MEMO

To	:	The Program Executive Board of Era-Net Road
From	:	Renilde Spriensma, DHV
Copies to	:	Project team CEREAL
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Subject	:	Deliverables WP 2 & 3 CEREAL
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Dear members of the PEB,

Included you will find the following deliverables from the CEREAL project team:

1. **The results of the international survey & interviews for CEREAL (WP2)**. We have amended the report according to your comments and we have added the results of the interviews.
2. **The second draft of the preliminary functional requirements (WP3).** Based on the results of the surveys and interviews and an extensive tool assessment, a draft version of the functional requirements has been prepared. This draft has been sent to the expert team for comments in June. All comments of the expert team have been integrated in this new version of the preliminary functional requirements.

Both deliverables will be part of the final report.

The report on tools assessment is being prepared at this moment and will be available in August.

Looking forward to your reactions,

Kind regards,

On behalf of the CEREAL project team
Renilde Spriensma

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1 RESULTS OF THE SURVEY & INTERVIEWS

In section 1.1 and 1.2 the goals, working method, conclusions and results of the survey is described. In section 1.3 the results and conclusions of the interviews are summarized.

1.1 Survey goals and working method

Goals
Within the overall goal of the CEREAL project the goal for the survey & interviews was to identify characteristics of the future CEREAL tool in a sense that the tool will be applicable for European countries, with a special focus on North-Western Europe. Furthermore, the identification of the potential user group in Europe in public and private organizations was a main challenge.

More specifically the goals of the survey are:
- Identify the general level of experience with CO_2 related tools in road projects.
- Inventory of existing tools.
- Identify the potential user group, the desired results and the use of specific protocols.
- Verification of the scope of the tool.
- Identify the requirements for effective and long term use.

Target group
The target was to get at least 40 complete filled out surveys by experts in Europe. Special focus was to get information of all NRA's of the funding countries, since these organizations will be the key-stakeholders in the development and implementation of the tool. The following selection criteria were applicable to the responders: knowledge of the road sector, working for a road authority, contractor or consultancy firm in Europe, and experience with or special interest in CO_2 calculations for road constructions.

Invitations and pre-announcements were made by using personal networks of all team members, the PEB and the project coordinators of the other Era-Net Road projects, several associations (EAPA, IRF, CEDR) and by using several groups on sustainability and pavement or building discussion groups in social networks such as LinkedIN. Some of these LinkedIN discussion groups: Pavement Engineer, Pavement Materials, National asphalt pavement association users group (all English) and Road Builders, "Duurzame GWW", "CO_2 prestatieladder", "CO_2 reductie GWW sector" (all Dutch)

The actual survey was online at 'Surveymonkey'[1] for about 6 weeks in February and March 2012. Also the survey was available through the project website www.cereal.dk. The main results of the survey are available at the website as well, excluding any personal information of the responders.

[1] Specific address; https://www.surveymonkey.com/s/WGKPVX3.

1.2 Survey results

1.2.1 General results and conclusions

- 47 completed surveys have been acquired, of which 18 from relevant stakeholders within NRA's (all NRA's of contributing countries included).
- The responders represent a good distribution over different countries, with different backgrounds working in different organizations.
- The current experience with CO_2 (tools) includes many different (specific) tools but very limited use. Only few responders use tools on a regular basis.
- The opinion on existing CO_2 tools varied, most tools were regarded as too complex, not transparent, too much of a black box, not user friendly software, too high requirements for input data.
- A few (national) tools were regarded as very useful and adequate.
- The quality and availability of input data is a key issue among the responders as well as the use of a wide scope.
- The intended use and purpose according to the responders is mainly optimizing design and calculation of scenario's, thus use in the design phase of the decision making process.
- Based on the answers we can make a preliminary conclusion that the new CEREAL tool needs to be simple but complete, including relevant country specific differences.
- Most of the tools are not embedded (yet) in national policies. It seems that only the use of Dubocalc in the Netherlands is obligatory in national design and contracting processes.

The results of the survey are used as a basis to conduct a series of in-depth interviews with NRA's of the funding countries. The results of the survey and interviews are the basis for the formulation of the functional requirements of CEREAL in the next phase of the project. The results of the interviews are described in section 1.3.

1.2.2 Background of the responders

Functions of responders:

– 20 of the 48 responders identified themselves as 'specialist / researcher'
– 4 identified themselves as 'policy maker'
– 12 identified themselves as 'consultant'
– 12 identified themselves as 'other' (for example: road engineer, technical manager, environmental expert, purchaser, HSE manager, marketing specialist, etc.)

Operational level of the organization:

– 6 of the 48 responders were working within an organization on a 'local level'
– 5 were working within an organization on a 'regional' level
– 30 were working within an organization on a 'national' level
– 14 were working within an organization on a 'multinational' level

Type of organization:

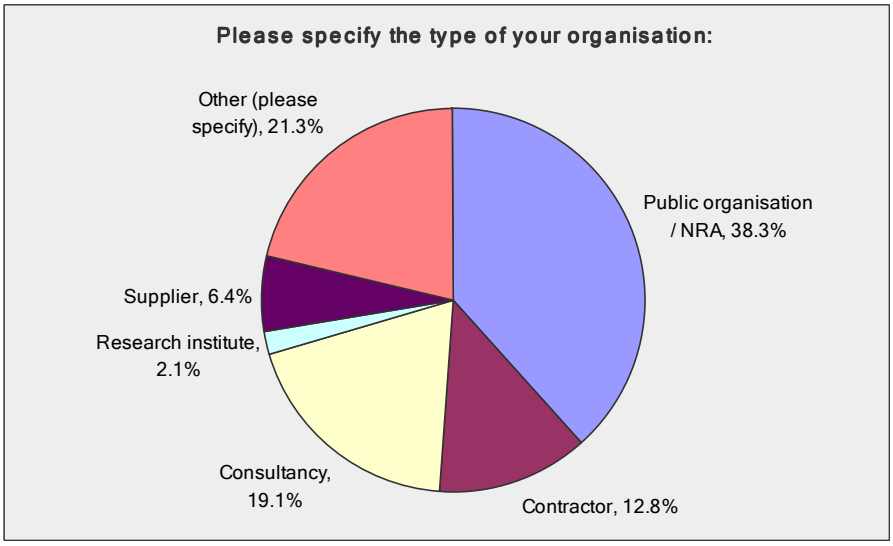

Figure 1.1: Type of organization of the responders

Others are specified as universities and associations related to infrastructure.

Field of expertise of the responders:

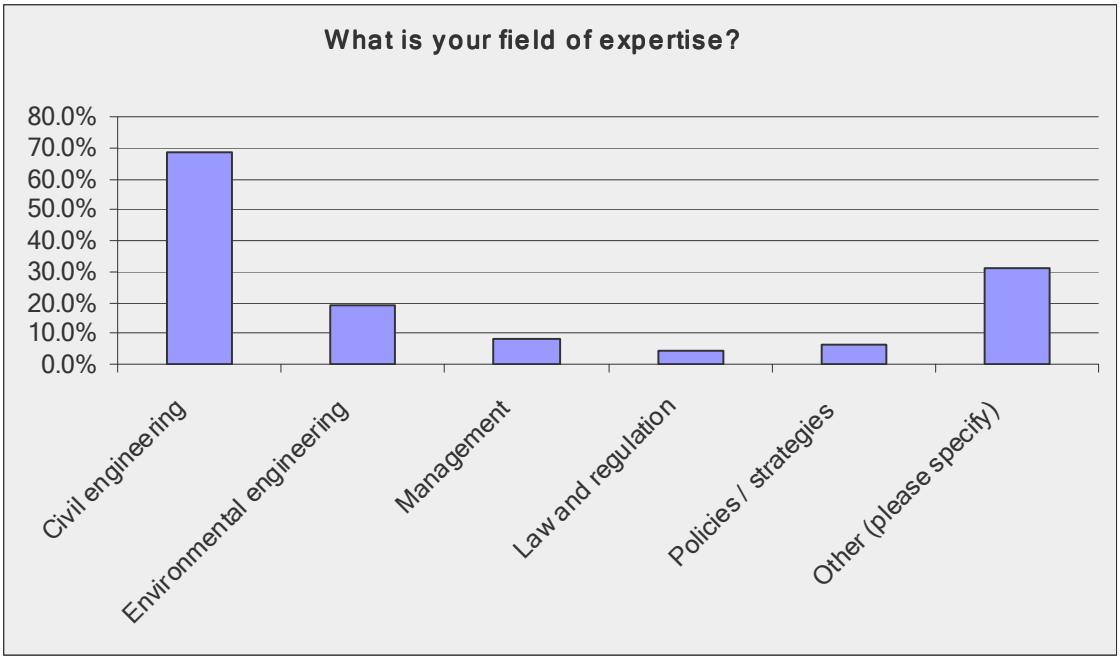

Figure 1.2: Field of expertise of the responders

The responders are mainly engineers, representing the potential user group quite well. Others are specified as chemical engineering, waste management, sustainability, climate change, software development, etc.

Home country of the organization:

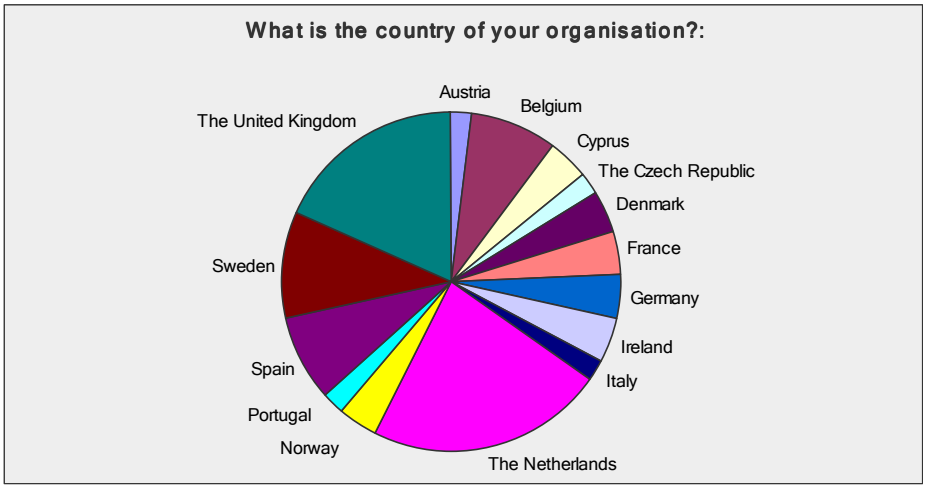

Figure 1.3: Home country of the organization

A lot of responses came from the UK and the Netherlands. This is coherent with the relative high level of development and implementation of CO_2 tools in these countries.

1.2.3 Knowledge and experience with CO_2 in road projects

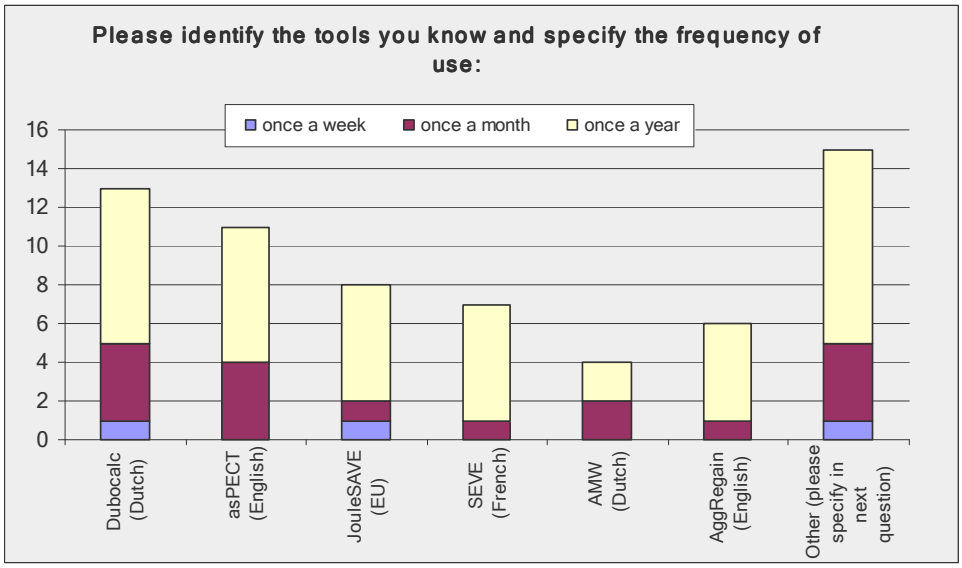

Figure 1.4: Experience with existing tools

Only a few tools, Dubocalc and Aspect, are used on a regular basis by a few responders. The majority of the tools is country specific and used in one country only.

Other tools mentioned were among others: GHG calculator for infrastructure, Highways Agency Carbon Calculation tool (UK), CO_2 ladder (Netherlands), Transport Scotland toolkit, ECORCE (French), GreenDOT and GreenRoads. All tools mentioned are subject to evaluation in the next phase of the project.

The Opinion on existing tools

The opinions on the existing tools differ a lot:

- The NRA's in France, the UK, Netherlands and Denmark are positive on their own national tools.
- JouleSAVE is seen as not user friendly and very complex. It is developed for a very specialist user group in combination with MX software.
- Users of Aspect and AMW are positive.
- Highways Agency Carbon Calculator is used for foot printing of organizations and is not applicable for scenario analysis in road projects.
- Many of the tools are not transparent and too much a black box.
- Tools are too complex and require too much input data.
- Data quality and availability are very important.

Motivation of interest in a (new) CO_2 tool

According to the responders there is a purpose for a (new) CO_2 tool mainly in policy-making, implementation in contracts and for research objectives. Other identified reasons to use CO_2 tools are monitoring and communication on CO_2 emissions in organizations.

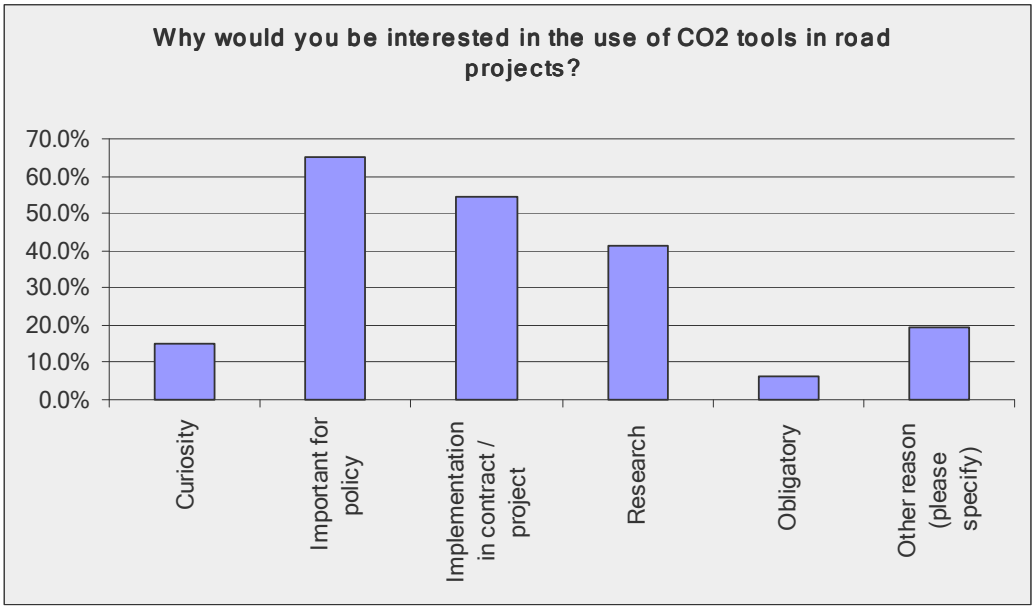

Figure 1.4: Motivation of interest in a (new) CO_2 tool

Examples of CO_2 in road projects

Some good examples in the UK, the Netherlands and Sweden were reported. If possible, these examples will be used in the testing phase of the CEREAL tool.

For JouleSAVE some specific 'pilots' were done: N25 Waterford to Glenmore (Ireland), M20 Cork to Limerick (Ireland), N11 Gorey Bypass (Ireland), A29 (Portugal), IC-6 (Portugal), Expressway R43 (Czech Rep), RD921 (France), Route 50 and 32 (Sweden).

1.2.4 Functional requirements (scope, requirements and implementation)

Scope

According to the responders all aspects mentioned are important and must be included in the CEREAL tool. Example: nearly 60% of the responders state that excavation and embankment should be included.

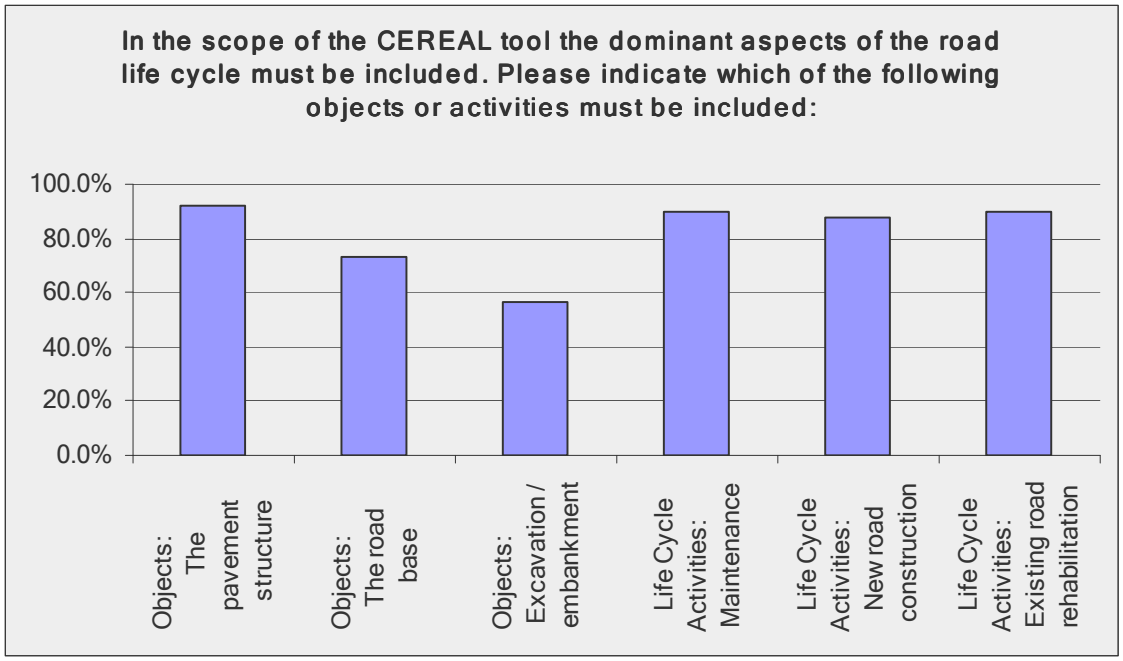

Figure 1.5: Desired scope of the CO_2 tool

The responders were asked what other objects and activities should be included in the CEREAL tool. This resulted in the following statements.

Objects considered to be included in the CEREAL model, other than in the graph above are: bridges, drainage, road marking and signs and safety objects. These objects may be included in the tool in a simple way.

Other CO_2 generating activities to be considered are: winter maintenance, demolition at the end of structural life, production and transport of constituent materials, routine maintenance, recycling of existing pavement materials. These activities are included in the life cycle if the relevance is evident.

Beside these activities a lot of responders mentioned the importance of the effect of *road user CO_2 emissions*. CO_2 emissions as a result of the use of the road are influenced by the traffic (intensity and speed) vehicles (vehicle type, construction and engine, tyres) and the road construction itself (slope, alignment and smoothness of the pavement, air resistance & influence of wind).

Methodologies and protocols

The responders proposed to use the following methodologies and protocols to help backbone the CEREAL tool: ISO 14040, ISO 14064 (and 14067 draft), NEN 8006 EN 15804, GHG Protocol including recent Scope 3 protocol, PAS 2050, Bath ICE, CESSM3 Carbon and Price Book, Proprietary Materials, EU requirements for GHG reporting and bitumen LCI (Eurobitume).

Most of the protocols are strongly related and include similar starting points, guidelines and working methods for LCA, which makes it possible to use most of the common protocols for the development of the tool.

Intended use

All possible application areas for a CO_2 tool are interesting for the responders. A majority of the responders wants to use such a tool for optimizing design and calculation of scenario's.

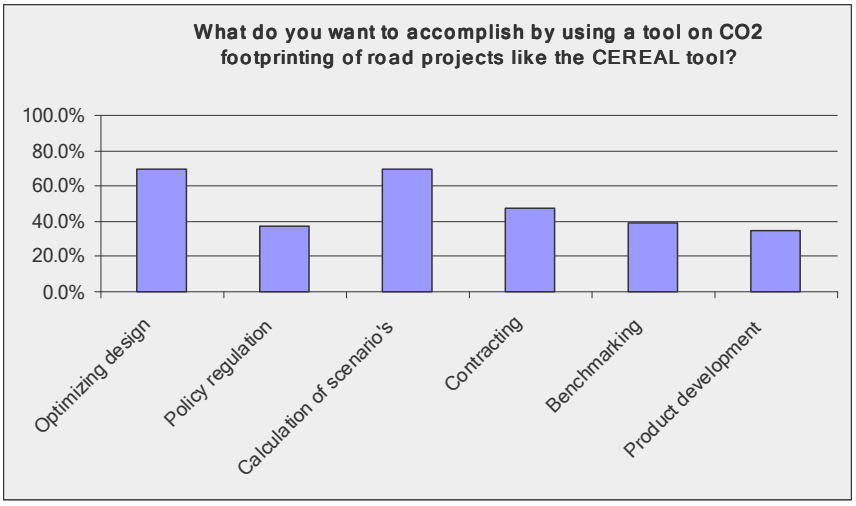

Figure 1.6: Intended use of the CO_2 tool

Contribution of the new CO_2 tool to the intended use

Many different answers were obtained on this issue. The expected added value of the new CO_2 tool can be summarized as:

- Assessment of alternative constructions for a given alignment and support of the decision making.
- Stimulation of contractors to provide sustainable solutions.
- Uniform calculation and benchmarking of CO_2 emissions across countries/EU.
- Monitoring and reporting of CO_2 emissions.

Contribution of CO_2 tools to the (policy of) the organization

How will the use contribute to the policy of the organization?

- Various responders mention that there organization has goals on sustainability, decreasing environmental impact and also CO_2.
- The most important identified contribution is the influence on the design, evaluation of different construction or rehabilitation options, and procurement. There may be an indirect contribution in the choice of applied materials.
- The use of the tool may lead to more dedicated marketing of the policy, demonstration of carbon savings (as non direct cost benefits) by providing numbers and improvement of knowledge and awareness of the organization.
- Not all responders believe that a CO_2 tool like CEREAL will effectively change the way decisions are made by the organization.

In which phase of the decision making process a CO_2 tool like CEREAL will be used?
The responders see the applicability of the tool mainly in the design and contracting phase.

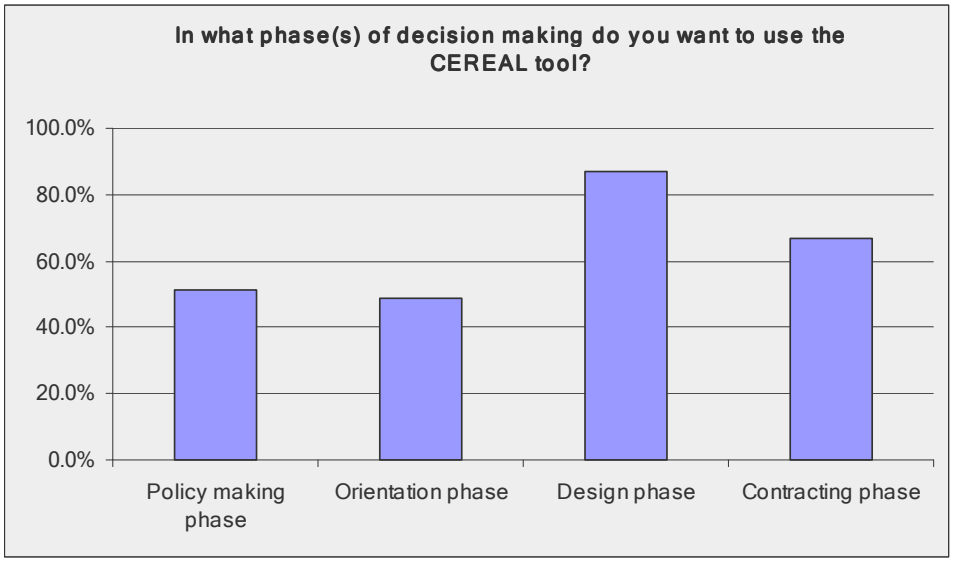

Figure 1.6: Use of the CO_2 tool in specific phase of the decision making process

Connection with existing management systems
The majority of the responders (66%) expect that that the CEREAL tool will fit into an existing management system mostly in order to work on continuous improvement of quality. They identified most organization specific management systems but also guidelines as ISO 9001 and 14001.

1.2.5 Data availability & project structures (Q21 – Q26)

Data availability
In general responders have most detailed data available on the amount of building materials used in road projects. Also data on operational maintenance activities is available on a high level of detail. Most general data is available on building logistics and energy use in road projects. A significant group of 12 (out of 47) states that no data is available on building logistics and 15 states that no data is available on the amount of energy used.

In road management projects, do you or does your organization have information on:	no data	general data	detailed data
Amount of building materials (such as ton asphalt, ton sand, etc)	5	15	28
Building logistics (such as types of trucks, km's, frequency)	12	22	13
Operational maintenance (such as type of maintenance activities, frequency, etc)	8	19	19
Energy use (by use of generators, electricity, etc.)	15	21	11

Table 1.1: Data availability

Is data on road management country specific?
The answers to this question are very diverse. Apparently many responders want to include specific data for materials. They mentioned they would like to have the focus on the development phase and maintenance phase of road projects, as new roads are rarely built in their countries. Also the need to have maintenance and construction activities for asphalt as well as concrete roads has been mentioned. Specific asphalt mixtures used as wearing coarse have been mentioned such as noise reducing mixture and porous asphalt.

Beside the general materials used in road constructions (bitumen, modifiers, fillers, aggregates, etc), the responders also mentioned the need for specific road construction materials in their countries. Examples are the recycling of (sub)base materials like used concrete and masonry applied in some countries in the EU. Further specific needs are inclusion of data on modified bitumen and light color aggregate. Some responders said they would like to have general data about transport distances in the program.

The responders mentioned some maintenance strategies as being country specific such as reinforcing, milling (planning) and paving. Some responders also said they would like to see in the new software specific activities related to weather and winter conditions (damage due to weather conditions).

Road classes
According tot the responders, they are mostly involved in projects on motorways, dual/multilane carriageway or single carriage way. Urban collector, low-volume roads and residential area's are less frequently subject of their work.

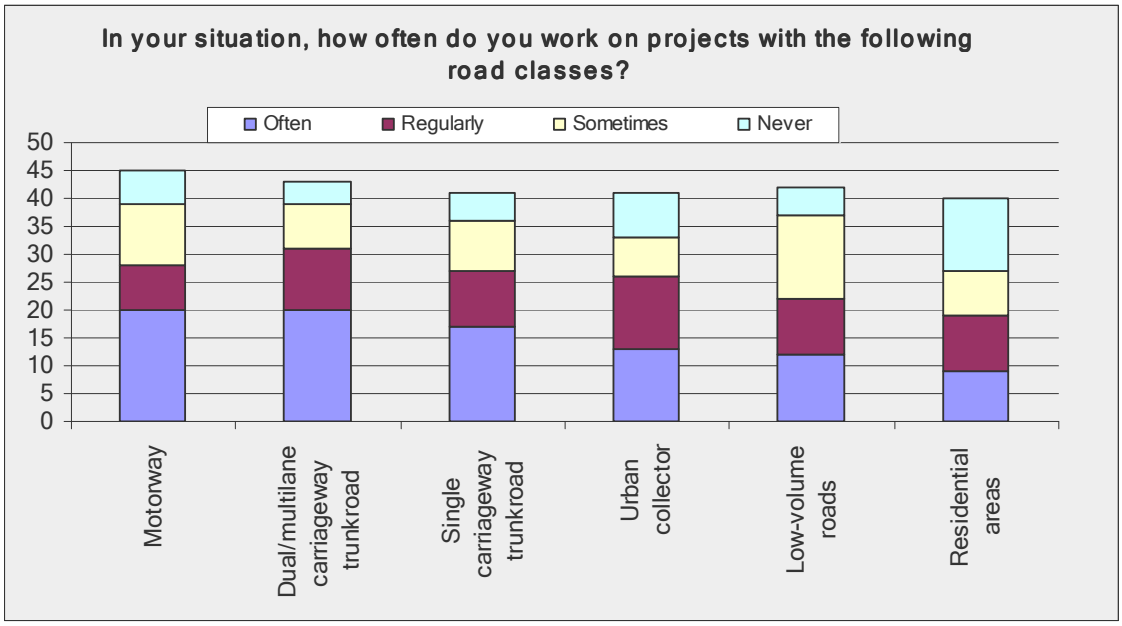

Figure 1.7: Relevant road classes

Pavement types

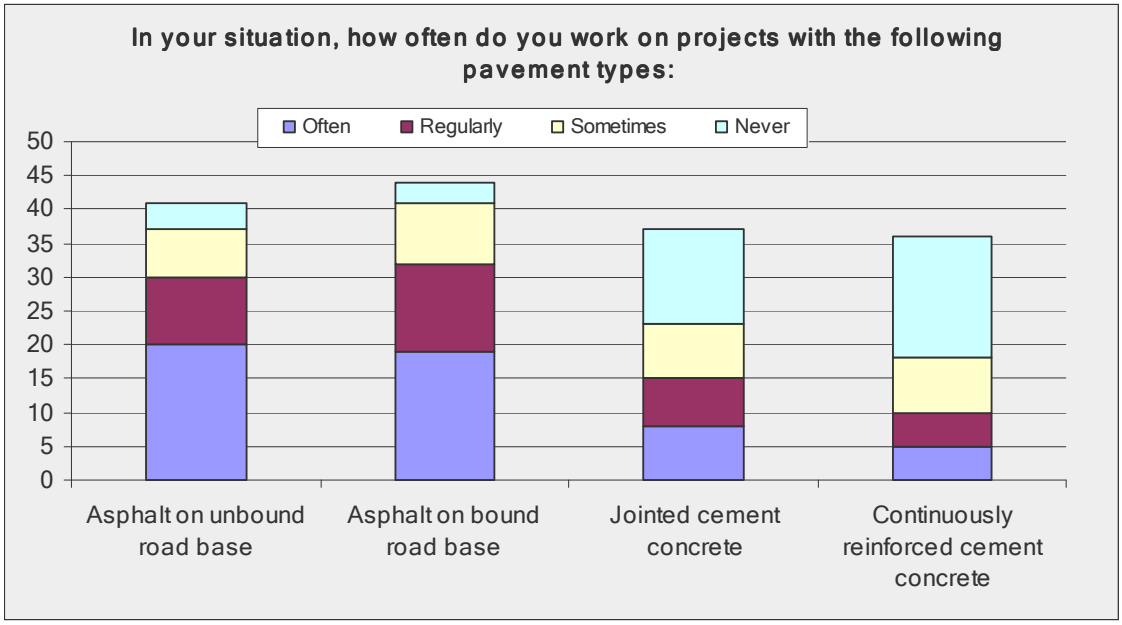

Figure 1.8: Relevant pavement types

The most used pavement type is asphalt. According to the responders the most used base on asphalt pavement is the unbound base, followed very close by the bound base. Those types of base are widely used.

Cement concrete pavements are less applied according to the responders. Jointed cement concrete is more used than the continuously reinforced cement concrete. Concrete pavement has still a higher initial investment and is mostly indicated for areas with solid subsoil.

Annual Average Daily Traffic intensity per road class

The reported intensities are quite high. The AADT differs very much per country or even per road. The intensities are a good match to the most mentioned road classes, such as motorways, dual multilane carriageway or single carriage ways. The AADT together with the available subsoil are the main input needed to determine the structure of the road and the maintenance strategies.

Maintenance measures

The four main maintenance measures mentioned by the responders are patching, asphalt overlay (reinforcing), milling (planning) in combination with asphalt overlay and total reconstruction of asphalt or cement concrete road. Again, the mentioned strategies match well with the type of strategies applied on the main road classes chosen by the responders. Their application on the road maintenance extends the life span considerably. Coating and rejuvenators are not indicated as maintenance for a long term measures. They are mainly used as a short term life span extension measure.

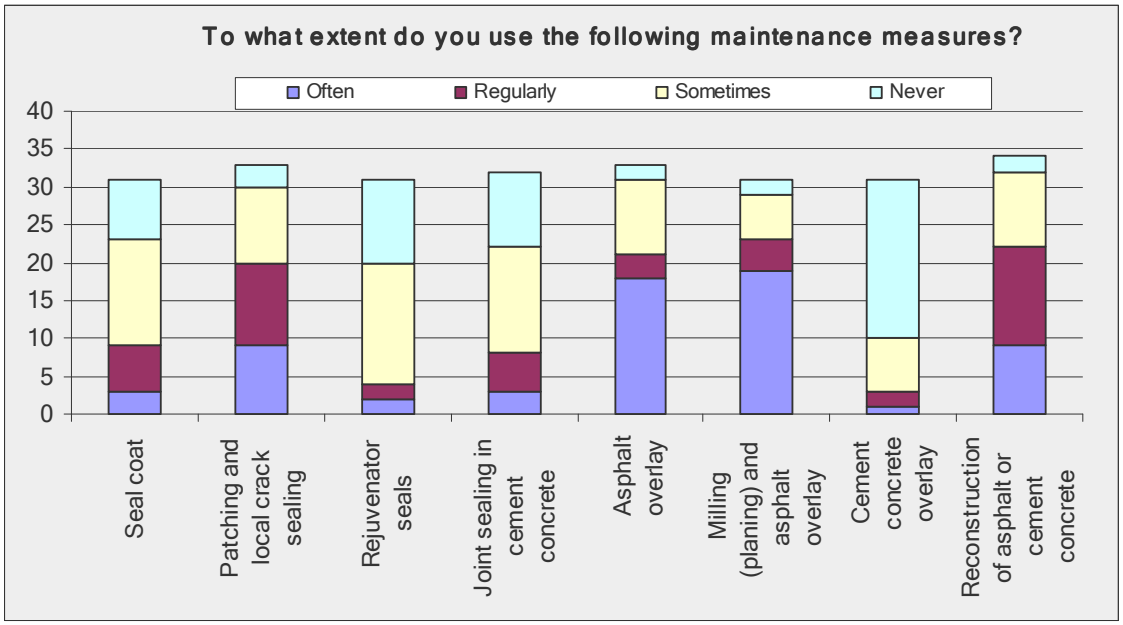

Figure 1.9: Relevant maintenance measures

1.3 Goals and results of the interviews

1.3.1 Interview goals and conclusions

From the survey and the meeting with the PEB it has become clear that the NRA's are the main users. If the tool is adopted by the experts from the NRA's involved in road management, contractors will follow, since NRA's have a leading position as commissioners of road projects. Therefore the interviews were focused on the NRA's of the contributing countries of Era-net Road. Gerwin Schweitzer (Netherlands), Karl Fredriksen (Norway), Martin Strid (Sweden), Jørn Raaberg (Denmark) and Tom Casey (Ireland) have been interviewed. The NRA contacts from Germany and the UK have not been able to follow-up on our request.

In the interviews a set of general questions were asked as well as country specific questions related to the existing tools.

From the interviews some general conclusions could be drawn:

1. A new European CO_2 tool will be successful if it:
    - Is easy to use.
    - Is easy to update with new data.
    - Is giving the almost right answer as a rough estimate.
    - Can compile valid data throughout Europe.
    - Can be used by many.
2. The tool must be helpful and successful for decision makers at NRA's, contractors, consultants and clients.
3. The tool must be able to use both default general global values and country specific values.
4. The tool must be able to compare results within the country, and does not have to be suitable for international comparison or benchmarking.

1.3.2 Summary of the answers of the general questions.

In this paragraph an overall short summary of the answers to the general questions is given. The full descriptions of the individual interviews can be included later on in the appendix of the report.

General questions:

1. Which CO_2 tools do you know of and what are the positive and negative points?
   ***Summary**: Different kinds of tools are used in the 4 countries, but not intensively. The repliers have no experience with the use of LCA tools and cannot give positive or negative points. Only the Netherlands seems to have used LCA tools more systematically.*
2. What is – in your opinion – most important for the design of CEREAL?
   ***Summary**: Designing a tool which is easy to use, easy to update with new data and which is giving the almost right answer as a rough estimate.*
3. What kind of use do you see if you think about successful use of CEREAL?
   ***Summary**: Helpful and a successful tool for decision makers in NRA's, contractors, consultants and clients.*
4. What can be learned about the implementation of CO_2 tools in other infrastructural projects?
   ***Summary**: It is difficult to compare different projects, and specific for the Netherlands the use of DUBOCALC and CO2PL is positive, but the main issue is data quality and availability.*
5. What are the most essential elements in the scope of CEREAL?

***Summary**: To have a tool which can be used by many and give the almost right answer. A normalized tool made compatible for input of new materials and innovations.*

6. What is more important: quick (general) results or use of country and project specific data?
   ***Summary**: Both are important. Use of default general global values but also possibilities for country specific values.*
7. What is the value of CO_2 data for your organization? How will they be used?
   ***Summary**: Important indicator for management of sustainability and important for communication on the political level. Assessment and choice of the project, either in investment or maintenance phase.*
8. What – in your opinion – is the value of comparing results? (international / national projects)
   ***Summary**: Only comparing results within the country, not for international comparison or benchmarking.*
9. How will NRA's in Europe use a tool like CEREAL?
   ***Summary**: Only answer from the Netherlands: different countries, different use!!*
10. What are success and failure factors for such a tool?
    ***Summary**: Success: To have a tool which can be used by many and give the almost right answer and which can compile valid data throughout Europe. Failure: Problems with getting data and updating the database, which will lead to no use of the tool.*
11. What should be the maximum time required to use CEREAL?
    ***Summary**: Depend on the project (no specific answer!!)*
12. Who would you advise to consult for the development of CEREAL?
    ***Summary**: Harpa Birgisdóttir, Danish Building Research Institute, Aalborg University (experience with ROAD-RES) Susanna Zammataro (IFR) (experience with CHANGER). Different kinds of contractors and decision makers who need it.*

2 PRELIMINARY FUNCTIONAL REQUIREMENTS

These preliminary Functional Requirements (FR) are based on the results and conclusions from the international survey and interviews (see section 1), the pre-assessment of existing CO_2 tools and additional analysis and discussion within the CEREAL project team. A draft version of these functional requirements was reviewed in June 2012 by the expert panel, consisting of about 20 civil engineers of NRA's and contractors, which resulted in positive feedback and various good comments: from technical to organizational, general to detailed. The document is revised according to these comments.

This draft document gives readers a preliminary overview of the content, structure and purpose of the tool. The functional requirements will be used as a guideline for the CEREAL tool development. After revision of the PEB the final version of the functional requirements will be part of the final report of the CEREAL project.

2.1 Goal & scope definition

Why develop the CEREAL tool?
From the survey and interviews it has become clear that most of the existing tools are not used or used only on a very limited basis, because they are too complex or require too much data. Furthermore, most tools are very country specific, which obstructs the comparison of projects among countries and makes it difficult to spread knowledge and learn from each other. The fact that there is no general European tool also leads to the development of more national tools in countries still lacking these tools. With CEREAL we aim to solve these problems.

What is the goal of the CEREAL tool?
The overall goal of the tool is to facilitate sustainable development in road construction and maintenance. The goal is to provide a user friendly interface (in Excel) that harmonizes existing national CO_2 tools, using country specific data. The results should help NRA's with decision making in the design and maintenance phase by comparing measurement scenario's and/or different designs. (see also Outputs and Results) The tool will focus on CO_2 equivalent emissions as an indicator for sustainability, the correlated energetic footprint (in MJ) is out of the scope of the CEREAL project.

Who will be the main users?
The main users will be civil engineers working for NRA's and contractors in the EU (primarily North-Western Europe). The main users are involved in the decision making process for design and maintenance of roads. While the main focus is on design and maintenance, other purposes like monitoring and reporting will not be excluded. The language of the tool will be English.

In which phase of the decision making process can the tool be used?
The tool can be used during the design phase and the maintenance phase (asset management). In both phases the tool will help NRA's and contractors to facilitate there decision making process by providing data on CO_2 emissions of road projects.

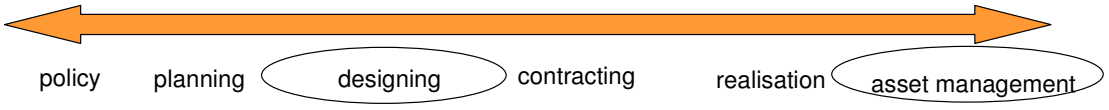

Figure 2.1: Phases for the use of the tool

What type of projects?

- The CEREAL tool will focus on a predefined time horizon (e.g. 50 years) of road projects including dominant life-cycle processes such as construction and maintenance and all upstream emissions associated with these processes. It is assumed that no roads will be demolished without renovation or building a new construction and therefore final demolition (e.g. end-of-life of the road itself) is formally out of the scope and the demolition processes will be included in the renovation/reconstruction processes. Thus it is assumed that all roads will be continuously kept in operation by maintenance and reconstruction.
- The CEREAL tool will make it possible to analyze new road constructions (green field), major renovation of roads and maintenance measures of roads.

Which activities are included or excluded?

- The CEREAL tool will include all directly related activities for road construction and maintenance activities in the time horizon of the project (cradle to grave). This means production and transportation of materials, activities for realization and reuse / recycling are included.

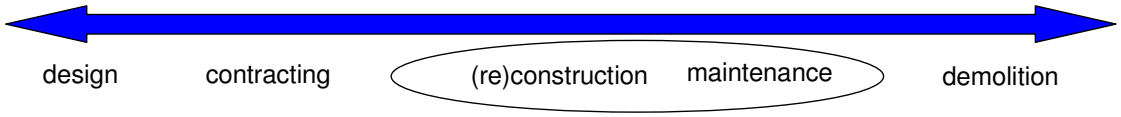

Figure 2.2: Main activities within the scope of tool

- Activities related to the design and contracting process itself (paperwork and people transport), and end-of-life demolition activities of the road are thus NOT included in the tool.
- All specific activities in construction and maintenance that contribute less than 1% of the overall footprint will NOT be included. The assessment of existing tools will help to identify all relevant activities and materials. Decisions on exclusion of less important processes will be made on the basis of the results of overall footprints reference calculations and pilot projects in the testing phase of the project.

Which objects are included or excluded?

- The CEREAL tool will focus on the CO_2 impact of pavement construction of roads and all related activities to the maintenance of the pavement construction.
- Within the road construction we specifically define: fast and slow-lane(s), hard shoulders and slip-roads (exit or entrance ramps).
- Hard shoulders and slip roads will be considered to be part of the road. Slip roads will be considered to have the same pavement structure and width as the truck traffic lane of the main carriage way. All slip roads will have a standard length and standard width in the tool. This implies that the user only has to specify the number of slip roads in the roadway section in the analysis.
- Generic, default data will be provided on other objects such as safety and noise barriers, tunnels, drainage systems and road markings. The reason to NOT include these objects in a detailed way, is that there is a lot of variation in the type of objects and therefore it is difficult to program in an easy way.
- The tool will NOT provide data on lampposts and traffic lights. These objects are very specific and probably will change many times during the time horizon of the project.
- The tool will NOT provide CO_2 data on emissions of road traffic (use of the road). It is well known that the emissions of the traffic are many times higher than the emissions related to the road maintenance and construction. The surface of the road, the inclination and air resistance can be influenced by the road construction, but scientific information is scarce and is researched in the project “MIRAVEC”. The CEREAL project therefore focuses on the direct influence of the NRA’s on the road maintenance and construction. In the user guide or background documents, available information on the impact of the traffic will be included to inform the users.

2.2 Design Principles & Methodology

What are the guiding principles for the tool development?

- The CEREAL tool will be developed in Excel, making it easy accessible and adjustable for all potential users. Users will be able to add data on specific materials used and processes applied.
- The CEREAL tool will be transparent in calculations and data used (so calculations are retraceable). The overview of data will highlight where default data is changed or overwritten.
- The CEREAL tool will make comparisons of various scenarios possible while providing clear overviews of in- and outputs.
- The CEREAL tool will be easy to use by providing a simple user interface including default values. (see figure 2.3). This means a standard calculation is available but individual parameters and data can be adjusted and added according to specific circumstances. The tool is open and gives more design freedom in the "detailed mode". Here the user can provide more specific and realistic data.
- The tool will be principally designed for the North-Western region of Europe. Later on, when sufficient information is available, the tool can be extended to the rest of Europe.
- The tool will include as much country specific data as necessary, derived mainly from existing CO_2 calculation models. Per sub region or country a specific dataset will be included and users will be able to add specific datasets.

What are the methodologies applied?

The structure and calculation rules of the tool will be based on general LCA principles (ISO 14040 through 45) as they are used for example in the Dutch models Dubocalc and AMW and a number of other models as well (e.g. Road-RES). CO_2 calculations will be based on the GHG-protocol, resulting in CO_2 equivalents.

Most recent and more specific protocols like the PAS 2050, ISO 14067, EPD – EN 15084 are all based on the ISO 14040-45 guidelines and focus on LCA, CO_2 and carbon footprinting of product life cycles. As CEREAL will calculate projects consisting of materials and various activities these specific protocols are less suitable and do not have a lot of added value compared to the basic principles described in the ISO 14040-45 & GHG-protocol.

2.3 Structure of the tool

What is the overall structure of the tool?

The CEREAL tool can be structured in 2 levels: the “user interface” and the “calculation core”. The database and the calculation rules will be hidden in the calculation core but of course the CEREAL tool won’t function without. For example, while filling out the input data the user is offered set menu’s and multiple choices out of the database to help.

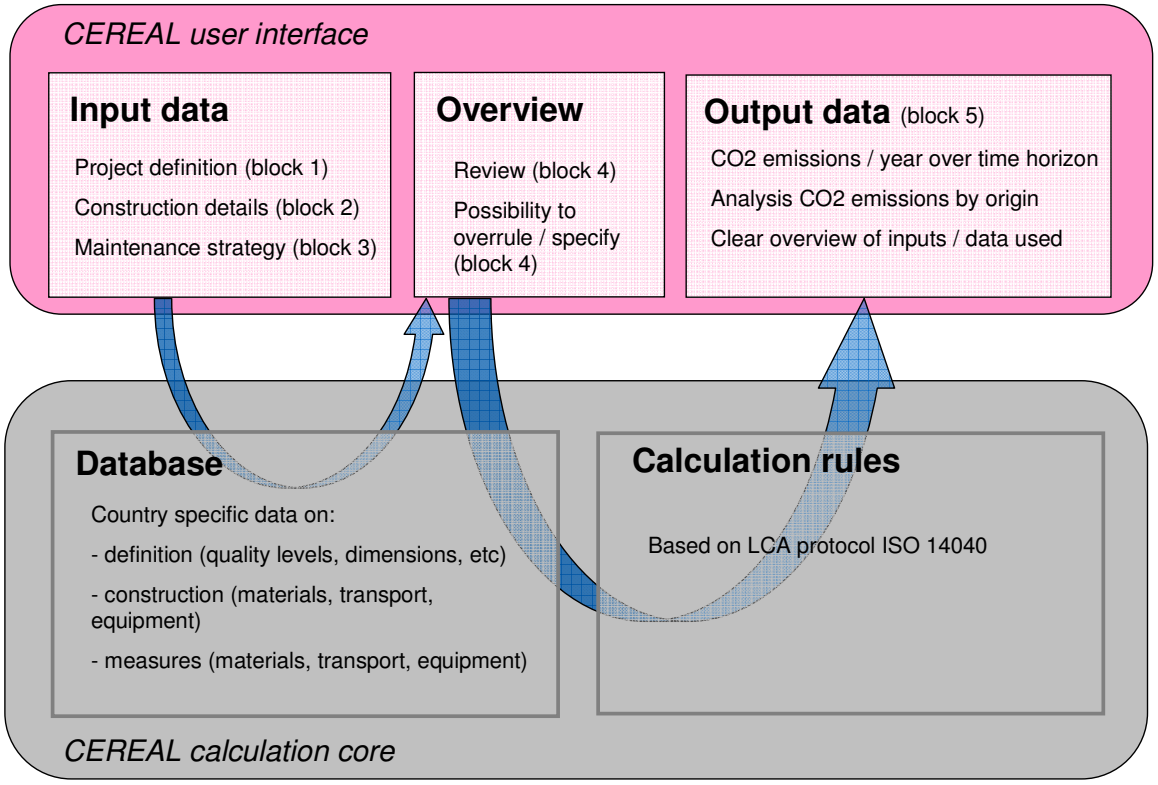

Figure 2.3: General structure of CEREAL tool

First the user should provide all necessary input data (block 1-3), Table 1 gives a detailed overview of the various input data. Where possible, the user will be helped by providing default values or sets of options.
Secondly, after providing all necessary input data, the user will see an overview of all data so the user can review and further specify all data (block 4). The user can decide to create extra scenario’s before (or after) generating results. By using the calculation rules the results of the scenario’s can be generated.

How can the user provide input?

The table below provides an overview of required user input and necessary actions to generate results. In the first block the user is asked to provide general information. For example in 1.2 the user will have to indicate the country where the road is located. This choice determines the type of database that will be used.

User interface blocks		Explanation input parameter
1) Project definition (block 1)		
1.1	Type of road project	Menu: New construction, renovation, maintenance strategy
1.2	Country / region	Menu: Denmark, Norway, Sweden, Germany, The Netherlands, UK and Ireland.
1.3	Road type	Menu: AC1motorway, AC2 motorway, AC3 motorway, etc. PC1 motorway, etc. (numbers of lanes per direction)
1.4	Identify elements	Menu: left/right lane, truck/slow lane, hard shoulders, slip roads, etc.
1.5	Length/Width	Open fields: length and width for all elements. (if possible, defaults will be derived from road type and country)
1.6	Traffic intensity ADT	Menu: ADT per carriage way
1.7	Time horizon project (in years)	Open field: # years
2) Construction details (block 2)		
2.1	Thickness of layers (of all elements)	Thicknesses will be derived from input on road type, quality level and maintenance scenario.
2.2	Use of (building) materials (of all elements)	Menu: asphalt type A, asphalt type B, asphalt type with 50% RAP, granular base course, soil cement, etc. (descriptions will be provided)
2.3	Transportation distances	Open field: providing default values for different materials per country (km's)
2.4	Means of transport	Menu: 10-20 ton truck, >20 ton truck, inland vessel, sea-going vessel, etc.
2.5	Other objects	Menu: tunnel, drainage, road markings, safety -, noise barriers
2.6	Number of other objects	Menu: # / km objects
3) Maintenance strategy (block 3)		
3.1	Maintenance scenarios	Menu: Sets of scenarios will be defined. The set will depend on the road type and whether the wearing course consists of an asphalt layer or a cement concrete layer. Each scenario will contain sets of maintenance measures. Scenarios will range from sets of repetitive simple and cheap measures, e.g. patching and seal coats to structural solutions consisting of milling and in/overlays. (see table 2.2)
4) Review input data (block 4)		
4.1	Review input data	List of default and user defined input data. The user will be allowed to change the default settings or add new specific data.
5) Overview results (block 5)		
5.1	Result	General results visualized and detailed analysis in tables. (see figures 4-7 and table 4 and 5)

Table 2.1: Outline of input data (example)

The maintenance scenarios (including frequency of measures) will be based on general national / regional quality of roads. The quality indicators will be determined based on levels of acceptable distress per type per country and road type. This means that if the quality is higher, the frequency of measures is higher. Defaults for frequency will be derived from target quality levels, maintenance scenario and time horizon per country. An example for a set of maintenance scenarios is demonstrated in table 2.2.

	AC1 motorway / dual carriageway				
year	**treatments**	**area%**	**out (mm)**	**in (mm)**	
15	patching wearing course 10% area	10	40	40	
20	milling and inlay wearing course slow lane	30	40	40	
25	patching wearing course 15%	15	40	40	
25	slurry seal fast lane	30	0	5	
30	milling, strenghtening and wearing course full width	100	40	90	start new cycle
	AC2 motorway / dual carriageway porous asphalt				
year	**treatment**	**area%**	**out (mm)**	**in (mm)**	
10	milling and inlay wearing course slow lane	30	50	50	
20	milling and inlay wearing course full width	100	50	50	
30	milling and inlay wearing course slow lane	30	50	50	
40	milling, strengthening and wearing course full width	100	50	110	start new cycle
	AC3 motorway / dual carriageway				
	or highway single carriageway, no height restrictions				
year	**treatment**	**area%**	**out (mm)**	**in (mm)**	
15	patching wearing course 10% area	10	40	40	
20	patching wearing course 15%	15	40	40	
25	milling, strengthening and wearing course full width	100	40	80	start new cycle
	AC4 motorway / dual carriageway				
	or highway single carriageway, with height restrictions				
year	**treatment**	**area%**	**out (mm)**	**in (mm)**	
15	patching wearing course 10% area	10	40	40	
20	patching wearing course 15%	15	40	40	
25	milling and inlay wearing course full width	100	40	40	
25	extra milling and inlay binder layer	20	60	60	start new cycle

Table 2.2: Example of set of default maintenance scenarios for different road types

2.4 Database

What is the structure and content of the database?

CEREAL will make use of country specific databases in order to calculate with specific national data, as much as possible. General data will be extracted from LCA databases such as Eco-Invent 2.0. The following tools and included databases are indicated at forehand:

1) Denmark, Norway and Sweden (ROAD-RES as basis),
2) Ireland and UK (AggRegain and asPECT as basis)
3) The Netherlands, Belgium and Germany (DuboCalc and AMW as basis).

The (country specific) databases can be divided in three blocks: data on project definition aspects, data on design and construction aspects and data on specific maintenance measures (see figure 3). The list below gives an idea of the data that will be included:

– Definition: standard types of road types per country (see 1.5 table 1), dimensions of standard national road types (cross section and width) (for 1.4 table 2.1), etc.
– Construction: various standard materials for pavement construction: approximately 15 scenario's with min. 5 types of granular materials, cement concrete, road base, etc. per country (for 2.2 table 1), environmental impact reference values per transportation module (for 2.4 table 2.1), reference value for transportation distances for building materials (for 2.3 table 2.1), etc.
– Measures / maintenance: various standard maintenance scenarios: approximately 10 scenarios for asphalt and 3 for cement concrete. Each scenario will consist of combinations of maintenance measures ranging from simple to structural.

Which data sources will be used?

In total 15 existing road construction tools have been extensively assessed to investigate the availability of the (potential) data. A short summary can be found in Table 3, a detailed tool analysis will be published later. Other tools that are assessed: JouleSAVE, GreenDot, Palate, Ceequal and HDM-4. Unfortunately Changer and SEVE were not available for assessment.

CO2 tools	Relevant data
asPECT	CO2e emissions for asphalt with a very detailed input on energy and materials used, transport etc..
AMW	For the environmental data the DuboCalc database (version 2006) the concrete database version 3.1 and the asphalt database of the VBW have been used. The data has been completed with producer specific material for innovative asphalt applications and lightweight materials.
AggRegain	Process parameters of unbound, HBM, concrete, unbound (like emissions of mixing, laying, waste and conversion factors of energy carriers)
	CO2e emissions of various transport modes
	Emissions of (many) materials
	Detailed data of asphalt
ROAD-RES	CO2 impact of production of materials
	Upgrading residues
	Road construction processes

	Landfilling processes
DuboCalc	CO2(e?) emissions of (many) materials
	Default values on maintenance measures.
	data on impact of building
Highway agency carbon calculator	CO2e impact of the productions of a wide variety of materials
	CO2e emissions of various transport modes

Table 2. 3: Data sources

2.5 Outputs and Results

What type of results will the CEREAL tool generate?

Besides the total of the CO_2 footprints of the analysis, CEREAL will provide results on specific activities or and origin of the data. The figures below indicate the type of results that will be generated. First, as CEREAL is focused on emissions over the whole time horizon, various scenarios will be indicated and thus be comparable over the years. The results will be visualized as is illustrated in figures 2.4 and 2.5.

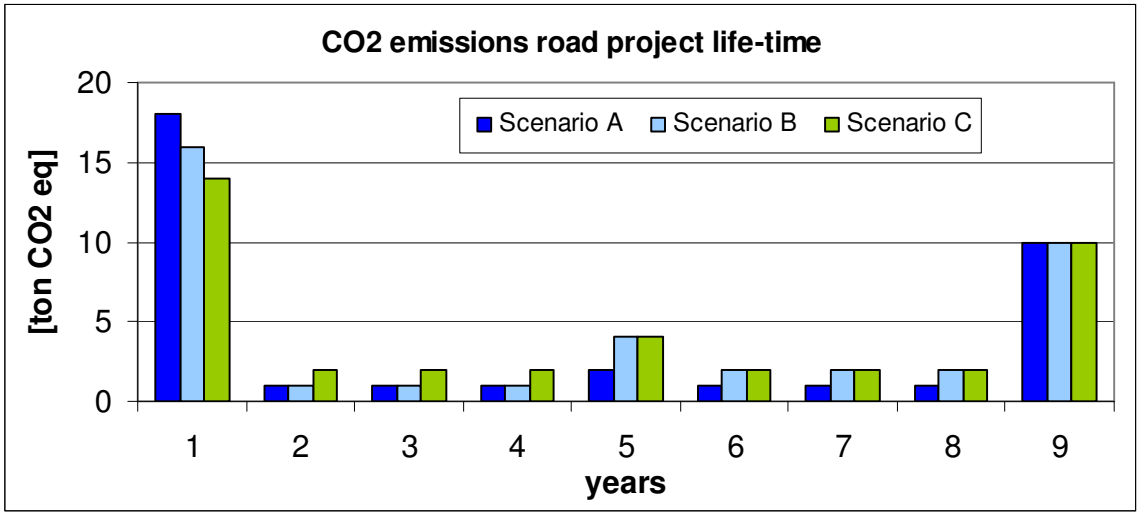

Figure 2.4: CO2 emissions over time horizon (example)

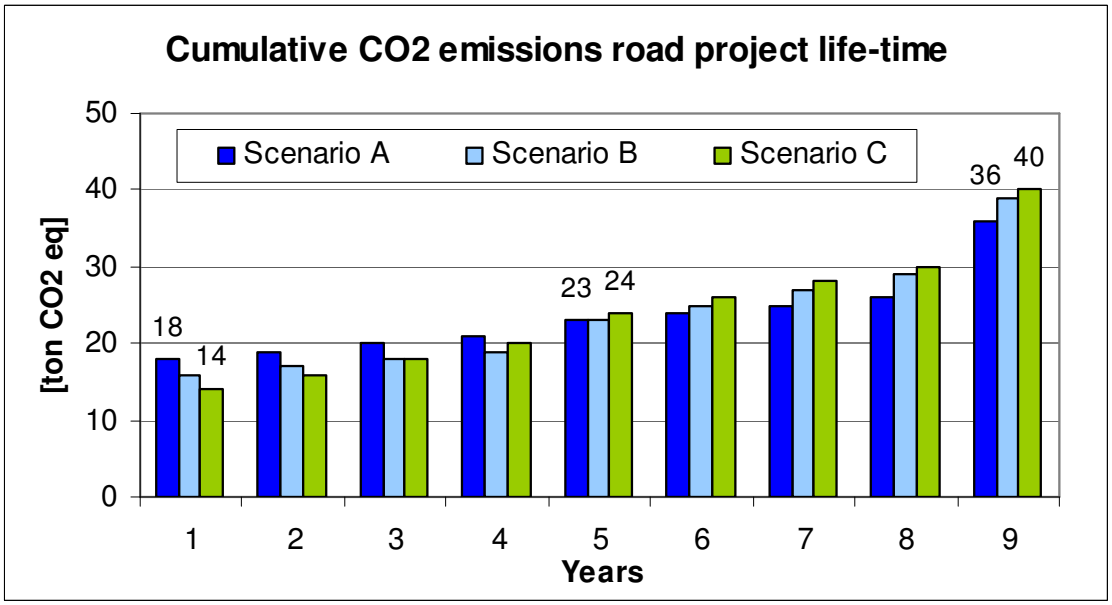

Figure 2.5: Cumulative CO2 emissions over the time horizon (example)

The figure shows the CO2 emissions of the scenarios in relation to their phase (construction, renovation and maintenance).

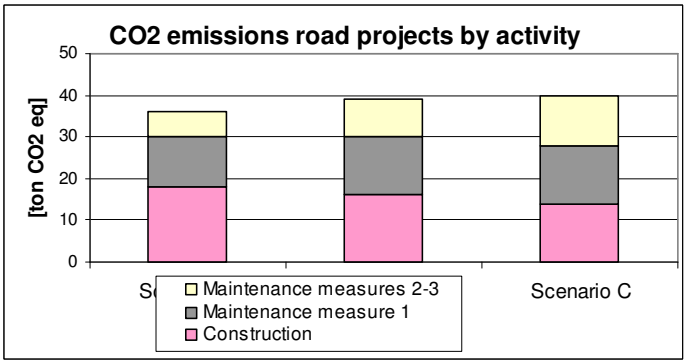

Figure 2.6: CO2 emissions by activity (example)

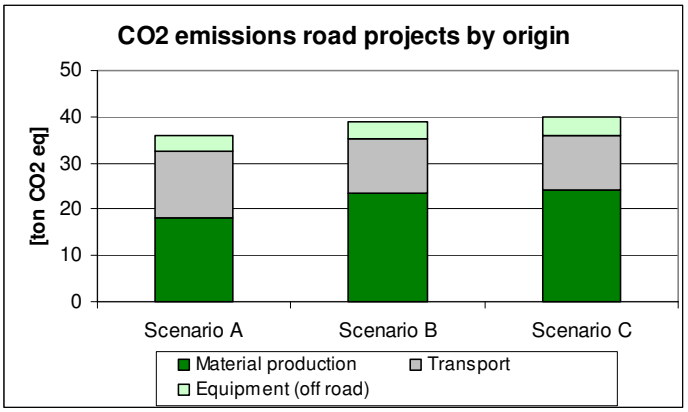

Figure 2.7: CO2 emissions by origin (example)

The figure shows the origin of CO2 emissions (i.e. material production, transportation and machines).

Detailed overviews

In the results the tool will also give an overall impact table providing a breakdown of all CO_2 generating activities / components per scenario, the table has an 'explorer' like program. The table makes it possible to analyze the origin of the CO_2 data in more detail. The table 2.4 gives an indication.

Scenario A					Scenario B			
1	**Construction - truck lane**				**Construction - truck lane**			
1.1	Materials	20	kton		Materials	x		
1.1.1	Toplayer	5			Toplayer	x		
1.1.2	Underlayer	10			Underlayer	x		
	…				…			
1.2	Transportation	10	kton		Transportation	x		
1.3	Equipment	5	kton		Equipment	x		
2	**Measure 1 - truck lane**				**Measure 1 - truck lane**			
2.1	Materials	1	kton		Materials	x		
2.2	Transportation	0.5	kton		Transportation	x		
2.3	Equipment	0.5	kton		Equipment	x		
3	**Measure 2 - truck lane**				**Measure 2 - truck lane**			
3.1	Material	1	kton		Material	x		
3.2	…	0.5	kton		…	x		
4	**Measure 3 - truck lane**				**Measure 3 - truck lane**			
4.1	Material	1	kton		Material	x		
4.2	…	0.5	kton		…	x		

Table 2.4 : Overall impact table (example)

	Years	1	2	3	4	5	Etc
Road elements	Activities						
Element A	Construction	30	0	0	0	0	
	Maintenance	0	0	0	0	5	
	…						
Element B	Construction	20	0	0	0	0	
	Maintenance	0	0	0	0	7	
Etc.							

Table 2.5: Impact table structured by road elements and years (example) [kton CO2e/year]