Life Cycle Assessment of the Overall Energy Consumption of a Road Construction Project and its Management in Cameroon

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ABSTRACT

A methodological approach of Life Cycle Assessment is presented in order to compare the energy consumption of three variants of a road tracing in Cameroon. In assessing this energy, construction, exploitation and maintenance phases are taken into consideration in two scenarios, Scenario 1 assumes that unit consumption based on traffic is constant, and scenario 2 assumes that this consumption is reduced by 50% as from 2022.
The results obtained show that in both cases, variant 1 consumes more energy than variant 3. Variant 2 consumes the least energy. The contribution of the exploitation phase to the energy consumption is high, amounting 85.5% in scenario 1 and 78.1% in scenario 2. Energy consumption in construction mainly depends on the presence of architectural arts works on the section and its contribution to the overall energy consumption that remains weak lower than to 5.32% or 8.08% in scenario 1 and 2, respectively

1. INTRODUCTION

Today, the decision to construct a road on a given territory should take into account the various developments in the domain of project monitoring and assessment. This decision is based on technical, financial, economic, social and environmental factors that consider the various impacts effected on the infrastructure during its life span. The ultimate objective of this multi-criteria decision is to make sure that the infrastructure that is being built effectively fits within a sustainable economic development and growth policy. But beyond its layout and the localities served, the construction, exploitation and maintenance of a road infrastructure entail some pressure on the environment. The ensuing impacts that differ in kind and intensity depending on the stage in the life span of the infrastructure are on the form of materials and energy flows, emission of polluting substances, disruption of the fauna and flora. Presently, the search for a global assessment of these environmental impacts is facing methodological difficulties, especially as concerns the assessment of the importance of long term effects at global level.
Consequently, to overcome these difficulties, this article intends to propose a method based on the Life Cycle Assessment (LCA) methodology widely used in industry (Grisel and Osset,

2004). This tool offers a structured approach that enables to assess the possible impacts of a product during its life span.
This methodological approach is used to compare the overall energy consumption of three variants of a road infrastructure in Cameroon.

2. LIFE CYCLE ASSESMENT

Life Cycle Assessment is a tool used for a rigorous assessment of material and energy flows, as well as environmental impacts linked to the construction, use and maintenance of an infrastructure. This assessment includes the extraction and transportation of raw materials, the fabrication of materials, their use and recycling. This assessment calls for a detailed listing of materials and energy generated or consumed by the infrastructure (Madjadoumbaye et al., 2008). The synthesis of these flows of materials and energy are transformed into indicators that could help decision makers and consumers make strategic choices (Legrand, 2002).

The Life Cycle Assessment methodology was standardized by the International Standardization Organization (ISO) in the 1404X standards series. It involves 4 interconnected steps as shown in figure 1 and comprises the following four linked components:

- Goal definition and scoping: identifying the LCA's purpose and the expected products of the study, and determining the boundaries (what is and is not included in the study) and assumptions based upon the goal definition;
- Life – cycle inventory: quantifying the energy and raw material inputs and environmental releases associated with each stage of production;
- Impact analysis: assessing the impacts on human health and the environment associated with energy and raw material inputs and environmental releases quantified by the inventory;
- Improvement and analysis: evaluating opportunities to reduce energy, material inputs, or environmental impacts at each stage of the product life-cycle

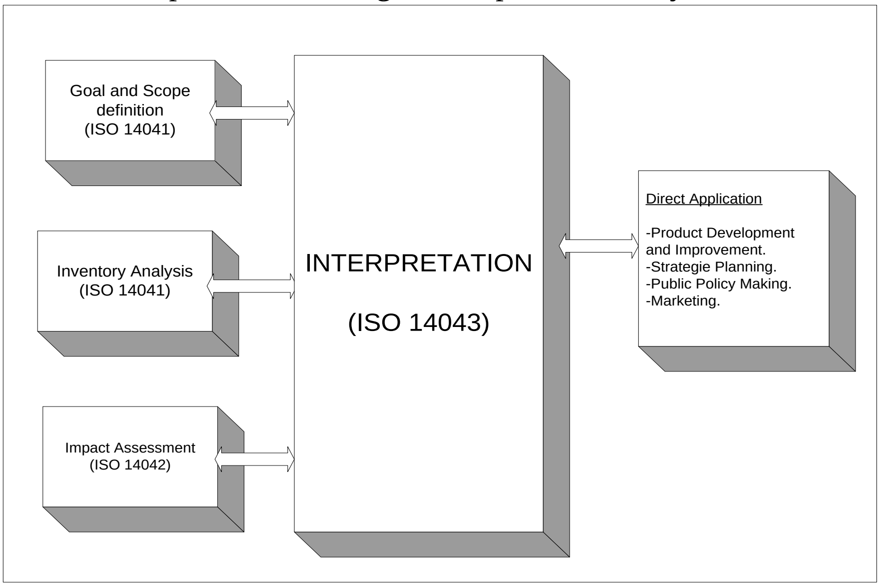


Figure 1. Relationships between the various steps involved in the Life Cycle Assessment process according to ISO 14040

3. CASE STUDY

3.1 Definition of objective and scope

3.1.1 Definition of objective

The aim of this survey is to apply the life cycle assessment in order to compare three variants of a road infrastructure in Cameroon. The survey that targets actors of the transports sector will enable us to identify the impact of a road infrastructure on overall energy consumption.

3. 1.2 Scope of the study

3.1.2.1 Life span

The life span of a road infrastructure, which depends on the traffic, is generally determined on the conception of the project (MTRF, 1986). It corresponds to the period during which the infrastructure performs the function for which it was built in all total security. However, the socio-economic assessment of road infrastructure is made on a long term perspective that is generally higher than thirty years. In this article, it is assumed that the road has a life span of fifty years; our life cycle assessment will thus be based on this period that we will call duration of reference.

3 .1.2.2 Function and functional unit

A road may perform various functions (transportation of goods, passengers, etc.). For the purpose of our survey, we will choose the movement of vehicles as function, and the functional unit will be the number of vehicles moving on that road for a period of fifty years. Thus, the functional unit is in line with the ISO 14041 standard, for it can be measured, it is additive and enables us to compare the various scenarios.

3 .1.2.3 Boundary of the System

The boundary defines the system within which the flows will be taken into account. The flows falling outside the framework in figure 2 shall not be taken into account. This boundary illustrates the situation in Cameroon which has no refinery or steelmaking plant. The system under study only covers the road’s construction, use and maintenance periods.

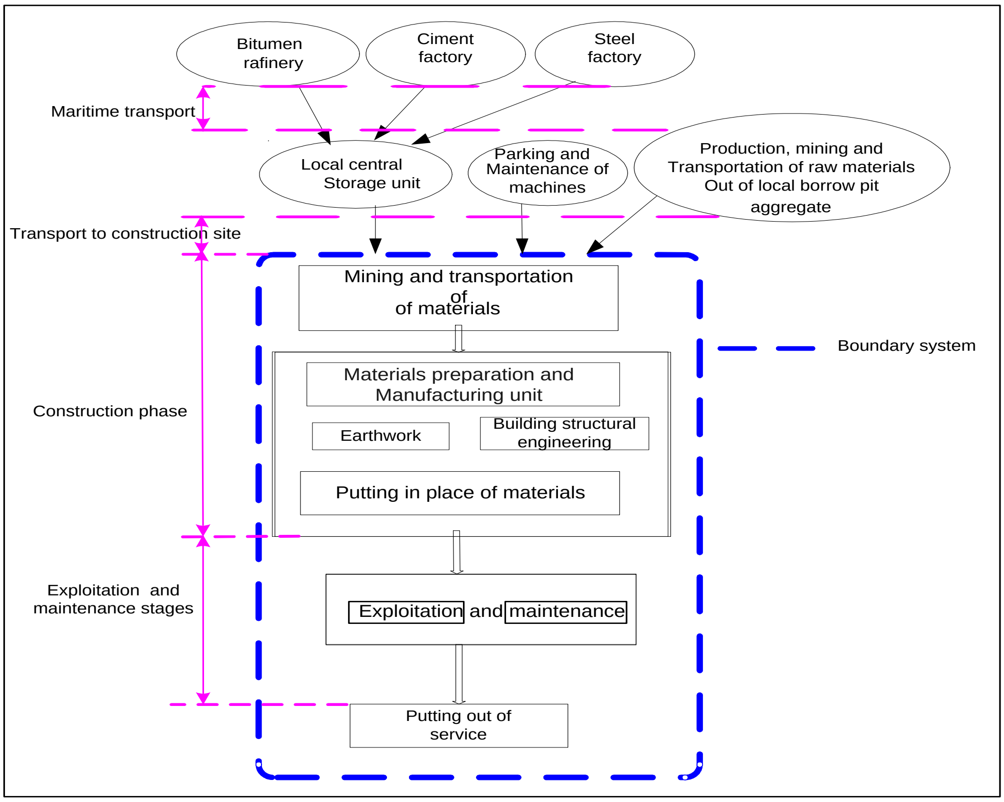


Figure 2. Boundary of the system whose inventory covers the overall energy consumption

Picture 1. The view of road after construction

3. 2 Flow inventory

In this survey, the inventory of flows or impact factors across the selected boundary of the system is given throughout the life span of the infrastructure. The task here is to record all the flows of energy consumption on the infrastructure during consumption works and over fifty years of exploitation. The results obtained are presented as one single synthetic indicator: energy consumption.

3. 3 Description of the site

The three variants on which our study is based are stretches of 11.99 km (variant 1), 9.68 km (variant 2) and 11.11 km (variant 3) on the road from Ngaoundéré (departure point in the North of Cameroon) to Moundou (arrival point in South-West of Chad). The map showing this stretch is in figure 3 below, and the variants are located in the hatched area. The road is a two-way road, covered with bituminous concrete.

The soil properties used for the construction of the pavement is presented in Table 1.

Table 1. Summary of soil properties and geotechnical characteristics

	Percent finer		
Particles size (mm)	**Maximal**	**Average**	**Minimal**
16	100	96	89
10	98	88	76
5	92	71	51
2	68	46	35
0.08	34	23	16

	Values		
Geotechnical characteristics	**Maximal**	**Average**	**Minimal**
Limit of Liquidity or LL (in %)	51.6	35.2	26
Index of Plasticity or IP (in %)	24.6	15.4	10.3
Density	2.11	2.03	1.92
Water content optimum or wopt (in %)	17.2	11.3	8.4
California Bearing Ration or CBR (in %)	14.3	47	32

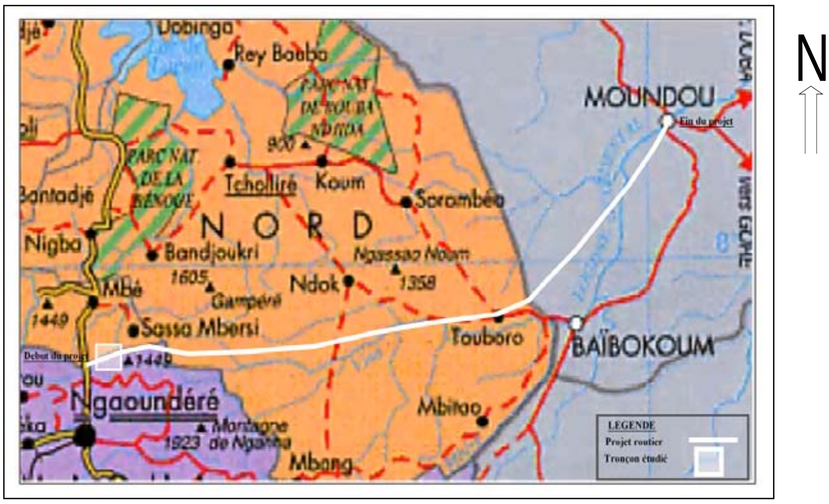


Figure 3. Stretch of the Ngaoundéré (North Cameroon) – Moundou (South - West Chad). Location of variances: hatched square.

3. 3.1 Hypotheses

Studies for the tarring of these stretches were conducted in the early 2000s on the following hypotheses (Elime, 2004):

H1 The life span of this tarred road is 50 years as from its opening on 1st January 2002.

H2 It will be assumed that maintenance works on the bituminous road will be done every year.

H3 The traffic taken into account is the one indicated in the draft project documents, that is $n_{j_0} = 2000$ vehicles daily in 2002 (average daily traffic) with a 3.5 increase until 2012. Then, due to the fact that long term traffic prospects are subject to many vagaries, we propose a traffic evolution (summarized in table I) where the increase is low, but remains positive (Elime, 2004).

Table 2. Traffic trends between 2002 and 2052 (Elime, 2004)

Periods	**Traffic growth in (%)**
2002-2012	3.5
2012-2022	2.5
2022-2032	2.0
2032-2042	2.0
2042-2052	1.5

3. 3.2 Variants' technical specifications

Variants' lengthwise profiles are shown in figures 4, 5 and 6, while the widthways ones feature in figure 7. The quantity of materials (whose details are shown in the draft project (MINTP, 2005) to be used for the construction of the various variants are shown in table 4.

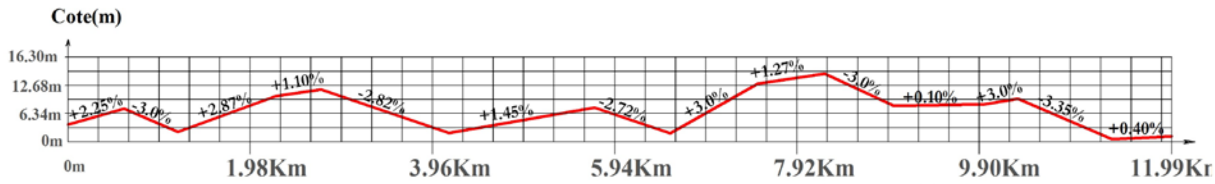


Figure 4. Variant 1(11.99 km)

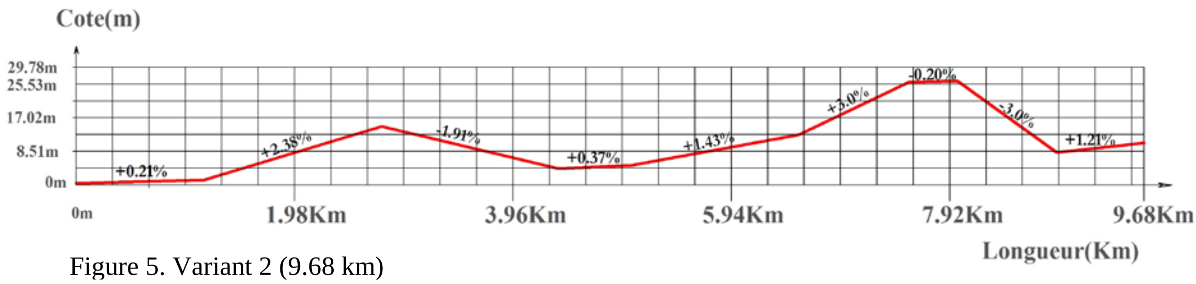


Figure 5. Variant 2 (9.68 km)

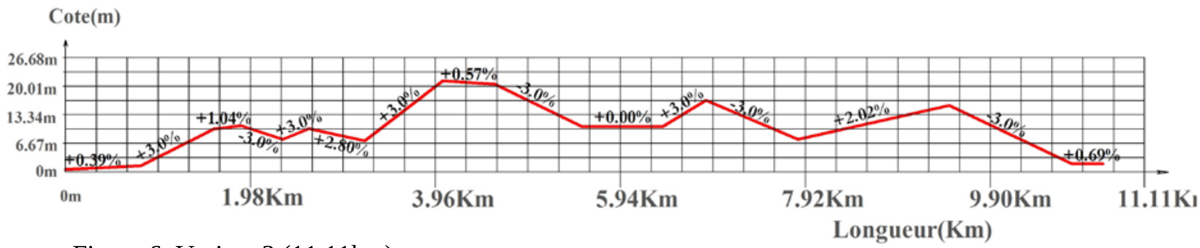


Figure 6. Variant 3 (11.11km)

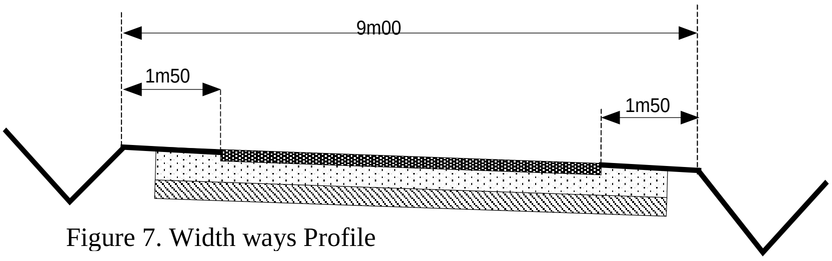


Figure 7. Width ways Profile

Table 3. Specifications of variants (MINTP, 2005).

Specifications	Variant 1	Variant 2	Variant 3
Total length (km)	11.99	9.68	11.11
Passable width (m)	9	9	9
Road's hold (m)	30	30	30
Simple box-culvert, h x w section (m2)	0	PK0+703, 3x2	0
Double box-culvert, section 2(h x w)(m2)	PK3 +127, 2(2x2)		
Reinforced concrete bridge with underneath girder (ml)	0	0	PK8+720, 25m

Table 4. Quantities of variants (Elime, 2005).

Tasks or materials	Variant 1	Variant 2	Variant 3
Excavations (crumbly materials) (*m^3*)	1 363 069	781114	2 180 140
Excavations (hard materials) (*m^3*)	0	390557	726785
Embankment works (*m^3*)	406077.66	314855	350358
Ballasts (transport) (*m^3*)	812155.34	629710	700716
Ballasts (transport) (*m^3*)	681534.5	585835.5	1453570
Stockpiling (*m^3*)	681534.5	585835.5	1453570
Concrete for simple box culverts (*m^3*)	0	46.23	0
Steel for simple box culverts (*tons*)	0	4.62	0
Concrete for double box culverts (*m^3*)	71.1	0	0
Steel for double box culverts (*tons*)	8.88	0	0
Concrete for bridge (*m^3*)	0	0	259.46
Steel for bridge (*tons*)	0	0	34.96
Pavement (*m^3*)	46430	40250	44175

3. 4 Energy flow assessment

In this assessment, we excluded the energy consumed for putting the road infrastructure out of order and the energy flows outside the boundaries of the system: energy used for the fabrication of building materials (cement, bitumen, steel) and the transportation of these materials to the construction site, energy used during the fabrication, and maintenance of machines and their transportation to the construction site, the eventual supply of electricity, etc. In this study we assessed the energy consumed for the construction, the use and the maintenance of the road.

3. 4.1 Evaluation of energy consumed during construction « E_1 »

Energy consumption during construction works was calculated on the basis of Table 5 which gives us unit energy consumption during construction works (MATET, 1995), and the quantities summarized for each variant as summarized in Table 4 . Given that the locations for the disposal of rubble and digging of fills are not known, we adopted a distance for the transportation of materials equal to half of the average distance of these variants, which was 5.46 km, and the density of rubble at 1.8t/m3.

Energy consumption for the construction of the tarred road is calculated according to the total surface area of the road and that of each variant, without excluding construction works (ATR, 1981). The results are presented in Table 6.

Table 5. Unit Energy Consumption at construction (ATR, 1981)

Tasks or materials	**Unit consumption 10^{-4} TOE[1]**
Cuts (loose materials)	3 m^3
cuts (hard materials)	8/m^3
Backfill materials	1.15/m^3
Transport backfill	0.5/t/km
Transport cuts	0.5/t/km
Stockpiling	1.3/m^3
Concrete for structure	400/m^3
Steel for reinforced concrete	6000/t
Tunnel (hard materials)	(3x) 8/m^3
Pavement	600/m^3
Double track guide	200/m

[1] Ton Oil Equivalent

Table 6. Energy consumption in construction for the different variants

Tasks or materials	**Variant 1**	**Variant 2**	**Variant 3**
	TOE	TOE	TOE
Excavations (crumbly materials) (*m^3*)	408.92	234.33	654.34
Excavations (hard materials) (*m^3*)		312.44	581.43
Embankment works (*m^3*)	46.69	36.21	40,29
Ballasts (transport) (*m^3*)	403.51	309.44	344.33
Ballasts (transport) (*m^3*)	334.91	287.88	714.28
Stockpiling (*m^3*)	88.60	76.16	188.96
Concrete for simple box culverts (*m^3*)	0	1.85	0
Steel for simple box culverts (*tons*)	0	2.77	0
Concrete for double box culverts (*m^3*)	2.85	0	0
Steel for double box culverts (*tons*)	5.33	0	
Concrete for bridge (*m^3*)	0	0	10,38
Steel for bridge (*tons*)	0	0	20.98
Pavement (*m^3*)	2785.80	2415	2650.5
E_1 or **Total (in TOE)**	**4076.61**	**3676.08**	**5205.50**

3.4.2 Energy consumption assessment during the use of the road infrastructure « E_2 »
Energy consumption resulting from the use of the road should take into account the following elements: energy consumption linked to the use of equipments « E_{21} » and energy consumption linked to the movement of vehicles « E_{22} ».

3. 4.2.1 Energy consumption linked to the use of equipments « E_{21} ».
Energy consumption from the use of equipments « E_{21} » is at least equal to the product of the energy consumed times the number of working hours during the total life span of the road infrastructure. The stretches under study have no lighting system or any other system that use energy; thus, E_{21} is zero.

3. 4.2.2 Energy consumption linked to the movement of vehicles « E_{22} ».
This energy E_{22} is the sum of fuel consumption by vehicles driving through the stretch under consideration during its life span.

Calculations were made on the basis of the following hypotheses: the average speed of vehicles is 100 km/h (90 km/h for heavy vehicles). The percentage of Diesel Light Vehicles (DLVs) which amounted approximately 15% in 2002 will remain the same until 2012; then, it will move to 36% and remain constant (Elime, 2005). The percentage of Diesel Heavy Vehicles (DHVs), now at 7%, will remain constant throughout the road's life span.

Energy calculations are done both ways to take into account the changes in gradients whose average stands at about 3% and 2%. Traffic in each way being half of the overall traffic defined in the draft projects shown in Table 2. Unit energy consumptions for each category of vehicle are constant over time and are shown in Tables 7 and 8 proposed in (Roumegoux, 1994 and Joumard, 1995)

Table 7. Unit energy consumption by type of vehicles at gradients less than 2% (Roumegoux,1994 and Joumard,1995)

Type of vehicle	k	Energy unit consumption TOE/km:C_k
Catalysed light Vehicle	1	58.7×10^{-6}
Diesel Light Vehicle	2	55.3×10^{-6}
Heavy vehicle	3	257.8×10^{-6}

Table 8. Energy consumption correcting factor depending on the gradient (Roumegoux, 1994 and Joumard, 1995)

Gradient (%)	**Type of vehicle**	**Correction factor**
	Catalysed LV	1.7
5 to 4	Diesel LV	1.8
	HV	3.7
	Catalysed LV	1.3
3 to 2	Diesel LV	1.4
	HV	2.1
	Catalysed LV	0.7
-2 to – 3	Diesel LV	0.7
	HV	0.2
-4 to -5	Catalysed LV	0.5
	Diesel LV	0.4
	HV	0

3. 4.2.2.1 Energy consumption according to the movement of vehicles

For the calculation of energy consumption according to traffic, we used the data in Table 8 that were deducted from Tables 7 and 8. In Table 9**,** le parameter « *m* » refers to a period in the life span, « *k* » is the type of vehicle involved, α_k^m the percentage of « *k* » type vehicles during « *m* » period, P_{1k} and P_{2k} are energy consumption correction factors for “k” type vehicles moving both ways.

Table 9. Unit energy consumption values according to types of vehicles used for calculations

Type of vehicle	**period**	**m**	**k**	α_k^m	P_{1k}	P_{2k}	$P_k = P_{1k} + P_{2k}$	C_k **(TOE/km)**
CLV	2002-2012	1	1	0.78	1.3	0,7	2.0	58.7x10^{-6}
DLV	2002-2012	1	2	0.15	1,3	0,7	2.0	55.3x10^{-6}
DHV	2002-2012	1	3	0.07	2.1	0.2	2.3	257.8 x10^{-6}
CLV	2012-2052	2	1	0.57	1.3	0,7	2.0	58.7 x10^{-6}
DLV	2012-2052	2	2	0.36	1.3	0.7	2.0	55.3 x10^{-6}
DHV	2012-2052	2	3	0.07	2.1	0.2	2.3	257.8 x10^{-6}

Year 2002 being considered as the starting year « *j=0* », and considering the evolution hypotheses presented in Table 2, we obtained Table 10 that gives the overall number of vehicles NC_j for period *j* (corresponding to the interval of time during which the growth rate of traffic is constant).

Table 10. Total number of vehicles plying the road per period

Number j	**Periods**	**Initial annual number of vehicles for various periods**	**Traffic growth rate during the period (λ_j)**	**Total number of vehicles per period:** NC_j
0	2002 to 2012	$n_0 = 365 n_{j0}$	1,035	$\frac{n_0(1-\lambda_0^{11})}{1-\lambda_0}$
1	2012 to 2022	$n_1 = n_0 \lambda_0^{10}$	1,025	$\frac{n_1 \lambda_1 (1-\lambda_1^{10})}{1-\lambda_1}$
2	2022 to 2042	$n_2 = n_1 \lambda_1^{10}$	1,020	$\frac{n_2 \lambda_2 (1-\lambda_2^{20})}{1-\lambda_2}$
3	2042 to 2052	$n_3 = n_2 \lambda_2^{20}$	1,015	$\frac{n_3 \lambda_3 (1-\lambda_3^{10})}{(1-\lambda_3)}$

a) **Scenario 1**

In scenario 1, we assumed that unit energy consumption remains constant over time (Table 9). Scenario 1 is perfectly realistic, given that it provides us with some indications on minimal energy consumptions, because we have noticed that as vehicles grow older, their consumption increases ; we should also point out that most of the vehicles in use in Cameroon (80%) are poorly maintained and whose age is higher than 15 years (Elime, 2005 and Elime, 2002).

Let's get $N_{TV1} = NC_0$ and $N_{TV2} = \sum_{j=1}^{3} NC_j$, we obtain the expression (1) for scenario 1, which is the value of total energy consumption for variant « l » associated with the movement of vehicles during the road's life span.

$$E_{22}^1(l) = C_k P_k \alpha_k^1 d_l \frac{N_{TV1}}{2} + P_k \alpha_k^2 d_l \frac{N_{TV2}}{2} \qquad (1)$$

Where d_l is the length of variant « l » (in km)
and l =1,2 *or* 3

b) **Scenario 2**

In scenario 2, it is assumed that this unit consumption will drop by 50% as from 2022.

Scenario 2 can be envisaged in Cameroon, given that this would correspond to two situations: the first, linked to world requirements on greenhouse effect gases (the Kyoto Protocol on environment protection, 1996), (Elime, 2005, 2002); and the second resulting from the arrival on the market of clean second hand vehicles.

Let's get $N'_{TV1} = NC_0 + NC_1$ and $N'_{TV2} = \sum_{j=2}^{3} NC_j$, we obtain expression (2) for scenario 2, which is the value of total energy consumption for variant « l » linked to the movement of vehicles during the road's life span.

$$E_{22}^2(l) = C_k P_k \alpha_k^1 d_l \frac{N'_{TV1}}{2} + 0.5 P_k \alpha_k^2 d_l \frac{N'_{TV2}}{2} \qquad (2)$$

Where d_l is the length of variant « l » (in km) and $l = 1, 2\, ou\, 3$

Results obtained for each variant and each scenario are summarized in Table 11. When we analyze the total energy consumption linked to the movement of vehicle in both scenarios (see Table 12), we notice that whatever the scenario, variant 1 consumes more energy.

Table 11. Energy consumption linked to the movement of vehicles during the road's life span (50 years)

variants	**Scenario 1**	**Scenario 2**
1	90365	54279
2	72955	42645
3	83733	50295

3. 5 Energy consumption assessment linked to maintenance E_3

In assessing this energy consumption that depends on heavy vehicles' traffic density, we used data in Table 12 (MTRF, 1986 and Pereira et al., 1996) that gives the annual energy consumption for the maintenance of T1 type roads (from 300 to 750 PL/J). Road maintenance carried out every ten years then coincides with the renovation of the wearing course. But thorough road maintenance include other works whose data are not available (Hydraulic works, construction works, right-of-ways, etc.). The complete inventory of energy consumption for the thorough maintenance of roads could thus be largely modified.

Table 12. Annual energy consumption linked to the maintenance of T1 type roads (MTRF,1986 and Pereira et al., 1996),

Type of road	**Specifications**	**Unit consumption TOE/km/yr**
I	2 + 3 ways all bitumen (mix, gravel-slag mixture)	46
II	2 x 2 ways all bitumen (mix, gravel-slag mixture)	32
III	2 ways all bitumen (mix, gravel-slag mixture)	16
IV	1 way all bitumen (mix, gravel-slag mixture)	8

Given the fact that the roadways of variants considered are of type III, we thus obtained annual energy consumptions linked to the maintenance of roadways for the variants presented in Table 13.

Table 13. Overall annual energy consumption for the maintenance of variants

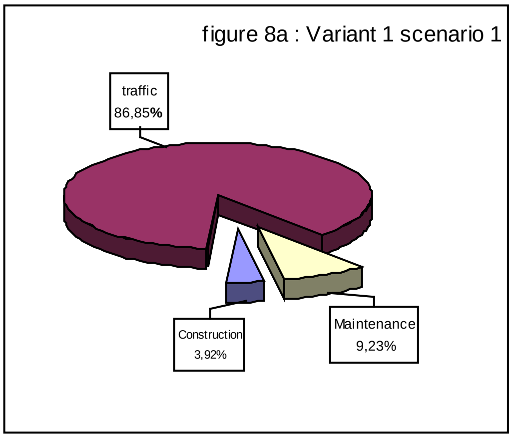
	Variant		
	1	2	3
a_l (TOE/an)	192	155	178
Total maintenance energy E_3 (in TOE)	9600	7750	8900

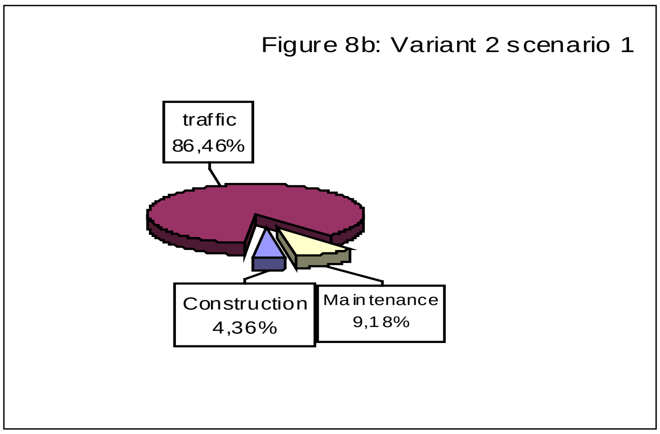
3. 5.1 Inventory of total energy consumption E of the road

The overall energy consumed by the road is, from our hypotheses, the aggregate of energy consumed during construction works, use (overall energy consumed in traffic) and maintenance during the road's life span. Energy consumption values we came out with are summarized in Table 14 and Figures 8 and 9.

Table 14. Total energy consumption « E » of variants

	Variant 1		Variant 2		Variant 3	
Scenario	1	2	1	2	1	2
Variable linked to «E »total energy	V_1^1	V_1^2	V_2^1	V_2^2	V_3^1	V_3^2
Construction « E_1 » (TOE)	4076.61	4076.61	3676.09	3676.09	5205.50	5205.50
Traffic «E_2 »(TOE)	90365	54279	72955	42645	83733	50295
Maintenance « E_3 » (TOE)	9600	9600	7750	7750	8900	8900
Total Energy E **(TOE)**	**104041.61**	**67955.61**	**84381.09**	**54071.09**	**97838.5**	**64400.5**
Overall energy consumption flows TOE/m^2	**0.964**	**0.630**	**0.969**	**0.621**	**0.978**	**0.644**





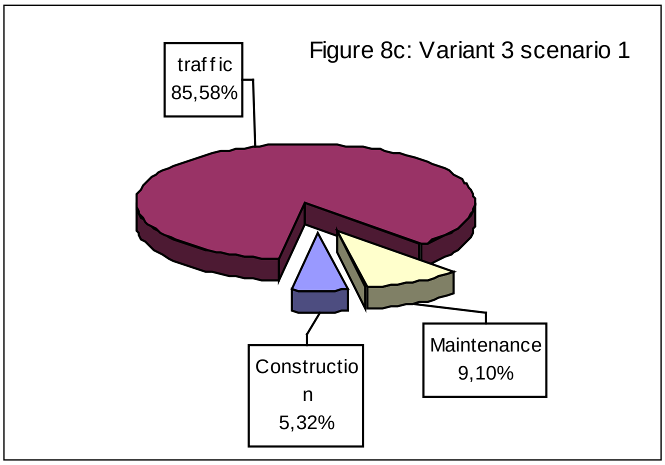
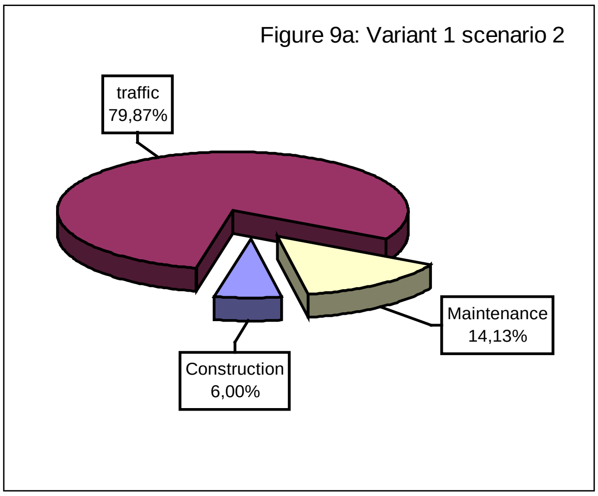
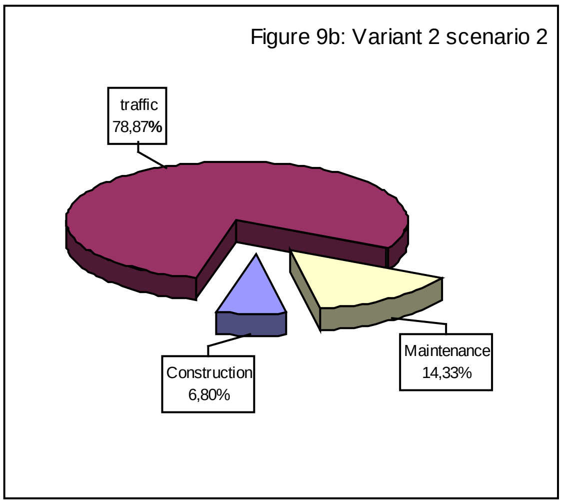


Figure 8. Scenario 1; Energy consumption percentage during the various phases of a road's life span (50 years)





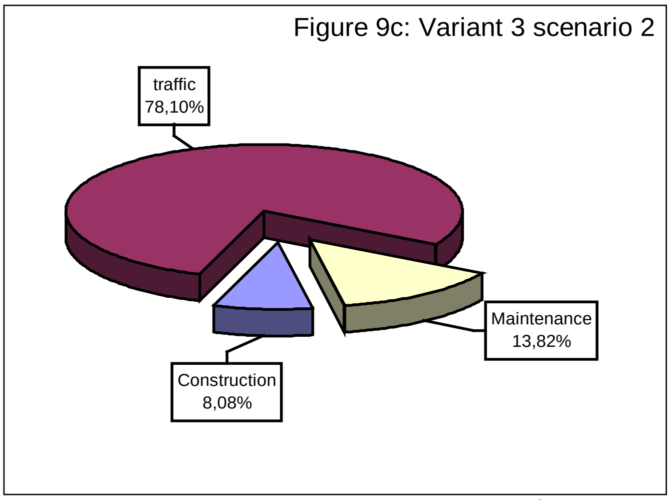


Figure 9. Scenario 2: Energy consumption percentage for the various phases of a road infrastructure over 50 years

4. RESULTS ASSESSMENT

4.1 Mode of energy consumption

Energy consumption at different stages of a road infrastructure for the variants considered is illustrated by Figures 8 and 9.One can notice that this consumption is mainly related to the use of fuel. It is higher than 85.58% for scenario 1 and 78.10% for scenario 2, for any value of variant. It should be noted that when one moves from scenario 1 to scenario 2, energy consumption for the use of the road reduces. This leads, through a simple mechanism, to an increase of the percentage of energy consumed during the construction and maintenance phases, although their values remain constant.

Energy consumption linked to the use of the infrastructure, which in our study is reduced to fuel consumption by vehicles over fifty years, is an important parameter, for it can provide information on the quantity of non renewable energy resources exploited and the volume of taxes a State may derive. During this exploitation phase and from the results obtained, we notice that irrespective of the scenario, variant 1 consumes more energy. Energy consumed amounts to 90365 TOE for scenario 1 and 54279 TOE for scenario 2. On the contrary, the infrastructure that consumes less energy at this stage is variant 2 (72955 TOE for scenario 1 and 42645 TOE for scenario 2).

At construction stage, the infrastructure that consumes more energy is variant 3 (5205.50 TOE). For this variant, the high energy consumption noticed at this stage is due to the presence of a reinforced concrete bridge on the stretch. On the contrary, at this same stage, variant 2 consumes less energy (3676 TOE), in spite of the presence of a double box-culvert on the stretch.

At the maintenance level, we note that variant 2 is the most interesting; because it consumes less energy (7750 TOE). On the contrary, variant 1 consumes most energy at this stage. It is worth to note the low contribution of energy consumption at the construction stage in the energy assessment over 50 years which, irrespective of the scenario and the variant, is less than 8.08%.

Our results correspond to those of Pereira *et al.* (1997), T89 (2005), and Jullien (2005) which show that energy related to maintenance is moderate and higher than 10%, while energy linked to construction and exploitation is average but higher than 80%, in spite of the fact that these authors used a lifespan of 30 years for their roads, while the lifespan used for this study is 50 years

4. 2. General Energy assessment

The overall energy assessment of the different variants during the 50 years (Table 15) shows that whatever the scenario, variant 1 is the most energy consuming (104041 TOE). Variant 2 consumes 84381 TOE and variant 3 consumes 97838 TOE. From the two scenarios considered, scenario 2 consumes less energy with a reduction of about 34% (34.7% for variant 1, 35.9% for variant 2 and 34.2% for variant 3).

Table 15. Comparative studies of total energy consumption for various scenarios

	Variant 1	Variant 2	Variant 3
	$\frac{V_1^2 - V_1^1}{V_1^1}100$	$\frac{V_2^2 - V_2^1}{V_2^1}100$	$\frac{V_3^2 - V_3^1}{V_3^1}100$
Gains obtained in scenario 2 (en %)	-34.7	-35.9	-34.2

5. CONCLUSIONS

Life cycle assessment is more and more used as a tool. The above study presents how life cycle assessment has been applied to a road stretch in Cameroon. Three variants of a same road stretch are compared by using energy consumption as factor of impact. Energy consumption at construction, use and maintenance stages was determined.

From the point of view of global energy consumption, results show that whatever the scenario, variant 2 is the most interesting, for it is the least energy consuming one.

Fuel consumption is the most significant part of overall energy consumption, which is more than 85.6% for scenario 1 and 78.1% for scenario 2. On the basis of this fuel consumption, one notices that variant 1 is the most interesting. Thus, many gains can be derived directly from the conception of infrastructures and vehicles.

In studying a road infrastructure energy impact assessment, life cycle assessment enabled us to determine the quantity of some inputs which, if used as indicators, can help decision makers in choosing variants. However, this methodology which limits itself to the assessment of a road infrastructure energy impact factor should include other social, financial and environmental impact factors, such as atmospheric emissions, water polluting wastes, space consumption, noise, etc., as well

Other issues remain open to research. Many data are unavailable for some impact factors. For energy consumption where data are available, there is a lack of information on energy consumption linked to maintenance. There is a need to update and check the reliability of existing data. The contribution to the life cycle assessment of a road infrastructure in Cameroon paves the way for applications to other transport infrastructure, and may even lead to a comparison between various means of transport.

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