

ECO-  
COMPARATOR

VARIWAYS®

## VARIWAYS®



### The road project variant eco-comparator, V 1.1

The VARIWAYS® road project variant “eco-comparator” enables comparison of the environmental performance of different possible alignments during the design-studies phase for road infrastructure projects. The software compares energy consumption (expressed in MJ) and greenhouse gas (GHG) emissions (expressed as tonnes of CO<sub>2</sub>) arising from the road traffic using the infrastructure over a service-life period chosen by the user.

The assumptions used as well as the results for each variant are presented in the form of tables and graphs. Transfer to CAD software allows for the production of an illustrated output.

The VARIWAYS® calculation methodology is associated with a database of unitary emission factors for vehicles, based on the COPERT methodology developed for the European Environment Agency (EEA) and described in SETRA Information Note no. 92. The programme takes into account the road gradient, speeds, and the cumulative heavy and light vehicle traffic over the study period.

EGIS, the software designer, is the sole user of the program and offers its use in the form of a service. The program is suited to the purposes of any entity (Client or Contractor) seeking to optimise an infrastructure project (choice of alignment, longitudinal profile, vehicle speed regulation strategy).

It has been used in the development of several projects in France and internationally.

Publisher: EGIS  
15, avenue du Centre – CS20538 Guyancourt  
78286 Saint Quentin-en-Yvelines Cédex  
Tél. Standard +33 (0)1 39 41 44 77  
Email: [innovation.egis@egis.fr](mailto:innovation.egis@egis.fr)

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# 1 PUBLISHER'S PRESENTATION OF THE TOOL

## A. A GENERAL PRESENTATION OF THE SOFTWARE

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The VARIWAYS® eco-comparator is a design-aid and decision-making software to aid the comparison of different variants for road and motorway projects. Its purpose is to indicate optimised alignment design in terms of two indicators:

- greenhouse gas (GHG) emissions;
- energy consumption (MJ) arising from the traffic using the infrastructure over its period of operation.

VARIWAYS® allows alignment variants to be ranked according to these two criteria and can be useful in:

- the preliminary phase, for environmental comparison of road design variants or during the environmental optimisation of an alignment;
- the design phase, for estimating the environmental footprints;
- the tendering phase, to show the Client the possibilities offered from the integration of this aspect into the environmental analysis.

VARIWAYS® allows clients to establish a position, from the early design stages, on their choice of alignment, that will contribute to the European Union's commitment to reducing its GHG emissions by 20% in relation to 1990 levels by 2020.

It is accepted by professionals that 80% of GHG emissions from road transport occur during the operating phase. Consideration of the impact of the operating phase, at the design stage, is therefore an important lever and an opportunity for project owners that are concerned about the environmental impacts of their projects.

VARIWAYS® also takes account of the monetary aspects of each proposed variant, over a given period of use, to integrate the impacts of the investment on the carbon emissions.

## B. SCOPE OF APPLICATION

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The VARIWAYS® road project variant eco-comparator can be used in the design phase (preliminary/detailed design); it also allows quantification of GHG emissions and energy consumption during the operation phase in terms of project parameters (geometric profile, traffic, speed,).

## C. TARGET USERS

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The VARIWAYS® road project variant eco-comparator is aimed at all project owners concerned with integrating environmental impacts at the design phase, and with optimising their infrastructure projects with regard to "GHG" and "energy consumption" indicators.

It provides them with quantitative indicators, from the design phase, to optimise their projects, allowing them to establish a position with regard to their choice of variant (choice of alignment, longitudinal profile, and vehicle speed regulation strategy).

## D. DATABASE AND MANAGEMENT

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The VARIWAYS® road project variant eco-comparator is associated with a database of unitary emission factors, which is based on the European Environment Agency's COmputer Programme to Calculate Emissions from Road Transport (COPERT) methodology, and referred to in SETRA Note No. 92 [1].

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These unitary emission factors are specific to each type of vehicle (light and heavy vehicles, etc.). They take account of fuel (petrol, diesel...), engine capacity, vehicle age and obsolescence (to take account of “Euro” standards), of vehicle speeds and, more widely, of traffic conditions.

In addition, VARIWAYS® also enables consideration of the monetary aspects of GHG emissions to enable a socio-economic evaluation of alignments. This evaluation is based on an annual estimation of the cost of a tonne of equivalent carbon. The values from the Sétra report [2] have been integrated as the default values, noting that it is possible to adapt them.

The databases are updated by the Egis Administrator to take account of updates to the COPERT database.

[1] *Emissions routières de polluants atmosphériques. Courbes et facteurs d'influence (Emission of atmospheric pollutants from roads. Curves and influencing factors)* – Setra Note Economie Environnement Conception n°92, November 2009

[2] *Monétarisation des externalités environnementales (monetisation of environmental externalities)* – Setra, Rapport d'études, May 2010

## E. TARGETED AREAS OF APPLICATION

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VARIWAYS® enables the evaluation of the impacts of the use of road infrastructure following the principle parameters of traffic, design speed, geometry (plan and longitudinal profile) with regard to the indicators “greenhouse gas emissions” and “energy consumption”.

With VARIWAYS® project owners can be made aware of and involved, from the design phase, in an environmental approach that complements elements produced by tools that target the construction phase, thereby enriching the design/construction process within a global and durable approach.

In addition, the inclusion of the monetary aspects of greenhouse gas emissions offers project owners a global approach to infrastructure cost that includes investment and estimated costs for a given period of operation.

## F. SCOPE OF ENVIRONMENTAL ANALYSIS

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VARIWAYS® allows evaluation of greenhouse gas emissions and energy consumption resulting from road traffic (passenger and freight) during the infrastructure’s operating phase.

The scope of the environmental analysis therefore corresponds to the operating phase, excluding maintenance and monitoring operations.

## G. THE INDICATORS

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VARIWAYS® proposes the comparison of different alignment variants in terms of two indicators:

- Greenhouse gas emissions GHG;
- Energy consumption arising from road traffic during the period of operation of the infrastructure.

The “GHG emissions” indicator (expressed as tonnes of CO<sub>2</sub>eq) indicates the potential impact on climate change.

The “energy consumption” indicator (expressed in MJ) indicates the impact on energy resources.

VARIWAYS® also takes account of the monetary aspect of GHG emissions to allow for socio-economic evaluation. This monetary indicator is expressed in euros (€).

## H. PRINCIPLE OF CALCULATION

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VARIWAYS® uses unitary vehicle emission factors (light and heavy vehicles, etc.) from the COPERT methodology to calculate greenhouse gas emissions and energy consumption in relation to alignment geometry, traffic growth and traffic conditions (allowing for technological developments in the petrol and diesel vehicle fleets, etc.) over the infrastructure’s operating period.

On this basis, VARIWAYS® can easily compare variants in terms of the two above-mentioned indicators according to, for example, the choice of alignment, longitudinal profile and the vehicle speed control strategy.

## I. DATA PROVIDED BY THE USER

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The main inputs to the VARIWAYS® road design variant eco-comparator are:

- project geometry data (in coordinates x, y, z and curve/linear abscissas);
- expected traffic and its evolution (numbers of light, heavy vehicles, etc.);
- vehicle speeds;
- chosen period of operation.

Project geometry can be retrieved via a standard transfer file in Excel format, thereby allowing trouble-free importing of most formats.

Traffic and speed levels are given per road section. It is possible to ascribe “origin/end” zones to linear sections to highlight specific features of a project, such as interchanges or speed restriction zones.

The user-friendly interface allows the input data to be reviewed, changed or added to, in part or in whole, at every step of the process.

## J. TYPES OF RESULTS OBTAINED AND THEIR PRESENTATION

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VARIWAYS® provides a range of outputs (tables, graphics, extracts on plan view, curves and longitudinal profiles, etc.) to suit specific needs:

- tables for each variant and for each section provide a single readout for the different variants, allowing for their comparison in terms of the carbon and energy indicators;
- graphics (plan views and longitudinal profiles) present, by direction and section, the indicators by a colour representation.

Automatic retrieval of the results for CAD software is possible, to generate graphic documents, if necessary, to illustrate for consultations on the indicators.

## K. AVAILABILITY

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VARIWAYS® is used by EGIS for its project management or engineering design assignments.

## 2 EXAMINATION PROCEDURE

This Eco-comparator technical appraisal, limited to the area of road transport infrastructure, is the result of an examination by a Specialist Group (SG) mandated by the *Institut Des Routes, des Rues et Infrastructures pour la Mobilité* (IDRRIM – France’s institute for roads, streets and infrastructure for mobility). The examination procedure for a technical appraisal request is as follows:

- 1/ The characteristics and functionalities of the software described by the publisher were verified by the SG against an analysis matrix produced by the publisher, attached as an annex to this appraisal report.
- 2/ The eco-comparator was examined against an analysis reference proposed by la commission infrastructure de l’Observatoire Energie – Environnement des Transports (the French Observatory for Energy and Environment in Transport OEET). The publisher provided a response to the 46 points detailed in this reference, which was examined by an independent expert, a member of the OEET and external to the Eco-comparator Specialist Group.
- 3/ The VARIWAYS® eco-comparator was the subject of presentations by EGIS at meetings of the SG. Two projects were presented during these meetings, of which one was the object of a demonstration and calculation by EGIS. The results for this project were subjected to analysis by an expert external to the SG (project for doubling of infrastructure with evaluation of the effects of speed restrictions).

## 3 EXAMINATION

### A. EXAMINATION WITH IDRRIM MATRIX

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#### a. Perimeter of application

VARIWAYS® enables comparisons between variants in terms of two indicators (GHG emissions and energy consumption) according to, for example, the choice of alignment, longitudinal profile, and vehicle speed regulation strategy.

The scope of application of the VARIWAYS® road project variant eco-comparator is the design phase (route selection/detailed design).

The software contributes to establishing environmental footprints by comparison of results during the project design phase. It can also be used to establish the footprint during operation.

#### b. Targeted users

The VARIWAYS® eco-comparator is used by EGIS for diverse project management and/or design assignments on behalf of project-owners and/or contractors.

#### c. Database and management

The VARIWAYS® road project variant eco-comparator is associated with a database of unitary emission factors based on the European Environment Agency’s COPERT (COmputer Programme to Calculate Emissions from Road Transport) methodology, described in SETRA information note No. 92.

This model, endorsed by the EEA and by the ADEME (French Environment and Energy Management Agency), is based on a database of road transport emission factors that allow the conversion of data relative to road traffic pollution emission characteristics.

The database is updated by the EGIS Administrator, to take account of updates of the COPERT base model.

#### ***d. Targeted areas of application***

In the design phase, the VARIWAYS® eco-comparator allows the establishment of environmental footprints in terms of the two target indicators (greenhouse gas emissions and energy consumption) and the evaluation of the impacts of use based on the road infrastructure's main parameters of traffic, reference speed and geometry (plan, longitudinal profile, etc.).

With VARIWAYS® project owners can be made aware of and be involved in, from the design phase, an environmental approach that complements elements targeted in the construction phase.

#### ***e. Scope of environmental analysis***

The scope of the environmental analysis covered by the VARIWAYS® eco-comparator is a partial life-cycle analysis (excluding road construction and maintenance) limited to the infrastructure operational phase. The program allows the evaluation of greenhouse gas emissions and energy consumption arising from road traffic during the transport infrastructure operating phase.

#### ***f. Available indicators***

The environmental indicators used in the VARIWAYS® eco-comparator are:

- Energy consumption arising from road traffic (in MJ)
- GHG emissions (CO<sub>2</sub> equivalent)

Additional information, not examined by the SG, is also available (monetary aspects of GHG, expressed in €).

#### ***g. Principle of calculation***

Greenhouse gas emissions and energy consumption are calculated as a function of vehicle emission factors defined according to speeds, alignment geometry, the planned period of operation, traffic growth and foreseeable changes in emission factors (base COPERT IV, which takes account of future technological developments in the petrol and diesel vehicle fleets).

#### ***h. Procedure, data to be provided by the user***

The main inputs to the VARIWAYS® road project variant eco-comparator are:

- project geometric data (with x, y, z coordinates and curve/linear abscissas);
- expected traffic levels and growth (number of light, heavy vehicles, etc.);
- vehicle speeds;
- the chosen duration of operation and evolution of traffic during that period.

The project geometry can be retrieved via a standard transfer file, in spreadsheet format, thus allowing easy importation of most formats.

Traffic and speeds are defined for each section.

#### ***i. Presentation of results***

The VARIWAYS® road project variant eco-comparator provides different types of outputs (tables, graphics, extracts in plan view, curves and longitudinal profiles, etc.), to meet different specific needs:

- tables per variant and section illustrate variants, allowing for their comparison in terms of the carbon and energy indicators;
- for each direction and linear section, graphic representations (plans and longitudinal profiles) present coloured representations of the indicators.

Automatic retrieval of the results by CAD programmes is possible, to generate graphic documents enabling, if required, illustrations for consultations on the above-mentioned indicators.

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### *j. Availability*

The VARIWAYS® eco-comparator is used by the company EGIS.

### *k. General appreciation of ease of appropriation by users*

Not-evaluated by the SG as VARIWAYS® is used exclusively by EGIS.

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## **B. SUMMARY OF EXAMINATION AGAINST OEET MATRIX**

### **(Observatory for Energy and Environment in Transport)**

Report on EXPERT ANALYSIS OF THE ELEMENTS OF RESPONSE OF THE PUBLISHERS OF THE Logiciel d'Evaluation Environnementale des Infrastructures de Transports – Eco-comparateur (LEEIT – software for environmental evaluation of transport infrastructure – eco-comparator) RELATIVE TO THE OEET INFRASTRUCTURES METHODOLOGY (V1, April 2011).

The elements of response to the 46 points in the OEET matrix are partial, as they are limited both by the scope of the evaluation relative to the OEET V1 methodology (operating phase of infrastructure use not covered) and by the replies provided, often incomplete as they are in line with a wider technical appraisal approach.

The elements provided in response to the different criteria of the methodology established by the OEET's Infrastructure Commission place the VARIWAYS® software tool in an area of evaluation not covered by this approach.

- VARIWAYS® covers the area of environmental analysis of use of road infrastructure, in line with a specific European approach, outside of the standards framework currently in force.
- The software tool is oriented towards the study of linear infrastructure.
- The tool evaluates a single environmental impact: climate change.
- The database used is taken from the COPERT programme (not analysed here).
- The tool has not been subject to a critical review, but to tests conducted internally.

Dedicated to the study of the usage of infrastructure by passenger and goods traffic, VARIWAYS® evaluates GHG emissions from road traffic. It is intended to meet the needs of a user seeking to make or optimise a choice of alignment in the preliminary stages of a road project.

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## **C – SUMMARY OF CALCULATIONS**

In order to evaluate this software tool, the company EGIS conducted a case study in the presence of members of the SG and allowed testing of the influence of regulatory measures by modifying traffic speeds (speed restrictions) on energy consumption and greenhouse gas emissions, without any changes to the geometrical characteristics.

Verification of the results of this study was entrusted to an outside expert.

The order of magnitude of the results was confirmed by the outside expert, with the observation that the results from VARIWAYS® were slightly higher. The difference observed between the two studies was very small and is acceptable.

## **4 THE COMMITTEE'S VIEW**

The VARIWAYS®, software version V 1.1, is an eco-comparator dedicated to environmental comparison of the operational phase of an infrastructure project, in the framework of the design of projects, following the geometric characteristics of the alignment, design speeds, traffic and the chosen operational duration.

It permits the calculation of GHG (expressed as tonnes CO<sub>2</sub>eq) and energy consumption (expressed in MJ), generated by traffic as a function of speed, the alignment geometry, traffic levels and their evolution, as well as the envisaged operational duration of the infrastructure.

It is intended to respond to the needs of every entity seeking to establish or optimise a choice of alignment in the early stages of a road project with regard to GHG emissions and energy consumption generated by the users of the infrastructure.

VARIWAYS® contributes to meeting the commitments on reducing GHG emissions taken by the partners at the time of the signature, on 25 March 2009, of the Convention d'Engagement Volontaire (CEV – French road industry's voluntary agreement) for participants in the design, realisation and maintenance of road infrastructure, carriageways and public spaces.

Use of the eco-comparator is reserved exclusively to the EGIS company, which proposes its use within the framework of engineering, procurement, and construction management or design assignments.

Lastly, the tool permits a monetary approach to the environmental impacts following the GHG emissions (expressed in €) of the chosen alignment choices. This parameter is not within the scope of the SG's analysis of the tool.

## 5 ANNEXES

### A. REFERENCES PRESENTED BY THE PUBLISHER FOR PUBLICATION OF APPRAISAL

Principal references: VARIWAYS®

VARIWAYS® version	Year	Project	Type of type	Project Owner	Use	Use pre-or post-project	Comments
1	2010	A304 motorway: construction of extension of A34 motorway to Belgium	32 km	Dreal Champagne Ardennes	Design	during	
1	2011	RD 642 A25 motorway/ Hazebrouck link	14 km	CG du Nord	Detailed Design	during	
1	2010	A89 motorway Violay - La Tour de Salvagny section (Boussuivres valley part)	9 km	ASF	test	post	
1	2012	New Coast Road (Reunion Island)	12 km	Region	Detailed Design	during	
1	2011	A63 motorway Landes (between Salles and Saint Géours de Maremne)	104 km	Atlantes	Detailed Design	during	
1	2011	Motorway Morinë Merdare motorway (Kosovo)	54 km	Bechtel-Enka Kosovo	Detailed Design	post	
1	2012	RN164 road on Lomeven – Plouguernevel section	15 km	DREAL Bretagne	Design	during	Investigating alignments
1	2010	A89 road, Tarare hill	9 km	ASF	test	post	
1	2012	RD30	4.2 km	CG78		IdrrimTest	

## B. IDRRIM TABLE

General:	
<b>Name of software</b>	VARIWAYS®
<b>Designer</b>	EGIS
<b>Release date</b>	2010
<b>Version examined</b>	Version V 1.1
<b>Origin of project</b>	Starting point for consideration: no internal tool at EGIS. In line with commitments made at the Grenelle Environment Forum, and with the observation accepted by the profession (that 80% of GHG emissions from infrastructure results from traffic), development of a decision-making aid for reduction of GHG emissions in the operating phase.
<b>Objectives</b>	Tool for PMC/EPCM services, in line with Grenelle commitments to reduce GHGs by integrating the infrastructure operating phase (traffic). Work on existing project, upgrading or new, to propose variant solutions by comparing GHG emissions and energy consumption as a result of for example reductions in speed, changes to the alignment, etc.
Scope of application:	
<b>Road project phase(s)</b>	Design phase (conceptual/detailed design) and operation
<b>Targeted users</b>	EGIS, on behalf of project owners
<b>Target area(s)</b>	Main parameters of alignments, design speed and geometry (plan and longitudinal profile)

<p><b>Scope of analysis</b></p>	<p>The VARIWAYS® functional unit corresponds to the road transport infrastructure operating phase/use (passenger and goods transport).</p> <p>VARIWAYS® evaluates GHG emissions from road traffic (passenger and goods transport) during the infrastructure operating phase, taking into account project geometry, the profile and alignment in plan, excluding any other step in the life cycle analysis of the infrastructure and vehicles.</p> <p>It also takes account of traffic levels with associated time horizons based on studies made for operation.</p> <p>In the operating phase, monitoring and major- and routine-maintenance are not covered by VARIWAYS®.</p>
<p><b>Time required to conduct a study</b></p>	<p>Dependent on project complexity, number of variants and input parameters.</p>
<p><b>Available indicators:</b></p>	
<p>GHG emissions (CO<sub>2</sub> eq)</p>	<p>Yes</p>
<p>Energy consumption (MJ)</p>	<p>Yes</p>
<p>Consumption of aggregates</p>	<p>No</p>
<p>Recovery of asphalt</p>	<p>No</p>
<p>Acidification</p>	<p>No</p>
<p>Chronic toxicity</p>	<p>No</p>
<p>Water consumption</p>	<p>No</p>
<p>Ecotoxicity</p>	<p>No</p>
<p>Eutrophication</p>	<p>No</p>
<p>Consumption of materials</p>	<p>No</p>
<p>Photo-chemical ozone</p>	<p>No</p>
<p><b>Addition of new indicators</b></p>	<p>No (but future inclusion of structures and tunnels, etc.)</p>
<p><b>The calculations:</b></p>	
<p><b>Principles of calculation</b></p>	<p>GHG emissions and energy consumption are calculated on the basis of vehicle emission factors and in accordance with speed, alignment geometry, evolution of traffic and also developments in emission factors (based on COPERT IV which takes account of future technological developments in the gasoline and diesel fleets), etc.</p>
<p><b>Data required</b></p>	<p>Alignment geometry in (s, x, y, z), speed, traffic and planned operating period.</p>

<b>Integration of company-specific data as complement to general database</b>	Not applicable
<b>Life cycle phases of structures covered:</b>	
Service life of the structure	No
Maintenance	No
Production and extraction of raw materials	No
Upstream transport	No
Production centres	No
Transport and implementation	No
Recycling of structure at end of service life	No
<b>Operation (traffic)</b>	Modulable period of operation
<b>Convenience and ease of use:</b>	
Information technology interface of the tool	Yes
Need for mastery of road works environment	No
Results obtained	Graphic results and easy-to-read tables
General appreciation of Human Machine Interface	User-friendly
<b>Management of central resources database:</b>	
<b>Modification or addition of information</b>	EGIS Administrator for integration of updates to COPERT database
<b>Possible frequency of update</b>	In line with COPERT updates
<b>Consolidation of new data</b>	Not applicable

Assistance - Support:	
Contact-person or Hot Line	Not applicable
Users' club	Not applicable; used solely by EGIS
Data:	
Origin of data in the central, common database	COPERT IV Note 92 SETRA SETRA report (May 2010) on monetisation of environmental externalities
Form of output results	Tables, graphics, extracts in plan view, curves and profile Automatic retrieval of results in AutoCAD
Deployment and use of the software	EGIS, on behalf of project owners and other companies
Reliability of data	See COPERT IV database
Data security - confidentiality	The data is not confidential. The data can be modified via the administrator function to incorporate, for example, updates to the European database or for use in other countries with data from ministries in the countries in question.
Critical review	No
Cost of product:	
Purchase	Not applicable
Licences	
Maintenance	

## C. CASE STUDIES

### Summary of RD 30 (Plaisir-Elancourt) project

26/02/2013

#### Project

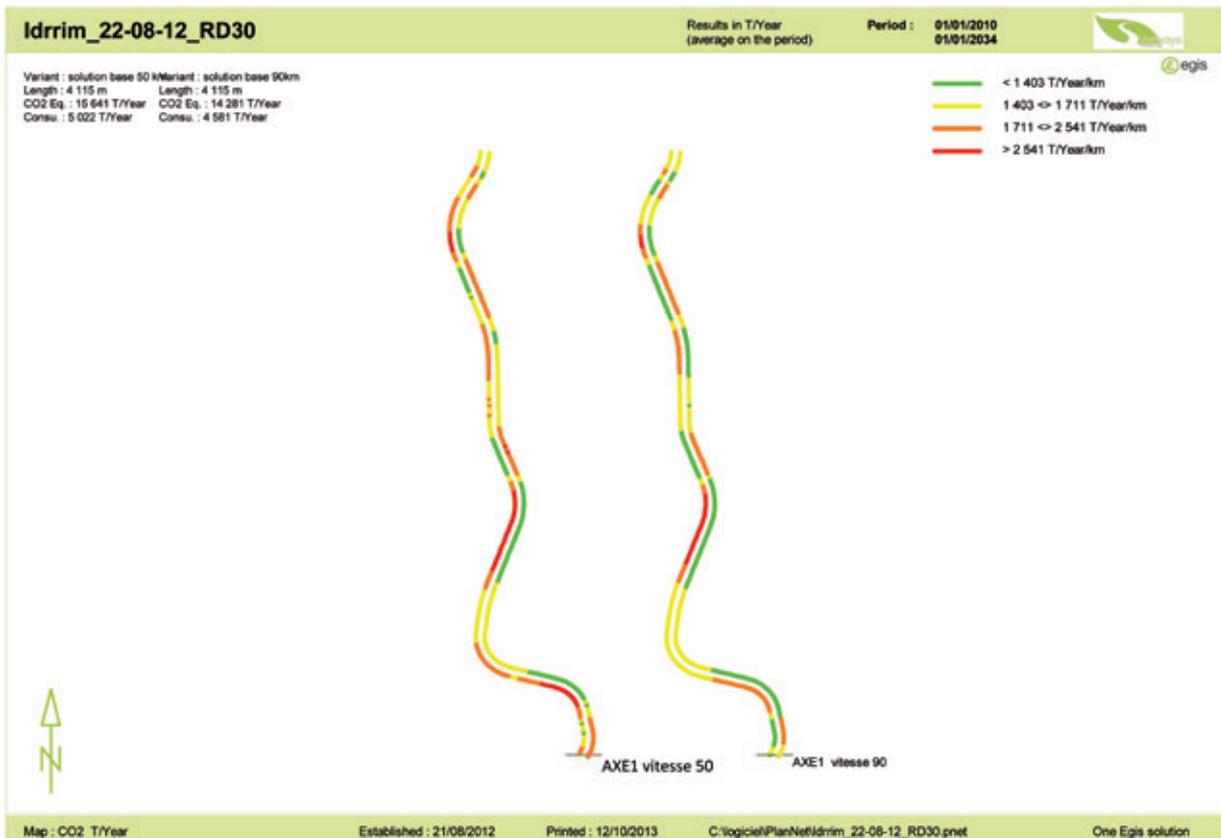
The project for upgrading and doubling of the RD 30 secondary road concerned a 4.1 km long section with gradients steeper than 5% on certain sections. This fairly accentuated longitudinal profile allowed the use of Variway’s potential with regard to user traffic speeds. The aim of the study, given the absence of variants for the alignment, was to identify potential reductions in GHG emissions by varying the speed.

The experiment performed on the RD 30 project allowed the comparison of two speed variants on the same alignment: a basic solution with a speed of 90 km/h and a variant with the speed at 50 km/h.

#### Result

The greenhouse gas emissions (GHG) and energy consumption (J) arising from road traffic for a given period of operation are shown below for the basic case and the possible variant.

Co-planar multi-variant graphic representation



## Presentation as histogram



## Analysis of results

	90 km/h	50 km/h
Length (km)	4.1	4.1
Mean GHG emission (tonnes CO2eq/km.yr)	3,483	3,814
GHG emissions for operating period (24 yrs) (tonnes CO2eq)	357,025	391,034
Relative difference in GHG emissions		10%

## Analysis of results (cont'd)

Where the GHG and J indicators are concerned, the “90 km/h” solution would be more favourable than the “50 km/h” solution over the project’s period of operation.

Lastly, it is of note that the extension of the Variways software currently under way will include GHG emissions arising in the construction phase, thereby making it possible to consider the GHG emissions over a road infrastructure “construction – operation” cycle. However, the order of magnitude of the results presented above should not be significantly affected since, in the light of current knowledge, the operating phase accounts for around 90% of GHG emissions from road infrastructure over its life cycle.

**Document prepared by the Institut Des Routes, des Rues et des Infrastructures pour la Mobilité**

IDRRIM - 9, rue de Berri - 75008 PARIS - France  
Telephone: +33 (0) 144 133 287 - Fax: +33 (0) 142 258 999  
E-mail: idrrim@idrrim.com

Downloadable at [www.idrrim.com](http://www.idrrim.com)

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**Caveat for readers:** This appraisal is intended to provide rapid information. The drawback being the risk of error or lack of completeness. This document does not in any way engage the responsibility of the authors nor that of the *Institut des Routes, des Rues et des Infrastructures pour la Mobilité*.

This technical appraisal was prepared by the Eco-comparator Specialist Group of the IDRRIM's operational appraisals committee.

**NB: The Eco-comparator SG draws readers' attention to the fact that the company EGIS has furthered development of the VARIWAYS® software in 2013 (from version 1.1, the subject of this appraisal, to version 2).**



Institut Des Routes, des Rues et des Infrastructures pour la Mobilité

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