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Directorate C - Energy, Climate and Transport
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Technical Guidelines

for the preparation of applications for the approval of innovative technologies pursuant to Regulation (EC) No 443/2009 and Regulation (EU) No 510/2011

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Commission européenne/Europese Commissie, 1049 Bruxelles/Brussels, BELGIQUE/BELGIË – Tel. +32 22991111
Contact: EC-CO2-LDV-IMPLEMENTATION@ec.europa.eu

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1. INTRODUCTION

1.1. Objectives

These guidelines provide:

- Technical guidance for preparing applications for the approval and certification of innovative technologies (‘eco-innovations’) to reduce CO_2 emissions from passenger cars and from light commercial vehicles.
- Technical guidance for preparing a request to amend an existing approval decision.
- Case studies.
- Input data for the preparation of testing and calculation methodologies.

1.2. Legal background

1.2.1. Regulation (EC) No 443/2009 and Regulation (EU) No 510/2011

Regulation (EC) No 443/2009[1] setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light duty vehicles, provides an average CO_2 emission target for new passenger cars of 130 g CO_2/km from 2015 onwards to be phased-in from 2012. Specific emission targets are assigned to each manufacturer, based on the average specific emissions for each new passenger car registered in the preceding calendar year. Additional measures specified in Commission Communication (2007) 19[2] final should bring a further reduction of 10 g CO_2/km. A new target of 95 g CO_2/km will be phased in from 2020 and fully applicable from 2021.

Similarly Regulation (EU) No 510/2011[3] setting emission performance standards for new light commercial vehicles as part of the Union's integrated approach to reduce CO_2 emissions from light duty vehicles, provides for a short term target of 175 g CO_2/km to be phased in from 2014 and a long term target of 147 g CO_2/km which will apply from 2020.

Article 12 of Regulation (EC) No 443/2009[1] and Regulation (EU) No 510/2011[3] provide a possibility for manufacturers to take into account CO_2 savings from innovative technologies, ‘eco-innovations’ in order to meet their specific CO_2 emissions targets. The Commission will assess applications for the approval of technologies as ‘eco-innovations’. Applications may be submitted by both manufacturers and suppliers. An approval decision may be used by manufacturers for the purpose of certifying the CO_2 savings as part of the type approval process. The maximum savings that a manufacturer may take into account for reducing the average emissions in a given calendar year is 7 g CO_2/km.

> *Example:*
>
> Manufacturer X fits, in year Y, an eco-innovation in 200 000 cars. Each eco-innovation brings a saving of 1.5 g CO_2/km. The total number of new vehicles registered in year Y of that manufacturer is 800 000. The total eco-innovation savings that the manufacturer X can use for reducing its average emissions are:
>
> $$1.5 \cdot \frac{200\ 000}{800\ 000} = 0.4\ \mathrm{gCO_2/km}$$

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[1] Regulation (EC) No 443/2009: http://europa.eu/!tJ77dB

[2] Commission Communication (2007) 19: http://europa.eu/!xx84dR

3 Regulation (EU) No 510/2011: http://europa.eu/!Rd67Bu

The average NEDC emissions in year Y of that fleet is 132.0 g CO_2/km. Since the total eco-innovation savings are less than 7 g CO_2/km, the average emissions can be reduced to 131.6 g CO_2/km.

Testing methodologies for eco-innovations that have been approved by the Commission will be available for manufacturers other than the holder of the approval and may be used for the certification of any relevant vehicle fitted with a technology corresponding to the approved eco-innovation, provided that the minimum savings threshold is met (see second subparagraph of Article 11(2) of Regulation (EU) No 725/2011[4] amended by Regulation (EU) No 2018/258[5]). The approval decisions will be accessible on Eur-Lex as well as on the Commission website[6].

1.2.2. Commission Implementing Regulation (EU) No 725/2011 – eco-innovations for passenger cars

Commission Implementing Regulation (EU) No 725/2011[4] amended by Regulation (EU) No 2018/258[5] establishing a procedure for the approval and certification of innovative technologies for reducing CO_2 emissions from passenger cars pursuant to Regulation (EC) No 443/2009[1] of the European Parliament and of the Council specifies the eligibility criteria and sets out the application procedure.

These guidelines give additional information on how to prepare the application as well as practical examples of potential technologies and testing methodologies.

1.2.3. Commission Implementing Regulation (EU) No 427/2014 – eco-innovations for light commercial vehicles

Commission Implementing Regulation (EU) No 427/2014[7] amended by Regulation (EU) No 2018/259[8] is in all essential elements similar to Commission Implementing Regulations (EU) No 725/2011[4] amended by Regulation (EU) No 2018/258[5].

Eco-innovation savings will be available for manufacturers of complete N1 vehicles, and in the case of multi-stage vehicles, the manufacturer of the base vehicle. These guidelines will apply also with regard to eco-innovations for N1 vehicles. However, it should be noted that the recording of eco-innovation savings in the certificates of conformity for N1 vehicles will be possible from 2016 only (see Directive 2007/46/EC[9]).

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[4] Commission Implementing Regulation (EU) No 725/2011: http://europa.eu/!xC77mW

[5] Commission Implementing Regulation (EU) No 2018/258: http://data.europa.eu/eli/reg_impl/2018/258/oj

[6] DG CLIMA: http://europa.eu/!RG73tN

[7] Commission Implementing Regulation (EU) No 427/2014: http://europa.eu/!jT67kv

[8] Commission Implementing Regulation (EU) No 2018/259: http://data.europa.eu/eli/reg_impl/2018/259/oj

[9] Directive 2007/46/EC: http://europa.eu/!gf96mW

2. PROCEDURE

2.1. Preparing submissions

In the following, 'file' is intended as the documents sent either to submit an application or to request an amendment of an existing decision.

It is recommended to contact the Commission prior to any submission in order to ensure that the file meets all the conditions required to be considered complete. The following functional mailbox can be used: EC-CO2-LDV-IMPLEMENTATION@ec.europa.eu.

Before any submission, every applicant or requester should ensure that the file includes the required supporting documentation. **The assessment of the application starts only if it is complete.**

It is important that the applicant indicates clearly which parts of the application/request for amendment should be considered as confidential commercial information and provides the relevant justifications. The testing methodology will however be publicly accessible once the eco-innovation is approved or once an existing decision is amended.

Before any submission of an application, every applicant shall verify if existing decisions may apply to the proposed eco-innovative technology. In the case where these decisions are not generic (i.e. not directly applicable), the applicant shall use as a basis the testing methodologies from the existing decisions.

2.2. Submitting an application

The procedure to assess eco-innovation applications is composed of the following phases:

1. Informal discussions to prepare applications
2. Official application submission
3. Assessment of the application:
    a. Completeness check
    b. Qualitative pre-screening (if necessary)
    c. Technical assessment and approval of the eco-innovation
4. Publication of the Commission Implementing Decision

The procedure and its duration are outlined in Figure 1 and explained in this paragraph.

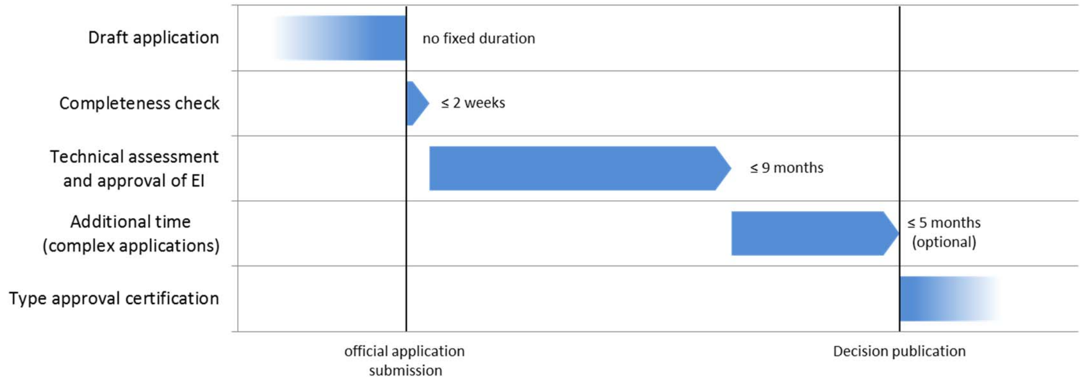

Figure 1: Eco-innovation procedure

2.2.1. *Supporting documentation*

Article 4 of Commission Implementing Regulations (EU) No 725/2011 and (EU) No 427/2014 amended respectively by Regulations (EU) No 2018/258 and (EU) No 2018/259.

To facilitate the check on completeness, the list below provides a detailed checklist of documents which must be provided by the applicant.

The following documents and data should be provided with an application for an innovative technology:

Elements to be provided when submitting an application - Checklist
1. Name and address and contact person of the applicant 2. Short description of the testing methodology, indicating whether the tests are conducted on components, systems or an entire vehicle. 3. Summary of the application for publication 4. List of supporting documentation 5. Technical description of the eco-innovation and the way it is fitted on a vehicle, described in writing and, where appropriate, by technical drawings 6. Demonstration that the proposed technology is innovative (See section 4.2) 7. Prediction on which vehicles Possibly broken down in categories defined for instance using the Inertia Weight classes, etc... the eco-innovation will be applied (estimate only) 8. Expected number of vehicles as a whole (or by categories of vehicles, see point 7) equipped with the particular eco-innovation coming to the market with expected timescale (estimate only) 9. Identification and technical description of the baseline technology[10] 10. Description of the technology characteristics that could cause increased CO_2 emissions (e.g. higher mass, higher drag resistance) 11. Check of possible deterioration effects 12. Description of testing methodology : a. Technology influencing parameters[11] b. Measurement or modelling condition and equipment c. Measurement or modelling procedure d. Method of calculation of CO_2 savings

[10] Article 5 of Commission Implementing Regulations (EU) No 725/2011 and (EU) No 427/2014 amended respectively by Regulations (EU) No 2018/258 and (EU) No 2018/259.

[11] Parameters must be identified and clearly reported, see paragraph 6.2.1

13. Description of the case study. The case study is the particular vehicle or component used in the application to demonstrate the fulfilment of the verifiability criterion (see section 4.4)

14. Application of the testing methodology for the case study and calculation of the corresponding resulting CO_2 savings (differentiated per envisaged vehicle segment, where relevant)

15. Application of uncertainty analysis and quantification of statistical uncertainties to the complete testing methodology

16. Check if all eligibility criteria specified in Article 2 and Article 4(2)(e), (f) and (g) of Commission Implementing Regulation (EU) No 725/2011[4] and (EU) No 427/2014[7] amended respectively by Regulations (EU) No 2018/258[5] and (EU) No 2018/259[8] and (EU) No 2018/259[8]. , described in Chapter 4 of these guidelines, are fulfilled; reasons and evidential data have to be provided for each of them:

    a. Non-exceeding requirements in EU law

    b. Innovativeness of technology

    c. Necessity of technology (non-comfort)

    d. Verifiability of CO_2 saving (minimum threshold)

    e. Coverage by the applicable CO_2 type approval tests

    f. Accountability (influence of driver)

17. Verification report(s)[12] from an independent certification body, according to paragraph 6.6 and including:

    a. Testing protocols of all relevant measurements

    b. Check of fulfilment of the eligibility criteria according to point 20.

    c. Check of possible deterioration effects

    d. Check of suitability of the testing methodology for determining the CO_2 savings from the eco-innovation (for new testing methodologies only)

18. Detailed technical data of case study vehicle(s), and/or components and/or hardware;

19. Data about experimental analyses of deterioration effects or sound argumentation in case of non-existence

20. Identification of interactions with existing approved eco-innovations

[12] Article 7 of Commission Implementing Regulations (EU) No 2018/258 and (EU) No 2018/259: Where the applicant is a group of manufacturers or suppliers, the independent and certified body shall carry out the verifications referred to (...) in relation to each member of the applicant group, where relevant.

Optional elements - Proposal for a simplified evaluation method
21. Description of the simplified evaluation method 22. Description of the demonstration cases. These are multiple case studies used in the application to demonstrate the suitability of the proposed simplified evaluation method. 23. Application of both the testing methodology and the simplified data evaluation method to the demonstration cases and calculation of the resulting CO_2 savings 24. To be added to the verification report (Point 18 of the main Checklist) Check of suitability of the simplified method[13]

2.2.2. Procedure for assessing applications for eco-innovations

Article 10 of Commission Implementing Regulations (EU) No 725/2011 and (EU) No 427/2014 amended respectively by Regulations (EU) No 2018/258 and (EU) No 2018/259.

An OEM or a supplier sends in an application for the approval of an eco-innovation to the Commission. It is important to note that this application should also contain a report of an independent verifier.

After receipt of the application, the Commission starts the assessment. In practice this work is divided between the Joint Research Centre that carries out the technical assessment and the Directorate General for Climate Action that is responsible for preparing the final decision to be adopted by the Commission.

The first step in this process is a completeness check, i.e. whether all necessary documents to start the assessment have been provided with the application. The checklist to evaluate the completeness of the application is described in Chap. 2.2.1. This step should take a maximum of fifteen working days.

If the application is found to be complete, the Commission has nine months, from the date the complete application is received, to finalize the assessment and take a decision to approve or reject it. In case of complex applications, the Commission is entitled to ask for an extension of 5 months and has therefore 14 months to finalize the assessment.

If the application is incomplete, the assessment deadline is not activated and the applicant is asked to provide the missing information. Only when the application is found to be complete will be further assessed. It should also be underlined that if an application cannot be completed within three months from the initial submission, the application will be considered void and the applicant will be requested to submit a new complete application.

The technical assessment of the complete application may take several weeks, depending on the complexity of the technology and the testing methodology.

It may include further exchanges between the Commission and the applicant in order to clarify issues. Such questions are usually submitted to the applicant as a result of the qualitative pre-screening, whose main objective is to verify whether the proposed testing methodology fulfils the basic requirements laid down in section 6.2. The qualitative pre-screening is optional and given as a possibility for the applicant to improve some elements of its application.

[13] When the CO2 savings depend on the vehicle and/or technology parameters, the suitability of the function has to be demonstrated, otherwise not.

The technical assessment should demonstrate that the eligibility criteria are met and that the testing methodology is fit for use. A draft decision is prepared outlining the reasons why the application should be approved or rejected. In case of an approval, the decision includes a description of the technology and the testing methodology or a reference to an already approved methodology. Following a consultation of other Commission services the decision is finally adopted by the Commission and is published in the Official Journal in all languages.

2.3. Submitting a request to amend of a decision

A manufacturer or supplier, including the original applicant, may submit to the Commission a request for an approval decision to be amended. (Article 12a of Commission Implementing Regulations (EU) No 2018/258 and (EU) No 2018/259.)

The procedure to assess requests to amend decisions is composed of the following phases:

1. Informal discussions to prepare the request
2. Official amendment request submission
3. Assessment of the amendment request:
    a. Completeness check
    b. Technical assessment
4. Publication of the amended Commission Implementing Decision

2.3.1. Supporting documentation

The request and all supporting documentation shall also be submitted by electronic mail or electronic data carrier or uploaded to a server managed by the Commission. The written request shall list the supporting documentation.

Elements to be provided when submitting a request to amend of a decision - Checklist
1. Name and address and contact person of the applicant 2. Reference to the approval decision to be amended 3. A short justification and a description of the amendments proposed 4. A summary of the application for publication 5. List of supporting documentation 6. Evidence demonstrating the necessity and the appropriateness of the amendments 7. Description of the case study. In this case, the case study shall demonstrate: a. the fulfilment of the verifiability criterion (see Chap. 4.4) b. In case of an amended testing methodology, the CO_2 savings with both the existing and the amended testing methodologies. 8. When applicable, and in case of an amended testing methodology, the application of uncertainty analysis and quantification of statistical uncertainties 9. When applicable, a specific validation report established by an independent and certified body that verifies the following: a. the amended testing methodology meets the requirements set out in Article 6(1) and, where

applicable, the requirements set out in Article 4(2)(f)(iv);

b. the emissions reduction achieved by the innovative technology as determined using the amended testing methodology or, where appropriate, the new or amended simplified evaluation method or pre-defined CO_2 savings, meets the relevant threshold specified in Article 9(1), taking into account any deterioration over time of the technology.

10. Check of possible deterioration effects

2.3.2. Procedure for assessing a request to amend a decision

The procedure for assessing a request to amend a decision is in its timing and sequence similar to the one used for assessing applications, and depending on the contents of the amendment, the applicant shall verify the following:

- When an amendment is proposed for the scope (i.e. addition of technologies and vehicles which the decision may apply to), the requester shall check that the newly added technologies and vehicles fulfil the innovativeness criterion (Section 4.2).

- When an amendment is proposed for the testing methodology, the requester shall check that the verifiability criterion (Section 4.4) is still fulfilled.

2.4. The recording of the eco-innovation savings in the certificate of conformity

Article 11 of Regulation (EC) No 443/2009[1] and (EU) No 510/2011[14]

A vehicle manufacturer can use eco-innovation CO_2 savings to lower its annual average CO_2 emissions in view of meeting its annual specific CO_2 emission target. The maximum savings that can be taken into account for that purpose are 7 g CO_2/km per year and per vehicle. The manufacturer must submit a request for the certification of the CO_2 savings for an eco-innovation fitted in a vehicle version[15] to the type approval authority. In this request a reference must be given to the relevant approval Commission Implementing Decision. The type approval authority will certify the savings if the manufacturer can demonstrate that the savings for the relevant vehicle version[15] are above the minimum thresholds (1 g CO_2/km for NEDC and 0,5 g CO_2/km for WLTP) .

For NEDC based decisions, the value of uncertainty resulting from Equation 4 in section 6.3.3 shall not exceed 0.5g CO2.

For WLTP based decisions the value of uncertainty resulting from Equation 4 in section 6.3.3 shall be verified. The uncertainty value may or may not be subtracted from the total savings to be certified, subject to the requirements of the approval decision (Article 11 of the Regulation).

[15] In terms of 'vehicle type, variant and version' as defined in Annex II B1 to Directive 2007/46/EC (type approval framework Directive). A vehicle version can differ, for instance in engine capacity, and power output. These differences can influence the CO_2 saving effect.

The certification request should be accompanied by a report with the CO_2 savings based on the specific testing methodology. The certified savings should be indicated in the certificate of conformity of the vehicles concerned.

Approval Commission Implementing Decisions are published in the EU Official Journal and on DG CLIMA website[6].

2.5. The monitoring of the implementation of eco-innovations

Every approved eco-innovation will get its own specific number which can be used to monitor the implementation of these eco-innovations. This monitoring is done by the Member States and the Commission in order to determine the performance of a vehicle manufacturer in meeting its annual targets.

2.6. Information

Detailed information about legislation, approved eco-innovations, and monitoring can be found in the DG CLIMA website[6].

3. DEMONSTRATION OF CO_2 SAVINGS

3.1. Testing methodology

Article 6 of Regulations (EU) No 725/2011 and (EU) No 427/2014

The reference method to demonstrate the CO_2 saving effect of an innovative technology should be to perform vehicle measurements on a chassis dynamometer. However, in accordance with Article 5(2) of Commission Implementing Regulation (EU) No 725/2011[4] and (EU) No 427/2014[7], the ‘testing methodology’ to demonstrate the CO_2 savings could also be based on components tests, simplified calculations or modelling methodologies.

Article 6(1). of Regulations (EU) No 725/2011 and (EU) No 427/2014

In order to ensure a level playing field and to have a common reference for all applications, the type approval 'Type 1' test laid down in:

- UN/ECE Regulation No 83[16] for NEDC based applications;

- Commission Implementing Regulation (EU) No 2017/1151 for WLTP based applications;

should be used as a basis for the measurements.

This includes all the parameters of the testing conditions (e.g. temperature, humidity, vehicle conditioning, road load...) and is not limited to the driving pattern.

For technologies whose functioning is influenced by the driving pattern, the driving pattern (i.e. speed versus time, road-load, gearshifts...) should therefore be used as test cycle for validation purposes within the testing methodologies in terms of velocity-over-time function. Test cycles or driving patterns with other speed/time profiles than the applicable 'Type 1' driving pattern or the restriction or over-weighting of specific parts of that cycle would therefore not be accepted. The driving pattern should therefore be followed as a whole, including an engine start at the beginning of the cycle.

Where it is clear that the CO_2 reducing effect of an innovative technology cannot be adequately demonstrated on a vehicle chassis dynamometer or from the use of the speed/time-profile of the applicable 'Type 1' driving pattern, it should be assessed on a case by case basis whether a deviation from the 'Type 1' driving pattern is appropriate. A request for such deviation in the testing methodology should be supported by a detailed justification. The independent and certified body shall confirm in its verification report that the deviations are appropriate.

> *Example A:*
>
> The CO_2 saving potential of a start/stop system depends on the number and duration of idling phases at the test cycle. A driving cycle with an overweighting of idling phases compared to the NEDC would not be considered representative.
>
> *Example B:*
>
> A technology results in CO_2 savings when the vehicle is operated under warm (start) conditions. The warming up of the vehicle should be done using the NEDC. The impact of the warm non-standard starting conditions should be demonstrated under the NEDC as well. The final CO_2

[16] UN/ECE Regulation No 83: http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/r083r4e.pdf

saving is the difference between the two test results.

Example C:

A technology shows its CO_2 reduction potential mainly at highest vehicle velocities. The maximum speed in the NEDC is 120 km/h, and only the CO_2 emission reduction up to 120 km/h should be considered for the application. An over-weighting of the 120 km/h part of the NEDC (> 7 seconds) would not be considered representative.

3.2. Calculation procedure

Article 8 of Regulations (EU) No 725/2011 and (EU) No 427/2014 2014 amended respectively by Regulations (EU) No 2018/258 and (EU) No 2018/259.

The CO_2 savings of an innovative technology are obtained from one or several tests conducted under modified testing conditions and shall provide the difference between the innovative and the baseline technology.

The corresponding CO2 savings are weighted by a usage factor.

$$\Delta CO_{2_{MC,i}} = (B_{MC,i} - E_{MC,i}) \cdot UF_{MC,i} \qquad i = 1,2, \ldots$$

- $\Delta CO_{2_{MC,i}}$ represents the eco-innovation CO_2 benefits under the modified conditions i
- $B_{MC,i}$ represents the CO_2 emissions of the baseline vehicle under the modified conditions i
- $E_{MC,i}$ represents the CO_2 emissions of the baseline vehicle under the modified conditions i
- $UF_{MC,i}$ represents the usage factor for the modified conditions i

In addition to the above: when active under the type approval conditions, the eco-innovative and the baseline technologies must be tested to subtract the corresponding CO2. Subtracting the benefit of the technology under the type approval conditions, the above formula is generalized as:

Equation 1:

$$C_{CO_2} = \sum_{i=1,2,\ldots} \Delta CO_{2_{MC,i}} - \Delta CO_{2_{TA}}$$

Where:

$\Delta CO_{2_{TA}} = (B_{TA} - E_{TA}) \cdot UF_{TA}$

The parameters addressed by the usage factors shall be carefully assessed by the applicant on a case-by-case basis. In many cases, the above Equation 1 can be simplified (e.g. identical values for $UF_{MC,i}$ and UF_{TA}, UF_{TA}=1, ...).

The definition of the baseline technology/baseline vehicle is crucial for ensuring that the savings obtained are realistic and this will be a key element considered in the assessment of an application. The definition of baseline technology/baseline vehicle should be evaluated on a case by case basis. I.e. it may not be sufficient to simply deactivate the eco-innovation on the baseline vehicle without considering other negative impacts of the eco-innovation (e.g. increase in the mass of the vehicle or in the drag resistance). In circumstances where a baseline vehicle cannot be build up a simulation or expert judgment may be performed.

The CO_2 emissions values $B_{MC,i}$, $E_{MC,i}$, B_{TA} and E_{TA} represent an arithmetic mean of a measurement series of individual and consecutive measurements. The testing conditions (e.g. temperature and humidity at the test cell, battery state of charge, road load...) should be equal for all measurement series and should be identical to the testing conditions of the type approval measurements (except those parameters naturally influencing the innovative technology's performance).

To avoid double counting, the CO_2 savings under modified testing conditions ($B_{MC,i}$ and $E_{MC,i}$ have to be corrected by the CO_2 emissions difference of the same two vehicles measured under type approval testing conditions (B_{TA} and E_{TA}). When it is evident that type approval conditions do not result in differences between CO_2 emissions of baseline and eco-innovation technologies, calculations could be done without measurements under type approval conditions (B_{TA} and E_{TA}). In practice, it is recommended to perform measurements always for all four combinations of technology and testing condition, since this procedure eliminates all possible differences between the eco-innovation and the baseline vehicle not caused by the eco-innovation technology itself.

To properly propose the modified conditions and the usage factors, the applicant shall proceed as indicated in Section 6 to properly justify:

- The parameters are influencing the functioning of the innovative technology;

- The parameters covered by the type approval test, the modified testing conditions and the usage factors.

The uncertainty of the CO_2 savings determined in such a way has to be assessed by the use of appropriate statistical measures (see Chap. 6.3).

3.3. Simplified methods or pre-defined CO2 savings

The applicant or amendment requester **may** propose one or several simplified methods and/or pre-defined values for the CO_2 savings.

The simplified methods or pre-defined CO2 savings shall be designed to limit the testing burden during the the type approval of the vehicle. They only complement the testing methodology, which remains the reference method to determine for the CO_2 savings and to provide higher and more robust CO_2 savings. The simplified methods and/or pre-defined CO2 savings **shall therefore not be proposed when no testing methodology exists**.

The *simplified method(s)* shall be designed to demonstrate the presence and to quantify the impact of the eco-innovative technology, comparing the baseline and the eco-innovative vehicles. The CO_2 savings resulting from the simplified method shall be obtained from a simple parametric function relating the measurements and/or the characteristics of the eco-innovative technology with the CO_2 savings.

The *pre-defined values* for the CO_2 savings shall be proposed in a way to represent the minimum savings achieved with the eco-innovative technology.

To demonstrate the validity and the robustness of the approach, the proposal for simplified methods or pre-defined CO2 savings must be supported by several case studies. For each of these case studies, the CO2 savings shall be presented for both the complete testing methodology and/or the simplified ones.

4. ELIGIBILITY CRITERIA

In the frame of an application, innovative technologies have to fulfil the criteria detailed in sections 4.1 to 4.6. to qualify for an application for eco-innovation.

4.1. Integrated approach measures

Article 2(1) of Regulations (EU) No 725/2011 and (EU) No 427/2014.

Some individual CO_2 saving technologies have been regulated in EU legislation or are going to be developed within a short period of time. Regulations (EC) No 443/2009[1] and (EU) No 510/2011[3] explicitly exclude these technologies from the scope of eco-innovation procedure.

Any technology falling within the scope of the following measures covered by the integrated approach, shall not be considered as innovative technologies:

- Efficiency improvements for air-conditioning systems
- Tyre pressure monitoring systems falling within the scope of Regulation (EC) No 661/2009[17]
- Tyre rolling resistance falling within the scope of Regulations (EC) No 661/2009[17] and (EC) No 1222/2009[18]
- Gear shift indicators falling within the scope of Regulation (EC) No 661/2009[17]
- Use of bio fuels

4.2. Innovativeness

Article 2(2)(a) of Regulations (EU) No 725/2011 and (EU) No 427/2014 amended respectively by Regulations (EU) No 2018/258 and (EU) No 2018/259.

Technologies that are already well represented in the existing fleet should not qualify as eco-innovations. Incentives should only be given to new technologies with a real CO_2 reducing potential with the aim of facilitating their introduction and wide-spread penetration into the market.

For applications submitted before 31 December 2019, technologies with a market penetration of 3% or less in newly registered vehicles in Europe in the reference year 2009 may be considered meeting the innovativeness criterion.

For applications submitted from 1 January 2020, technologies with a market penetration of "3 % or less of all new passenger cars registered in the year n-4, n being the year of application;" may be considered meeting the innovativeness criterion.

Where the innovative technology consists of a combination of several technologies with similar technical features and characteristics (referred to in these guidelines as a ‘technology package’, see Chap. 4.4.2) each individual technology has to fulfil the innovativeness criterion defined above separately.

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[17] Regulation (EC) No 661/2009: http://europa.eu/!Qq67yf

[18] Regulation (EC) No 1222/2009: http://europa.eu/!pp74pN

Applicants are asked to provide supporting information, such as the applicable sales numbers of vehicles already equipped with the innovative technology, or the number of products including the innovative technology that were sold to vehicle manufacturers in that year.

Where no such information is available due to the novelty of the technology, the applicant should provide a statement to that effect. It is recognised that precise data may not always be readily accessible. Where relevant data bases are not available, an estimate based on the best information available to the applicant, such as information about the applicant's own products, should be made. Well-argued expert judgements on market penetration would be considered.

It should be noted that evidence provided to support this part of the application will be made public as part of the summary to be provided in accordance with Article 4(2)(c) of Commission Implementing Regulation (EU) No 725/2011[4] and (EU) No 427/2014[7].

Example A (lighting technologies)

In order to determine the market penetration of lighting technologies, a reference was made to the *CLEPA Light Sight Safety*[19] initiative. As part of that initiative, suppliers of headlamps and rear lamps have individually estimated the penetration rates of innovative technologies in the different lighting applications, based on production in figures the EU for the year 2009.

In a subsequent market review these figures have been condensed to a single value per application and technology. The Commission considered this result as representative since the companies providing the information represent the majority of the actors present in the automotive lighting market in Europe (around 75%).

Type of lighting	**Technology**	**Estimated Fitting rate** ***(new cars, EU 2009)***
Low beam headlamp	LED	<1%
	Xenon (D1/D2) *Mercury-containing*	~13%
	Xenon (D3/D4) *Mercury-free*	~2%
	Xenon (D5/D6/D7) *Low-power (25W)*	0%
High beam headlamp	LED	<1%
	Xenon (D1/D2) *Mercury-containing*	~13%
	Xenon (D3/D4) *Mercury-free*	~2%
	Xenon (D5/D6/D7) *Low-power (25W)*	0%
Front position	LED	~2%
Fog – front	LED	<1%
Turn signal - front	LED	<2%
Rear position	LED	>15%
Fog – rear	LED	<1%
Turn signal – rear	LED	~3%
License plate	LED	<1%
Reversing	LED	<1%

[19] *CLEPA Light Sight Safety*, March 2nd, 2012: http://www.clepa.eu/working-groups/lightsightsafety-initiative-lss/

Example B (engine bay encapsulation)

The market penetration of the engine encapsulation technology has been demonstrated on the report *Market penetration of an underhood encapsulation in the EU in 2009* created by the *Institute for Automotive Engineering – RWTH Aachen University*.

In the study the market penetration of combined thermal management measures in vehicle engine bays in the European Union was analysed for the year 2009. A thermal engine encapsulation is an example for a combined thermal management. Regarding combined thermal management, a market penetration of 0% was defined.

Additionally, the market penetration of active and advanced active thermal management was analysed. Active thermal management can be considered as an intermediate step towards combined thermal management. The market penetration of advanced active thermal management in the EU in 2009 was less than 3%. Overall, it can be found that the share of newly registered vehicles in the EU in 2009 equipped with advanced active thermal management, as well as combined thermal management, did not exceed 3%.

4.3. Necessity (non-comfort)

Article 2(2)(b) of Regulations (EU) No 725/2011 and (EU) No 427/2014

An applicant should demonstrate that the technology does not serve purely for comfort, without any link to either the performance or the safety of the vehicle. A technology that improves the energy use of a vehicle compared to a baseline technology and that in addition is relevant for the transport function of the vehicle could however qualify as an eco-innovation. This would also include technologies which are able to convert unused (internal or external) energy into usable energy or improve the energy storage capacity. However, in order to accurately take into account the extent to which the energy use of a vehicle may be improved through such technologies, it is necessary to get a better understanding of the energy consumed for the operation of devices aimed at enhancing the comfort of the driver or the passengers.

Example A:

Technologies like photo-voltaic elements applied on the vehicles (solar roof), heat recovery systems, more efficient generators and more efficient lighting (LED) may potentially qualify as eco-innovations.

Example B:

Technologies like thermal comfort controls and efficient HiFi systems would not qualify for eco-innovations.

4.4. Verifiability (minimum threshold)

Article 4(2)(f)(i) of Regulations (EU) No 725/2011 and (EU) No 427/2014 amended respectively by Regulations (EU) No 2018/258 and (EU) No 2018/259.

The CO_2 savings of an eco-innovation should be verifiable. Hence, the technical limits of determination of standard measurement equipment should not exceed the total CO_2 savings value. The savings should be calculated in accordance with the procedure described in Chap. 3.2 and should be:

- 1 g CO2/km in the case of NEDC based applications;

- 0,5 g CO2/km in the case of WLTP applications.

For this comparison, calculated CO_2 savings values must be rounded up and expressed to a maximum of two decimal places.

Each value used in the calculation of the CO_2 savings can be applied unrounded or must be rounded up and expressed to a minimum number of decimals which allows the maximum total impact (i.e. combined impact of all rounded values) on the savings to be lower than 0.25 gCO_2/km.

4.4.1. Statistical significance

Article 6(1) of Regulations (EU) No 725/2011 and (EU) No 427/2014

The applicant should demonstrate that the minimum threshold is exceeded in a statistically significant way. A confidence interval of at least 84 % should be observed. This means, that the statistical uncertainty determined as described in Chap. 6.3 and indicated as a standard deviation should not be greater than the difference between the total CO_2 savings and the minimum threshold (see Equation 2).

Equation 2:

$$\mathrm{MT} \leq \mathrm{C}_{\mathrm{CO_2}} - \mathrm{s}_{\mathrm{C}_{\mathrm{CO_2}}}$$

MT: Minimum threshold
$\mathrm{C}_{\mathrm{CO_2}}$: Total CO_2 saving
$\mathrm{s}_{\mathrm{C}_{\mathrm{CO_2}}}$: Standard deviation of the total CO_2 saving (see Chap. 6.3)

If the total CO_2 saving exceeds the minimum threshold but its standard deviation is greater than the difference between the total CO_2 saving and the minimum threshold, the verifiability criterion is not fulfilled. In this case, the applicant should undertake suitable measures to reduce the uncertainty of the total CO_2 saving (e.g. by increasing the number of measurements, by updating the measurement instrumentation, by improving the modelling method).

4.4.2. Technology package

Article 3(a) of Regulations (EU) No 725/2011 and (EU) No 427/2014

The combination of different innovative technologies into one ‘technology package’ to exceed the minimum threshold (1 g CO_2/km for NEDC and 0,5 g CO_2/km for WLTP) should in principle be admissible. The individual technologies combined into one ‘technology package’ should be tested using one and the same testing methodology and should therefore belong to the same technology class as specified in Chap. 5.

The total CO_2 savings should be determined taking into account the interaction between the technologies forming the package. The single CO_2 savings for each technology being part of the package may be shown in the verification report, but only one figure should be reported for the final total savings of the combined technologies, taking into account any potential interaction between the single technologies.

> *Example A:*
>
> A considered valid ‘technology package’ is the combination of different lighting technologies.

Example B:

A combination of heat recovery and lighting system would not be considered a valid 'technology package'.

4.5. Coverage (type approval procedure)

Article 4(2)(f)(ii) of Regulations (EU) No 725/2011 and (EU) No 427/2014

Incentives can be granted to technologies whose CO_2 saving is not or partially covered by the CO_2 type approval test procedure. If the CO_2 reducing effect of an eco-innovation is only partially covered by the type approval procedure, the granted CO_2 saving is the difference between the CO_2 saving at modified testing modalities and CO_2 saving under type approval conditions (see Equation 1): e.g. any savings that can be demonstrated using the normal type approval procedure must be deducted from the total savings of the eco-innovation in order to avoid double counting. Technologies whose CO_2 reducing effects are fully covered by the EC type approval procedure will not qualify.

4.6. Accountability (influence of driver)

Article 4(2)(f)(iii) of Regulations (EU) No 725/2011 and (EU) No 427/2014

CO_2 savings of eco-innovations must be accountable to the applicants (e.g. manufacturers or suppliers, or groups of manufacturers and suppliers). All other possible influencing parameters should be excluded to ensure a verifiable and constant rate of activation. Where basic technical features are not activated permanently during a vehicle's operation, average usage factors should be derived from strong statistical data. Normally, such statistical surveys cannot be performed for new technologies before their market introduction.

In general, only technologies whose CO_2 saving effect is not under the influence of the driver's choice or behaviour would normally qualify. However, devices which can be switched on and off, but are normally activated or deactivated because of changing ambient conditions to ensure a safe operation of the vehicle would be eligible, provided that relevant statistical data can be provided to support the CO_2 reducing effect of the device (usage factor).

Example A:

Lighting as technology can be switched on and off by the user. However, the normal way of using lights will not change with the lighting technology. In this case the technology might be eligible.

Example B:

Amongst the possible technologies that should not qualify as eco-innovations are driver-aid systems indicating the "eco level" of a driver, eco-driving training and engine control systems for more ecological driving that can be switched on/off by the user.

As regards eco-driving devices it should be noted that these could be eligible only where the applicant or requester can prove that these devices have a CO_2 reducing effect that is independent of the driver's behaviour. This could potentially be the case where the device ensures an eco-driving mode regardless of the choices of the driver, i.e. no switch on/off possible.

For any other type of device which depends on the driver behaviour, the applicant or requester would have to demonstrate either that the mere existence of an eco-driving device in a vehicle has a positive and quantifiable effect on fuel consumption/CO_2 emissions. The causal link between the device, the driver's behaviour and the subsequent CO_2 reductions should be statistically proven to such a degree that variations in the driver's behaviour would have an insignificant impact on the final savings (see Chap 6.3). In general, the driver should not be conscious of the existence of the technology.

5. CLASSES OF POTENTIAL ECO-INNOVATION TECHNOLOGIES

Potential eco-innovation technologies have been grouped into classes of similar technical features and characteristics. The following list describes the current state of knowledge, must not be seen as finalised or completed and should not exclude potential technologies belonging to other classes.

The following 9 classes are described:

Class 1: Improved electrical components

Class 2: Improved mechanical components

Class 3: Use of ambient energy sources

Class 4: Heat energy storing systems

Class 5: Kinetic energy storing systems

Class 6: Heat energy – to – electricity converters

Class 7: Kinetic energy – to – electricity converters

Class 8: Measures lowering engine speed

Class 9: Active aerodynamics

5.1. Improved electrical components

Any improvement of the efficiency of electrical components lowers the total electric power requirement. Hence, the mechanical workload of the alternator gets reduced and fuel consumption and CO_2 emissions fall. For calculation approaches it is essential to know the efficiencies of both alternator and engine. For electrical components which are not always activated during vehicle's operation, a particular temporal share of usage has to be taken into account. Possible opponent effects, e.g. caused by extra required control units, have to be taken into account when calculating the CO_2 benefit. Especially for electrical components it is important to check if the 'necessity' eligibility criteria are fulfilled since not every electrical device is essential for the operation of the vehicle.

5.2. Improved mechanical components

Any improvement of mechanical components which lowers the driving resistance of the vehicle leads directly to reductions of fuel consumption and CO_2 emissions. Measures of this class may reduce the rolling resistance, aerodynamic drag or the friction of mechanical devices. They may also improve the engine's efficiency.

5.3. Use of ambient energy sources

Ambient energy sources like solar radiation, wind, heat etc. may be transformed to usable energy by special devices. If these external energy flows are used directly for propulsion of the vehicle or are transformed to electric energy, the energy requirement from on-board fuels gets reduced.

5.4. Heat energy storing systems

Heat energy which cannot be used or only be used at a low efficiency level at a certain time may be stored and used afterwards at a more favourable opportunity. E.g. heat storage by measures of insulation may increase the temperature of vehicle parts and, hence, reduce friction of mechanical components.

5.5. Kinetic energy storing systems

Kinetic energy which cannot be used or only be used at a low efficiency level at a certain time may be stored and used afterwards at a more favourable opportunity.

5.6. Heat energy – to – electricity converters

Waste heat from the exhaust or from the coolant may be transformed to electricity and can therefore reduce the alternator's workload. Possible technologies are:

- Heat exchanger, turbine and generator
- Turbo compressor and generator
- Heat exchanger and thermoelectric semiconductor

Exhaust heat recovery systems reduce the exhaust temperature and increase the exhaust back pressure. This counter-reaction has to be taken into account when determining the CO_2 saving effect of the system. Current standard vehicle models are not able to cover the complex interactions of these systems. Hence, the testing methodology should be based on measurements.

5.7. Kinetic energy – to – electricity converters

Kinetic energy may be transformed to additional electric energy in different ways, like efficiency improvements of the alternator.

In case of efficiency improvement of an already existing converter, the baseline technology is the converter with the highest market penetration at the reference period.

5.8. Measures lowering engine speed

Measures lowering engine speed may include changes in transmission ratios, different gear changing strategies or engine shut-off during idling phases. These measures are widely covered by the type approval test procedure or are influenced strongly by the behaviour of the driver. Hence, the fulfilment of the eligibility criteria has to be checked carefully.

5.9. Active aerodynamics

Devices adapting the vehicle aerodynamic to the environmental conditions or vehicles parameters (e.g. speed, ambient temperature, engine temperature). These devices can modify the drag resistance and, as consequence, the coast down curve.

6. TESTING METHODOLOGIES

6.1. Introduction and general principles

The application for an approval of an innovative technology as eco-innovation has to include a testing methodology which is suitable to robustly quantify the CO_2 saving effect of the technology. The methodology shall provide accurate and verifiable results. In principle, a physical test, a modelling approach or a combination of both may be applied. Occurring statistical uncertainties resulting from the physical or virtual testing (modelling) have to be quantified and reported (see Chap. 6.3).

Where an application for approval concerns a technology for which a testing methodology has already been approved, it is recommended that the application refers to the approval decision setting out the relevant testing methodology. This means that the same testing methodology may be used for several eco-innovations (e.g. alternators, lighting systems), see also Chap 1.1. For information about approved eco-innovations see the DG CLIMA website[6]. The applicant shall always aim at improving the robustness of existing methodologies, using the best available knowledge and practices. When deviations with respect to the approved testing methodologies are proposed, they must be duly justified and the improvement of the robustness must be demonstrated.

Chap. 7 of these guidelines provides a list of reference values which can be used for both NEDC and WLTP based applications. All assumptions – other than those given in Chap. 7 – used for calculating the CO_2 reduction potential of an innovative technology by a testing methodology need to be justified and, if applicable, shall be accompanied by relevant data. Calculation methodologies and equations taken from open literature or technical standard shall be correctly cited. A detailed derivation of equations is in this case not needed.

When applicable, the reference values in Chap. 7 should in principle be used. However, deviations from that rule could be permitted, provided that the applicant justifies the deviation by providing data which are representative for the case of study, based on robust statistical evidence. In this case, a data collection shall be conducted and the data collection protocol and the methodology used to analyse the data shall both be publicly available[20]. The applicant shall demonstrate that the collected data is representative for the European Union. In case of driving data (e.g. speed, acceleration, deceleration, stop times….): the basic characteristics of the collected data must be compared with the ones from the EU WLTP database. The methodology used to analyse the data should not exceed a certain level of complexity in order to ensure its reproducibility by third parties. Specific simulation models owned by the applicant will in principle not be considered as valid basis for demonstrating CO_2 savings.

If the CO_2 savings depend on the vehicle version[15], a parametric function has to be developed and applied. Where such a parametric function cannot remove the differences between the vehicle versions completely, an appropriate security margin added to the resulting CO_2 savings should be taken into account. This ensures that all vehicle versions concerned by the specific eco-innovation application are covered by the proposed testing methodology. The eligibility of the parametric function should be checked by the independent and certified body. The results of this assessment should be included in the verification report (see Chap. 6.6). The derived equations should be used for the certification procedure for a specific vehicle version.

> *Example:*
>
> The CO_2 saving effect of a heat storage measure depends on the engine size of the vehicles. The connection can be described with the following equation:

[20] The requirement for the data to be publicly available applies only when questioning the reference values in Chap. 7

$$C_{CO_2} = A + B \cdot (\text{engine displacement } [cm^3]).$$

This equation has to be submitted together with the engine displacement of the specific vehicle version to the national type approval authority for certification of the CO_2 saving of a specific vehicle version.

6.2. Testing methodology - Development steps

The testing methodology of an eco-innovation saving often consists of:

- A test (physical or virtual) of a component or a vehicle under modified testing conditions;

- Usage Factor(s) describing the mean share of the eco-innovative technology usage under real world conditions.

The purpose of the physical/virtual test is to evaluate the CO_2 reduction between the baseline and the innovative vehicles. The physical/virtual test shall be able to cover the influencing parameters of the eco-innovation technology.

The development of a new or the modification of an existing testing methodology shall be based on the three following steps:

Step 1: Identification of the independent parameter(s) influencing the EI savings: Applicants may use the list in Annex 1 to determine which parameters (or combination of parameters) primarily influence the technology activation and the associated level of savings.

Step 2: Definition of the (modified) conditions under which the eco-innovations savings are measured and/or calculated.

Step 3: Definition of the usage factor(s).

Step 4: Determination of the CO_2 benefits under the 'modified conditions' by means of component/vehicle testing and/or model calculation (physical or virtual testing).

Step 5: Calculation of the CO_2 savings (Multiplication of the tests results in Step 4 by the Usage Factor obtained at Step 3) and the uncertainty.

6.2.1. Step 1 - Parameter(s) identification and selection

In the first step, the applicant shall properly determine which parameter(s) are influencing the technology functioning (e.g. number of accelerations/decelerations, average speed, temperature, driver…). These parameters are responsible for the activation, de-activation and associated level of CO_2 savings. A non-exhaustive list of parameters is provided below and may be used as preliminary checklist.

Examples: Families of parameters and their importance for some technologies (non-exhaustive list)

Families of Parameters (Sub-parameters)	Efficient lightings[21]	Engine encapsulation	Slope predictive energy management
Vehicle (Mass, operating modes, power, fuel)	0	0	++ (Vehicle mass)
Ambient (temperature, humidity, day/night, weather)	+++	+++	0
Environment (Traffic, country, infrastructure)	0	++	+++
Driver (Speed, acceleration, usage of systems...)	+	+	+

At this step, it is not required to establish any relationship between the parameters and the associated levels of CO_2 savings. However, the applicant shall clearly demonstrate:

- The underlying motivations for neglecting some parameters;
- Which parameters have a 'negative effect', i.e. increase the CO_2 emissions of the vehicle.

According to the general principles laid down in paragraph 3.2, the type approval test has to be used "as test cycle for validation purposes within the testing methodologies in terms of velocity-over-time function". As a first step, the applicant shall assess which parameters play a role in the activation/deactivation and the level of savings of the technology to demonstrate:

- Whether the technology is active or inactive under the type approval conditions
- When the technology is active under the type approval conditions, which are the triggering parameter(s) and their values.

> *Example 1*
>
> For efficient lightings, the vehicle systems/lights are off under the type approval conditions. The speed/time profile of the NEDC and all the other parameters have no influence.
>
> *Example 2*
>
> For engine encapsulation, the vehicle is tested "cold" and its conditioning under the Type 1 does not allow the EI technology benefits

6.2.2. Step 2 - Definition of Modified conditions

The 'modified conditions' are intended as conditions under which the CO_2 benefits will be measured and/or calculated. The 'modified conditions' shall be defined in such a way that they trigger the activation of the

[21] Light Emitting Diode

proposed technology allowing for the calculation/measurement of the corresponding CO_2 savings in a robust manner.

The type approval Type 1 test must be used as reference test cycle to define the modified conditions. It provides the reference values (e.g. duration, distance, shares of driving conditions, maximum speed) to be considered for the definition of the modified conditions and the measurement/calculation of the CO_2 savings.

6.2.3. Step 3: Definition of the usage factor(s)

When proposing modified conditions which do not represent the full set of operating conditions for the eco-innovative technology, the ‘usage factor’ shall be used to represent the occurrence of parameter(s) which are not covered under the modified conditions. The usage factor’ has to represent ‘a mean share of technology usage'.

For example, the modified conditions might represent the EI technology usage due to one parameter (e.g. lights on/off, driving cycle characteristics) whereas the usage factor might represent the mean usage of the technology due to parameters which are different from the ones addressed under the modified conditions (e.g. driver, temperature, vehicle mode).

Usage factors must be developed avoiding the ‘double counting’: for instance, for modified testing conditions that exactly represent the real-world usage of the technology, the usage factor shall be equal to 1.

6.2.4. Step 4 - Determination of the CO2 benefits under the ‘modified conditions’ by means of component/vehicle testing and/or model calculation

Once the ‘modified conditions’ are defined as a result of Step 2, the CO_2 benefits can be quantified by means of semi or fully experimental approaches. The CO_2 benefits (ΔCO_2, difference between the CO_2 emissions of the vehicle with and without innovative technology) and the influencing parameters **must be quantified for the reference situations, i.e. both the type approval and the modified condition(s).** Depending on the considered technology and the level of accuracy required, the CO_2 benefits have to be quantified using one of the three following approaches:

- Test method type A: Component / vehicle function testing and estimation of corresponding CO_2 savings over fixed reference conditions;

- Test method type B: Vehicle testing under controlled conditions (both modified and type approval) and measurement or estimation of CO_2 savings;

- Test method type C: Vehicle / component testing under un-controlled conditions (e.g. real-world, vehicle equipped with a data logger and/or fuel consumption meter, PEMS CO_2 analyser).

> *Example 1*
>
> For efficient lightings, only the component is tested, measuring their power consumption and transforming it into CO_2 using the Willans' factors. The CO_2 savings are scaled to the duration of the type approval test, using its duration and distance.
>
> *Example 2*
>
> For engine encapsulation, the entire vehicle is tested at two specific testing conditions: cold and hot start at 14 °C; also the performance of the engine encapsulation is tested evaluating its temperature decay curve. A model is used to convert the testing results into CO_2 savings for each parking time situation.

- In all cases:

The modelling results should in principle be reproducible by a third party with commercial vehicle simulation software. The applicant may have to provide hardware (both baseline and eco-innovation technologies) for validation

The applicant may need to provide comprehensive vehicle data to be used for modelling approaches. A first list of possible data needs include:

- Engine: type, displacement, number of cylinders, number of strokes, idle speed, maximum speed, mass moment of inertia, heat capacity, full load characteristic
- Coolant temperature increase after engine start
- CO_2 emission engine map
- Fuel consumption engine map
- Fuel density
- Efficiency map of alternator
- Gear box: type, number of gears, transmission ratios
- Efficiency map of gearbox
- Axle drive: transmission ratio, efficiency
- Curb weight
- Driving resistance parameters
- Frontal area
- Drag coefficient
- Clutch: maximum transferable torque
- Wheel: inertia moment, dynamic rolling radius
- Alternator: inertia moment, nominal voltage, maximum current, efficiency curve, idle voltage, torque loss
- Battery: nominal voltage, charge capacity, idle voltage, internal resistance
- Data specific for the individual eco-innovation technology

6.2.5. Step 5: Calculation of the CO2 savings and the uncertainty.

Upon completion of the physical or virtual tests, the final CO2 savings is quantified according to the calculation principles laid down in Section 3.2. The resulting uncertainties shall also be quantified according to the methods described in Section 6.3.

6.3. Data quality and uncertainties

The testing methodology should provide verifiable and accurate results as defined in of Article 6(1) Commission Implementing Regulation (EU) No 725/2011[4] and (EU) No 427/2014[7]. The resulting CO_2 savings have to be reproducible by a third party equipped with standard measurement and modelling techniques.

6.3.1. Uncertainty quantification

The uncertainty of the testing methodology's results (due to measurement or modelling uncertainties) should be quantified and delivered with the resulting CO_2 saving value.

To allow a straightforward statistical treatment of test results, it is assumed that the uncertainty distribution is characterized by its standard deviation (being equivalent, in the case of a normally distributed uncertainty, to a 68% confidence interval around the mean). Equation 3 shows the formula to quantify the uncertainty, as standard deviation of the mean.

Equation 3:

$$s_{\bar{x}} = \frac{s_x}{\sqrt{n}} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n(n-1)}}$$

$s_{\bar{x}}$: Standard deviation of the sample mean $\bar{x}$

s_x Standard deviation of the sample x

x_i: Sample data

$\bar{x}$: Mean of the sample data

n: Number of observations of the sample

The uncertainties should be minimised by applying suitable measures. In case of high variation between the individual measurement values, the number of measurements should be further increased to reduce the uncertainty of the resulting mean value.

6.3.2. Propagation of the uncertainties

The propagation of the uncertainties should be taken into consideration.

The uncertainty values of the variables (e.g. individual measurement series) shall be combined to a total value using the uncertainty propagation law (Equation 4) or a more sophisticated 'Monte Carlo method'.

Equation 4:

$$s_{C_{CO_2}} = \sqrt{\sum_{j=1}^{m} \left(\frac{\partial C_{CO_2}}{\partial x_j}\bigg|_{x_j=\bar{x}_j} \cdot s_{\bar{x}_j} \right)^2}$$

$s_{C_{CO_2}}$:	Standard deviation of the total CO_2 saving rounded to two decimal places
$\frac{\partial C_{CO_2}}{\partial x_j}\Big\vert_{x_j=\bar{x}_j}$:	Sensitivity of calculated CO_2 saving related to the variable x_j
$s_{\bar{x}_j}$:	Standard deviation of $\bar{x}_j$
m:	Number of variables with uncertainty

6.3.3. Testing effort and maximum permissible uncertainty

All tests (physical or virtual[22]) should be validated by the independent verification body. Discarded tests have to be documented, and reasons for discarding them have to be given.

All the physical measurements should be performed at least five (5) times.

In case of virtual tests (modelling), the uncertainty should be estimated using a sound engineering judgement: in particular, a list of key parameters and the effect of their variation within a range should be documented.

In exceptional cases, when the applicant can demonstrate an inappropriate high effort in testing, a reduction on the minimum number of physical measurements could be proposed, pending the compliance with stricter requirements on the statistical uncertainty.

In case of high variation between the individual measurement values, the number of measurements should be further increased to reduce the uncertainty of the resulting mean value.

The number or the accuracy of the tests should be increased until the following criteria are fulfilled:

For NEDC based applications:

– The value resulting from Equation 4 is not exceeding 0.5 g CO_2/km;

– The minimum threshold (1g CO_2/km) is exceeded in a statistically significant way (i.e. fulfilling Equation 6).

For WLTP based applications:

- The value resulting from Equation 4 is not exceeding 30% of the CO_2 savings;

- The minimum threshold (0,5 g CO_2/km) is exceeded in a statistically significant way (i.e. fulfilling Equation 6).

[22] Tests simulating the eco-innovative technology functioning and using a model

Uncertainty of the total CO_2 saving

The uncertainty determined for the total CO_2 saving of the proposed testing methodology should not exceed the maximum permissible uncertainty U_{max} (Equation 5).

Equation 5:

$$s_{C_{CO_2}} = \sqrt{\sum_{j=1}^{m}\left(\left.\frac{\partial C_{CO_2}}{\partial x_j}\right|_{x_j=\bar{x}_j} \cdot s_{\bar{x}_j}\right)^2} \leq U_{max}$$

$s_{C_{CO_2}}$: Standard deviation of the total CO_2 saving rounded to two decimal places

$\left.\frac{\partial C_{CO_2}}{\partial x_j}\right|_{x_j=\bar{x}_j}$: Sensitivity of calculated CO_2 saving related to the variable x_j

$s_{\bar{x}_j}$: Standard deviation of $\bar{x}_j$

m: Number of variables with uncertainty

U_{max} Maximum permissible uncertainty (0,5 g CO_2/km for NEDC based applications and 30% of the CO2 savings for WLTP based applications)

Minimum threshold statistical significance

Concerning the check of the fulfilment of the verifiability criterion (see Chap. 6.3.1), the uncertainty determined should not be greater than the difference between the total CO_2 savings and the minimum threshold of 1 g CO_2/km for NEDC based applications resp. 0,5 g CO_2/km for WLTP based applications (see Equation 6).

Equation 6:

$$MT = \leq C_{CO_2} - s_{C_{CO_2}}$$

MT: Minimum threshold of (1 g CO_2/km for NEDC and 0,5 CO_2/km for WLTP)

C_{CO_2}: Total CO_2 saving, rounded maximum to two decimal places

$s_{C_{CO_2}}$ Standard deviation of the total CO_2 saving (see Chap. 6.3.2) rounded to two decimal places

6.3.4. Examples of uncertainty quantification (NEDC based)

In this paragraph, examples about number of tests and uncertainties are described. The examplesare provided for the NEDC case but the principles are similar for the WLTP.

Example A:

Uncertainty of the CO_2 saving criteria

Two vehicles are tested under modified conditions on a roller bench. The results are given in Table 1.

Each of the 2 measurement series described at Table 1 consists of 5 individual values.

The total CO_2 saving (TS) is:

$$\mathrm{TS} = \overline{\mathrm{B_{MC}}} - \overline{\mathrm{E_{MC}}} = 3.57\,\mathrm{gCO_2/km}$$

without consideration of the usage factor.

The usage factor $\mathrm{UF} = 0.7$ has a standard deviation of the mean of $s_{\mathrm{UF}} = 0.05$

The total CO_2 savings (C_{CO_2}) are therefore

$$C_{CO_2} = \Delta CO_{2_{MC}} = \mathrm{TS} \cdot \mathrm{UF} = 2.50\,\mathrm{gCO_2/km}$$

Table 1		
	B_{MC} [g CO_2/km]	**E_{MC} [g CO_2/km]**
Test 1	131.0	127.9
Test 2	133.7	130.4
Test 3	132.4	128.1
Test 4	134.4	130.8
Test 5	130.4	126.8
Arithmetic mean after 5 tests [g CO_2/km]	132.38	128.80
Uncertainty (Equation 4) [g CO_2/km]	0.76	0.77

Uncertainty of the $\Delta CO_{2_{MC}}$ is calculated as such (pursuant Equation 4)

$$s_{\mathrm{TS}} = \sqrt{\sum_{j=1}^{m}\left(\left.\frac{\partial \mathrm{TS}}{\partial x_j}\right|_{x_j=\bar{x}_j} \cdot s_{\bar{x}_j}\right)^2} = \sqrt{s_{B_{MC}}{}^2 + s_{E_{MC}}{}^2} =$$

$$s_{\mathrm{TS}} = \sqrt{(0.76\,\mathrm{gCO_2/km})^2 + (0.77\,\mathrm{gCO_2/km})^2} = 1.08\ \mathrm{gCO_2/km}$$

Uncertainty propagation for the total CO_2 saving (C_{CO_2}) (pursuant Equation 4):

$$s_{C_{CO_2}} = \sqrt{\sum_{j=1}^{m}\left(\left.\frac{\partial C_{CO_2}}{\partial x_j}\right|_{x_j=\bar{x}_j} \cdot s_{\bar{x}_j}\right)^2} = \sqrt{\left(\frac{\partial C_{CO_2}}{\partial \mathrm{TS}} \cdot s_{\mathrm{TS}}\right)^2 + \left(\frac{\partial C_{CO_2}}{\partial \mathrm{UF}} \cdot s_{\mathrm{UF}}\right)^2} =$$

$$s_{C_{CO_2}} = \sqrt{(\mathrm{UF} \cdot s_{\mathrm{TS}})^2 + (\mathrm{TS} \cdot s_{\mathrm{UF}})^2} =$$

$$s_{C_{CO_2}} = \sqrt{(0.7 \cdot 1.08)^2 + (3.57 \cdot 0.05)^2} = 0.78\,\mathrm{gCO_2/km}$$

The uncertainty resulting from the error propagation law exceeds the minimum requirement of 0.5 g CO_2/km.

$$s_{C_{CO_2}} = 0.78 \nleq U_{max}(0.5\,gCO_2/km)$$

Further efforts are necessary to lower the uncertainties.

Minimum threshold statistical significance criteria

The uncertainties of the previous example have been decreased e.g. using a driving robot for chassis dynamometer measurements. All other parameters are unchanged.

The new standard deviations are:

$$s_{B_{MC}} = s_{E_{MC}} = 0.32\ gCO_2/km$$

Following the previous calculation, the uncertainty of the total saving (TS) is

$$s_{TS} = 0.45\ gCO_2/km$$

Uncertainty propagation for the total CO_2 saving (C_{CO_2}) (pursuant Equation 4):

$$s_{C_{CO_2}} = \sqrt{(UF \cdot s_{TS})^2 + (TS \cdot s_{UF})^2}$$

$$s_{C_{CO_2}} = \sqrt{(0.7 \cdot 0.45\ gCO_2/km)^2 + (3.57\ gCO_2/km \cdot 0.05)^2} = 0.36\ gCO_2/km$$

The minimum requirement on uncertainty is now fulfilled.

$$s_{C_{CO_2}} = 0.36\ gCO_2/km < U_{max}(0.5\,gCO_2/km)$$

Equation 6 is also fulfilled:

$$MT \leq C_{CO_2} - s_{C_{CO_2}}$$

$$MT = 1\,gCO_2/km \leq 2.50\,gCO_2/km - 0.36\,gCO_2/km$$

Example B:

Uncertainty of the CO_2 saving

The efficiency of an alternator has been tested in accordance with the ISO 8854:2012 (see Chap 9.5.1 for details).

The test results are the efficiencies of the alternator (η_{A-EI}) at 4 different speeds in rounds per minute (rpm):

- At a speed of 1 800 rpm
- At a speed of 3 000 rpm

- At a speed of 6 000 rpm
- At a speed of 10 000 rpm

For each speed, 5 tests are performed as minimum requirement. The results are given in Table 2.

Table 2					
Speed		**1 800 rpm**	**3 000 rpm**	**6 000 rpm**	**10 000 rpm**
Efficiency η_{A-EI} [%]	Test 1	87.70	89.93	84.89	74.50
	Test 2	88.23	90.46	85.40	74.95
	Test 3	87.53	89.75	84.72	74.35
	Test 4	88.05	90.28	85.23	74.80
	Test 5	88.14	90.37	85.31	74.87
Arithmetic mean [%]		87.93	90.16	85.11	74.70
Uncertainty [%]		0.14	0.14	0.13	0.11

The efficiency of the alternator is calculated as follows.

$$\eta_{A-EI} = 0.25 \cdot \eta_{A@1\,800} + 0.40 \cdot \eta_{A@3\,000} + 0.25 \cdot \eta_{A@6\,000} + 0.10 \cdot \eta_{A@10\,000}$$

$$\eta_{A-EI} = 86.79\%$$

Applying Equation 3:

$$s_{\eta_{A-EI}} = \sqrt{\left(0.25 \cdot s_{\overline{\eta_{A@1\,800}}}\right)^2 + \left(0.40 \cdot s_{\overline{\eta_{A@3\,000}}}\right)^2 + \left(0.25 \cdot s_{\overline{\eta_{A@6\,000}}}\right)^2 + \left(0.10 \cdot s_{\overline{\eta_{A@10\,000}}}\right)^2} =$$

$$s_{\eta_{A-EI}} = 0.00073$$

Uncertainty for the total CO_2 saving (C_{CO_2}) (pursuant Equation 4):

$$s_{C_{CO_2}} = \sqrt{\left(\frac{\partial C_{CO_2}}{\partial \eta_{A-EI}} \cdot s_{\eta_{A-EI}}\right)^2}$$

$$s_{C_{CO_2}} = \frac{(P_{RW} - P_{TA})}{\eta_{A-EI}{}^2} \cdot V_{Pe-P} \cdot CF_P / v \cdot s_{\eta_{A-EI}} = 0.00714\, gCO_2/km$$

$$s_{C_{CO_2}} < U_{max} (0.5\, gCO_2/km)$$

The minimum requirement on data quality is fulfilled.

Minimum threshold statistical significance criteria

The requirement that statistical uncertainty determined should not be greater than the difference between the total CO_2 savings and the minimum threshold is also fulfilled.

$$MT \leq C_{CO_2} - s_{C_{CO_2}}$$

$$MT = 1\,gCO_2/km \leq 2.49\,gCO_2/km - 0.01\,gCO_2/km$$

6.4. Deterioration

The certified CO_2 savings of a particular eco-innovation is related to an aged system. The ageing procedure and the criteria to reach the aged condition of the particular technology should be sufficient to reach the aged condition being equivalent to a total vehicle mileage of 160 000 km or, in case of expected exchange of the technology during a vehicle's lifetime, being equivalent to the innovative technology's expected lifetime.

There is no need to age a complete vehicle system. It would also be sufficient to age the specific technology device under realistic conditions. Even time reduced bench testing under tighter conditions (e.g. higher temperatures) could be feasible.

If there is expected to be no deterioration of the eco-innovation with time and mileage, the applicant should demonstrate this by suitable measurements or by sound argumentation (expert's judgement).

The assessment of the deterioration procedure and the influence of ageing effects to the CO_2 saving effect shall be part of the verification report undertaken by an independent and certified body.

6.5. Interactions

The identification and quantification of interaction between eco-innovations have to be performed by an OEM when it applies for a type-approval certificate for a vehicle fitted with more than one eco-innovation.

Where interaction between eco-innovations cannot be ruled out, the vehicle manufacturer shall indicate this in the application to the type approval authority and shall provide a report from the independent and certified body on the impact of the interaction on the savings of the eco-innovations in the vehicle (see Article 11(4) of Commission Implementing Regulation (EU) No 725/2011[4] and (EU) No 427/2014[7]).

To evaluate the impact of the interactions on the savings, the type approval authorities should - when possible - develop a methodology according to the following principles:

- Apply the general formula (from paragraph 3.2) to calculate the CO_2 savings;

- The baseline vehicle shall have no eco-innovations;

- The eco-innovative vehicle shall have all eco-innovations installed.

This approach can be used as long as the values in the general formula can be expressed as functions of the technology specific parameters. The JRC report on interactions provides guidance for such calculations.

Alternatively, a simplified approach may be used to quantify the interactions using the best available practice published by the Commission.

6.6. Verification report

The applicant shall provide a verification report established by an independent and certified body.

The verification report shall include **a complete scrutiny of the fulfilment of the eligibility criteria and of the suitability of the testing methodology for determining the CO_2 savings** from the eco-innovation.

It shall also include a confirmation that the structure of the testing methodology allows an independent verification of the resulting CO_2 saving by standard measurement techniques or commercial vehicle modelling software.

Where an improved testing methodology is proposed, **the verification report shall specify to what extent the proposed methodology is in contrast to the already approved one**. The verification report shall also consider the deterioration effects. If one or more parametric functions have to be applied, the verification report shall confirm their suitability and accuracy.

The completeness of the verification report is checked together with the completeness of the application, in particular for the presence and the quality of the abovementioned elements.

6.7. Summary of the application or request to amend a decision

When a complete application or a request to amend a decision has been received by the Commission, a summary of the application will be published on the Commission website. This summary is to be prepared by the applicant and should accompany the application. The following items should be included in the summary:

For a complete application:

- Applicant name;
- Summary description of the technology;
- Summary description of the testing methodology or a reference to an approved one ;
- Evidence demonstrating that the innovativeness criterion (section 4.2) is fulfilled;
- Evidence demonstrating that the necessity criterion (section 4.3) is fulfilled;

For a request to amend a decision:

- Requester name;
- Summary description of the technology;
- Reference to the approval decision to be amended;
- A short justification and a description of the amendments proposed;
- Evidence demonstrating the necessity and the appropriateness of the amendments;
- Evidence supporting that the verifiability criterion (section 4.4) is fulfilled;

7. REFERENCE VALUES FOR TESTING METHODOLOGIES

This chapter contains reference values which may be used as input data for the testing methodologies proposed by the applicants. Using them does not require any justification and/or data collection by the applicant.

Unless specified, the reference values apply both to M1 and N1 vehicles.

The reference values are usually expressed as average values for mean European conditions on an annual time basis. Where technical data vary between different vehicle versions[15], a security margin is included in the listed values to ensure that all potential vehicles are covered. Another security factor is included where deterioration effects have to be taken into account.

The data sources of the dataset are described in Annex I of this document.

7.1. Efficiencies

7.1.1. Efficiency of engine

A reduction of electrical or mechanical power requirement lowers fuel consumption rates and CO_2 emissions. The 'consumption of effective power' V_{Pe} describes the reduced fuel consumption with a reduction of required power at a particular point of the engine map and represents the marginal engine's efficiency. Following the 'Willans' approach', the 'consumption of effective power' is nearly constant and almost independent from engine speed at low engine loads.

Type of engine	Consumption of effective power V_{Pe}	Unit
Petrol (V_{Pe-P})	0.264	l/kWh
Petrol Turbo (V_{Pe-PT})	0.28	l/kWh
Diesel (V_{Pe-D})	0.22	l/kWh
LPG (V_{Pe-LPG})	0.342	l/kWh
LPG Turbo (V_{Pe-LPG})	0.363	l/kWh
E85 (V_{Pe-E85})	0.367	l/kWh
E85 Turbo (V_{Pe-E85})	0.389	l/kWh
CNG (G20) (V_{Pe-NG})	0.259	m^3/kWh
CNG (G20) Turbo (V_{Pe-NG})	0.275	m^3/kWh

7.1.2. Efficiency of abaseline alternator (NEDC based applications)

The knowledge about the efficiency of the alternator is essential for the conversion from mechanical into electric power and vice versa:

Efficiency of alternator (η_A)
0.67

7.1.3. Electrical solar system efficiency

The conversion of solar radiation into electric energy, the DC-DC transformation, the storage in a battery and the use by an electrical consumer is linked with energy losses:

Component	Efficiency
DC/DC-converter[23]	0.92
Battery (charge and discharge)	0.94
Temperature, reflection and deterioration effects	0.88

[23] The value is valid in the range of 12V to 48V (secondary). Its applicability to other technologies than the solar roof must be demonstrated by the applicants.

Total solar system (η_{SS})[24]	0.76

7.2. Driving cycle characteristics

Cycle	Distance [m]	Duration [s]	Mean speed [km/h]
UDC	4 052	780	18.70
EUDC	6 955	400	62.60
NEDC	11 007	1 180	33.58

Cycle	Distance [m]	Duration [s]	Mean speed [km/h]
WLTP - Low speed Phase	3 095	589	18.9
WLTP - Medium speed Phase	4 756	433	39.5
WLTP - High speed Phase	7 162	455	56.7
WLTP - Extra high speed Phase	8 254	323	92.0
WLTP	23 266	1 800	46.5

7.3. Fuel characteristics

7.3.1. Fuel densities

Type of fuel	Density at 15 °C [kg/m^3]
Petrol	743
Diesel	833
LPG	550
CNG	0.790
E85	786

[24] The total efficiency of the solar system does not include the efficiency of the PV cells which is already covered by the PV peak power value

7.3.2. Conversion fuel consumption – CO_2 emission

Type of fuel	**Conversion factor l/100 km → g CO_2/km**	
	[100 g CO_2/l]	[g CO_2/l]
Petrol	23.3	2330
Diesel	26.4	2640
LPG	16.3	1629
E85	16.6	1657
	[100 g CO_2/m^3]	[g CO_2/m^3]
CNG (G20)	18.0	1795

7.4. Usage factors

If a technology is not activated to full extent during the whole time of vehicle's operation, a usage factor UF should be applied to the measured or modelled results of CO_2 savings:

7.4.1. M1 Vehicle lighting

Type of lighting	**Usage factor**
Low beam headlamp	0.33
High beam headlamp	0.03
Daytime running light (DRL)[25]	--
Front position	0.36
Fog – front	0.01
Turn signal - front	0.15
Turn signal - side	0.15
Centre High-Mount Stop Light (CHMSL)[26]	--
Rear position	0.36
Stop[26]	--
Fog – rear	0.01
Turn signal – rear	0.15
License plate	0.36
Reversing	0.01

[25] DRL is mandatory for newly type-approved M1 and N1 vehicles since 7 February 2011 (Directive 2008/89/EC and Annex III to Regulation (EC) No 692/2008). DRL is automatically activated with running engine. Potential improvements of DRL technologies are therefore fully covered by the type approval measurements and cannot qualify for an eco-innovation.

[26] The temporal share of deceleration phases during the NEDC amounts to 15.1% in relation to roughly 11% of braking during 'real-world' conditions. Potential improvements of brake lights technologies are therefore fully covered by the type approval measurements and cannot qualify for an eco-innovation.

7.4.2. Shading of solar panels

Vehicles equipped with photovoltaic panels may be shaded by buildings, trees, garages, etc. Hence, the maximum amount of solar radiation cannot be achieved. In this case the usage factor is: (1 – share of shading).

Type of vehicle	**Irradiation of solar panels Usage Factor**
M1 (UF_{IR-M1}) [27]	0.51

7.4.3. Windscreen wipers

Speed of wiper motor	**Usage factor**
low speed (front wiper)	0.08
high speed (front wiper)	0.02

7.5. Power requirements of lighting types

7.5.1. Halogen tungsten

Type of lighting	**Number of lights**	**Halogen tungsten**	
		Nominal power per light [W] (12 V)	**Total electric power [W] (13.4 V)**
Low beam headlamp	2	55	137
High beam headlamp	2	60	150
Daytime running light (DRL)[25]	2	21	52
Front position	2	5	12
Fog – front	2	55	124
Turn signal – front	2[28]	21	13[29]
Turn signal – side	2[28]	5	3[29]
Centre High-Mount Stop Light (CHMSL)[26]	3	5	19
Rear position	2	5	12
Stop [26]	2	21	52
Fog – rear	1	21	26
Turn signal – rear	2[28]	21	13[29]
License plate	2	5	12
Reversing	2	21	52

[27] Conservative value derived from JRC analysis reported in Paper “Battery charging photovoltaic roofs on conventional combustion engine-powered passenger cars: CO_2 benefits for European vehicles”.

[28] Only one side activated

[29] Assuming a 50/50 flashing cycle

7.5.2. Xenon gas discharge

Type of lighting	Number of lights	Xenon high intensity gas discharge (HID)		
		Power per light [W]	Electronic driver [W]	Total electric power [W]
Low / high beam “Xenon 35 W”	2	35	5	80
Low / high beam “new Xenon 25 W”	2	25	5	60

7.6. Emissions due to extra weight[30]

The CO_2 correction coefficient due to the extra mass of the eco-innovative technology and, where applicable, the additional components needed.

Type of fuel	CO_2 correction coefficient due to the extra mass [g CO_2/km kg][31]
Petrol ($\Delta CO_{2_{mP}}$)	0.0277
Diesel ($\Delta CO_{2_{mD}}$)	0.0383

7.7. Total electric power requirements

The vehicle’s total electric power requirement during the NEDC testing under type-approval conditions differs from that one of averaged ‘real-word’ driving.

Driving condition	Type of vehicle	Total electric power requirement [W]
Type-approval NEDC[32]	M1 (P_{TA-M1})	350
	N1 (P_{TA-N1})	350
Type-approval WLTP[33]	M1 (P_{TA-M1})	TBD
	N1 (P_{TA-N1})	TBD
Real-world driving	M1 (P_{RW-M1})	750
	N1 (P_{RW-N1})	750

[30] Value derived from JRC analysis from Report "Parametrisation of fuel consumption and CO2 emissions of passenger cars and light commercial vehicles for modelling purposes, 2011."

[31] The values have been defined with the best available data in 2011 and should be revised as soon as new data is available

[32] All switchable electrical consumers off

[33] TBD

7.8. Solar radiation

7.8.1. Solar radiation in Europe

Applications for technologies converting solar radiation into usable electric energy may use a uniform value. The annual average horizontal solar radiation for Europe on the earth's surface is:

Solar irradiation in Europe(P_{SR}) [W/m²][34]	120

7.8.2. Solar correction coefficient

The gain of additional electric power depends on the electric on-board storage capacity. If the reserved capacity in the battery system on sunny and clear summer days is below 8 Wh (or 0.666 Ah for a 12V battery system) per Watt peak power of the PV panel, the arising solar radiation cannot be used completely because of fully charged batteries. In this case a correction coefficient has to be applied to derive the usable share of the incoming solar energy. For ratios between the given data points in the table below, the solar correction coefficient can be determined by linear interpolation.

Total storage capacity battery system (C_{N_Wh}) / PV peak power (P_P) [Wh/Wp]	1.2	2.4	3.6	4.8	6.0	7.2	> 8
Total storage capacity 12 V battery system (C_{N_Ah}) / PV peak power (P_P) [Ah/Wp][35]	0.10	0.20	0.30	0.40	0.50	0.60	> 0.666
Solar correction coefficient (SCC)	0.481	0.656	0.784	0.873	0.934	0.977	1

7.9. Ambient temperature

The mean ambient air temperature in Europe is calculated considering the distribution of the cars on the European land surface and the car density of the Member States.

Since the temperature encountered by vehicles is dependent on their use, two main vehicle statuses are defined: driving time and parking time.

Driving ambient temperature

The value for the mean ambient air temperature during driving time includes a security margin to cover uncertainties caused by regional differences in ambient temperatures and in the driving distribution over the day.

Mean annual ambient air temperature in Europe during driving time for M1 vehicles (T_{Adt-M1}) [°C][36]	12

[34] Conservative value derived from JRC analysis reported in Paper "Battery charging photovoltaic roofs on conventional combustion engine-powered passenger cars: CO_2 benefits for European vehicles".

[35] The total storage capacity includes a mean usable storage capacity of the starter battery of 10 Ah (12 V). All values refer to a mean annual solar radiation of 120 W/m², a shading share of 0.49 and a mean vehicle driving time of 1 hour per day at 750 W electric power requirement

Mean monthly ambient air temperature in Europe during driving time for M1 vehicles (T_{Mdt-M1}) [°C]					
January	February	March	April	May	June
3	3	7	12	15	19
July	August	September	October	November	December
22	21	17	13	8	4

Parking ambient temperature

The value for the mean ambient air temperature during parking time includes a security margin to cover uncertainties caused by regional differences of ambient temperatures, parking distribution over the day and share of vehicles parked inside garages at higher temperatures.

Mean annual ambient air temperature in Europe during parking time for vehicles (T_{Apt-M1}) [°C]	14

7.10. Parking time distribution

M1 vehicles

	Parking times [h]											
	< 1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
Share of vehicle stops (SVS) [%]	36	13	6	4	2	2	1	1	3	4	3	1

	Parking times [h]											
	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Share of vehicle stops (SVS) [%]	1	3	3	2	1	1	1	1	1	1	1	1

(> 24 h: 7 %)

7.11. Mileages

The mean annual driven mileages for passenger cars in Europe (EU-27) are:

[36] Reference value derived from JRC analysis reported in Malfettani, C. Lodi, T. Huld, and P. Bonnel, "Latest Developments on the European Eco-innovation Scheme for Reducing CO_2 Emissions from Vehicles: Average Input Data for Simplified Calculations", Transp. Res. Procedia, vol. 14, pp. 4113–4121, 2016.

Type of vehicle	Type of fuel	Mean annual mileage [km/y]
M1	Petrol (M_{P-M1})	12 700
	Diesel (M_{D-M1})	17 000
	LPG (M_{LPG-M1})	22 300

7.12. Road roughness

The road roughness coefficients for the road classes from A to C

Road class	Road roughness coefficient (Gr) [m·cycle]
A	$4 \cdot 10^{-7}$
B	$16 \cdot 10^{-7}$
C	$64 \cdot 10^{-7}$

7.13. Stiffness of one tire

The average stiffness of one tire

Type of vehicle	Stiffness (k_1) [N/m]
M1	200 000
N1	300 000

8. QUALIFICATION OF TECHNOLOGIES

In the following, a first, preliminary and not binding, assessment on the potential qualification of vehicle technologies as 'eco-innovation' is given. 'Potentially qualifying' technologies may be linked to certain conditions that are cited in the table in Chap. 8.1. If a technology is assessed as 'potentially non-qualifying', the reasons for this assessment are cited in the table in Chap. 8.2.

8.1. Potentially qualifying technologies

No.	Technology	Technology class	Conditions
Q01	LED exterior lighting	1	Also packaging of different lighting types will fulfil 'verifiability' criterion
Q02	Battery charging solar roof	3	
Q03	Engine heat storage	4	
Q05	Predictive energy management	5	
Q06	Thermoelectric generator	6	Coverage criterion to be fulfilled
Q07	Efficient alternator	7	Verifiability criterion to be fulfilled

8.2. Potentially non-qualifying technologies

No.	Technology	Technology class	Reasons for non-qualification
N01	Efficient HiFi system	1	2.3 - 'Necessity' criterion not fulfilled
N02	Efficient cabin lighting	1	2.4 - 'Verifiability criterion not fulfilled
N03	Start/Stop system	8	2.5 - 'Coverage' criterion not fulfilled
N04	Electronic valve gear	2	2.5 - 'Coverage' criterion not fulfilled
N09	Flywheel	5	2.5 - 'Coverage' criterion not fulfilled
N10	Eco-driving mode	8	2.6 - 'Accountability' criterion not fulfilled
N11	Gear shift indicator	8	2.1 - 'Integrated approach measure' + 2.6 - 'Accountability' criterion not fulfilled
N12	Efficient air-conditioning system	2	2.1 - 'Integrated approach measure' + 2.3 - 'Necessity' criterion not fulfilled
N13	Tyre pressure monitor	2	2.1 - 'Integrated approach measure' + 2.6 - 'Accountability' criterion not fulfilled
N14	Low rolling resistance tyres	2	2.1 - 'Integrated approach measure' + 2.5 - 'Coverage' criterion not fulfilled
N15	Daytime running lights (DRL)	1	2.5 - 'Coverage' criterion not fulfilled
N16	Brake lights	1	2.5 - 'Coverage' criterion not fulfilled

9. APPROVED ECO-INNOVATIONS

The list of approved eco-innovations can be found here:

https://ec.europa.eu/clima/policies/transport/vehicles/cars_en#tab-0-1

Appendix I – Template for an application

NB: In case of:

- proposals for simplified methodologies or pre-defined credits;

- requests for amendments;

Please check the additional information required, detailed in Chapter 2.

1. APPLICANT CONTACTS

Name and address and contact person of the applicant

2. TESTING METHODOLOGY (SHORT DESCRIPTION)

Description of the testing methodology, providing the information required to complete the steps described in section 6.2.

3. SUMMARY OF THE APPLICATION

Summary of the application for publication on the DG CLIMA website[6]. The summary should not contain any confidential information.

A template for the summary of the application is available in Appendix II.

4. LIST OF SUPPORTING DOCUMENTATION

List of documents.

5. TECHNICAL DESCRIPTION OF THE TECHNOLOGY

Technical description of the eco-innovation and the way it is fitted on a vehicle described in writing and, when appropriate, by technical drawings.

6. INNOVATIVENESS

Demonstratiion that the proposed technology is innovative (See section 4.2).

7. VEHICLES DEPLOYMENT PREDICTION

Prediction on which types/categories of vehicles the eco-innovation will be applied (estimate only).

8. MARKET PENETRATION PREDICTION

Expected number of vehicles per vehicle type/categories equipped with the particular eco-innovation coming to the market with expected timescale (estimate only).

9. DEFINITION OF THE BASELINE TECHNOLOGY

Proposal and technical description for the baseline technology.

10. EVALUATION OF NEGATIVE EFFECTS

Description of the technology characteristics that could cause increased CO_2 emission (e.g. higher mass, higher drag resistance).

11. DETERIORATION EFFECTS

When relevant, experimental analyses or sound argumentation of deterioration effects (Section 6.4)

12. TESTING METHODOLOGY

Description of the testing methodology, following the guidance provided in section 6.2.

Identification of the uncertainties and description of the methodology to quantify the statistical uncertainties (see Chap 4.4.1).

13. DESCRIPTION OF THE CASE STUDY

Description of the case study.

14. APPLICATION OF THE TESTING METHODOLOGY

Application of the testing methodology for the case study and calculation of the corresponding resulting CO_2 savings.

15. QUANTIFICATION OF THE UNCERTAINTIES

Application of uncertainty analysis and quantification of statistical uncertainties .

16. CHECK IF ALL ELIGIBILITY CRITERIA

Check if all eligibility criteria specified in Article 2 and Article 4(2)(e), (f) and (g) of Commission Implementing Regulation (EU) No 725/2011 and (EU) No 427/2014[7] and described in Chap. 4 of these guidelines are fulfilled; reasons and evidential data have to be provided for each of them:

1. Non-exceeding requirements in EU law
2. Innovativeness of technology
3. Necessity of technology (non-comfort)
4. Verifiability of CO_2 saving (minimum threshold)
5. Coverage (type approval procedure)
6. Accountability (influence of driver)

17. VERIFICATION REPORT

Verification report(s) from an independent certification body, according to section 6.6 and including:

Testing protocols of all relevant measurements

Check of fulfilment of the eligibility criteria according to point 20.

Check of possible deterioration effects

Check of suitability of the testing methodology for determining the CO2 savings from the eco-innovation (for new testing methodologies only)

Appendix II – Template for the summary description of the application

TITLE OF THE INNOVATIVE TECHNOLOGY

CONTACT DETAILS

Applicants name:	

SUMMARY

Brief description of the innovative technology and its potential CO_2 savings:

INNOVATIVENESS

Market penetration of the new technology based on the reference year 2009:

NECESSITY

Information whether the innovative technology is intrinsic to the efficient operation in terms of performance and/or safety of the vehicle:

TESTING METHODOLOGY

Description of the testing methodology or reference to an existing methodology:

Appendix III – Data sources of Chapter 7

1. Efficiencies

Efficiency of engine

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
Vehicle Emissions Laboratory (VELA)
- Internal measurements

European Association of Automobile Suppliers (CLEPA)

ECE/TRANS/WP.29/2014/27

Efficiency of alternator

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
Vehicle Emissions Laboratory (VELA)
- Internal measurements

ISO 8854:2012 Alternators with regulators - Test methods and general requirements[37]

European Association of Automobile Suppliers (CLEPA)

Electrical solar system efficiency

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
Vehicle Emissions Laboratory (VELA)
European Solar Test Installation (ESTI)[38]
- Internal measurements based on:

Hacker, F.; Zimmer, W.; Vonk, W.; Bleuanus, S.: Assessment of eco-innovation technologies - Final report. On behalf of the European Commission, framework contract no.: ENV/C.5/FRA/2006/0071. 18 May 2010.

2. Driving cycle characteristics

WLTP: EC, Regulation (EU) No 2017/1151 of 1 June 2017 supplementing Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and

[37] ISO 8854:2012:

[38] European Solar Test Installation (ESTI): http://re.jrc.ec.europa.eu/esti/

Commission Regulation (EU) No 1230/2012 and repealing Commission Regulation (EC) No 692/2008, Off. J. Eur. Union. OJ L 175 (2017) 1–643.

NEDC: UN/ECE Regulation No. 83: Uniform provisions concerning the approval of vehicles with regard to the emission of pollutants according to engine fuel requirements[39].

3. FUEL CHARACTERISTICS

Fuel densities

European Commission - Joint Research Centre
Institute for Energy and Transport

Commission Regulation (EC) No 692/2008 of 18 July 2008 implementing and amending Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information[40]

Hass, H.; Huss, A.; Maas, H.: Tank-to-Wheels Report Report – Version 4.a. JRC Technical Reports[41]

Conversion fuel consumption - CO_2 emission

European Automobile Manufacturers' Association (ACEA) / Verband der Automobilindustrie (VDA)

4. USAGE FACTORS

Vehicle lighting

European Association of Automobile Suppliers (CLEPA)

Shading of solar panels

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
Vehicle Emissions Laboratory (VELA)
- Internal calculations, based on vehicles GPS-data in the city of Modena.

Hacker, F.; Zimmer, W.; Vonk, W.; Bleuanus, S.: Assessment of eco-innovation technologies - Final report. On behalf of the European Commission, framework contract no.: ENV/C.5/FRA/2006/0071. 18 May 2010.

Windscreen wipers

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
- Expert judgement

[39] UN/ECE Regulation No 83: http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/r083r4e.pdf

[40] Regulation (EC) No 692/2008: http://europa.eu/!Fp86uj

[41] Tank-to-Wheels Report: http://europa.eu/!tU34TV

5. POWER REQUIREMENTS OF LIGHTING TYPES

Halogen tungsten

European Association of Automobile Suppliers (CLEPA)

Based on input from CLEPA Light Sight Safety given in December 2012

Xenon gas discharge

European Association of Automobile Suppliers (CLEPA)

Based on input from CLEPA Light Sight Safety given in December 2012

Total electric power requirements

European Automobile Manufacturers' Association (ACEA) / Verband der Automobilindustrie (VDA)
European Association of Automobile Suppliers (CLEPA)

6. EMISSIONS DUE TO EXTRA WEIGHT

Mellios, G.; Hausberger, S.; Keller, M.; Samaras C.; Ntziachristos L.; Dilara P.: Fontanas G.: Parametrisation of fuel consumption and CO_2 emissions of passenger cars and light commercial vehicles for modelling purposes. JRC Scientific and Technical Reports.
European Commission - Joint Research Centre
Institute for Energy and Transport

7. SOLAR RADIATION

Solar radiation in Europe

European Commission - Joint Research Centre
Institute for Energy and Transport
Renewable Energy Unit
- Photovoltaic Geographical Information System (PVGIS)[42]

Solar correction coefficient

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
Renewable Energy Unit
Vehicle Emissions Laboratory (VELA)
- Internal calculations based on measurements of solar radiation in Europe by the BSRN Network[43]

8. AMBIENT TEMPERATURE

European Environment Agency
European Commission - Joint Research Centre
Institute for Energy and Transport

[42] Photovoltaic Geographical Information System (PVGIS): http://re.jrc.ec.europa.eu/pvgis/

[43] World Radiation Monitoring Center (WRMC): www.bsrn.awi.de

Sustainable Transport Unit
Renewable Energy Unit
- Internal calculation based on:

Global and European temperature (CSI 012). Assessment published June 2010[44]
Corine Land Cover 2006[45]
ECMWF operational forecast data[46]
TRACCS transport data collection[47]

9. ENGINE STARTING TEMPERATURE

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
Vehicle Emissions Laboratory (VELA)
- Internal measurements

10. PARKING TIME DISTRIBUTION

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
- Expert judgement based on:

Kühlwein, J.: Unsicherheiten bei der rechnerischen Ermittlung von Schadstoffemissionen des Straßenverkehrs und Anforderungen an zukünftige Modelle. - Dissertation, University of Stuttgart, 30.11.2004[48]

Infras AG: Handbook emission factors for road transport (HBEFA). Version 3.1. Parking time distribution for Switzerland[49]

11. MILEAGES

University of Stuttgart, Germany
Institute for Energy Economics and the Rational Use of Energy
Unit for Technology Assessment and Environment

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
- Internal calculations based on:

Transport & Mobility Leuven, Belgium: TREMOVE: an EU-wide transport model (Calculations for Euro 3, Euro 4 and Euro 5 passenger cars in 2010)[50]

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[44] Global and European temperature (CSI 012/CLIM 001): http://europa.eu/!KW77kj

[45] Corine Land Cover 2006: http://europa.eu/!mK84bQ

[46] ECMWF: http://old.ecmwf.int/research/ifsdocs/CY38r1/

[47] TRACCS: http://traccs.emisia.com/

[48] Uncertainties in the arithmetical determination of pollutant emissions from road traffic and demands on future models: http://elib.uni-stuttgart.de/opus/volltexte/2004/2079/

[49] HBEFA: http://www.hbefa.net/e/index.html

TRACCS transport data collection[51]

12. ROAD ROUGHNESS

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
- Expert judgement based on:

Zuo, L.; Nayfeh, S.A.: Structured H2 Optimization of Vehicle Suspensions Based on Multi-Wheel Models. Vehicle System Dynamics, Vol. 40, No. 5, pages 351 – 371

Greco, G.; Nepote, A.; Van Grootveld, G.; Martini, G.: Kinetic Energy to Electric Energy Conversion Using Regenerative Shock Absorbers. FISITA 2014 World Automotive Congress p. F2014-IVC-020[52]

13. STIFFNESS OF ONE TIRE

European Commission - Joint Research Centre
Institute for Energy and Transport
Sustainable Transport Unit
- Expert judgement based on:

van Zyl, S.; van Goethem, S.; Kanarachos S.; Rexeis, M.; Hausberger, S.; Smokers, R.: Study on Tyre Pressure Monitoring Systems (TPMS) as a means to reduce Light-Commercial and Heavy-Duty Vehicles fuel consumption and CO_2 emissions. Final Report. TNO 2013 R10986[53]

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[50] TREMOVE economic transport and emissions model: http://www.tmleuven.be/methode/tremove/home.htm

[51] TRACCS: http://traccs.emisia.com/

[52] FISITA 2014 World Automotive Congress p. F2014-IVC-020: http://www.fisita2014.com/programme/sessions/F2014-IVC-020

[53] TNO 2013 R10986: http://europa.eu/!uC94hG