IDRRIM

Institute for Roads, Streets and Mobility Infrastructures

TECHNICAL RULING N° 163

FEBRUARY 2016

Validity: 5 years

ECO-COMPARATOR

VARIWAYS®

VARIWAYS® v2.1
(Construction Module)

VARIWAYS® v2.1, an eco-comparison software for road alignment alternatives, allows for the environmental comparison of alignments within the context of design studies for road infrastructure, for the operational and construction phases of the infrastructure. It is this latest VARIWAYS module that is covered by this opinion, inasmuch as that the operational section that was initially developed, which was the subject of the eco-comparator IDRRIM Technical Opinion No. 159, is identical in this version.

The functional unit of this VARIWAYS® v2.1 module corresponds to the construction phase of the road infrastructure. VARIWAYS® takes into account the specific features of the project (characteristics of the facilities, nature of the structures, pavement structure, road furniture, viaducts, tunnels and drainage systems), as well as, as a function of the available data, the quantitative project estimations (lengths, volumes of materials, etc).

It can thus be used to calculate the greenhouse gas emissions (GHG - expressed as t eq CO2) resulting from the construction phases for the various works following the parameters set by the user, by integrating the project geometry.

For all of these phases and for several types of work, the emissions linked to the extraction of the constituent materials, their transport, as well as the manufacture and installation of the materials are taken into account. The maintenance of the works is not taken into account.
The hypotheses chosen, along with the results, are provided by variant, in the form of tables and graphs.

EGIS, the designer of this software, is its sole user. It offers its use in the form of a service. Its use is adapted to all entities (developers and construction contractors) wishing to optimize a road infrastructure project.

The main alignment parameters, the geometry, the details and the nature of the works (earthworks, pavement, standard structures, tunnels, road furniture and drainage systems) are integrated into the tool. The software has been used for the elaboration of several projects in France and abroad.

Contents

1 PRESENTATION OF THE TOOL BY THE PUBLISHER

A. GENERAL PRESENTATION OF THE TOOL

The VARIWAYS® eco-comparator for road alignment alternatives is a program for aiding design and decision-making. It allows for a comparative analysis of various road alternatives in order to propose an optimized design of the layouts with regard to two indicators :

- For the “construction” phase, the subject of this ruling: the greenhouse gas emissions induced by the main works categories for road infrastructure (earthworks, pavements, road furniture, structures, tunnels and drainage).

- For the “operations” phase (see Technical Ruling No. 159): the energy consumption (MJ) and the greenhouse gas emissions induced by road traffic (passenger and freight) over the reference duration for the infrastructure.

VARIWAYS® can be used to establish a hierarchy of the alignment alternatives with regard to these two criteria and can be advantageously used:

- In the preparation phase, for an environmental comparison of road alternatives or for the environmental optimization of an alignment ;

- In the design phase, for carrying out environmental assessments;

- In the tender phase, to show the project developer the possibilities offered by including this aspect in the environmental analysis.

VARIWAYS® thus allows clients (project developer) to take a position, from the preparation phase, on their choice of alignment on contributing to the engagement of the European Union to reduce its greenhouse gas emissions by 20 % between now and 2020 with respect to the levels of 1990.
It is accepted by the profession that:

- About 20% of the greenhouse gas emissions result from the “construction” phase, notably through the manufacture of materials,

- About 80% of the greenhouse gas emissions result from the “operations” phase, through vehicle emissions (over an average period of twenty years).

Understanding the impact of the “construction” phase, as of the design phase, therefore constitutes a major lever and an opportunity for project owners who are concerned about the environmental impacts of their projects, given the spectrum of the nature of the work proposed. This was already the case for the “operations” phase, allowing clients to identify the levers that have the greatest impact in terms of greenhouse gas emissions on the alignment alternatives integrating the parameters of the project (speed, traffic) once it has been opened to traffic.

B. SCOPE OF APPLICATION

The scope of application for the eco-comparator of road alignment alternatives VARIWAYS® (Construction Module) is the design phase (conceptual / detailed design).
During the design, the tool allows for the quantification of the greenhouse gas emissions resulting from the main work categories for road infrastructure (earthworks, pavement, road furniture, structures, tunnels and drainage) as a function of the parameters of the project (quantities and/or main characteristics).

C. TARGETED USERS

The eco-comparator for road alignment alternatives VARIWAYS® is intended for all project owners who are concerned about integrating environmental impacts into the design phase and optimizing their infrastructure projects with regard to “greenhouse gas emission” indicators (and “energy consumption” solely for the operations module).

D. DATABASE AND MANAGEMENT

For the construction phase, the eco-comparator uses unit emission factors linked to the manufacturing of the materials, their transport and their placement/installation, taken from the available reference databases. These include :

- Unit emission factors of the Bilan Carbone™ (carbon footprint assessment) method by ADEME/ABC,
- Unit emission factors by IEA (energy),
- Unit emission factors of the Inventory of Carbon and Energy (ICE) or of EcoInvent (manufacture and use of materials),
- Manufacturers’ data (consumption by equipment).

The databases are updated by the EGIS administrator to take account of the updates of the COPERT database (uniquely for the operations module) and all other reference databases used by the tool.

E. TARGETED FIELDS OF USE

The design phase, VARIWAYS® helps to raise the awareness of clients and to involved them in an environmental approach with regard to “greenhouse gas emission” indicators (and “energy consumption”, uniquely for the operations module) and to thereby enrich the design / construction process within a comprehensive and sustainable approach.

F. SCOPE OF THE ENVIRONMENTAL ANALYSIS

The eco-comparator for road alignment alternatives VARIWAYS® (Construction Module) allows for the evaluation of the greenhouse gas emissions resulting from the manufacturing of materials, their transport and their placement for the main works categories for road infrastructure (earthworks, pavements, road furniture, structures, tunnels and drainage).
The scope of the environmental analysis corresponds to the “construction” phase, not including the monitoring and maintenance of the infrastructure. The end of life phase of the infrastructure (demolition, rehabilitation) is not taken into account.

G. THE INDICATORS

The eco-comparator for road alignment alternatives VARIWAYS® (Construction Module) offers the comparison of various layout alternatives according to an indicator: the greenhouse gas emissions resulting from the main work categories of the construction phase for road infrastructure (earthworks, pavements, road furniture, structures, tunnels and drainage).
The “greenhouse gas emission” indicator, expressed in t eq CO2, allows for evaluation of the potential impact on climate change.

H. CALCULATION PRINCIPLE

The eco-comparator for road alignment alternatives VARIWAYS® (Construction Module) calculates the greenhouse gas emissions resulting from the manufacturing of materials, their transport and their placement for the main works categories (earthworks, pavements, path facilities, structures, tunnels and drainage) on the basis of the available reference databases as a function of the main characteristics of the project and its quantities.
VARIWAYS® can thus easily compare alternatives with regard to the above mentioned indicator as a function, for example, of the choice of layout, the earthworks characteristics, the nature of the structures, the type of pavement structure, etc.

I. DATA TO BE ENTERED BY THE USER

The main inputs for the eco-comparator for road alignment alternatives VARIWAYS® (Construction Module) for the “construction” phase are, as a function of the available data:

- The general characteristics of the project in the form of some fifteen indicators to be detailed: alignment, type of road (motorway, national road, regional road), type of work (new, rehabilitation, widening), environment (rural, urban), nature of the soils, type of pavement, nature of the structures, tunnels;

- The quantities specific to the project (volumes of materials) as a function of the known types of work.

The general characteristics of the project allow for a pre-calculation of the greenhouse gas emissions. The user can then refine the evaluation with the quantities specific to the project.

The transport distances can be modified by the administrator.

The user-friendly interface allows the user to revisit his data, modify it and update it, in whole or in part, at any stage.

J. TYPE OF RESULTS OBTAINED AND PRESENTATIONS

The eco-comparator for road alignment alternatives VARIWAYS® (Construction Module) proposes various outputs (tables, graphs, histograms, etc.) in order to meet the various needs of the user:

- Tables by alternative and by section that allow for the placement, in one single visual, of the different alternatives, and for their comparison with regard to the carbon and energy indicators;

- Graphs that present the indicators by phase and by work type by associating them, using colours, with each alternative studied and by the nature of the work.

K. AVAILABILITY

The eco-comparator for road alignment alternatives VARIWAYS® (Construction Module) is used by the EGIS Company within the framework of project management and design services.

2 EXAMINATION PROCEDURE

This “Eco-comparator” technical opinion, limited to the fields of road transport infrastructure, is handled by a Specialized Group (SG) appointed by IDRRIM (Institut Des Routes, des Rues et Infrastructures pour la Mobilité). The procedure for the handling of the opinion application is as follows:

1/ The characteristics and functionalities of the tool described by the publisher are verified by the SG according to an analysis table, included as an appendix to this Opinion.

2/ The eco-comparator was examined with regard to the set of analysis references proposed by the infrastructure commission of the Observatoire Energie – Environnement des Transports (Observatory Energy - Environment of Transport) - OEET. The publisher proposed responses to the 46 points detailed in the set of references, which were examined by an independent expert member of the Observatoire Energie – Environnement des Transports and outside of the Eco-comparator Specialized Group.

3/ Presentations were made regarding the VARIWAYS® v2.1 eco-comparator (Construction Module) by the company EGIS at the SG meeting. During these sessions, a project was presented involving a demonstration and a calculation by the company EGIS. The results of this project were analyzed by the SG and an external appraisal concerning the tunnels and structures.

3 PROCESSING

A. EXAMINATION OF THE IDRRIM TABLE

a. Scope of application:

The scope of the eco-comparator for road alignment alternatives VARIWAYS® v2.1 (Construction Module) covers mainly the design phase (ex-ante: preparation / completion of design studies). Furthermore, it is possible to provide an execution assessment (ex-post) based on unit emission factors and real quantities. VARIWAYS® v2.1 (Construction Module) allows for comparisons of road layout alternatives with regard to the greenhouse gas emissions (expressed in t eq CO2). These layouts can include, in particular, tunnels and structures (standard and/or non-standard).
The comparison is undertaken by integrating the various types of work:

- Earthworks (general)
- Pavements (French and AASHTO standards)
- Road furniture (of the road)
- Drainage
- Tunnels and viaducts (non-standard civil engineering structures)
- Structures (standard structures and walls)

b. Targeted users:

The eco-comparator VARIWAYS® v2.1 (Construction Module) is used by the company EGIS on behalf of various developers and/or contractors who are concerned about taking environmental impacts into account from the design phase and optimizing their infrastructure projects with regard to the “greenhouse gas emissions” indicator. It is used in France and internationally within the framework of project management and design assignments.

c. Database and management:

The eco-comparator for road alignment alternatives VARIWAYS® v2.1 (Construction Module) is associated with several databases of unit emission factors (from manufacturers’ databases and bibliographic reference databases).

These include:

- Unit emission factors of the Bilan Carbone™ (carbon footprint assessment) method from the ADEME/ ABC,
- Unit emission factors of the IEA (energy),
- Unit emission factors of the Inventory of Carbon and Energy (ICE) or of EcoInvent (manufacture of materials and placement),
- Manufacturer data for the consumption of equipment.[1]

These databases are updated regularly by the Software Administrator.

[1] *The equipment database used at present is that of the manufacturer Caterpillar. This data may be updated (publication of other data)*

d. Targeted fields of use:

The eco-comparator VARIWAYS® v2.1 (Construction Module) allows, as of the design phase of a road infrastructure project, for the carrying out of environmental assessments according to a targeted indicator: greenhouse gas emissions, with the purpose of increasing the awareness of clients and getting them involved in an environmental approach.

e. Scope of the environmental analysis:

The eco-comparator for road alignment alternatives VARIWAYS® (Construction Module) allows for the evaluation of the greenhouse gas emissions resulting from the manufacturing of materials, their transport and their placement within the main works categories for road infrastructure (earthworks, pavements, road furniture, structures, tunnels and drainage).

The scope of the environmental analysis thus corresponds to the construction phase, not including the monitoring and the maintenance of the infrastructure (upkeep is not taken into account). The end of life phase of the infrastructure (demolition, rehabilitation) is not taken into account.

f. Available indicators:

The environmental indicator chosen for the comparisons of alternatives in the eco-comparator VARIWAYS® v2.1 (Construction Module) is the indicator of greenhouse gas emissions expressed in t eq CO2, which allows for evaluation of the potential impact on climate change.

g. Calculation principle:

For the construction phase, the greenhouse gas emissions are calculated as a function of the unit emission factors linked to the manufacturing of materials, their transport and their placement within the main works categories (earthworks, pavements, road furniture, structures, tunnels and drainage) from reference databases available as a function of the main characteristics of the project and its quantities.

As an example,

- Earthworks: taking into account of the transport of materials (cut/fill) over average distances calculated from the project typology or entered by the user, of the treatment with a hydraulic binder (manufactured in factory and on a lump sum basis for transport to the work site);

- Tunnels: taking into account of the construction of the tubes (production of concrete, extraction of materials, placement), possible ventilation plant, tunnel portals;

- Road furniture:

    o Signage: taken into account as a function of the type of road, the number of lanes and the environment (urban or rural),

    o Guard rails: taken into account as a function of the project typology and choice of the nature of the constituent materials (metallic/concrete/mixed);

- Structures: taken into account for the construction for standard engineering structures (mixed steel/ concrete, reinforced or pre-stressed concrete or steel) as a function of the project characteristics and the environmental context (mountainous, urban, etc.).

VARIWAYS® (Construction Module) can also easily compare alternatives with regard to the GHG indicator as a function, for example, of the choice of layout, longitudinal profile, the earthworks characteristics, the nature of the structures, and the type of pavement structure (French and AASHTO standards). As a function of the nature of the work, the layout can be divided into sections.

The calculation of the greenhouse gas emissions for the materials elements of the construction phase comes from the manufacturers' database (1) and the reference bibliographical databases cited previously.

h. Procedure, data to be provided by the user:

The software proposes quantities of materials by default as a function of a general description of the tool. It is possible to modify these quantities of materials and their unit emission factors as a function of the knowledge of the nature of the work and the level of detail for the choice of materials.

The main inputs for the eco-comparator for road alignment alternatives VARIWAYS® v2.1 (Construction Module) are based on fifteen parameters:

- The type of project (e.g.: pavement widening from the exterior or from the interior, construction of a new project, or a rehabilitation project (reinforcement)),
- The road typology (highway, main road, regional road),
- The environment (rural, urban), the nature of the soils
- The natures of the structures and traffic classes
- The volumes of earthworks

The general characteristics of the project allow for a pre-calculation of the greenhouse gas emissions. The user can then fine tune the evaluation with the measurements specific to the project. It may be possible for the Administrator to modify the transport distances (distances proposed by default but modifiable by the user).

For projects that include standard structures and tunnels, the software proposes a pre-calculation of usual quantities of materials according to 3 standard structure types (mixed (concrete/steel), reinforced concrete, pre-stressed concrete) and 3 types of tunnels (cut and cover, arch, bored tunnel).
For projects including "non-standard" engineering structures, the software takes into account the quantities of concrete and steel.

The user-friendliness of the interface lets the user go back to his data, modify it and update it, in whole or in part, at any stage of its use.

i. Presentation of the results:

The eco-comparator for road alignment alternatives VARIWAYS® v2.1 (Construction Module) offers different outputs (tables, graphs, plan excerpts, etc.) to allow for their comparison with regard to the indicator of the greenhouse gas emissions (t eq CO2) and to respond to the various needs of the user:

- Tables by alternative and by section which make it possible to have different alternatives in one single visual and to compare them with regard to the GHG indicator,

(1) *The equipment database currently in use is that of the manufacturer Caterpillar. This data may be updated (publication of other data)*

- Graphs that present the GHG indicator by issuing category by associating them, using a set of colours, with each alternative studied and by the work type.

It is also possible to represent the VARIWAYS® v2.1 results (Operations Module) so as to highlight the construction portion with regard to the Operations Phase of the project, for each variant.

j. Availability

The eco-comparator VARIWAYS® v2.1 (Construction Module) is used exclusively by the company EGIS.

k. General evaluation of the ease of familiarization:

Not applicable, as the eco-comparator VARIWAYS® v2.1 (Construction Module) is used exclusively by the company EGIS.

B. SUMMARY OF THE EXAMINATION OF THE OEET TABLE

The elements presented here are partial because they are limited as much by the field of the evaluation relating to the OEET V1 methodology, as by the responses given, often incomplete, as they are placed within a broader technical ruling process. They therefore cannot, in and of themselves, constitute an exhaustive judgment regarding the quality of the tools presented.

The responses to the various criteria of the methodology given by the infrastructure commission of the OEET place the VARIWAYS® v2.1 tool in a double field of evaluation:

1/ Construction of road infrastructure, within the framework of the OEET reference methodology,

2/ Operation of road infrastructure (passenger and freight traffic), outside of the framework of the OEET reference methodology.

Concerning the first field of evaluation, the answers to the various criteria of the OEET evaluation table allow us to establish the following summary points:

- The tool VARIWAYS® v2.1 allows for the carrying out of a truncated(2) environmental evaluation of road infrastructure solely for the steps of production, transport and placement of materials,
- The tool evaluates from user entries the various elements that constitute road infrastructure, including, in a simplified manner, tunnels, structures and road furniture,
- The tool evaluates one single impact category, climate change,
- By default, the tool uses several general public databases, which calls for vigilance regarding the compatibility of the data. These databases can be modified according to the local context,
- The tool has not yet been covered by a critical review, and it is relies on tests carried out in house and within the framework of this opinion.

(2) *The environmental evaluation is said to be "truncated" because it only takes into account the first stages of the Life Cycle Analysis in the meaning of standard NF EN 15 804 (A1-A3 Stage of PRODUCTION & A4-A5 Stage of the CONSTRUCTION PROCESS), the steps B1-B7 USE and C1-C4 END OF LIFE were not taken into account.*

The VARIWAYS® v2.1 tool, originally dedicated to the study of the use of road infrastructures for passengers and freight, now allows for an environmental evaluation, at the design stage, of the construction of a road infrastructure through the phases of production, transport and placement of materials. The tool takes into account the linear and punctual elements that constitute an infrastructure project.

Through its double field of evaluation, the VARIWAYS® v2.1 tool is intended to meet the expectations of a user wishing to choose or to optimize a choice of layout within the framework of a road project in the planning phase. It constitutes an overall evaluation tool, the characteristics of which orient it towards the quantification of greenhouse gas emissions at the design and realization stage. The simplified evaluation of tunnels and structures does not allow for a use adapted to the project phase.

C. SYNTHESIS OF THE CALCULATIONS

For the purpose of evaluating this tool, a case study was carried out by the company EGIS in the presence of the members of the SG. It allowed for an evaluation of the GHGs linked to the construction of an inter-urban road infrastructure project, including a structure and a tunnel.

The SG verified the following elements:

- Verification by outside experts of the dimensional elements and the results for the standard structures and tunnels.
- Verification of the dimensional elements and the results for the remainder of the construction phase, pavement and earthworks in particular, with the help of the eco-comparator SEVE.

The results are the following:

- The observed results are coherent for both of the studies (VARIWAYS and SEVE) for the pavement element.
- The order of magnitude of the results was confirmed by the outside expert for the standard structures.
- The order of magnitude of the results was confirmed by the outside expert for the non-standard structures.

VARIWAYS® v2.1 is not intended for finely comparing specific work types with each other but rather, in a more global manner, within the framework of alignment choices integrating different natures of work typology.

4 OPINION OF THE COMMITTEE

The VARIWAYS® v2.1 software (Construction Module) is an eco-comparator dedicated to the environmental comparison of infrastructure alignment alternatives within the framework of project design studies (ex-ante).

It allows for the calculation of greenhouse gas emissions (expressed in t eq CO2) induced by the construction phase (extraction of materials/ transport/ manufacturing and placement) according to the default parameters (project characteristics, measurements) and/or those set by the user.

It allows for the establishment or optimization of the geometric and structural characteristics, the choice of layouts and structures within the framework of a road infrastructure project by calculating the greenhouse gas emissions generated by the construction phases for the infrastructure.

The results observed for the two studies covering the pavement work and earthworks (VARIWAYS vs. SEVE) are coherent. The order of magnitude for the case studies with the structures and tunnels were also approved by outside experts. Let us remember that the analysis of the results is integrated in a more comprehensive manner within the choice of alignments.

VARIWAYS® v2.1 (Construction Module) contributes to reaching the commitments in terms of reduction of greenhouse gas emissions made by the partners at the time of the signing on March 25, 2009 of the Convention d'Engagement Volontaire (CEV - voluntary commitment agreement) of companies involved in the design, construction and maintenance of road infrastructures, roads and urban public spaces.

The use of this eco-comparator is exclusively reserved to the company EGIS, which offers its use within the framework of project management or design assignments.

The reader's attention is drawn to the fact that VARIWAYS® v2.1 is an eco-comparator for road alignment alternatives and that it is not intended for designing the proposed works. The software is not intended for the design of a complex structure (tunnel or non-standard structure) in an isolated manner.

Nevertheless, it can be used to take into account most of the greenhouse gas emissions from the construction phase of a road project, integrating all of its components (pavement, earthworks, tunnel, structures, road furniture, etc).

The publisher was informed when transmitting results he should be sure to provide a reminder of the scope of the study, the assumptions, the inputs and the limits of the tool.

5 APPENDICES

A. REFERENCES PRESENTED BY THE PUBLISHER UPON PUBLICATION OF THE OPINION

Main VARIWAYS® v2.1 references (Construction Module)

Project	Country	Length	Year	Use
A89	France	30 km	2013	Test
RN 164	France	16 km	2013	Project incl. Operation
Brazzaville	Congo	4.5 km	2013	Test
Doha expressways P16 (30 km)	Qatar	30 km	2013	Project
New Section Tunnel - Viaduct	Mauritius	4.4 km	2013	Test
Enlargement Section	Mauritius	4 km	2013	Test
Rehabilitation	Mauritius	2 km	2013	Test
A45	France	45 km	2014	Bid
RN154 - RN12	France	100 km	2015	Preliminary studies
A 355	France	30 km	2015	Bid

B. B. IDRRIM TABLE

General:	
Name of the software	VARIWAYS® (Construction Module)
Designer	EGIS
Launch date	2012
Version Examined	Version V 2.1 (Construction Module). The operations part was not covered by the analysis using this table. It was covered by an analysis in technical ruling 159.
Origin of the project	V1.1 included an operations module without taking the Construction Module into account. EGIS wanted to develop a Construction Module in order to carry out an environmental study that would be more representative of the life cycle.

Objectives	Tool developed for studies intended for Clients / Project Coordinators within the framework of the Grenelle de l'environnement for the purpose of reducing GHGs during the infrastructure construction phase. The operations phase was taken into account in the preceding ruling.
Perimeters of application and analysis:	
Phase(s) of the road project	Design phase (preparation) and study realization phase.
Targeted users	EGIS on behalf of various Clients
Field(s) targeted	Main parameters of layouts, geometries (plan and longitudinal section...), structures and natures of structures (earthworks, pavements, structures, tunnels, facilities and drainage)
Analysis perimeter	The functional unit of VARIWAYS® corresponds to the road infrastructure for the construction phase of the transport infrastructure. VARIWAYS® evaluates the GHG emissions from the construction phases, integrating the project geometry. On all of these phases and for several natures of structures, the emissions linked to the extraction of the constituents, the transports, the manufacturing and laying of the materials are taken into account.
Time for carrying out a study	As a function of the complexity of the project, the number of alternatives and the input parameters.
Available indicators:	
GHG emissions (CO2 equivalent)	Yes
Energy consumption (MJ)	No
Consumption of aggregate	No
Used of coated asphalt mix aggregate	No
Acidification	No
Chronic toxicity	No
Water consumption	No
Ecotoxicity	No
Eutrophication	No
Consumption of materials	No
Photochemical ozone	No
Addition of the indicators	No

Les calculs :	
Principles of the calculation	For the construction phase, the eco-comparator uses the unit emission factors linked to the manufacturing of materials, their transport and their laying, taken from manufacturer databases and reference bibliographic databases. These are in particular: - Unit emission factors of the Bilan Carbone™ (carbon footprint assessment) method of the ADEME/ABC, - Unit emission factors of the AIE (energy), - Unit emission factors of the Inventory of Carbon and Energy (ICE) or of EcoInvent (manufacturing of materials and laying), - Manufacturer data (consumption of equipment). These databases are regularly updated by the administrator.
Necessary data	The user can choose the type of project (e.g.: pavement enlargement or new project; rehabilitation, etc.), a road typology (highway, main road, departmental road), a structure nature and traffic classes. The software offers by default unit emission factors, transport distances and pre-calculation of the quantities of materials, which can be changed.
Integration of data specific to contractors to complement the general database	Yes (based on manufacturer data which can be changed)
Phases of the life cycle of the structure taken into account:	
Life expectancy of the structure	No
Upkeep	Yes (possible for the pavement part)
Production, raw material extraction	Yes
Upstream transport	Yes
Manufacturing plants	Yes
Transport and laying	Yes
Use of the structure at the end of its life	No
Operation (traffic)	Subject of ruling 159

Attractiveness & ease of use:	
Computer interface of the tool	Yes
Need to control the environment of the road work	Yes
Results obtained	Obtaining of graphic results and in the form of user-friendly tables
General evaluation of the Human / Machine interface	User friendly
Management of the central resources database of:	
Modification or addition of information	EGIS Administrator
Possible frequency of updates	As a function of the update of the reference databases
Consolidation of new data	Not applicable
Assistance - Help:	
Referent(s) or Hot Line structure	Not applicable
User club	Not applicable, exclusive use of EGIS
Data:	
Origin of the information of the common central database	- Bilan Carbone™ (carbon footprint assessment) of the ADEME/ABC, - AIE (energy), - Inventory of Carbon and Energy (ICE) - EcoInvent (manufacturing of materials and laying),
Form of restitution of the results	Table, graph, curve and the construction/operations breakdown
Deployment and use of the software	EGIS on behalf of various Clients and contractors
Reliability of the data	Depending on the available databases (except modification forced by the user)
Data security - confidentiality	The data is not confidential. The data can be modified with the administrator function to take into account for example new updates of the European databases or for a use abroad as a function of the ministerial data of the country in question.
Carrying out of a critical review	No
Cost of the products:	
Purchase	Not applicable
Licenses	
Maintenance	

C. CASE STUDY

> Input data and case study

The following data was provided by the IDRRIM.
General characteristics:

- Inter-urban project
- Path: 3 km

Pavements:

- Pavement width: 7 m
- No central reservation
- Shoulders: 1.5 m x 2
- Pavement structure: 8 cm of semi-coarse asphalt concrete, 2 x 20 cm of cement-treated base material3 and 35 cm of soil improvement with 6% of hydraulic binder and 1% lime.

Earthworks:

- 40,000 m3 cut
- 20,000 m3 fill
- 20,000 m3 removed
- No materials brought from outside

For the civil engineering structure, tunnel, drainage and facilities categories, the hypotheses are detailed below:

Structures:

- Mixed steel-concrete structure with 3 spans of respective lengths 6 m, 10 m and 6 m and 9 m wide.
- This structure is supplied by 4 piles of dimensions 3.5 m x 0.6 m and 5.5 m high.

Tunnel:

- Mono-tube cut and cover, 320 m long, with “access ramp” type portals, a service area and an emer gency exit.
- No ventilation plant.

Drainage:

- Longitudinal drainage 50% coated and 50% earth.

Equipment:

- Type of retention system: 3000 lm concrete barrier.
- The eco-comparator takes into account the police and traffic signs.

The transport distances and the unit emission factors are those of VARIWAYS® v2.1. They are detailed hereafter..

> Variways Construction - Inputs

The input data were transcribed as follows to be usable in the software.

Designation	Unit	Value/ Quantity	Comment
Type of road/ Cross-section			
Type of work	List	New layout	
Length of the layout	Meter	3 000	
Number of lanes	Unit	2	
Width of the lane	Meter	3.5	
Width of central reservation	Meter	0	
Type of central reservation	List	x	
Emergency lane width	Meter	1.5	
Emergency lane Type	List	Non-structured	We took as a hypothesis that the emergency lanes were surfaced but not structured.
Width of the existing cross-section	Meter	0	
Earthworks			
General longitudinal section	%	- 33	100 % = fill only,
- 100% = cut only.	%	0	
The percentage indicated allows for 2 times more cut than fill as in the example proposed by the IDRRIM.	%	50	Le chantier étant interurbain, nous avons retenu une valeur de 50%.
Length of the road in mountainous terrain in % of the length of the road project	%	0	
Length of the road in urban area (in % of the length of the road project)	%	50	As the project is inter-urban, we used a value of 50%.
Parameter which reflects the equilibrium between cut and fill	%	50	Half of the cut will be reused as fill, the other half will be removed.
Rocky materials in % of the cut volume	%	0	
Volume of fill to be treated as a percentage of the volume of fill reused	%	80	Average value based on experience. By default, in Variways, the treatment of the fill is as follows: 1% lime for the fill and 6% cement for the subgrade (upper part of earthworks)

Designation	Unit	Value/ Quantity	Comment
Pavements			
Pavement structure	List	MTLH	MTLH = Materials Treated with Hydraulic Binders
Type of road	List	RD (VRNS)	VNRS = Non-Structuring Network Lane
Formation class	List	AR 1	The structures proposed in Variways (in French standard) come from the catalogue of the standard new pavement structures (1998). The AR/PF/ Trafic combination presented here allows for the obtaining of the structure that comes closest to that requested by the IDRRIM, i.e. 6 semi-coarse asphalt concrete 0/10 + 40 cement-treated base material3 on 30 cm of treated capping layer. By default, in Variways, the treatment in place of the sub-base layer is as follows: 1.8% lime + 4.5% Hydraulic road binder.
Roadbed class	List	PF 2	
Total traffic expected (millions of trucks)	List	2.5 to 6.5	
Zone where the sub-base layer must be treated with hydraulic binders	%	100	
Structures			
Type of structures	List	Mixed (steel/ concrete)	
Tunnels			
Path of the section in tunnel		320	
Number of tubes		1	
Type of construction for tunnel	List	Cut and cover	
Road facilities			
Length of the illuminated project	%	0	
Type of retention system	List	Concrete	
Drainage			
Length of the existing longitudinal drainage	%	0	New layout, no existing drain.
Length of the existing transversal drainage	%	0	New layout, no existing drain.

> Variways Construction - Results

The greenhouse gas emissions (GHG) induced by each of the construction phase categories are presented in the two tables below distinguishing the materials, the equipment and the transport.

Based on the hypotheses and inputs presented above, the construction of the inter-urban project would induce more than 9,000 t CO2eq, or about 300 kg/m2.

Earthworks:

	Unit	Quantity	Materials	Equipment	Transport	TOTAL
			$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$
Clearing and stump removal	m2	20 000		5 260		5 260
Preparation of the subgrade	m2	30 000		3 210		3 210
Cut	m3	40 000		11 980		11 980
Materials removed	m3	20 000		1 950	208 000	209 950
Materials put in fill	m3	20 000		12 960	20 800	33 760
Treated fill	m3	16 000		340		340
Treated subgrade	m3	9 000		190		190
Hydraulic binder	t	1 260	674 100		72 450	746 550
	674 100	35 890	301 250	1 011 240	301 250	1 011 240

Chaussées :

	Area	Structure	Materials	Equipment	Transport	TOTAL
			$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$
Treated capping layer	31 500	30 cm treated capping layer	633 150	56 700	315	690 165
Lanes	22 800	6 BBSG + 40 GC3	399 000	114 000	1 824	514 824
Shoulder	9 600	6 BBSG + 40 GNT	39 360	48 000	576	87 936
			1 071 510	218 700	2 715	1 292 925

BBSG = Semi-coarse asphalt concrete, GC3= cement-treated base material3, GNT = pit-run gravel

Engineering structures:

	Unit	Quantity	Materials	Equipment	Transport	TOTAL
			$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$
Concrete	m^3	265	85 330	2 080	6 060	93 470
Steel	t	38	109 820		2 190	112 010
			195 150	2 080	8 250	205 480

Tunnel:

	Unit	Quantity	Materials	Equipment	Transport	TOTAL
			$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$
Concrete for tunnel	m^3	6 400	2 060 800	50 354	732 163	2 843 317
Steel for tunnel	t	768	2 219 520		49 916	2 269 436
Concrete for portals	m^3	800	257 600	6 294	91 520	355 415
Steel for portals	t	96	277 440		6 239	283 679
Concrete for underground structures	m^3	190	61 180	1 495	21 736	84 411
Steel for underground structures	t	12,35	35 660		803	36 493
Concrete for exterior premises	m^3	250	80 500	1 967	28 600	111 067
Steel for exterior premises	t	20	57 800		1 300	59 100
Excavated materials	m^3	32640		51 220	135 780	187 000
			5 050 530	111 330	1 068 058	6 229 918

Road Furniture:

	Unit	Quantity	Materials	Equipment	|Transport	TOTAL
			$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$
Steel for barriers	t	6	17 340		350	17 690
Concrete for barriers	m^3	750	183 750	4 000	17 160	204 910
Length of barriers	ml	3 000		90		90
Steel for police signs	t	0.56	1 630		30	1 660
Steel for traffic signs	t	1.73	5 000		100	5 100
Concrete for traffic signs	m^3	8.04	1 970	40	180	2 190
Road signs	m^3	40.20		570		570
			209 690	4 700	17 820	232 210

Drainage:

	Unit	Quantity	Materials	Equipment	|transport	TOTAL
			$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$	$kgCO_2eq$
Concrete for drainage coated	m^3	810	198 450	4 320	18 530	221 300
Steel for drainage coated	t	57	164 730		3 280	168 010
Concrete for piping	m^3	21.12	9 990		1 880	11 870
Steel for piping	t	1.73	4 990		100	5 090
Concrete for box-culverts	m^3	16.80	9 500	90	380	9 970
Steel for box-culverts	t	1.74	5 030		100	5 130
Drainage longitudinal coated	m	3 000		430		430
Drainage longitudinal in earth	m	3 000		430		430
Piping	m	96		10		10
Box-culverts	m	96		90		90
			392 690	5 370	24 270	422 330

> Variways Construction - Outputs

The illustrations below give an overview of the outputs proposed by the tool.

The listing by category and by alternative (Figure 1) gives an overview of the results.
The comparative histogram (Figure 2) shows the share of each work category in the total emissions induced by the construction phase.

When several alternatives are involved (Figure 3), they are given a specific color, which makes it possible to view them on a single output. When the study is carried out on both the construction and the operation phases (Figure 4), the footer gives an idea of the breakdown of the emissions between these two phases. A square is associated with each of them with an area proportional to the emissions induced. In the example below, as the operations have not been processed, only the “construction box” is visible.

Figure 1: Summary of the greenhouse gas emissions induced by construction, by category and by alternative

CO2 Equivalent in tons during the Works

Unit : t eq. CO2

Section	Nature of works	Materials	Equipment	Transport	Totals	%
Section :	Chantier inter-urbain					
10	Earthworks	673	36	301	1 010	11%
10	Pavement	1 072	219	3	1 294	14%
10	Drainage	393	5	24	422	4%
10	Standard bridges	195	2	8	205	2%
10	Tunnels	5 051	111	1 068	6 230	66%
10	Road Furniture	210	5	18	233	2%
Section :	*Totals*	7 594	378	1 422	9 394	
10	*%*	81%	4%	15%		100%

Figure 2: Breakdown of the overall GHG emissions

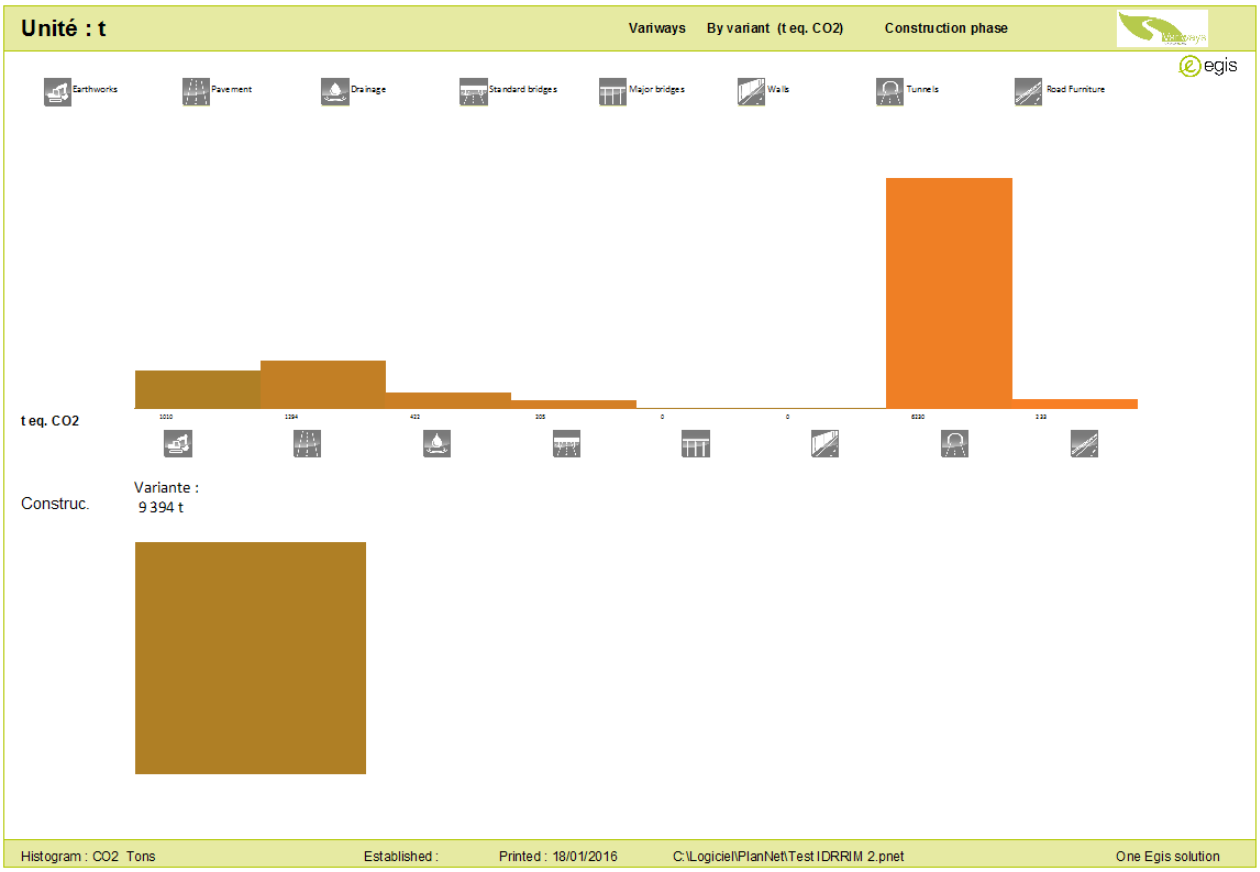


Figure 3: Comparison of alternatives by construction category (RN 164 project)

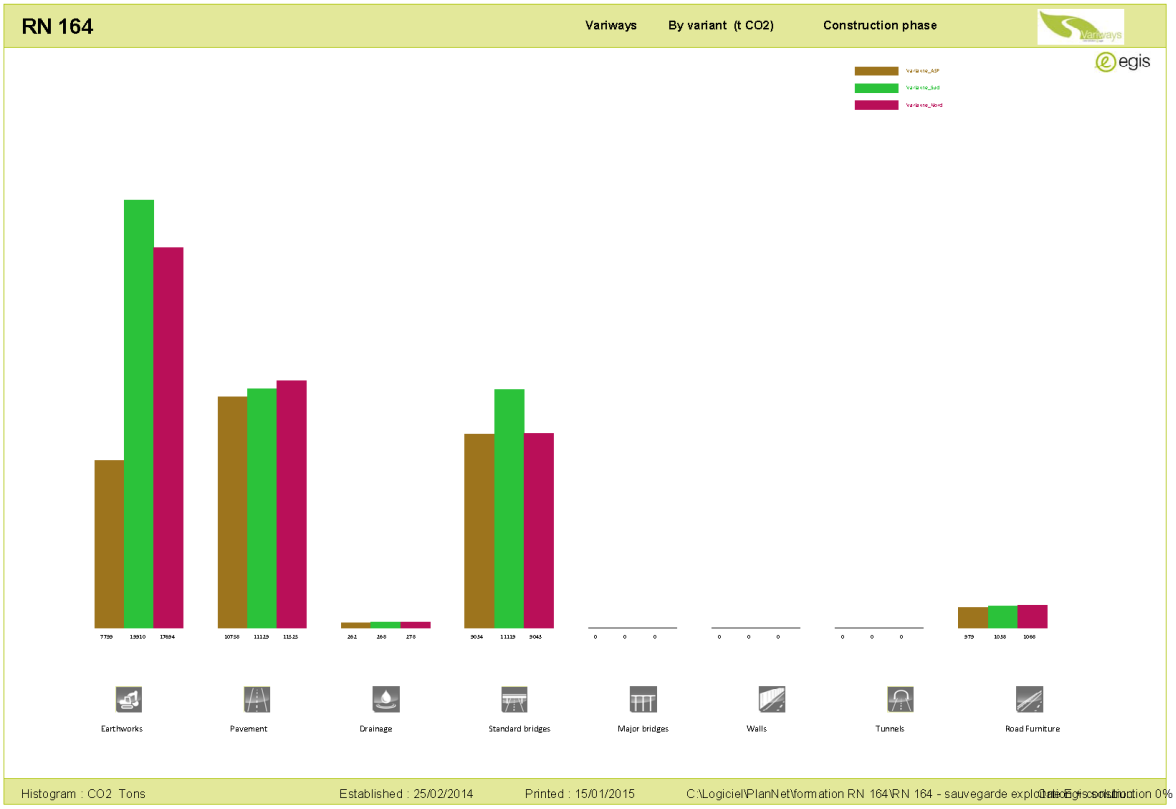
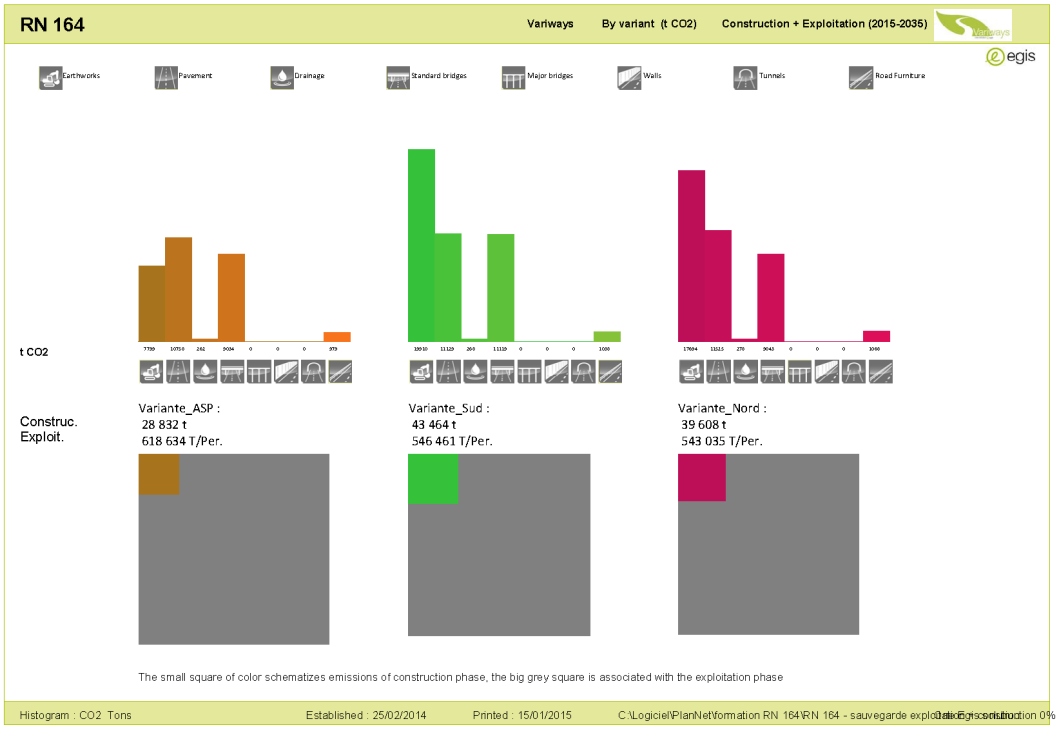


Figure 4: Comparison of alternatives integrating the construction and operations phases (RN 164 project)



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Document reference: AT163 - 0216

This technical ruling was prepared by the ECO-COMPARATOR Specialized Group (SG) of the Operational Ruling Committee of the IDRRIM.

NB: The Eco-comparer SG draws the reader's attention to the fact that in 2013 the EGIS Company modified the VARIWAYS® v2.1 software (Construction Module) (version 1.1 which was covered by Opinion No. 159 concerning the Operations module). This opinion only covers the Construction Module of Version v2.1.

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