VCA, 1 Eastgate Office Centre,
Eastgate Road, Bristol, BS5 6XX, United Kingdom
enquiries@vca.gov.uk |
www.vehicle-certification-agency.gov.uk |
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Vehicle Certification Agency

Decision Number: 2022/563977-VCA

Issue: 0

Official Decision – Eco-Innovation Approved

Legislation

Statutory Instruments 2019 no. 550, *The Road Vehicle Emission Performance Standards (Cars and Vans) (Amendment) (EU Exit) Regulations 2019.*
(In particular: Amendment of Commission Implementing Regulation (EU) No 725/2011 and 427/2014)

Details

Reason for Record: Application approved

Application Details

Applicant Name and Address:	Stellantis, Engineering Center Germany Bahnhofsplatz, IPC S1-04, D-65423 Rüsselsheim/Germany
Application Title/Description:	Smart Diesel Fuel Heater
Date submitted:	31/03/2022

Assessment Details

Assessment Number:	RDX563977
Date of Assessment Completion:	28/11/2022

Conclusion

The above-mentioned Application was assessed by the Vehicle Certification Agency in accordance with the above-mentioned legislation and was found to comply in all respects.

As of the date below, this Official Decision, and its Annexes, may allow manufacturers to benefit from a reduction of its average specific CO_2 emissions in the United Kingdom, by means of the CO_2 savings from the use of the innovative technology approved by this Official Decision. This shall be done in accordance with the above-mentioned legislation and shall reference this Decision in the application for a GB type-approval for the vehicles concerned.

Signature:	C McCABE Chief Technical and Statutory Operations Officer
Date:	16/12/2022
Assigned eco-innovation code for UK:	38 (aligned to EU)

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Information regarding Certification of CO_2 Savings

1. A manufacturer may apply to VCA for certification of the CO_2 savings in the UK from the use of the innovative technology by reference to this Decision.

2. The manufacturer shall ensure that the application for the certification is accompanied by a verification report from an independent and certified body confirming that the technology conforms to the intended scope of the approved eco-innovation and meets any relevant technical requirements as set out in the Annexes.

3. the manufacturer shall ensure that the certified CO_2 savings and the eco-innovation code are recorded in the certificate of conformity of the vehicles concerned.

4. VCA shall ensure that CO_2 savings achieved from the use of the innovative technology have been determined using the methodology set out in the Annexes.

5. Where a manufacturer applies for the certification of the CO_2 savings for more than one type of this innovative technology in relation to one vehicle version, VCA shall determine which of those tested delivers the lowest CO_2 savings. That value shall be used for the purpose of paragraph 6.

6. VCA shall record the certified CO_2 savings calculated in accordance with the approved methodology (with the quantified uncertainty subtracted from the total savings to be certified) and the eco-innovation code referred to in this Decision in the relevant type-approval documentation.

7. In the case pre-defined CO_2 savings determined in accordance with Article 4(2)(ea) of Retained Implementing Regulation (EU) No 725/2011 and 427/2014, the relevant pre-defined savings value may be entered directly into the type approval documentation, provided that VCA is in a position to confirm that the vehicle is fitted with the technology in accordance with the specifications of this Decision.

8. VCA shall record all the elements considered for the certification in a test report and keep that together with the verification report referred to in paragraph 2.

9. VCA shall only certify CO_2 savings from the use of the innovative technology if it finds that the technology conforms with this Decision, and if the CO_2 savings determined in accordance with paragraph 6 are 0,5 g CO_2/km or higher, as specified in Article 9(1)(b) of Retained Implementing Regulation (EU) No 725/2011 in the case of passenger cars, or in Article 9(1)(b) of Retained Implementing Regulation (EU) No 427/2014 in the case of light commercial vehicles.

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Annexes

	Title	Number of pages
Annex I	*Stellantis Application ECO Innovation Smart Diesel Heater (VCA)*	57
Annex II	*Extracts from Commission Implementing Decision (EU) 2022/716 Test Methodology to support UK Official Decision (aligned methodology)*	1

ANNEX I

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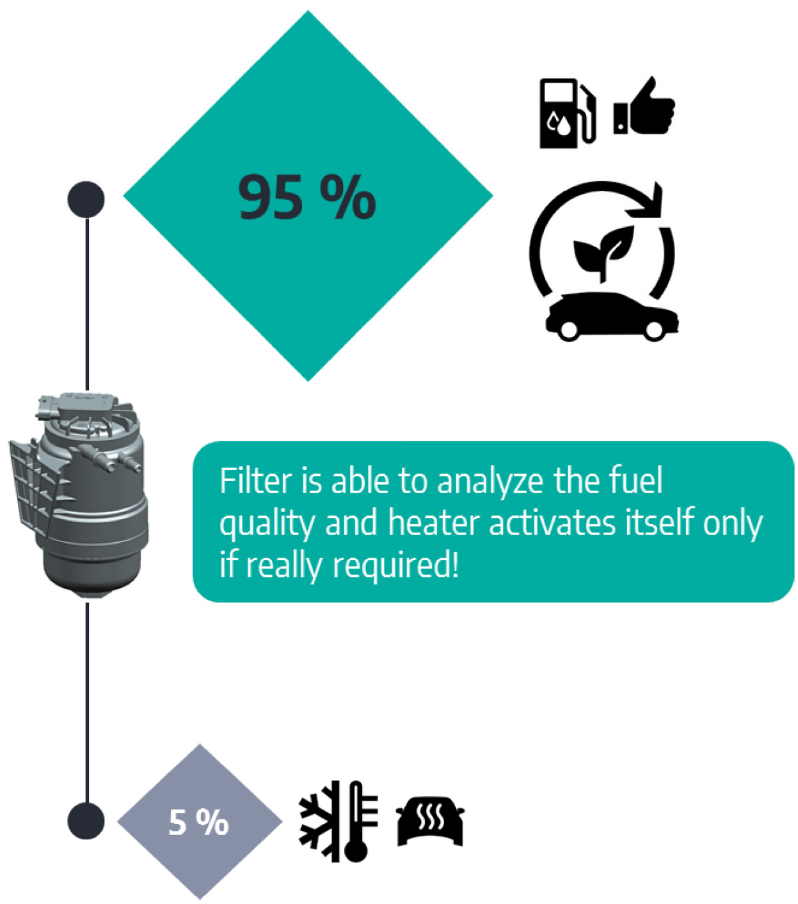
STELLANTIS

ECO Innovation Application
“Smart Diesel Fuel Heater”



Index	Date	Modifications
DRAFT	01/12/2021	
1.0	31/03/2022	Official submission

Table of content

Abbreviations

ADAC	Allgemeiner Deutscher Automobil-Club
KBA	Kraftfahrt-Bundesamt
CP	Cloud Point
CFPP	Cold Filter Plugging Point
DWD	Deutscher Wetter Dienst (German Weather Service)
ECU	Electronic Control Unit
FWD	Front Wheel Drive
HPP	High Pressure Pump
JRC	Joint Research Center
LCV	Light Commercial Vehicle
ME	Measurement Equipment
UF	Usage Factor
UK	United Kingdom
PC	Passenger Car
PTC	Positive Temperature Coefficient
RDE	Real Drive Emission

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UK Approval Authority

Vehicle Certification Agency

16-Dec-22

1 Applicant Contacts

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[redacted]

2 Testing Methodology (short description)

The proposed test methodology is a combination of modelling approach and physical test to calculate the CO_2 savings for improved electrical components. Therefor information obtained from vehicle testing as well as modelling data the usage factor is based upon is considered. Modeling data means the information on which the UF is based on, such as heater characteristics, fuel data, ambient temperature data etc.

$$C_{CO_2} = (P_{Base} - P_{Eco}) \cdot \frac{V_{Pe-D} \cdot CF_D}{\eta_A \cdot v} \cdot UF$$

C_{CO_2}: CO_2 savings [g CO_2/km]
P_{Base}: Electrical power consumption with base technology [W]
P_{Eco}: Electrical power consumption with ECO innovation technology [W]
V_{Pe-D}: Consumption of effective power for Diesel-driven vehicles [l/kWh]
η_A: Efficiency of the alternator [-]
CF_D: Conversion factor (l/100 km) - (g CO_2/km) for Diesel fuel [g CO_2/l]
v: Mean driving speed of the WLTP [km/h]
UF: Usage factor [-]

The electrical power consumption of the base heater technology (P_{Base}) and under modified conditions (P_{Eco}) is determined with physical testing or sound expert judgement, as further explained throughout the application.

The usage factor UF represents the mean share of the innovative technology usage under real world conditions once applied to a vehicle. Amongst others, it considers fuel quality, ambient temperature, technical component characteristics as well as traffic counting data.

3 Summary of the Application

3.1 Title of the Innovative Technology

Smart Diesel Fuel Heater

3.2 Contact Details

Applicants name:	Stellantis N.V. The Corporate Seat of Stellantis N.V. is situated in Amsterdam (The Netherlands) and its Corporate Office is in Lijnden (The Netherlands), Singaporestraat 92, 1175 RA.

3.3 Summary

The diesel fuel heater activates itself based on the dynamic paraffin load situation of the filter cartridge. On average this drives significant heater activation time reduction compared to the baseline technology and CO_2 savings higher than 0.5 g CO_2 / km according WLTP conditions.

3.4 Innovativeness

Potential market penetration assessed lower than 3% on the reference year n-3 (2019).

3.5 Necessity

The technology is required for safe vehicle operation.

3.6 Testing Methodology

The proposed test methodology is a combination of modelling approach and physical test to calculate the CO_2 savings for improved electrical components.

This Eco Innovation application has also been submitted to the EU **Yes**

4 List of supporting Documentation

[redacted]

5 Technical Description of the Technology

Diesel fuel needs to be filtered according engine requirements to ensure a high-quality combustion process and proper customer vehicle operability. Unlike gasoline fuel, diesel fuel has the inherent characteristic that at a fuel specific low temperature the heaviest paraffins start to precipitate and form wax crystals. This temperature is called “Cloud Point (CP)” and below it, the fuel becomes increasingly “cloudy”. The paraffins clog the filtration elements within the fuel system leading to non-startability of the engine, misfire or loss of engine power while driving. Figure 1 visualizes this situation exemplarily and the right side of the figure shows a clogged filter cartridge.

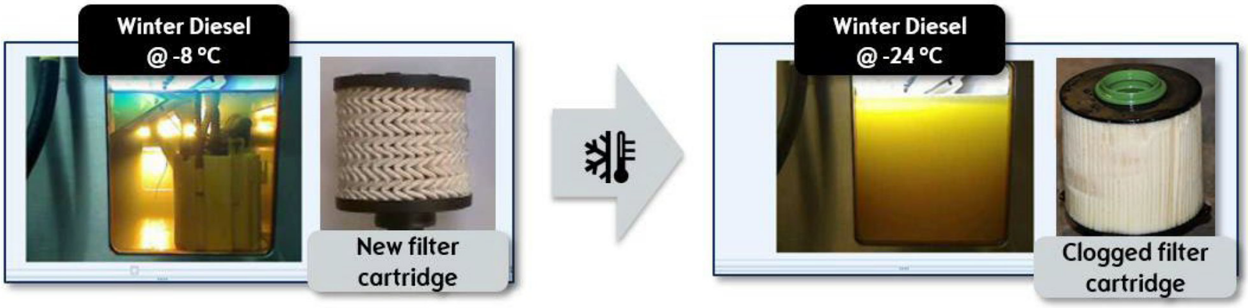

Figure 1: Example new vs. clogged filter cartridge

Furthermore, the lowest temperature at which the fuel can still flow through the filter according a standardized laboratory procedure is characterized as “Cold Filter Plugging Point (CFPP)”.

Fuel filter integrated heating devices are widely used in the automotive industry to melt in-fuel paraffins in order to prevent diesel filter clogging during cold climatic. However, this problem is not limited to cold climatic only since paraffins could appear also on temperatures above 0 °C depending presented local fuel quality tailored in accordance to the climatic conditions. Today these heating devices are often activated even if the present fuel quality is sufficient to operate the vehicle without appliance of a heater. This is driven by the fact that the heater activation is simply controlled by a temperature threshold (open loop control) that needs to be chosen based on expected present fuel qualities relevant to ensure robust vehicle operability for the customer. The fuel temperature is sensed inside the fuel filter near the inlet. Since climatic conditions and fuel properties widely vary all over the world - even looking on Europe only where fuel properties are widely not standardized related to the CP - the temperature threshold drives heater activation very early for most of the countries (e.g. see Figure 2). However, this open loop control strategy works technically fine to ensure vehicle operability, leads to moderate component integration cost and requires relatively low technical complexity.

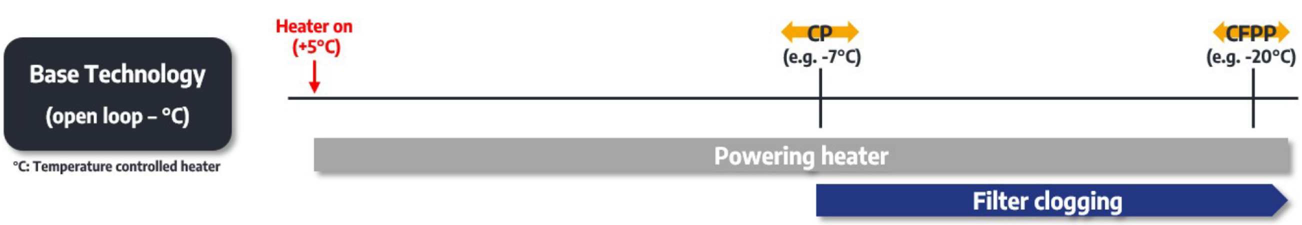

Figure 2: Base Technology - Heater control strategy (open loop)

In relation to other electrical automotive consumers, diesel fuel heaters settle amongst the top consumers (see Table 1). Representations of Varta Automotive[1] or Allgemeiner Deutscher Automobil-Club (ADAC)[2] show comparable insights.

1 Varta Automotive, https://bit.ly/3fHMhe6, retrieved on 29.03.22
2 Allgemeiner Deutscher Automobil-Club (ADAC), https://bit.ly/34klVJU, retrieved on 29.03.22

Electrical Consumer	Power [W]
PTC Cabin Heater	1000
Heated Front Windscreen	700
Electrical Water Pump (Engine)	600
Diesel Fuel Heater (Fuel System)	**300**
Heated Fear Window	300
Urea Heater (Fuel System)	250
Diesel Glow Plugs (Engine)	210
Lights (High Beam)	150
Cooling Fan (Engine)	150
Lights (Low Beam)	135

Table 1: Electrical Automotive Consumers (Stellantis Internal Representation)

In order to activate the fuel heating device only when it is required to prevent filter clogging we propose to consider an innovative activation strategy. Besides the temperature threshold, the filtration-media loading caused by paraffin's shall be taken into account in order to activate the heater earliest at the fuel specific CP temperature. In other words, the diesel filter shall be enabled to analyze the given fuel quality and activates itself as soon as required (see Figure 3). The heating device will be in activated state when paraffin's occur below the fuel specific CP and start to clog the filtration media. This two-way controlled regulation strategy (closed loop) tailored to utilized fuel properties leads to reduced electrical power consumption and consequently CO_2 emission reduction in real driving situations compared to a heating device simply controlled via temperature threshold. Introducing a closed loop approach drives higher technical complexity and component cost due to the need of additional sensor systems and electrical algorithm implementation.

Once approved as eligible ECO innovation technology Stellantis considers a broad implementation of the technology where it can be integrated beneficially into the vehicle package. This enables a significant contribution to off-cycle CO_2 reduction for the next generation of Stellantis' diesel vehicles since the diesel engine is expected to play still a certain role for the next years especially in the LCV segment.

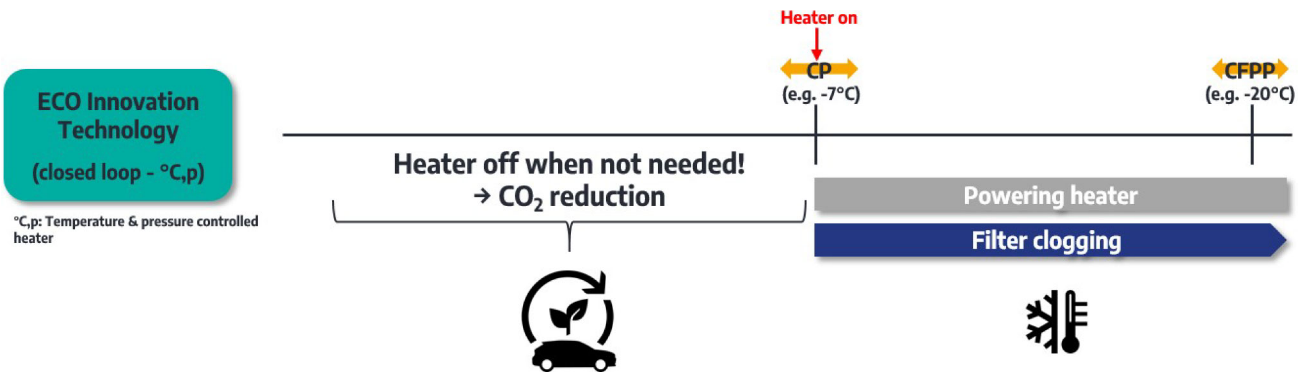

Figure 3: ECO Innovation Technology - Heater control strategy (closed loop)

Based on the conducted study we conclude that on average, activating the heater is only mandatory in about less than 5 % of the present environmental conditions in the United Kingdom. In approximately 95 % of typical activation situations of the baseline technology the heater can be deactivated since the fuel quality is good enough to ensure safe vehicle operation. Chapter 12 and subsequent describe further details.

6 Innovativeness

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7 Vehicles Deployment Prediction

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8 Market Penetration Prediction

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9 Definition of the Baseline Technology

The baseline technology is the conventional diesel fuel heater as described in Chapter 5 (open loop control). The heater turns on below +5 °C fuel temperature and turns off again above +8 °C fuel temperature based on the signal coming from the temperature sensor inside the diesel filter assembly. This is the standard component design that will be pursued if the ECO innovation incentive does not exist.

10 Evaluation of negative Effects

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11 Deterioration Effects

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12 Testing Methodology

The proposed test methodology is a combination of modelling approach and physical test to calculate the CO_2 savings for improved electrical components (see Equation 1). Therefor information obtained from vehicle testing as well as modelling data the usage factor is based upon is considered. Modeling data means the information on which the UF is based on, such as heater characteristics, fuel data, ambient temperature data etc. (see Figure 8). According JRC Guidelines chapter 6.2.4 the approach follows a “Test method type A: Component / vehicle function testing and estimation of corresponding CO_2 savings over fixed reference conditions”.

In contrast to the CO_2 saving calculation for improved electrical devices (see JRC Technical Guidelines November 2017, p. 45, “Efficient wiper motor”) and with regards to the proposed innovative technology it is not expedient to consider a partial numerical representation of base and ECO technology in parallel.

Equation 1:

$$C_{CO_2} = (P_{Base} - |P_{Eco}) \cdot \frac{V_{Pe-D} \cdot CF_D}{\eta_A \cdot v} \cdot UF$$

C_{CO_2}	CO_2 savings	[g CO_2/km]
P_{Base}	Electrical power consumption with base technology	[W]
P_{Eco}	Electrical power consumption with ECO innovation technology	[W]
V_{Pe-D}	Consumption of effective power for Diesel-driven vehicles	[l/kWh]
η_A	Efficiency of the alternator	[-]
CF_D	Conversion factor (l/100 km) - (g CO_2/km) for Diesel fuel	[g CO_2/l]
v	Mean driving speed of the WLTP	[km/h]
UF	Usage factor	[-]

The electrical power consumption of the baseline heater technology (P_{Base}) and under modified conditions (P_{Eco}) is determined with physical testing or sound expert judgement as further described in this chapter.

As part of the modelling approach V_{Pe-D}, η_A, CF_D and v are being applied as defined in the Technical Guidelines, July 2018.

$$V_{Pe-D} = 0{,}22 \frac{l}{kWh}$$

$$\eta_A = 0{,}67$$

$$CF_D = 2640 \frac{g\ CO_2}{l}$$

$$v = 46{,}5 \frac{km}{h}$$

The usage factor UF represents the mean share of the innovative technology usage under real world conditions once applied to a vehicle. Amongst others, it considers fuel quality, ambient temperature, technical component characteristics as well as traffic counting data. Figure 8 shows an overview about the parameters influencing the usage factor and the following describes how the CO_2 savings are determined in detail. For introduction purpose, the savings are calculated according Equation 1 respectively as shown in Figure 8 considering the usage of the innovative technology. Later in Chapter 14 we will extend the formula slightly to consider corrections due to negative and anticipated deteriorative effects.

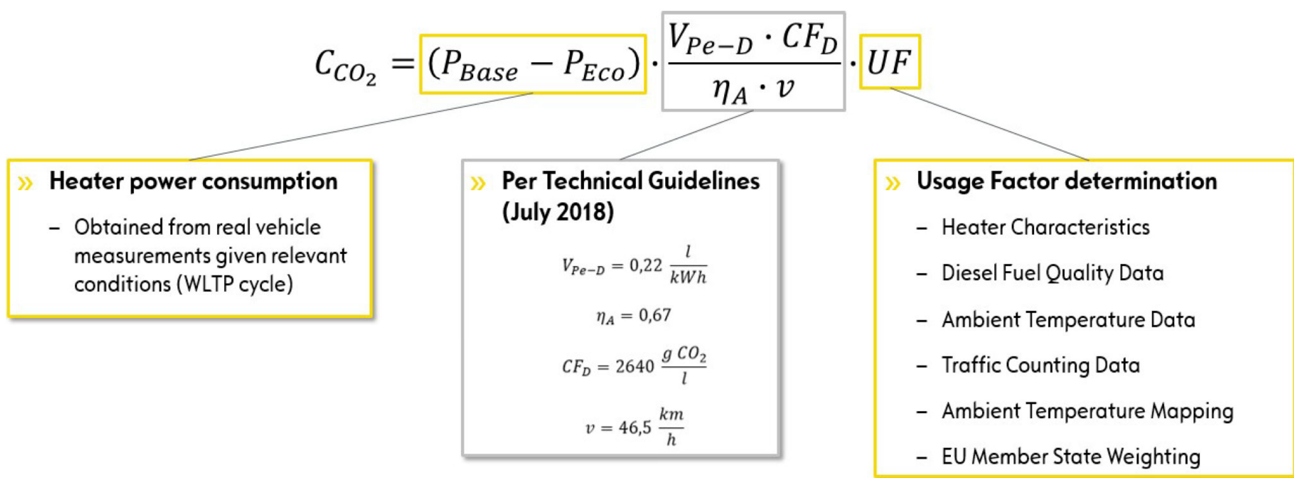

Figure 8: Usage Factor - Overview Influence Parameters

First, we made the theoretical evaluation of the CO_2 reduction potential on a representative automotive industry heater power level:

$$(P_{Base} - P_{Eco}) = 300\ W$$

In that case P_{Base} is the corresponding power consumption assuming the vehicle would be still equipped with the base technology in the driving situations represented by the usage factor of the ECO innovation technology (= UF). In other words, this would be the power consumption of the heater if the vehicle would be not equipped with the ECO innovation technology.

Since the heater power consumption varies amongst vehicles, real vehicle tests shall be performed to determine vehicle specific $(P_{Base} - P_{Eco})$ under representative conditions as proposed as follows.

Determination of P_{Base}

Two test scenario frameworks were supposed representative to determine P_{Base}:

1. **Vehicle Test "WLTC using Artic Fuel with CP < -20 °C"**
   - Cool down vehicle in climatic chamber to approximately -20 °C & drive WLTC
   - Calculate mean heater power consumption over the entire cycle

2. **Vehicle Test "WLTC using Winter Diesel Fuel with CP < -8 °C"**
   - Cool down vehicle in climatic chamber to approximately -8 °C (cooling undershoot below CP temperature needs to be avoided to ensure non-existence of paraffin wax crystals inside the fuel circuit) & drive WLTC
   - Calculate mean heater power consumption over the entire cycle

<u>Note:</u> The fuel heater related power consumption is measured directly on the battery voltage supply since the power loss over the wire harness from battery to fuel heater is also avoided by using the ECO innovation technology.

The resulting overall P_{Base} $(ø\ (test\ 1, \ldots, test\ n))$ describes the mean fuel heater related power consumption over all tests done under the conditions described above. To reflect real world customer variances & tolerances as best as possible the two test scenarios were considered:

- WLTC as representative drive cycle that reflects vehicle propulsion system behavior and its impact on heater power consumption
- Typical European winter fuel qualities the customer is using in cold / winter climatic periods
- Temperature levels in conjunction with fuel quality on which the base technology is active but not needed

For the application submission (based on EU-COM / JRC testing with independent body), it has been agreed with the independent body to consider overall eight vehicle tests with the utilized technology carrier vehicle in alignment to the two scenarios described above:

- **Reflect customer representative heater power level:**
  - 3 x "*Vehicle Test "WLTC using Artic Fuel with CP < -20 °C" with an average heater power consumption*
  - 3 x "*Vehicle Test "WLTC using Winter Diesel Fuel with CP < -8 °C" with an average heater power consumption*

- **Show upper / lower border of heater power level:**
  - 1 x "*Vehicle Test "WLTC using Artic Fuel with CP < -20 °C" with upper limit heater power consumption*
  - 1 x "*Vehicle Test "WLTC using Artic Fuel with CP < -20 °C" with lower limit heater power consumption*

The same procedure can be applied for specific ECO credit certification later with customer representative parts.

<u>Evolution after initial submission to EU-COM</u>

During the post submission consultation phase with the JRC it has been agreed to use Arctic Diesel fuel class 2 to class 4 of EN 590 classification to determine the baseline power consumption based on at least five complete WLTC tests. This enables the application of a clear general procedure and reproduceable test conditions since only for Arctic Diesel the CP is well defined per EN 590.

To determine the baseline heater power consumption, the diesel fuel heater shall be put into activated state during the entire tests, and its operation shall not be affected by the filter pressure sensor. This requires the usage of an open ECU that to align the pressure threshold calibration for credit certification purpose. Utilization of an open ECU is common practice to evaluate the compliance of type approval relevant functions that can be only tested in externally induced driving conditions. Therefor see official statement from the independent body attached to Supporting Documentation (“12 Testing Methodology → Independent Body Statement on open ECU”).

See further procedure to determine $\boldsymbol{P_{Base}}$ as follows:

The generic or applicant specific tool to be used for the read-out of the ECU, as well as the most suitable software to be used for the identification of the pressure threshold calibration label, should be agreed upon between the applicant and the type-approval authority.

(1) The type-approval authority performs a calibration read-out of the production ECU installed on the eco-innovative vehicle.

(2) The type-approval authority installs on the vehicle an open ECU that enables to set the threshold for the heater filter pressure sensor.

(3) The type-approval authority performs a calibration read-out of the open ECU.

(4) The pressure threshold calibration label, as outlined by the applicant, is identified using the appropriate Software.

(5) The heater pressure threshold is set to 0 kPa to ensure that the fuel heater is activated during the entire baseline test.

(6) The type-approval authority verifies and confirms that the only difference between the production and the open ECUs settings is the diesel fuel heater pressure threshold calibration.

(7) Cool down the vehicle filled to 50% fuel tank volume until the climatic chamber and fuel are stabilized at -20 °C.

Note: The 50% fill level is based on the simple assumption that most of the customers refuel completely just before running out of fuel and thus the tank is approximately filled by 50% on average. The tank fill level does not impact the heater power consumption and therefore not the final CO_2 savings.

(8) Start measuring and recording the diesel fuel heater voltage and current with an acquisition frequency of at least 100 Hz at least 30 seconds prior starting to drive the WLTC start to document the pre-WLTC vehicle status. Check that the heater is in activated state.

(9) Drive complete WLTC, with the climatic chamber and fuel temperature stabilized at -20 °C.

(10) Steps (7) to (9) shall be repeated at least five times.

For each WLTC completed, the energy consumed by the diesel fuel heater over the cycle (W_{base_i}) and the corresponding power consumption of the baseline diesel fuel heater (P_{base_i}) shall be calculated according to Formula 1 and Formula 2, respectively:

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Formula 1

$$W_{base_i} = \int_{t_s}^{t_e} U_{base}(t) \cdot I_{base}(t)\, dt$$

Formula 2

$$P_{base_i} = \frac{W_{base_i}}{t_e - t_s} \cdot 3600\ s - U_{PS} \cdot I_{PS}$$

Where:

W_{base_i}: Energy consumption of the diesel fuel heater during the i-th WLTC test [Wh]

$U_{base}(t)$: Battery voltage measured at time t [V]

$I_{base}(t)$: Diesel fuel heater current intensity measured at time t [A]

t_s: Starting point in time of WLTC, counted from the start of the measurements [s]

t_e: End point in time of WLTC, counted from the start of the measurements [s]

P_{base_i}: Power consumption of the baseline diesel fuel heater during the i-th WLTC test [W]

U_{PS} : Pressure sensor supply voltage [V]

I_{PS}: Pressure sensor supply current intensity [A]

The arithmetic mean of the baseline diesel fuel heater power consumption ($\overline{P_{base}}$) over all WLTC tests performed shall be calculated.

Determination of P_{ECO} (power consumption of the eco-innovative technology)

To determine P_{ECO} the following aspects need to be considered:

The innovative heater technology is turned off whereas the base technology would be turned on, so its corresponding power consumption is converging towards ~0 W. However as already mentioned in chapter 10 the power consumption for the pressure sensor needs to be considered. The power consumption depends as well on the specific heater control strategy (e.g. maybe it's recommendable to activate the heater per default for few seconds after vehicle start to ensure more robust cold operability when needed, …).

At the time of submission, the final innovative heater control strategy was still under evaluation and we need to keep a kind of flexibility in terms of customer robustness – if needed. Even though at the date of submission, it was not intended to activate the heater a certain time for default. A sound argumentation or expert judgement on P_{ECO} maybe be also sufficient to calculate or estimate the corresponding power consumption of the ECO innovation technology in non-activated state (e.g. based on electronic data sheets for pressure sensor). Nevertheless, similar vehicle test scenarios and calculations as described for P_{Base} can be applied.

Further we need to distinguish between two phases for P_{ECO}:

1. **New ECO Innovation application submission:**

   - It's was not possible to have prototype eco innovation hardware (with representative power consumption properties) available that can be tested in a vehicle until application submission to EU mid-2021 and to VCA early 2022. See Chapter 12.8 for prototype tests done during application in 2021.
   - Therefore P_{ECO} is assessed based on the latest supplier data available until submission to show the general potential of the ECO innovation technology to the best of our state-of-the-art knowledge. Worst-case estimate for pressure sensor power consumption is around ~1–3 W and needs to be understood more in detail with suppliers as soon as representative hardware information is being made available when component development progresses further.

2. **Vehicle specific ECO credit certification once the ECO Innovation has been approved:**

   - ECO innovation hardware is available to be tested in the vehicle subject to credit certification.
   - Sound argumentation / expert judgement on the individual design of the ECO innovation technology may be sufficient to calculate/estimate P_{Eco} (e.g. based on electronic data sheets for pressure sensor) in appropriate manner.

The application of the test methodology under independent body supervision is described in chapter 13 and 14.

Evolution after initial submission to EU-COM

See further procedure to determine $\boldsymbol{P_{ECO}}$ as follows:

The applicant shall provide the following information to the type-approval authority:

i. The ECU heater filter pressure signal(s) that would trigger the deactivation of the eco-innovative diesel fuel heater during the WLTC test.
ii. The operating voltage (U_{PS}) and current (I_{PS}) required by the pressure sensor of the eco-innovative diesel fuel heater, based on its electrical property data or measurement data provided by the supplier of the sensor.

For each WLTC test run as set out in the P_{Base} procedure before using the ECU signal referred to in point i. above, the type-approval authority shall determine the time $\overline{X}$ [s] after which the eco-innovative diesel fuel heater would be deactivated.

The power consumption of the eco-innovative technology [P_{ECO}] shall be determined according to Formula 3:

Formula 3

$$P_{eco} = \frac{\overline{X}}{1800} \cdot \overline{P_{base}} + (U_{PS} \cdot I_{PS})$$

Where:

P_{eco}: Power consumption of the eco-innovative technology [W]

$\overline{P_{base}}$: Arithmetic mean of the baseline technology power consumption [W]

$\overline{X}$: Average value, across all WLTC tests performed, of the earliest time after the start of the WLTC test when the eco-innovative diesel fuel heater would be deactivated [s]

U_{PS} : Pressure sensor supply voltage [V]

I_{PS}: Pressure sensor supply current intensity [A]

In case the diesel fuel heater is turned off by default at the start of each WLTC test, the value $\overline{X}$ will be zero and Formula 3 becomes $P_{eco} = U_{PS} \cdot I_{PS}$

12.1 Heater Characteristics

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12.3 Ambient Temperature Data

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12.4 Traffic Counting Data

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12.5 Ambient Temperature Mapping

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12.6 Overnight Garage Parking

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12.7 Example – United Kingdom

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12.8 Additional CO_2 reduction potential below CP temperature

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13 Description of the Case Study

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14 Application of the Testing Methodology

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<u>Note after initial submission to EU-COM</u>

Referring to the latest discussions with the Joint Research Center the formula for the final CO_2 saving has been simplified along the application process to:

$$C_{CO_2} = (\overline{P_{base}} - P_{eco}) \cdot \frac{V_{Pe_D} \cdot CF_D}{\eta_A \cdot v} \cdot UF_{N1}$$

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15 Quantification of Uncertainties

To capture and quantify potential uncertainties in the study this chapter is divided into four different aspects:

- Uncertainties CO_2 Saving / Vehicle Tests
- Uncertainties Measurement Equipment
- Interaction of the technology with other ECO Innovations
- Uncertainties of Usage Factor Study

Uncertainties CO_2 Saving / Vehicle Tests

The uncertainties from vehicle testing have been calculated as follows considering the progress on this part after submission of the application to the EU-COM.

The standard deviation of the baseline technology power consumption ($s_{\overline{P_{base}}}$) shall be calculated according Formula 5:

Formula 5

$$s_{\overline{P_{base}}} = \frac{\sqrt{\sum_{i=1}^{n}(P_{base_i} - \overline{P_{base}})^2}}{n(n-1)}$$

Where:

$\overline{P_{base}}$: Baseline power consumption as determined in Chapter 12 [W]
P_{base_i}: Baseline power consumption of the i-th WLTC test as determined in Formula 2 (Chapter 12) [W]
$s_{\overline{P_{base}}}$: Standard deviation of the baseline technology power consumption [W]
n: number of WLTC tests performed for determining the power consumption of the baseline technology [-]

The uncertainty of the CO_2 savings ($s_{C_{CO_2}}$) is then calculated in accordance with Formula 6. This uncertainty shall not exceed 30 % of the CO_2 savings.

Formula 6

$$s_{C_{CO_2}} = \frac{V_{Pe\_D} \cdot CF_D}{\eta_A \cdot v} \cdot UF \cdot s_{\overline{P_{base}}}$$

Where:

CF_D: Conversion factor, which is 2 640 [gCO_2/l]
$\overline{P_{base}}$: Baseline technology power consumption as determined as determined in Chapter 12 [W]
$s_{\overline{P_{base}}}$: Standard deviation of the baseline technology power consumption as determined in accordance with Formula 5 [W]
UF: Usage Factor, which is 0.2
v: Mean driving speed of the WLTC which is 46.5 km/h
V_{Pe_D}: Consumption of effective power which is 0.220 for diesel [l/kWh]
η_A: Efficiency of the alternator, which is 0.67.

Formula 6 does not consider a deterioration factor and assumes the UF as constant value, meaning no standard deviation needs to be considered.

To verify the minimum threshold criteria Formula 7 needs to be taken into account, considering the final CO_2 savings and the uncertainty calculated according Formula 6.

Formula 7

$$(C_{CO_2} - s_{C_{CO_2}}) \geq MT$$

Where:

MT: is 0,5 g CO_2/km as specified in Article 9(1)(b) of Implementing Regulation (EU) No 725/2011 and Commission Implementing Regulation (EU) No 427/2014

C_{CO_2}: is the CO_2 savings [g CO_2/km]

$s_{C_{CO_2}}$: is the uncertainty of the CO_2 savings as determined in Formula 6 [gCO_2/km]

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16 Eligibility Criteria

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17 Verification Report

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ANNEX II

Extracts from Commission Implementing Decision (EU) 2022/716 Test Methodology to support UK Official Decision (aligned methodology)

Arithmetic mean of the baseline diesel fuel heater power consumption:

The arithmetic mean of the baseline diesel fuel heater power consumption ($\overline{P_{base}}$) over all complete WLTC drives performed shall be calculated in accordance with Formula 3.

Formula 3

$$\overline{P_{base}} = \frac{\sum_{i=1}^{n} P_{base_i}}{n}$$

Rounding:

5. **ROUNDING**

The CO_2 savings (C_{CO_2}) calculated in accordance with Formula 5 and the uncertainty of CO_2 savings ($s_{C_{CO_2}}$) calculated in accordance with Formula 7 shall be rounded 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 to the minimum number of decimal places 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.

Certification of the CO2 Savings:

7. **CERTIFICATION OF THE CO_2 SAVINGS**

The CO_2 savings to be certified by the type-approval authority in accordance with Article 11 of Implementing Regulation (EU) No 725/2011 and Implementing Regulation (EU) No 427/2014 (CS_{CO_2} [g CO_2/km]) are those calculated in accordance with Formula 9.

The CO_2 savings shall be recorded in the type approval certificate for each vehicle version fitted with the Smart Diesel Fuel Heater.

Formula 9

$$CS_{CO_2} = C_{CO_2} - s_{C_{CO_2}}$$

Where:

CS_{CO_2}:	is the CO_2 savings to be certified by the type-approval authority [g CO_2/km]
C_{CO_2}:	is the CO_2 savings as determined in point 3 (Formula 5) [g CO_2/km]
$s_{C_{CO_2}}$:	is the uncertainty of the CO_2 savings as determined in point 4 (Formula 7) [g CO_2/km]