding the infrastructure sector in each country and determine the opportunities for LCE4ROADS. These activities are follow-up activities of the analyses performed within the LCE4ROADS project.

- **Stake- & shareholder engagement;** activities aimed at engaging with interested parties for certification related activities (certification owner, software, certification bodies, etc.) and to seek out actors to endorse and commit to LCE4ROADS (road authorities, contractors, etc.).
- **Pilot projects LCE4ROADS**; an important step in the implementation of LCE4ROADS is to stimulate use of the LCE4ROADS methodology. It is foreseen that several pilot projects will be carried out in each country as a stepping stone to wider use of the methodology and certificate.
- **Certification organisation development;** activities to develop an organisation that owns, maintains and further develops the LCE4ROADS methodology and certification system.
- **LCE4ROADS methodology development;** The methodology is to be further developed (see D3.5) and the development needs to be tailored to stakeholder requirements.
- **Standardisation;** standardisation activities are required to align LCE4ROADS to relevant standards and to incorporate LCE4ROADS into standards.
- **Financing**; these activities are aimed at getting the required financial resources necessary for the activities in the other activity groups.

These activities are aimed at supporting the successful implementation of LCE4ROADS in the EU and neighbouring countries.

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