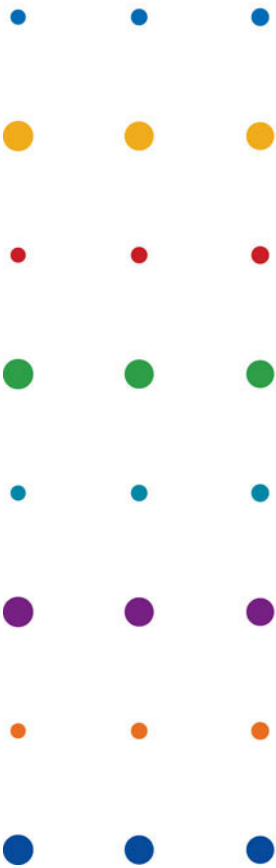


Tool assessment for CEREAL

Evaluation of existing CO2 tools for
roads



Deliverable Work Package 3

ERANET

September 2012
DRAFT

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SUMMARY

This Tool Assessment outlines the pros and cons of 9 existing CO₂ calculation tools applied in road infrastructure projects over Europe in comparison with the results from a survey and interviews. In total 16 CO₂ calculation tools were briefly assessed. Based on the criteria that the tool should focus on infrastructure and calculation of CO₂, 9 tools were selected for a more thorough assessment. The outcomes of this assessment are combined with the results of the survey and interviews and together form the base of the functional requirements of the CEREAL tool.

The goal – concluded from the survey and interviews– is to build a tool that:

- does not require a lot of data, but is open for adding project specific data,
- uses the best available engineering knowledge and process data resulting in easy calculation of reliable results.
- has predefined maintenance measures and scenario's based on present engineering technology which can be changed or added,
- includes principally the full life cycle of roads, but focuses in more detail on maintenance projects and differences in maintenance scenario's,
- includes the main road objects if sufficient information is available on the life cycle of road objects like tunnels etc.,
- uses existing databases and calculation rules from the existing models, with available country specific databases on e.g. maintenance measures, asphalt mixes, transport distances, electricity generation etc.,
- is designed to calculate carbon footprints for projects in North-Western Europe,
- does not include calculations on use phase based on road characteristics.

The general conclusion is that none of the existing instruments fulfils the needs expressed by the survey, the interviews and the Program Executive Board. The following general conclusions can be made:

- Existing tools are mostly closed (difficult to add project specific data) and are not transparent,
- Existing tools mainly require a lot of data and/or are complex in structure,
- Existing tools focus mainly on construction (new constructions) and give little variation on maintenance,
- European models appear to have problems with generating results in an easy way, American (US) models are more user-friendly than their European equivalents.
- European models contain the same scope or subjects as CEREAL and thus they contain useful components and material data.
- The DuboCalc tool, contains detailed information about the Dutch situation, whereas asPECT and ROAD RES do the same for the United Kingdom and the Scandinavian countries.

From this perspective the overview below gives the key pros and cons of the most valuable tools assessed.

CO2 calculation tools	Pros (one of)	Cons (one of)
asPECT (UK)	+ useful (accessible) database	- amount of input data needed
<i>Afwegingsmodel wegen</i> (NL)	+ transparent and easy in use + includes maintenance and rehabilitation measures	- no option of editing of adding to the database
AggRegain / ESRSA (UK)	+ useful (accessible) database	- input-intensive and detailed

		knowledge required
ROAD-RES (DK)	+ good methodological structure	- input-intensive and detailed knowledge required
DuboCalc (NL)	+ completeness and databases (NL)	- transparency of generation of results
JouleSave (EU)	+ includes effect of interaction between road (design) and traffic	- requires advanced knowledge of detailed road design
GreenDOT (US)	+ good look and feel	- based on US data / circumstances
PaLATE (US)	+ structure / look and feel	- based on US data / circumstances
WLCO2T (UK)	+ useful database based on Price Book (UK)	- not known

1 INTRODUCTION

1.1 Availability and usefulness of existing tools

An important part of the CEREAL project is the evaluation of the existing tools that calculate the CO₂ emissions of road construction and pavement maintenance. This part of the project is termed 'tool assessment'. The goals of the tool assessment are:

- determination of the usefulness of (parts) of the existing tools;
- evaluation of the availability of the possible input data of the CEREAL tool.

With help of the expert-judgment of the CEREAL-team and the results of the survey the following 11 tools were selected for detailed assessment. Some other tools were also identified but were not analyzed in detail (see list below). The tools that were assessed in detail are:

- 1) asPECT
- 2) Afwegingsmodel wegen
- 3) AggRegain CO₂e emissions estimator tool (ESRSA)
- 4) ROAD-RES
- 5) DuboCalc
- 6) JouleSave
- 7) GreenDOT
- 8) PaLATE
- 9) WLCO₂T
- 10) SEVE*
- 11) CHANGER*

* Unfortunately these tools were not accessed. The reasons are elaborated in chapter 2.

After a brief review the following tools were not analyzed in detail:

- Ecologiciel (Colas, France):
- CO₂NSTRUCT
- LCI Model
- HDM-4
- VETO:

1.2 Analysis approach

The CEREAL team divided the evaluation into three subjects:

- 1) Background of the CO₂ calculation tool
- 2) Technical related aspects
- 3) User related aspects

Furthermore these subjects contain the following assessment questions:

- 1) Background of the CO₂ calculation tool
 - What is the name of the CO₂ calculation tool and what is the language used?
 - What is the purpose of the CO₂ calculation tool?

- What is the availability of the CO₂ calculation tool? Who can use the tool?
- Which organization developed the program?
- Who funded the development of the CO₂ calculation tool?
- For which region is the tool suitable?
- Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

2) Technical related questions

- What is the program language of the tool?
- Is the source code (program language) transparent and easy to access?
- Is the source data (databases) transparent and easy to access?
- Is the data useful for implementation in CEREAL?
- Is it transparent what the origin is of the source data?
- Are the calculation rules transparent and easy to access/alter?
- Are the results easy to reproduce?
- Which kind of pavement does the program treat?
- Which phase in the road lifecycle is the program for?
- Which are the (main) inputs needed?
- Is the database easy to change/add?

3) User related questions

- What is the intended user group?
- Who are the main users of the tool?
- How are the results used?
- For what purpose are results generated?
- Please judge the user friendliness of the CO₂ calculation tool
- Are the results of the CO₂ calculation tool useful?
- For which type of use?
- For which type of organization?
- How much time is needed to fill the model before you have results?
- Is this time in proportion in relation with the goal of the tool?
- Is the program easy to use?
- Does it provide a tutorial?
- Is there a clear user manual available?
- Is there a installed database to start working with?
- Are the needed inputs easy to gather and apply?
- Which are the end-result units? (kgCO₂e, €, other)

2 DETAILED TOOL ASSESSMENT

This section will elaborate on the benefits (pros) and drawbacks (cons) of the analyzed tools. The complete lists of answers of the questions listed aforementioned (chapter 1.2), is provided in the annexes.

2.1 asPECT (asphalt Pavement Embodied Carbon Tool)

The program considers the CO₂e impacts of building and maintaining a road pavement, from sourcing raw materials and laying mixtures to maintenance through periodic interventions to ultimate deconstruction. The protocol considers all emissions that contribute to climate change from sources including energy use, combustion processes, chemical reactions, service provision en delivery.

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Calculation of the results for different phases of the project
This enables the user to see where the largest sum of emission takes place helping him to focus on those features only for accomplishing improvements.
→ CEREAL should generate CO₂e per phase (construction, maintenance) over the years of a project.
- Detailed level of environmental databases
The detailed level of the environmental database makes it possible to differentiate a lot among the asphalt mixtures, energy origin and equipment used. This means that calculations can be made very project specific rather than just generating a rough estimate.
→ The CEREAL databases should be editable for facilitating detailed project specific calculations.

Notable negative aspects (cons) of this program from which can be learned from:

- Too detailed level of the database
The detailed level of the databases makes it impossible to use this program quickly from the start. For example, the need for specification of your own asphalt mixtures and origin of energy used during asphalt production makes it hardly possible for a non-specialist to acquire reliable calculation results or even rough estimates.
→ CEREAL should have a default mode that enables non-specialists to perform some estimating calculations/comparisons between different constructions.
- The program is limited to flexible pavements only
Comparison between asphalt pavements and cement concrete pavements, and to compare cement concrete mutually on the same basic calculation rules, is not possible.
→ CEREAL should allow entry of both types of materials and pavement structures.

2.2 AfwegingsModel Wegen, AMW 1.1

The CROW-software "Afwegingsmodel Wegen (AMW)" is an objective and transparent model where the user has the choice between several types of pavements: asphalt, concrete or block paving. The purpose of the tool is to provide a transparent and objective choice between different pavement types or maintenance strategies based on environmental, financial and other aspects as criteria.

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Applicable for as well asphalt as cement concrete road constructions
What we learn from this is, it is very well possible to compare energy consumption and CO₂ emission of asphalt roads with cement concrete roads within the same project, calculation rules and report. This really adds an extra choice to the users of the program.
→ This choice / comparison should be included in CEREAL.
- Construction and maintenance / rehabilitation measures
Construction as well as major and local maintenance and rehabilitation measures can be defined. These measures may be applied at a given moment in time or cyclic.
→ CEREAL will have the whole life cycle encompassing construction and maintenance in it's scope.
- Input can be saved to (re)use later
What we can learn from this is that saving of input and results adds to the user friendliness of the program. An export file of the results to Excel would make it even better for copying and pasting of the results in presentations or reports.
→ CEREAL will give user the possibility to save (and reuse).

Notable negative aspects (cons) of this program from which can be learned from:

- There is no option of editing of adding to the database
What we can learn from this is that a preset database is limited in its use in time and its users. Preset databases should be updated regularly preventing them to become obsolete and lack behind on material innovations. This might lead to incorrect use or no use at all for project specific calculations due to the fixed, preset (average) parameters. The unchangeable distance from asphalt plant to the project site is an example of an unwanted feature.
→ CEREAL will have an open database in which project specific data can be added. However, user defined entries should be labeled as "user data" allowing to trace the origin of the data.
- The tool could be a little more user-friendly
The layout of the program makes it difficult to compare the differences and similarities in input between two constructions. Looks of the screen changes while working on one construction.
→ What we can learn from this is that a simple and consequent setup and "look" of the program makes it most user-friendly to work with. Consistency through the program and "knowing where you are" during input or in results will improve the user-friendliness.

2.3 AggRegain CO₂e emissions estimator tool

The English AggRegain CO₂e emissions estimator tool focuses on giving an estimate of the climate change contribution by selecting different construction techniques and supply alternatives (use of primary or recycled and secondary aggregates). The tool was developed by UK's TRL (Transport Research Laboratory) and funded by WRAP (Waste & Resources Action Program).

The tool itself seems not directly useable for the purpose of CEREAL, mainly because of the large amount of data that is needed to generate results. However, the CO₂ emission sources are largely the same as the CEREAL concept, so specific numbers are very useful.

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Detailed accessible databases with emission factors

The AggRegain tool provides a large database with CO₂ emission sources which are largely the same as CEREAL.

→ CEREAL will make use of the data (CO₂ emission factors) for the UK situation.

- Four types of construction applications
The tool assesses the carbon dioxide output resulting from four types of construction applications: bitumen bound, concrete, hydraulically bound, unbound.
→ This structure will be applied in the CEREAL tool as well.

Notable negative aspects (cons) of this program from which can be learned from:

- Large amount of input variables
Because of the large amount of input variables needed, the results are not easy to reproduce.
→ CEREAL will work with a default and expert mode. In the default mode, little input data is required (and most detailed data is hidden) and in the expert mode the user can modify detailed choices.
- Not saving input data
AggRegain is input-intensive and when generating a scenario or second option all the data should be provided (once) again.
→ CEREAL will have an option to copy / take over the base-case inputs when a second option / scenario will be built.

2.4 ROAD-RES

The Danish ROAD-RES model has two purposes: (i) to evaluate the environmental impacts and resource consumption in different life cycle stages of road construction with virgin materials and residues from waste incineration; (ii) to evaluate and compare two disposal methods for waste incineration residues, namely landfilling, and utilization in roads. ROAD-RES was developed by the Technical University of Denmark in collaboration with the Danish Road Directorate, two incinerators and a contractor.

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Possibility to use other databases
EDIP97 is the default life cycle impact assessment method in ROAD-RES. The user can, however, supplement the model with other life cycle impact assessment methods, such as Eco-indicator 95, Eco-indicator 99 or CML 2001.
→ This requires advanced software linked to other LCA software and thus will not be included in the CEREAL (excel based) tool.
- Detail / focus in demolition phase
In the demolition phase, removal of road materials and disposal or recycling of the materials can be modeled as well as the rehabilitation of the area.
→ In reality, demolition of roads is something that hardly ever happens and is thus not included in the scope of CEREAL.

Notable negative aspects (cons) of this program from which can be learned from:

- Complicated to use and not transparent

- Specific software required
ROAD-RES is developed as a software program using C++ and PARADOX database.
→ CEREAL will be developed as a (stand alone) excel based file

2.5 DuboCalc

Purpose of DuboCalc is to optimize design on environmental impact (original purpose). Now DuboCalc is mainly used for contracting, the contractor with the lowest calculated environmental impact is awarded. DuboCalc was developed and funded by the Dutch Rijkswaterstaat (RWS).

The Dubocalc tool is closed, since the focus is on contracting, no data can be added in an easy way. Dubocalc is not very transparent, has no focus on maintenance and the life cycle is predefined and is based on the Dutch situation. Therefore the model as a whole is not suitable to link to the CEREAL tool, but the basic principles, calculation rules and data are.

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Basic principles, calculation rules and data
DuboCalc is a good example of how the CEREAL tool could look like. It is pretty user friendly, the LCA methodology is good and there are useful databases for the user.
→ CEREAL will copy the structure, methodology and data where possible.

Notable negative aspects (cons) of this program from which can be learned from:

- Little variation in maintenance
DuboCalc focuses on construction / renovation and offers little detail in maintenance measures.
→ CEREAL will include detailed treatments in the maintenance phase of roads.
- Not transparent in calculations
DuboCalc is not transparent in the way calculations are made. Results are not easy to reproduce. The database is managed by SBK (*Stichting Bouwkwiteit*), data layer is owned by Conesco and RWS is the main user and overall manager.
→ CEREAL will include a sheet with an overview of data used, what is the base for the calculations.
- Somewhat outdated data
Data is not easy to extract from DuboCalc. There is plenty of (typically Dutch) data available, although some data is old.
→ Old data is not always a problem as most development is not so fast. CEREAL will thus make use of data from DuboCalc

2.6 JouleSave

JouleSave is a specific software product of an earlier European program. JouleSave is built as a additional module to the MX software, which is used by detailed (road) designers. The main comment of this program from which we can learn is that the specific software (MX) makes it only accessible for a very small user group. Besides this small user group the main comment is that the tool is little used, as far as known. As reason for this limited use the developers state that CO₂ is hardly ever a criteria for the detailed design, mostly functional requirements are leading. Road designers in this (final) design phase have little incentive to apply such a tool.

JouleSave is too detailed in terms of input and output data (to be applied in final design phase) and too specific in the software (MX). The tool is therefore not useful for the intended user group of CEREAL.

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Very detailed (integral) analysis possible
JouleSave makes it possible to include the CO₂ effect of traffic related to the road.
→ For CEREAL this application is too detailed.

Notable negative aspects (cons) of this program from which can be learned from:

- Extraordinary knowledge necessary
In order to use (and access) JouleSave, the user should have good road design skills.
→ CEREAL will not be developed for road designers.

2.7 GreenDOT

The purpose of Greenhouse Gas Calculator for State Departments of Transportation (GreenDOT) is to calculate carbon dioxide emissions from the operations, construction, and maintenance activities of state Departments of Transportation (DOTs). GreenDOT was developed by ICF International and Venner Consulting and was part of the National Cooperative Highway Research Program (NCHRP) Project 25-25.

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Good look and feel for users
The interface and structure are very user friendly.
→ The tool provides great inspiration of the 'look and feel' for the CEREAL tool.
- Provides good assistance
Most of the inputs are not easy to collect. However, the tool provides other possibilities to estimate these inputs.
→ CEREAL will work with defaults (and suggestions) in order to simplify the input for less frequent users.

Notable negative aspects (cons) of this program from which can be learned from:

- Data is specific for US circumstances
→ CEREAL will include European data.

2.8 PaLATE

The purpose of Pavement Life-cycle Assessment Tool for Environmental and Economic Effects (PaLATE), is to calculate life-cycle assessment (LCA) of environmental and economic effects of pavements and roads. The program was developed by the Consortium on Green Design and Manufacturing, University of California, Berkeley and was funded by Recycled Materials Resource Center of the University of New Hampshire and the University of California Transportation Center.

PaLATE is a very useful tool because it has a very simple and clear structure. This tool can be an inspiration of how CEREAL should look like.

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Structure and look and feel

PaLATE assesses emissions associated with materials production, construction, transportation, and maintenance of asphalt and Portland cement concrete pavement, sub base, embankment and shoulders materials.

→ PaLATE provides a good structure and great inspiration of the 'look and feel' for the CEREAL tool.

Notable negative aspects (cons) of this program from which can be learned from:

- Data is specific for US circumstances
→ CEREAL will include European data.

2.9 WLCO2T

The WLCO2T tool is developed by URS in the UK. Unfortunately the CEREAL team was not able to access the tool itself but only (on of) the database(s). Therefore no complete detailed analysis is possible (so far).

Notable positive aspects (pros) of this program that can be used in the CEREAL software are:

- Provides good UK data
The unit costs are generic and are taken from previous work done by the Highways Agency. The emission factors for each activity are based on CESSM3 Carbon and Price Book.
→ CEREAL will make use of the same emission factors based on CESSM3 Carbon and Price book.
- Opportunity to change and add (own) local data
The tool offers users the possibility to ad (own) locally available data.
→ CEREAL will offer this option as well.

2.10 SEVE

It was not possible to obtain the French model SEVE. Therefore it is not assessed. Despite various attempts no password was provided by the organisation behind the program and thus access has not been gained.¹

2.11 CHANGER

The CEREAL team was unable to assess the CHANGER tool. The tool seems to be distributed from Lausanne. For this reason Prof. André-Gilles Dumont of LAVOC in Lausanne was contacted for acting as a go between. Valuable information was gathered via Prof. Dumont, but unfortunately no CHANGER related information could be gathered.

¹ Attempts were made by contact with Lars Ladehoff and Jean Paul Michaut: <http://international.seve-tp.com>, and password: admin@seve-tp.fr

2.12 Other tools

As mentioned not all identified CO₂ calculating tools are within the same intended scope of CEREAL. The following tools were briefly analyzed but not assessed in detail.

2.12.1 Ecologiciel (Colas, France)

Ecologiciel is the first carbon footprint comparison tool for road projects. The developer Colas was a key participant in the development of the eco-comparison tool known as SEVE® (see 2.3)

2.12.2 CO2NSTRUCT

A database and Web application called CO2NSTRUCT has been developed starting from an intense research, analysis and data collection. The application proposed aims to quantify direct and indirect emissions associated with each item based on the database and to assign them to each stakeholder. This tool is a first approach to GHG quantification and allocation in the road life cycle, but is currently non-existent in state of the art, although there exist other attempts of quantification in specific road projects or in structures such as bridges.

2.12.3 LCI MODEL (EAPA/EuroBitume)

This tool is focuses on CO₂ emissions of materials and thus not constructions and maintenance. The tool is also used in AggRegain. Therefore the use of the tool is included in AggRegain.

2.12.4 HDM-4 RUC

The HDM-4 RUC Model is excel-based and focus mainly on the user phase of a road. It could therefore be useful for estimations in the user phase.

2.12.5 VETO

The program VETO, which was developed by the Swedish National Road and Transport Research Institute, calculates fuel consumption when pavement parameters such as IRI and texture are known. It does not calculate the emissions of the construction phase.

3 CONCLUSIONS

3.1 General findings

Generating results

In general it can be concluded that the European tools appear to have problems with easy generating of results. They are usually complicated to fill with all necessary data. In most cases they are country specific and cannot be used Europe wide without adaptation in one way or another.

The use of the best available engineering knowledge and process data must result in easy calculation of reliable results. Easy generation of results, no complicated input data and European wide use are three important requirements of the CEREAL-tool. None of the existing tools complies fully with these specifications.

The assessed models from the United States are far more user-friendly than their European equivalents. They clearly separate 'general input data' from 'detailed input data'. They are therefore an inspiration for what a clear and user-friendly Excel-tool should look like.

Scope of the tool

Most of the European models cover the same subjects as CEREAL will do. This implies that the existing tools contain components and material data that might be applicable to CEREAL. The tool DuboCalc, for example, contains detailed information about the Dutch situation, whereas asPECT and ROAD RES do the same for the United Kingdom and the Scandinavian countries, respectively.

3.2 Pros and contras of analyzed tools

CO2 calculation tools	Pros (one of)	Cons (one of)
asPECT (UK)	+ useful (accessible) database	- amount of input data needed
<i>Afwegingsmodel wegen</i> (NL)	+ transparent and easy in use + includes maintenance and rehabilitation measures	- no option of editing of adding to the database
AggRegain / ESRSA (UK)	+ useful (accessible) database	- input-intensive and detailed knowledge required
ROAD-RES (DK)	+ good methodological structure	- input-intensive and detailed knowledge required
DuboCalc (NL)	+ completeness and databases (NL)	- transparency of generation of results
JouleSave (EU)	+ includes effect of interaction between road (design) and traffic	- requires advanced knowledge of detailed road design
GreenDOT (US)	+ good look and feel	- based on US data / circumstances
PaLATE (US)	+ structure / look and feel	- based on US data / circumstances
WLCO2T (UK)	+ useful database based on Price Book (UK)	- not known

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ANNEX 1 Assessment of asPECT

Background of Aspect

Evaluator: KOAC•NPC

What is the name of the CO₂ calculation tool and what is the language used?
asPECT (asphalt Pavement Embodied Carbon Tool). The language is English.

What is the purpose of the CO₂ calculation tool?

It is a made to provide a framework which contains the necessary formulae, emissions factors and default data to calculate the 'cradle-to-grave' GHG emissions of asphalt products. The program considers the CO₂e impacts of building and maintaining a road pavement, from sourcing raw materials and laying mixtures to maintenance through periodic interventions to ultimate deconstruction. The protocol considers all emissions that contribute to climate change from sources including energy use, combustion processes, chemical reactions, service provision en delivery.

What is the availability of the CO₂ calculation tool? Who can use the tool?

Free download via website: www.sustainabilityofhighways.org.uk

Which organisation developed the program?

Joint initiative of the Highways Agency, Minerals Products Association, Refined Bitumen Association and TRL (Transport Research Foundation).

Who funded the development of the CO₂ calculation tool?

Sponsored by Highways Agency, Minerals Products Association and Refined Bitumen Association. Supported by WRAP (Waste & Resources Action Program) and ADEPT (Association of Directors of Environment, Economy Planning and Transport).

For which region is the tool suitable?

United Kingdom

Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

Publically Available Specification for the Assessment of the Life Cycle Greenhouse Gas Emissions of Goods and Services (PAS 2050) was followed.

Technical related questions

What is the program language of the tool?

The tool is programmed in MS Excel.

Is the source code (program language) transparent and easy to access?

No, the source code is not easy to access or change.

Is the source data (databases) transparent and easy to access?

Yes, in the published project report

Is the data useful for implementation in CEREAL?

No, the way the program is built it seems rather complicated to use. In the end it is a software that is supposed to be used indeed only by asphalt producers. The producers have access to all the data needed in the tool. However, the CEREAL team is confident that even asphalt producers will have difficulties in gathering all the data..

Is it transparent what the origin is of the source data?

Yes, data origin available in background report.

Are the calculation rules transparent and easy to access/alter?

Via the published project report the calculation rules are easy to access. It is not possible to change them in the software.

Are the results easy to reproduce?

Results can be saved and are therefore easy to reproduce.

Which kind of pavement does the program treat?

Flexible pavement

Which phase in the road lifecycle is the program for?

Design, major maintenance, broad repair and local repair

Which are the (main) inputs needed?

There are some types of bitumen, cement, fibres, hydrated lime and water for the UK market. Data about aggregate are not available and to add them, there are a lot of data needed. For each added material the yearly data needed are: electricity, other fuel, water usage, emulsion, explosive

Is the database easy to change/add?

No

User related questions

What is the intended user group?

Asphalt producer, to evaluate their mixtures. Or contractors to evaluate their projects. But if the contractor doesn't own the asphalt plant, it will be a bit more complicated to gather the needed information.

Who are the main users of the tool?

Primarily to be used by asphalt producers and contractors, who have access to the detailed information that it requires to operate.

How are the results used?

The end result is the total GHG-emission per tonne (kg CO₂e). This results can be calculated for different phases of the project:

- Materials and processing
- Transport to plant
- Asphalt production
- Transport to site
- Laying and compacting

- Project works
- Maintenance
- End of life.

For what purpose are results generated?

Quantitative calculation of the total emission for a certain project, from mining of raw materials till end phase of the project.

Please judge the user friendliness of the CO₂ calculation tool

It is user friendly on the way is built, with pop down menu's, maps per subject is treating. There are still some bugs such as for printing (generate a report). The data needed make the program very difficult to use.

Are the results of the CO₂ calculation tool useful?

Yes

For which type of use?

Certification of projects or asphalt mixtures

For which type of organisation?

Contractors, asphalt producers

How much time is needed to fill the model before you have results?

Even for a simple project there will be a lot of time needed. Once the data base is enough, the calculations should become easier and faster. Because a lot of input is needed (for every single phase of a construction), the program is very flexible for new products, new asphalt plants, and projects. Unfortunately it appears to be very complicated for a engineering consultancy company to gather all the needed information.

Is this time in proportion in relation with the goal of the tool?

It depends on what the goal of the user is. If the calculation are frequently performed, the data base should be at a certain point good enough to have the results faster. For a consultancy company, the needed data are almost unreachable. If achievable, data collection will be extremely time consuming.

Is the program easy to use?

Rather easy, if the user has knowledge in environmental en road construction areas

Does it provide a tutorial?

No

Is there a clear user manual available?

There is a user manual available. It seems a bit complicated to use the software if you don't have both background on environment and road construction.

Is there a installed database to start working with?

A small set of data is available. Mostly bitumen (some polymer modified) , cement, Hydrated lime, water, explosives. Fibres and wax. Prior to making calculations, the user must first have all the specific raw materials. In a next step, the user has to create (virtually) an asphalt plant. Also here a detailed

information about electricity, fuels, water usage, heating & drying consumption, materials transport to plant is needed. After these details are known, the user can 'make' the different mixtures that this asphalt plant can produce. After having created the plant and mixtures, a project has to be created.

Are the needed inputs easy to gather and apply?

No, not easy at all to gather the requested information. Maybe for a big contractor with knowledge of the mining industry for raw materials, the asphalt plants to produce the mixtures, the project to apply the mixtures, maintenance, etc. It seems a good alternative for a DCM contract.

Which are the end-result units?

kg CO₂-equivalents (question remains: which gasses are included)

Conclusion

The Aspect-tool itself seems not directly useable for the purpose of CEREAL, mainly because of the large amount of data that is needed to generate results. However, the CO₂ emission sources are largely the same as the CEREAL concept so specific numbers for the British situation are very useful.

KOAC•NPC (data)

ANNEX 2 Assessment of AfwegingsModel Wegen (AMW)

Background of Afwegingsmodel wegen

Evaluator: KOAC•NPC

What is the name of the CO₂ calculation tool and what is the language used?

AMW (versie 1.1); Dutch language.

What is the purpose of the CO₂ calculation tool?

The CROW-software "Afwegingsmodel Wegen (AMW)" is an objective and transparent model at the choice between several types of pavements: asphalt, concrete or blocks. In 2007-2008 the AMW have been actualised. Thereby the model has been extended with new material and the last material and environment data has been processed. The purpose is to provide a transparent and objective choice between different pavement types or maintenance strategies based on environmental, financial and other aspects.

What is the availability of the CO₂ calculation tool? Who can use the tool?

available to everyone; Excel download for € 102,- (KOAC•NPC location of the file)

<http://www.crow.nl/nl/Publicaties/publicatiedetail.aspx?code=D926a>

Which organisation developed the program?

Developed by CROW; database exist of the DuboCalc database of RWS; database update is being made by INTRON.

Who funded the development of the CO₂ calculation tool?

CROW

For which region is the tool suitable?

The Netherlands; depends on the materials available in the database (regional availability of construction materials)

Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

CML2-baseline, GWP100

Technical related questions

What is the program language of the tool?

The tool is programmed in Excel

Is the source code (program language) transparent and easy to access?

The source code is not easy to acces

Is the source data (databases) transparent and easy to access?

Databases are transparant as the origin of the data used is known (DuboCalc database). Next to that its easy to acces the database and add informatio to or change information in the database..

Is the data useful for implementation in CEREAL?

Yes but due to specific materials in the database probably only for the Netherlands

Is it transparent what the origin is of the source data?

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.

* VBW is the Department Bituminous Works which is formed by the asphalt producing and processing members of *Bouwend Nederland*. Available knowledge with the VBW is accessible to everyone interested in the product or the application.

Are the calculation rules transparent and easy to access/alter?

The calculation rules are transparent (tons of material used times environmental impact per ton). However the calculation rules cant be altered.

Are the results easy to reproduce?

Results can be saved and are therefore easy to reproduce.

Which kind of pavement does the program treat?

Flexible pavement, concrete en block pavement.

Which phase in the road lifecycle is the program for?

Design, major maintenance, broad repair and local repair.

Which are the (main) inputs needed?

pavement design or pavement maintenance both in amounts of square meters and layer thickness and materials being used.

Is the database easy to change/add?

No, the environmental database is not easy to access nor alter.

User related questions

What is the intended user group?

Anyone may use the program however for good results is recommended that the user has an understanding of pavement maintenance and construction. This knowledge is needed to assure that different pavements which are compared to each other are technically and (at least) functionally in the same condition over their lifetime. If this is not an issue it would be at least nice to know what to expect of a construction you calculate the environmental impact for.

Who are the main users of the tool?

Consultants and road authorities/administrators.

How are the results used?

The results (in this program) are used to make a comparison constructions based on environmental impact, costs and others aspects.

For what purpose are results generated?

The results are used to compare different pavement constructions or maintenance policies and their environmental impact.

Please judge the user friendliness of the CO₂ calculation tool

Pretty friendly. Next to CO₂ calculation it also calculates loads of other environmental impacts. All these impacts are summed up and converted to Euros. However in detailed reports you still find the individual environmental impacts.

Are the results of the CO₂ calculation tool useful?

Yes

For which type of use?

Policy making decisions.

For which type of organisation?

Road authorities/administrators but also could be useful for producers when they get their products listed in the database.

How much time is needed to fill the model before you have results?

Depends on the degree of detail and number of maintenance policies and constructions you want to calculate. However there is no possibility to calculate environmental impact of materials not already listed in the database.

Is this time in proportion in relation with the goal of the tool?

Yes

Is the program easy to use?

it works, but could be a little more user friendly.

Does it provide a tutorial?

Yes

Is there a clear user manual available?

Yes

Is there a installed database to start working with?

Yes, there is a database with most used materials.

Are the needed inputs easy to gather and apply?

Not for the environmental data

Which are the end-result units?

End result is in Euros and also combines all environmental impacts (more then just CO₂) however in detailed results you can find the CO₂ emission calculations.

Conclusion

The AMW-tool itself seems not directly useable for the purpose of CEREAL, mainly because of the large amount of data that is needed to generate results. However, the CO₂ emission sources are largely the same as the CEREAL concept so specific numbers for the Dutch situation are very useful.

(KOAC•NPC PLEASE SPECIFY)

ANNEX 3 Assessment of AggRegain

Background of AggRegain

Evaluator: DHV

What is the name of the CO₂ calculation tool and what is the language used?

The AggRegain CO₂e emissions estimator tool, version 2.0, may 2010. English.

What is the purpose of the CO₂ calculation tool?

The tool focuses on giving an estimate of the climate change contribution saved by selecting different construction techniques and supply alternatives (use of primary or recycled and secondary aggregates).

The tool highlights the savings that can be made in terms of CO₂ emissions by choosing different materials and construction techniques. The users can quantify the savings that can be realised by, for example, increasing the quantities of materials imported from the closest source available, starting from using recycling on site. Different construction techniques might also yield considerable emissions savings. The estimates can then be used in the decision process for the procurement of the material and the specification of the construction technique.

What is the availability of the CO₂ calculation tool? Who can use the tool?

Free download from:

http://aggregain.wrap.org.uk/sustainability/try_a_sustainability_tool/co2_emissions.html

Which organisation developed the program?

TRL Limited, (UK's Transport Research Laboratory). TRL is an internationally centre of excellence providing research, consultancy, testing and certification for all aspects of transport.

Who funded the development of the CO₂ calculation tool?

WRAP (Waste & Resources Action Programme) works in England, Scotland, Wales and Northern Ireland to help businesses and individuals reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way.

WRAP has two priorities: 1) "To help the UK Governments to meet their national and international commitments and build the green economy; and 2) to support resource efficiency in the UK so that householders, businesses and the public sector save money and make better use of resources."

For which region is the tool suitable?

Where possible, UK specific data is used; however, this is not available for all processes. In these cases, data from European studies is used instead. The ECRPD report is used for data on equipment operation and some references still remain to the EAPA/EuroBitume Life Cycle Inventory. The ECRPD report was compiled by European partners representing The Netherlands, Czech Republic, France, Ireland, Finland, Portugal and Sweden. Data from the EAPA/EuroBitume LCI were collected mainly in Nordic Countries and so may not be as relevant as UK data. However, the tool allows for specific data to be entered by the user to increase the data set relevance.

Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

Unknown

Technical related questions

What is the program language of the tool?

It's an Excel based calculation tool

Is the source code (program language) transparent and easy to access?

VBA code inaccessible, furthermore it seems there are no limits.

Is the source data (databases) transparent and easy to access?

It's transparent and there are links to asPECT. Calculations and results can be reproduced.

Is the data useful for implementation in CEREAL?

Question is: what is the added value of this tool, compared to asPECT?

Is it transparent what the origin is of the source data?

Yes, all used data can be traced to the original source.

Are the calculation rules transparent and easy to access/alter?

Users can access the background calculations, where the CO₂ from the different processes are estimated (e.g. embodied energies, transport, construction techniques) and the data used. This enables the users to:

- identify areas realizing the major savings or contributing most to the overall emissions (e.g. transport modes, transport distances, techniques including choice of binders, etc.) and quantify the savings in CO₂ emissions;
- introduce data on their own equipment and materials.

Are the results easy to reproduce?

Because of the large amount of input variables needed, the results are not easy to reproduce.

Which kind of pavement does the program treat?

The tool assesses the carbon dioxide output resulting from four types of construction applications: bitumen bound, concrete, hydraulically bound, unbound.

Which phase in the road lifecycle is the program for?

The estimates can be used in the decision process for the procurement of the material and the specification of the construction technique.

Which are the (main) inputs needed?

The input sheets prompt the users to enter a set of data needed to perform the calculations. Data needed include overall quantities of materials (concrete, bituminous mixtures etc.) and components used (coarse and fine aggregates, binders and minor constituents), distances travelled and processes used. Generally, the users who have the most site-specific information are likely to obtain the best results from the tool. The userguide gives the following warning: Users should input the same level of information in the tool for all options chosen for the same single application to ensure that comparisons between options are done on the same basis. Where information is not available (e.g. a certain transport distance), the tool assigns zero emissions to the component.

Is the database easy to change/add?

Yes

User related questions

What is the intended user group?

Contractors and developers to enhance their chances of winning work from certain categories of clients, e.g. public bodies.

Who are the main users of the tool?

Unknown

How are the results used?

The tool highlights the savings that can be made in terms of CO₂ emissions by choosing different materials and construction techniques. The users can quantify the savings that can be realised by, for example, increasing the quantities of materials imported from the closest source available, starting from using recycling on site. Different construction techniques might also yield considerable emissions savings.

For what purpose are results generated?

The results are used to estimate the CO₂ emissions for each option and then compares the second two options with respect to the first, which is considered the base case scenario, highlighting any CO₂ savings. The purpose of the results are therefor to compare one option with two alternatives.

Please judge the user friendliness of the CO₂ calculation tool

Low. It's very input-intensive. Not only because a large number of variables are needed tot calculate the base-case, but mainly because the same amount is needed for the 2 options.

Are the results of the CO₂ calculation tool useful?

Yes

For which type of use?

Comparison of different alternatives for Road construction.

For which type of organisation?

Contractors and public bodies.

How much time is needed to fill the model before you have results?

Not known

Is this time in proportion in relation with the goal of the tool?

No

Is the program easy to use?

No, worse looking excel with far to many tabs.

Does it provide a tutorial?

Yes

Is there a clear user manual available?

Yes

Is there a installed database to start working with?

Yes, there is a database with most used materials.

Are the needed inputs easy to gather and apply?

No, especially because not only input of the baseline is needed, but also input of two different options.

Which are the end-result units?

CO₂ savings of CO₂ of option 2 and 3 compared to option 1.

Conclusion

The tool itself seems not directly useable for the purpose of CEREAL, mainly because of the large amount of data that is needed to generate results. However, the CO₂ emission sources are largely the same as the CEREAL concept so databases for the Dutch situation are very useful.

ANNEX 4 ROAD-RES

Background of ROAD-RES

Evaluator: DHV

What is the name of the CO₂ calculation tool and what is the language used?

ROAD-RES - English

What is the purpose of the CO₂ calculation tool?

The model has two purposes: (i) to evaluate the environmental impacts and resource consumption in different life cycle stages of road construction with virgin materials and residues from waste incineration; (ii) to evaluate and compare two disposal methods for waste incineration residues, namely landfilling, and utilization in roads.

What is the availability of the CO₂ calculation tool? Who can use the tool?

Unknown

Which organisation developed the program?

The Technical University of Denmark, in collaboration with the:

- Danish Road Directorate
- I/S Amagerforbraending (incineration plant)
- I/S Vestforbraending (incineration plant)
- Aalborg Portland A/S

Who funded the development of the CO₂ calculation tool?

The Danish Road Directorate
The Technical University of Denmark
I/S Amagerforbraending (incineration plant)
I/S Vestforbraending (incineration plant)

For which region is the tool suitable?

The Nordic region.

Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

EDIP97 is the default life cycle impact assessment method in ROAD-RES. The user can, however, supplement the model with other life cycle impact assessment methods, such as Eco-indicator 95, Eco-indicator 99 or CML 2001.

Technical related questions

What is the program language of the tool?

ROAD-RES is developed as a software program using C++ and PARADOX database.

Is the source code (program language) transparent and easy to access?

Unknown

Is the source data (databases) transparent and easy to access?

The following databases are in place: Environmental exchanges: a list presenting resources and emissions included in the model and that in the LCA-databases are linked to different impact categories. Unit process datasets: including environmental exchange data for production of materials, upgrading of residues, road construction, landfilling, transport etc. Leaching profiles for construction materials: including leaching data for both monolithic and granular residues as well as conventional materials (asphalt, concrete and gravel pit material). Transfer coefficients for the distribution of the constituents into different environmental compartments are a part of the leaching profiles. LCA databases: including impact categories, characterization factors and assessment methods.

Is the data useful for implementation in CEREAL?

The model is divided into two parts: the road construction part and the disposal part. The road construction part, which is the most important for the road sector, can be used to assess road construction with both natural materials and residues. The ROAD-RES model enables the user to assess environmental impacts and resource consumption in different stages of the road construction and compare several solutions for road design and maintenance. The user can track where in the life cycle of a road construction environmental impacts are most important and which materials and processes contribute to the environmental impacts. If residues are used in the model, the environmental impacts from the residue are seen in context with the environmental impacts in the whole life cycle of the road construction.

Is it transparent what the origin is of the source data?

No

Are the calculation rules transparent and easy to access/alter?

No

Are the results easy to reproduce?

No

Which kind of pavement does the program treat?

The road construction part includes the following scenario-modules: Road (Motorway, Primary road, Secondary road, Urban road, Gravel road), parking area, embankment.

Which phase in the road lifecycle is the program for?

The life cycle of road construction is divided into three phases: construction phase, operation and maintenance phase, and demolition phase. In the model, the construction phase is, however, divided into two screen dumps: design, where the physical structure of the road is defined and materials chosen and construction, where processes such as earth works, transportation and construction of materials are being modeled. In the operation and maintenance phase, activities such as regular maintenance, pavement maintenance and winter service are being modeled. In this phase, potential leaching from materials and distribution to the surroundings can be modelled. This part is particularly important if residues are used as road construction materials. In the demolition phase, removal of road materials and disposal or recycling of the materials can be modelled as well as the rehabilitation of the area. In reality, demolition of roads is something that hardly ever happens and therefore inclusion of the demolition phase is optional in the ROADRES model. However, this part can be important for the results of the modelling, especially if residues have been used for the road construction.

Which are the (main) inputs needed?

Unknown, the model is very complicated.

Is the database easy to change/add?

Unknown

User related questions

What is the intended user group?

The road sector (environmental decision support tool on road design, operation and maintenance)

Who are the main users of the tool?

P.M., Developer has been contacted

How are the results used?

Developer has been contacted

For what purpose are results generated?

Decision support

Please judge the user friendliness of the CO₂ calculation tool

Complicated

Are the results of the CO₂ calculation tool useful?

Yes

For which type of use?

Decision support on road design, operation and maintenance, and disposal of residues (either utilization in roads or landfilling)

For which type of organisation?

Road authorities and incineration plants

How much time is needed to fill the model before you have results?

Developer has been contacted

Is this time in proportion in relation with the goal of the tool?

Developer has been contacted

Is the program easy to use?

Developer has been contacted

Does it provide a tutorial?

Developer has been contacted

Is there a clear user manual available?

Developer has been contacted

Is there an installed database to start working with?

Yes

Are the needed inputs easy to gather and apply?

Developer has been contacted

Which are the end-result units?

CO₂e and more

Conclusion

The tool itself seems not directly useable for the purpose of CEREAL, mainly because of the large amount of data that is needed to generate results. However, the CO₂ emission sources are largely the same as the CEREAL concept so databases for the Danish situation are very useful.

ANNEX 5 DUBOCALC

Background of DUBOCALC

Evaluator: DHV

What is the name of the CO₂ calculation tool and what is the language used?

DuboCalc (*Duurzaam Bouwen Calculator*), Dutch

What is the purpose of the CO₂ calculation tool?

To optimize design on environmental impact (original purpose). Now DuboCalc is used for contracting, the contractor with the lowest calculated environmental impact is awarded.

What is the availability of the CO₂ calculation tool? Who can use the tool?

Employees of Rijkswaterstaat and - when used in contracting phase - all contractors and consultancy's.

Which organisation developed the program?

Rijkswaterstaat

Who funded the development of the CO₂ calculation tool?

Rijkswaterstaat

For which region is the tool suitable?

The Netherlands (and surrounding)

Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

LCA, NEN-EN-ISO 14040

Technical related questions

What is the program language of the tool?

Unknown

Is the source data (databases) transparent and easy to access?

No, it is somewhat a black box. Database is managed by SBK (*Stichting Bouwkwiteit*), data layer is owned by Conesco and RWS is the main user and overall manager.

Is the data useful for implementation in CEREAL?

Data is not easy to extract from DuboCalc. There is plenty of (typically Dutch) data available, although some data is old.

Is it transparent what the origin is of the source data?

Yes and No. Yes in case of materials (production of aggregates, asphalt). No in case of activities such as paving, rolling, transportation.

Are the calculation rules transparent and easy to access/alter?

No, not easy at all

Are the results easy to reproduce?

No

Which kind of pavement does the program treat?

All kind of Dutch pavement systems.

Which phase in the road lifecycle is the program for?

Main design (varianten) but also contracting.

Which are the (main) inputs needed?

Various input parameters possible. Example: m2 pavement, ton of

Is the database easy to change/add?

No

User related questions

What is the intended user group?

Designers and policy makers.

Who are the main users of the tool?

Rijkswaterstaat, consultants and contractors. So far little local authorities.

How are the results used?

For policy reasons, optimizing design and during contracting. In contracting phase as reference score, contractors are challenged to reduce the score by coming up with design / solutions with less impact.

For what purpose are results generated?

Creating a design with less environmental impact.

Please judge the user friendliness of the CO₂ calculation tool

User-friendly but not transparent.

Are the results of the CO₂ calculation tool useful?

Yes they are.

For which type of use?

Optimizing design and creating greater awareness of impact

For which type of organisation?

Various: RWS, consultancy's, public organisations, etc.

How much time is needed to fill the model before you have results?

Depends on the scope of the project. Once data is available, the program can generate results within 1 hour.

Is this time in proportion in relation with the goal of the tool?

Yes it is.

Is the program easy to use?

Yes

Does it provide a tutorial?

Yes

Is there a clear user manual available?

Unknown

Is there a installed database to start working with?

No

Are the needed inputs easy to gather and apply?

Depends on the knowledge of the project. If budget calculations are available then data is easy to apply.

Which are the end-result units?

MKI; milieu kosten indicator, a weighed general factor in which CO₂ is one of 10.

Conclusion

The Dubocalc tool is closed, since the focus is on contracting, no data can be added in an easy way. Dubocalc is not very transparant, has no focus on maintenance and the life cycle is predefined and is based on the Dutch situation. Therefore the model as a whole is not suitable to link to the CEREAL tool, but the basic principles, calculation rules and data are.

ANNEX 6 JOULESAVE

Background of JOULESAVE

Evaluator: DHV

What is the name of the CO₂ calculation tool and what is the language used?

JouleSave, English

What is the purpose of the CO₂ calculation tool?

JouleSave calculates the amount of energy used in the construction of a particular road design and also the energy which would be used by vehicles on that road over a 20 year lifetime. The designer can then make comparisons between construction energy and vehicles energy of different route options to select the optimum route in terms of overall energy use.

What is the availability of the CO₂ calculation tool? Who can use the tool?

Nobody, the project stopped, the website included.

Which organisation developed the program?

Bentley Systems, Incorporated

Who funded the development of the CO₂ calculation tool?

The project 'Energy Conservation in Road Pavement Design, Maintenance and Utilisation' (ECRPD) was part-funded by the European Commission and was undertaken by a team of roads, energy, geotechnical and software experts. Waterford County Council, Ireland was the lead partner and project co-ordinator and the partners were from the Czech Republic, Finland, France, Portugal, Sweden and the United Kingdom. In 2006, nine of the twelve partners in this consortium successfully completed the project 'the Integration of the Measurement of Energy Usage into Road Design' (IERD). The outcome of the project was a piece of software, Joulesave.

For which region is the tool suitable?

The European Union.

Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

Unknown

Technical related questions

What is the program language of the tool?

The software was developed by Bentley and operates with their MX Road design package. The software also incorporates the VETO program which has been developed by VTI and this evaluates the vehicles energy use on a road. The Joulesave software which was developed in the IERD project was designed to operate with the version of MX which was in use at that time i.e. 2006. A new version of EIE/06/039 ECRPD Joulesave Report MX has been released since that time and Joulesave has been modified to operate with the latest version, MX Suite v8i.

Is the source code (program language) transparent and easy to access?

No, the program language seems to be owned by Bentley

Is the source data (databases) transparent and easy to access?

No.

Is the data useful for implementation in CEREAL?

No, it seems that databases are not accessible not transparent.

Is it transparent what the origin is of the source data?

Unknown

Are the calculation rules transparent and easy to access/alter?

No

Are the results easy to reproduce?

No

Which kind of pavement does the program treat?

The Joulesave software calculates the energy used during construction of a road and also the energy which will be used by vehicles on the road over a 20 year lifetime. The construction energy is divided into Machinery Energy and Materials Energy. The Machinery Energy covers the following sectors: Drainage, Services, Earthworks, Pavement, Road Markings Traffic Signs and Structures. For the Materials Energy, data was gathered from site visits to establish the energy requirements in aggregate and bitumen production, which are the two main road-building materials. The fuel consumption of the various machines involved in aggregate and bitumen production was recorded. The quantities of aggregate and bitumen per kilometer (tone/km) were determined and from this the Total Material Energy per kilometer was calculated. For the purposes of this project, the traffic using the roads was split into three categories: cars, trucks and trucks with trailers. Road geometry, road surface, road surface conditions, meteorological conditions, vehicle details and driving behavior were input into the Veto program. Each country supplied the road geometry data for its routes. Driver behavior data, e.g. desired speed, was input for each country and for each scheme. Standard weather and road surface conditions were used for all routes. Current and predicted traffic data was known for each route.

Which phase in the road lifecycle is the program for?

The Joulesave software should ideally be used at the Route Selection stage of a road design project so that the different options can be compared and the best route in terms of energy can be selected. This would show the energy savings which are possible to achieve on a scheme. Joulesave can also be used to optimize the design of an alignment in order to achieve a reduction in energy, for example the vertical alignment can be modified and Joulesave will evaluate the impact of different gradients on vehicles energy.

Which are the (main) inputs needed?

As an alignment is being designed in MX, Joulesave is analyzing the data and calculates the construction energy. The user is required to input details such as predicted traffic volumes, speed limits, type of surface etc. and the program calculates the energy which will be used over a 20 year life time.

Is the database easy to change/add?

No

User related questions

What is the intended user group?

Unknown.

Who are the main users of the tool?

Unknown.

How are the results used?

Different options can be compared and the best route in terms of energy can be selected.

For what purpose are results generated?

Unknown

Please judge the user friendliness of the CO₂ calculation tool

Unknown

Are the results of the CO₂ calculation tool useful?

The results are expressed in terms of energie, not in CO₂-eq. In order to use this model we need access to all underlying calculations so we can add CO₂ calculations.

For which type of use?

Unknown

For which type of organisation?

Unknown

How much time is needed to fill the model before you have results?

Unknown

Is this time in proportion in relation with the goal of the tool?

Unknown

Is the program easy to use?

Unknown

Does it provide a tutorial?

Yes

Is there a clear user manual available?

Unknown

Is there a installed database to start working with?

Unknown

Are the needed inputs easy to gather and apply?

Unknown

Which are the end-result units?

The end-results are presented in terms of energy / km.

Conclusion

JouleSave is too detailed in terms of input and output data (to be applied in final design phase) and too specific in the software (MX). The tool is therefore not useful for the intended user group of CEREAL.

ANNEX 7 GreenDOT

Background of GreenDOT

Evaluator: DHV

What is the name of the CO₂ calculation tool and what is the language used?

The Greenhouse Gas Calculator for State Departments of Transportation (GreenDOT).

What is the purpose of the CO₂ calculation tool?

GreenDOT calculates carbon dioxide (CO₂) emissions from the operations, construction, and maintenance activities of state Departments of Transportation (DOTs).

What is the availability of the CO₂ calculation tool? Who can use the tool?

Free download at: NCHRP website

<http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2621>

Which organisation developed the program?

ICF International and Venner Consulting.

Who funded the development of the CO₂ calculation tool?

This study was requested by the American Association of State Highway and Transportation Officials (AASHTO), and conducted as part of the National Cooperative Highway Research Program (NCHRP) Project 25-25. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 25-25 is intended to fund quick response studies on behalf of the AASHTO Standing Committee on the Environment.

For which region is the tool suitable?

The United States

Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

Unknown

Technical related questions

What is the program language of the tool?

GreenDOT is an Excel spreadsheet.

Is the source code (program language) transparent and easy to access?

The Excel formulas can be accessed and the VBA source code is open for access too.

Is the source data (databases) transparent and easy to access?

Yes

Is the data useful for implementation in CEREAL?

The data is for the United States only.

Is it transparent what the origin is of the source data?

Yes, all data comes with a source

Unknown

Are the calculation rules transparent and easy to access/alter?

GreenDOT calculates emissions in four separate modules:

- The Electricity Module calculates emissions from electricity used in street lights, street lamps, signs, and other roadway appurtenances, based on either electricity consumption or detailed data on types of appurtenances and hours of use. The module estimates the impact of mitigation strategies including more efficient lighting technologies and reducing the amount of lighting used.
- The On-Road Module calculates emissions from cars and trucks, based on either fuel consumption or detailed data on VMT and vehicle types. The module estimates the impact of mitigation strategies including VMT reduction, measures to improve the fuel economy of vehicles, and alternative fuels and vehicle types.
- The Off-Road Module calculates emissions from construction and maintenance equipment, based on either fuel consumption or detailed data on equipment types and hours of use. The module estimates the impact of mitigation strategies including activity reduction, measures to improve the fuel economy of equipment, and alternative fuels and vehicle types.
- The Materials Module calculates emissions embodied in roadways, based on volumes and types of materials used. Embodied emissions are associated with energy used in the extraction, processing, and transportation of materials. The module estimates the impact of mitigation strategies including using recycled materials and warm mix asphalt.

An auxiliary calculator included in the tool also estimates the impact of traffic management strategies, based on changes in average vehicle speeds. DOTs can use GreenDOT to help calculate their current emissions and to evaluate mitigation strategies.

Are the results easy to reproduce?

Yes

Which kind of pavement does the program treat?

Concrete panels, asphalt, Cement Treated Aggregate, Base Aggregate.

Which phase in the road lifecycle is the program for?

GreenDOT calculates carbon dioxide (CO₂) emissions from the operations, construction, and maintenance activities of state Departments of Transportation (DOTs). GreenDOT is designed to calculate emissions for geographical areas ranging from a single project to an entire state, and over time periods ranging from one day to several years.

Which are the (main) inputs needed?

Electricity module:

- Input electricity use in MWh **OR**
- Input detailed data on type, number, and usage of electrical appliances

Materials module:

- Metric tonnes of the different materials **OR**
- Alternative mixing ratios

On-road module

- Fuel use **OR**
- Vehicles miles travelled

Off-road module

- Aggregate data of fuel use **OR**
- Aggregate data of fuel use by equipment type **OR**
- Input detailed data on activity by equipment type.

Is the database easy to change/add?

Yes

User related questions

What is the intended user group?

State Departments of Transportation in the US

Who are the main users of the tool?

Unknown.

How are the results used?

The two most likely uses of the tool are: (1) calculate agency-wide emissions, and (2) calculate emissions related to a specific project, covering a period of days or years.

For what purpose are results generated?

Unknown

Please judge the user friendliness of the CO₂ calculation tool

The tool is very user friendly and transparent.

Are the results of the CO₂ calculation tool useful?

The results are not necessarily useful, but the structure and the interface are.

For which type of use?

Unknown

For which type of organisation?

Unknown

How much time is needed to fill the model before you have results?

15 minutes

Is this time in proportion in relation with the goal of the tool?

Yes

Is the program easy to use?

Yes, very easy

Does it provide a tutorial?

No

Is there a clear user manual available?

No, but that's not really necessary because in the tool itself the working is explained.

Is there a installed database to start working with?

Yes

Are the needed inputs easy to gather and apply?

Most of the inputs are not easy to collect. However, the tool provides other possibilities to estimate these inputs.

Which are the end-result units?

The end-results are presented in terms of tones of CO₂

Conclusion

The tool provides great inspiration of the 'look and feel' for the CEREAL tool.

ANNEX 8 PaLATE

Background of PaLATE

Evaluator: DHV

What is the name of the CO₂ calculation tool and what is the language used?

Pavement Life-cycle Assessment Tool for Environmental and Economic Effects (PaLATE).

What is the purpose of the CO₂ calculation tool?

PaLATE is an Excel-based tool for life-cycle assessment (LCA) of environmental and economic effects of pavements and roads.

What is the availability of the CO₂ calculation tool? Who can use the tool?

A copy can be received by the Department of Civil and Environmental Engineering, University of California, Berkeley. (Mail to Professor Arpad Horvath, horvath@ce.berkeley.edu)

Which organisation developed the program?

Consortium on Green Design and Manufacturing, University of California, Berkeley.

Who funded the development of the CO₂ calculation tool?

Recycled Materials Resource Center of the University of New Hampshire and the University of California Transportation Center.

For which region is the tool suitable?

The United States

Which protocol is used to calculate the Greenhouse Gas (GHG) emissions?

Unknown

Technical related questions

What is the program language of the tool?

PaLATE is an Excel spreadsheet.

Is the source code (program language) transparent and easy to access?

Unknown.

Is the source data (databases) transparent and easy to access?

Yes

Is the data useful for implementation in CEREAL?

The data is for the United States only.

Is it transparent what the origin is of the source data?

Yes, all data comes with a source.

Are the calculation rules transparent and easy to access/alter?

The tool takes the user through a series of input worksheets to gather data about:

- The general design of the roadway
- Initial construction materials as well as material transportation distances and modes
- Maintenance materials as well as material transportation distances and modes
- On-site construction equipment (e.g., asphalt paver) and off-site processing equipment (e.g., rock crusher)
- Life-cycle economic costs

Design, initial construction, maintenance, equipment, and costs are sheets in PaLATE that accept data from the user. Most cells with numbers or zeros are subject to values inserted by the user.

Are the results easy to reproduce?

Yes

Which kind of pavement does the program treat?

Concrete and asphalt pavement.

Which phase in the road lifecycle is the program for?

Design, initial construction, maintenance, equipment, and costs are sheets in PaLATE that accept data from the user. Most cells with numbers or zeros are subject to values inserted by the user.

PaLATE assesses emissions associated with materials production, construction, transportation, and maintenance of asphalt and portland cement concrete pavement, subbase, embankment and shoulders materials.

Which are the (main) inputs needed?

The tool takes the user through a series of input worksheets to gather data about:

- The general design of the roadway
- Initial construction materials as well as material transportation distances and modes
- Maintenance materials as well as material transportation distances and modes
- On-site construction equipment (e.g., asphalt paver) and off-site processing equipment (e.g., rock crusher)
- Life-cycle economic costs

Is the database easy to change/add?

Unknown

User related questions

What is the intended user group?

Pavement designers, transportation agency decision-makers, civil engineers, and researchers are the intended users of this tool. Users should have a working knowledge of pavements and a desire to learn more about the environmental and economic implications of their decisions.

Who are the main users of the tool?

Unknown

How are the results used?

Some example questions that the user may keep in mind when working with PaLATE are:

- For a particular roadway, which material is better for the environment: Concrete or asphalt?
- Will changing the recycled material content in a particular pavement affect the environmental results?
- Does sending demolished portions of a road to a processing plant or to a landfill make more environmental and economic sense?
- Which maintenance option(s) will minimize environmental and economic effects? For example, should full depth reclamation be performed instead of more frequent, smaller maintenance procedures?
- Will changing the type and/or capacity of equipment used on-site reduce emissions?
- How much of a difference do materials transportation distance and mode make for my case study? For example, should I use materials from a local source to reduce emissions? Is it better to transport via rail or truck?

For what purpose are results generated?

Unknown

Please judge the user friendliness of the CO₂ calculation tool

PaLATE is very a user friendly tool.

Are the results of the CO₂ calculation tool useful?

No, it concerns the situation in the USA. However, the 'look and feel' of the tool is very useful.

For which type of use?

NA

For which type of organisation?

NA

How much time is needed to fill the model before you have results?

15 minutes for a simple analysis.

Is this time in proportion in relation with the goal of the tool?

Yes

Is the program easy to use?

Yes

Does it provide a tutorial?

Yes

Is there a clear user manual available?

Yes

Is there a installed database to start working with?

Yes

Are the needed inputs easy to gather and apply?

PaLATE is not a simple tool and some knowledge is required to carry out the analysis.

Which are the end-result units?

Environmental effects include:

- Energy consumption
- CO2 emissions
- NOx emissions
- PM10 emissions
- SO2 emissions
- CO emissions
- Leachate information

Conclusion

PaLATE is a very useful tool because it has a very simple and clear structure. This tool can be an inspiration of how CEREAL should look like.

APPENDIX 9 Other

EcologicieL

Colas is the developer of EcologicieL®, the first carbon footprint comparison tool for road projects, and was a key participant in the development of the eco-comparison tool known as SEVE®, which is used by all industry players in France and has been officially recognized by the French government for use in connection with bids for public works contracts, so that green alternatives proposed to customers can compete on a level playing field.

SEVE

Changer