AAA Real-World Testing Program

ANNEX IV – Additional Procedures:

Pure Electric Vehicles (PEV) Real-World Energy Consumption & Driving Range Test Procedure

Version: 1.1

March 2025

Australian Automobile Association | Real-World Testing Program

ANNEX IV

Real-World Testing Program Additional Procedures: Pure Electric Vehicles (PEV) Real-World Energy Consumption & Driving Range (Ver 1.1)

PREFACE

This document sets out the Additional Procedures: Pure Electric Vehicles (PEV) Real-World Energy Consumption and Driving Range for the Real-World Testing (RWT) Program to be delivered by the Australian Automobile Association (AAA).

These Additional Procedures form Annex IV of the RWT Operating Procedures and describes the procedures to determine the Real-World energy consumption and electric driving range of Pure Electric Vehicles (PEV) in the AAA's Real-World Testing (RWT) Program

These Procedures will be regularly reviewed and updated as needed to ensure the RWT Program objectives are achieved.

VERSION CONTROL

Version	Published	Details
1.0	June 2024	Initial version of RWT Program Additional Procedures: Pure Electric vehicles (PEV) Real-World Energy Consumption & Driving Range
1.1	Mach 2025	Update for consistency of terms. Updates from PEV Validation Program: • 2.3.5.3 – inclusion of maximum of charging time of 18 hours. • 2.4.1 – to allow up to 60 min stop between the two circuits of a Test. • 2.4.3 – change in repeatability criteria of 10 minutes total trip time between Test 1 and Test 2. Inclusion of Appendix 3 – Summary of changes to Boundary Conditions: • Clarify that test mass is Tare plus 370 kg.

1. Introduction

This document supplements the RWT Operating Procedures and Test Procedures and describes the additional procedures to determine the Real-World energy consumption and electric driving range of Pure Electric Vehicles (PEV) in the AAA's Real-World Testing (RWT) Program. Unless a different procedure is outlined in this document, the RWT Operating Procedures and Test Procedures will be followed.[1]

The Real-World energy consumption and electric driving range will be the average of the energy consumption and electric driving range calculated from each of two valid tests.

These test protocols are based on existing test procedures used by Green NCAP, ADAC EcoTest and Australian legislation (ADR 81/02, ADR 79/04, ADR 79/05 and ADR 111/00) and the corresponding UN Regulations (Regulations 101, 83 and 154).[2]

2. RWT – General Requirements

This section outlines a standardized vehicle discharge and recharge procedure and the procedures to determine the energy drawn from the grid and the traction battery capacity (amount of energy in the REESS that is usable) for PEVs.

Each Test starts with the test vehicle fully charged and the energy required to fully recharge the test vehicle is used to calculate the energy consumption and electric range.

The recharging process is designed to be similar to how consumers would recharge their PEV. Owners of PEVs not only pay for the amount of energy "filled" into the REESS, but the entire amount of energy obtained from the grid.

Due to operational practicalities and recognising that some vehicles may trigger performance restrictions when the REESS levels drop below a threshold of 10%, the discharge and test processes aim to not operate the vehicle with a REESS capacity (as shown on the vehicle's dashboard/display) of less than 10%.[3]

2.1. General requirements.

Each PEV will be conditioned and tested in the following order:

1. Initial discharge of the test vehicle as per section 2.2.
2. The test vehicle is fully recharged as per section 2.3.
3. PEV Test as per section 2.4 with the test vehicle being fully recharged after Test 1 and Test 2 (and Test 3 if conducted) as per section 2.3.

[1] See Appendix 3 for summary of changes from the RWT Operating Procedure or Annex I - Test Procedures.
[2] See Appendix 1 for full list of reference documents.
[3] If the OEM advises the REESS has a threshold to trigger performance restrictions > 10%, the OEM threshold figure will be used with a +5% tolerance. E.g. if the brand advises the threshold is 20%, the initial discharge procedure will use "between 20% and 25%" in sections 2.2.1 and 2.2.2.

2.2 Initial vehicle discharge procedure.

The initial vehicle discharge procedure is to be undertaken when the test vehicle has arrived at the test service provider and immediately prior to beginning a RWT Test described in section 2.4.

2.2.1 The test vehicle shall be driven in normal road traffic and in compliance with the traffic regulations to discharge the REESS until the vehicle's dashboard/display shows a value of between 10% and 15%.

2.2.1.1 If, when arriving at the test service contractor, the vehicle shows a REESS capacity of less than 10%, the vehicle must be recharged in accordance with section 2.3 and the initial discharge procedure must be restarted.

2.2.1.2 If the vehicle's dashboard/display indicates a capacity-related performance restriction the REESS must be fully recharged in accordance with section 2.3 and the initial discharge procedure must be restarted.

2.2.2 With a residual capacity of between 15% and 10% the test vehicle shall be recharged in accordance with paragraph 2.3.

2.2.3 The electric energy delivered from the mains to fully recharge the test vehicle, after the initial discharge, in Wh is calculated as follows:

$$E_{AC\text{-}discharge}\ (Wh) = E_{AC-charge}\ (Wh) / (100 - REESS_{Discharge}) \times 100$$

where:

$E_{AC\text{-}charge}$ is the electric energy delivered from the mains in Wh;

$REESS_{Discharge}$ is the REESS residual charge capacity as shown on the vehicle's dashboard/display (%) at end of initial vehicle discharge procedure.

2.2.4 The electric energy absorbed by the test vehicle to fully recharge the REESS, after the initial discharge, in Wh is calculated as follows:

$$E_{PEV\text{-}discharge}\ (Wh) = E_{PEV-charge}\ (Wh) / (100 - REESS_{Discharge}) \times 100$$

where:

$E_{PEV\text{-}charge}$ is the electric energy absorbed by the test vehicle in Wh;

$REESS_{Discharge}$ is the REESS residual charge capacity as shown on the test vehicle's dashboard/display (%) at end of initial vehicle discharge procedure.

2.3 Standardised recharge procedure.

The standardised recharge procedure outlines the process to be used for any recharging of the test vehicle using a Type 2 AC Charger.

2.3.1 The recharging shall commence not later than 30 minutes after the end of the initial discharge procedure described in section 2.2, or the end of Test 1 or Test 2 (or Test 3 if conducted) described in section 2.4.

2.3.2 The test vehicle shall be charged at a stable ambient temperature of 23°C ± 3°C. The ambient temperature, air pressure and humidity shall be recorded during this time.

2.3.3 The charging limit of the REESS shall be set to "100%" or to "maximum", as applicable.[4]

2.3.4 The on-board charger, if fitted with the standard vehicle charging cable supplied by the manufacturer, shall be used for recharging.

Where there are several AC charging power levels available, the highest normal charging power shall be used.

Options for charging:

2.3.4.1 if applicable with supplied cable charging at 230V, 32A (7.4kW), 400V, 16A (11 kW) or 400V, 32A (22kW), or

2.3.4.2 otherwise agreed between AAA and the Test Service Provider.

2.3.5 End-of-charge criterion:

2.3.5.1 when the on-board or external instruments indicate that the REESS is fully charged, or

2.3.5.2 corresponds to a charging time of 12 hours except if a clear indication is given by the standard instrumentation that the battery is not yet fully charged. In this case, [5]

$$\textit{The maximum time is} = \frac{3\ x\ claimed\ battery\ capacity\ (Wh)}{mains\ power\ supply\ (W)}$$

or

2.3.5.3 corresponds to a maximum charging time of 18 hours.

2.3.6 The resulting electrical energy shall be calculated as follows:

2.3.6.1 The resulting electric energy delivered from the mains is $E_{AC\text{-}charge}$ (Wh), calculated by the measured current and voltage, as prescribed in Section 2.5, with the formula:

$$E_{AC\text{-}charge}\ (Wh) = 1/3600 \int_0^{100\%} I_{AC\text{-}charge}\ (A) \times U_{AC\text{-}charge}\ (V)\ dt$$

2.3.6.2 The resulting electric energy absorbed by the vehicle is $E_{PEV\text{-}charge}$ (Wh), calculated by the measured current and voltage, as prescribed in Section 2.5, with the formula:

$$E_{PEV\text{-}charge}\ (Wh) = 1/3600 \int_0^{100\%} I_{PEV\text{-}charge}\ (A) \times U_{PEV\text{-}charge}\ (V)\ dt$$

2.3.7 The recharging process shall not be interrupted.

2.3.8 If there is a power failure during the recharging process:

2.3.8.1 If the data shows the environmental chamber remained within tolerance, recharging shall continue after the power is resumed and the 12-hour end of charge criteria shall be extended by the length of the power failure.

2.3.8.2 Otherwise:

2.3.8.2.1 If recharging after the initial REESS discharge, the initial vehicle discharge procedure will be repeated in accordance with Section 2.2.

[4] The terms "100%", "maximum" and "fully charged" mean the REESS is fully charged, regardless of level of charge shown on the dashboard/display.

[5] Based on ADR 81/02 Appendix B (UN R101)

2.3.8.2.2 If recharging after a Test, the Test will be repeated in accordance with Section 2.4

2.4 PEV Test.

Each PEV Test includes 2 valid Tests.

For each Test (i.e. Test 1, Test 2 & Test 3 if conducted) the test vehicle will drive 2 circuits of the RWT Test Route provided there is sufficient REESS capacity. Where there is not sufficient REESS capacity for 2 circuits, each Test will comprise only 1 circuit of the RWT Test Route.

2.4.1 **Test 1:** The test vehicle is fully charged and is driven on the RWT Test Route:

2.4.1.1 Provided the REESS is at least 60% capacity (as shown on the test vehicle's dashboard/display) at the end of one (1) circuit of the RWT Test Route, the test vehicle will be driven for a total of two (2) circuits of the RWT Test Route.

2.4.1.2 The two circuits will be undertaken consecutively on the same day without recharging the test vehicle.

2.4.1.3 A short stop of no more than 60 minutes is permissible for driver safety and comfort. During this time, the test vehicle is to be parked in the test facility and switched off.

2.4.1.4 If the REESS is at less than 60% capacity (as shown on the test vehicle's dashboard/display) at the end of one (1) circuit of the RWT Test Route, the test vehicle will not be driven on second circuit of the RWT Test Route and the results of only one (1) circuit will be used.

2.4.2 **Test 2:** Repeat Test 1.

2.4.3 **Test 3:** If the variation in the total trip time between Test 1 and Test 2 is greater than (>) 10 minutes and the variation in energy consumption (as measured during the recharge procedure) between Test 1 and Test 2 is greater than (>) 5%, a third test, Test 3, will be undertaken.

2.4.3.1 Repeat Test 1.

2.4.4 Each Test will commence within 4 hours of disconnecting the test vehicle from the Vehicle AC charger.

2.4.5 After each Test, the test vehicle will be recharged in accordance with standardised recharge procedure in section 2.3.

2.5 Data measurement and recording:[6]

During any recharging of the test vehicle the electrical current and the electrical voltage shall be determined and recorded in accordance with this section.

2.5.1 The energy measurement equipment, placed between the mains and the Vehicle AC charger, shall measure the electric energy $E_{AC\text{-}charge}$ delivered from the mains to the vehicle charger.

2.5.1.1 The current $I_{AC\text{-}charge}$ in Ampere shall be measured in accordance with Table 1 at a storage rate of 0.1 Hz as an average of the high-resolution data.

[6] Based on Green NCAP, Test Procedure – Driving Range, Version 2.0.0, February 2022

2.5.1.2 The Voltage $U_{AC\text{-}charge}$ in Volt shall be measured in accordance with Table 1 at a storage rate of 0.1 Hz as an average of the high-resolution data.

2.5.1.3 The calculated (from high resolution data) amount of energy $E_{AC\text{-}charge}$ of the traction battery in Wh shall be stored at a rate of 0.1 Hz as an average of the high-resolution data.

2.5.2 The energy measurement equipment, placed between the Type 2 AC Charger and the test vehicle, shall determine the electric energy $E_{PEV\text{-}charge}$ absorbed by the vehicle to recharge the REESS. The following data shall be measured and recorded:

2.5.2.1 The current $I_{PEV\text{-}charge}$ in Ampere shall be measured in accordance with Table 1 at a storage rate of 0.1 Hz as an average of the high-resolution data.

2.5.2.2 The Voltage $U_{PEV\text{-}charge}$ in Volt shall be measured in accordance with Table 1 at a storage rate of 0.1 Hz as an average of the high-resolution data.

2.5.2.3 The calculated (from high resolution data) amount of energy $E_{PEV\text{-}charge}$ of the traction battery in Wh shall be stored at a rate of 0.1 Hz as an average of the high-resolution data.

2.5.3 The duration $T_{100\%}$ of the recharging process in seconds until the REESS is fully charged according to the end-of-charge criterion shall be logged.

2.5.4 Electric energy measurement may be stopped when the end-of-charge criterion, is reached.

Table 1: Parameters, units, accuracy and resolution of measurements

Parameter	Units	Accuracy	Resolution
Electrical Energy (1)	Wh	± 1 per cent	0.001 kWh (2)
Electrical current	A	± 0.3 per cent FSD or ± 1 per cent of reading (3) (4)	0.1A
Electric voltage	V	± 0.3 per cent FSD or ± 1 per cent of reading (3)	0.1 V

(1) Equipment: static meter for active energy.
(2) AC watt-hour meter, Class 1 in accordance with IEC 62053-21 or equivalent.
(3) Whichever is greater.
(4) Current integration frequency 20 Hz or more

3 Electric Energy Consumption for PEVs[7]

The total electric energy consumption will include the losses from the mains to vehicle charger.

3.1 Determination of electrical energy consumption from the mains.

Determination of the consumption of electric energy delivered from the mains (EC_{AC}) in Wh/km during each Test is calculated as follows:

[7] Based on Green NCAP, Test Procedure – PEMS+ (Real World Environmental Performance custom tailored for Green NCAP), Version 3.0.0, February 2022

$$EC_{AC}\ (Wh/km) = E_{AC-charge}\ (Wh) / d\ (km)$$

Where:

$E_{AC-charge}$	is the electric energy delivered from the mains (Wh) after each Test according to paragraph 2.3.
d	is the distance travelled during the Test (km), e.g. 93km or 186km.

3.2 Determination of consumption of electrical energy absorbed by the test vehicle.

Determination of the consumption of the electric energy absorbed by the test vehicle (EC_{PEV}) in Wh/km during each Test is calculated as follows:

$$EC_{PEV}\ (Wh/km) = E_{PEV-charge}\ (Wh) / d\ (km)$$

Where:

$E_{PEV-charge}$	is the electric energy absorbed by the test vehicle (Wh) after each Test according to paragraph 2.3.
d	is the distance travelled during the Test (km), e.g. 93km or 186km.

4 Electric Driving Range for PEVs[8]

The test vehicle's electric driving range is calculated from the test vehicle's energy consumption during a Test and the energy required to fully recharge the REESS.

4.1 The calculation of the electric driving range (R_{PEV}) in km uses the energy absorbed by the test vehicle to fully recharge the REESS after initial discharge ($E_{PEV-discharge}$) over the energy consumption during a Test, (i.e. the energy absorbed by the vehicle for a recharge of the REESS after a Test, E_{PEV}), as described in the following formula:

$$R_{PEV}\ (km) = E_{PEV-discharge}\ (Wh) / E_{PEV}\ (Wh/km)$$

5 Results for Publication

This section outlines the Real-World energy consumption and driving range results to be reported by the Test Service Provider.

[8] Based on Green NCAP, Test Procedure – Driving Range, Version 2.0.0, February 2022

5.1 Validity of test results

5.1.1 Where only two (2) tests are conducted (as required in Section 2.4) the results for publication from these two tests will be reported by the Test Service Provider in accordance with Sections 5.2 and 5.3.

5.1.2 Where a third test is triggered (as per Section 2.4.3), the following process will be followed to determine the results for publication:

5.1.2.1 If the variation in energy consumption between two (2) of the three (3) tests conducted is less than or equal to (≤) 5.00%, results for publication for those two tests will be reported by the Test Service Provider in accordance with sections 5.2 and 5.3.

5.1.2.2 If the variations in energy consumption between each of the three (3) tests conducted are greater than (>) 5.00%, the vehicle will be considered to have inconsistent performance, and its performance will be raised with the vehicle brand.

In this case, the Test Service Provider will report the average of all three tests, rather than two tests as described in Sections 5.2 and 5.3.

5.2 Energy consumption

The Real-World energy consumption (EC_{RWT}) to be reported will be the average of the electric energy consumption calculated in accordance with Section 3 from two valid tests.

$$EC_{RWT}\ (Wh/km) = \{EC_{RWT1}\ (Wh/km) + EC_{RWT2}\ (Wh/km)\} / 2$$

Where:

EC_{RWT1} is the energy consumption (EC_{AC} in Wh/km) for Test 1 as calculated in accordance with Section 3.

EC_{RWT2} is the energy consumption (EC_{AC} in Wh/km) for Test 2 as calculated in accordance with Section 3.

5.3 Real-World driving range

The Real-World driving range (R_{RWT}) to be reported will be the average of the electric driving range calculated in accordance with Section 4 from two valid tests.

$$R_{RWT}\ (km) = \{R_{RWT1}\ (km) + R_{RWT2}\ (km)\} / 2$$

Where:

R_{RWT1} is the electric driving range (R_{PEV} in km) for Test 1 as calculated in accordance with Section 4.

R_{RWT2} is the electric driving range (R_{PEV} in km) for Test 2 as calculated in accordance with Section 4.

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Appendices:

1. References
2. Glossary
3. Summary of Changes to Boundary Conditions

Appendix 1. References

This document is based on the following existing documents:

- ADR 81/02 – Fuel Consumption Labelling for Light Vehicles Appendix C (UN R101/01):
  - Annex 7 – Method of Measuring the Electrical Energy Consumption of Vehicles Powered by an Electric Powertrain Only.
  - Annex 9 – Method of Measuring the Electric Range of Vehicles Powered by an Electric Powertrain Only or by a Hybrid Electric Power Train and the OVC Range of Vehicles Powered by a Hybrid Electric Powertrain.

- Green NCAP Test Procedure – Driving Range, Version 2.0.0 February 2022.
  - Green NCAP procedure to determine the driving range of a range of ICEs as well as PEV (Pure Electric Vehicles, i.e. BEV) and other alternative fueled vehicles.

- Green NCAP Test Procedure – PEMS+ (Real World Environmental Performance custom tailored for Green NCAP), Version 3.0.0, February 2022.
  - Section 9.7.2 Electric energy consumption of PEVs

- ADAC Ecotest Test and Evaluation Criteria (4/2021 update).

With the introduction of Euro 6d in ADR 79/05, from December 2025, new ADRs for WLTP (ADR 111/00) and RDE (ADR 112/00) have also been introduced:

- ADR 111/00 – Advanced Emission Control for Light Vehicles 2024:
  - Note: Appendix A (UN R154), Introduction: “The WLTP Type 1 test replaces both the Type 1 test in UN Regulation No. 83 and UN Regulation 101.”

- ADR 112/00 – Control of Real Driving Emissions for Light Vehicles 2024:
  - Note: Appendix A (UN R168), 1. Scope “Pure Electric Vehicles and Fuel Cell Vehicles are out of scope of this Regulation.”

Appendix 2. Glossary[9]

Term	Acronym	Description
Energy consumption (Wh/km)		The vehicle's electricity consumption measured in Watthours per km.
Electric driving range (km)		The estimated distance the vehicle can travel on a fully charged REESS.
Not off-vehicle charging hybrid electric vehicle	NOVC-HEV	A hybrid electric vehicle that **cannot** be charged from an external power source (also referred to as a HEV).
Off-vehicle charging hybrid electric vehicle	OVC-HEV	A hybrid electric vehicle that **can** be charged from an external power source (also referred to as a Plug-in HEV or PHEV).
On-board charger		The electric power converter between the traction REESS and the vehicle's recharging socket.
Pure electric vehicle	PEV	A vehicle equipped with a powertrain containing exclusively electric machines as propulsion energy converters and exclusively rechargeable electric energy storage systems as propulsion energy storage systems. Also referred to as battery electric vehicle (BEV).
Rechargeable electric energy storage system	REESS	The rechargeable energy storage system that provides electric energy for electric propulsion of the vehicle. A battery whose primary use is to supply power for starting the engine and/or lighting and/or other vehicle auxiliaries' systems is not considered as a REESS. The REESS may include the necessary systems for physical support, thermal management, electronic controls and casing.
RWT Test Route		The test route used for the Real-World Testing Program as outlined in the RWT Operating Procedures Section 13.
Test		A complete "test" that may comprise 1 or 2 circuits of the RWT Test Route as outlined in Section 2.4
Type 2 AC charger		A Type 2 AC charger often used for a home installation for recharging a vehicle at up to 22kW. A Type 2 AC charger will be used to recharge the test vehicle in accordance with paragraph 2.3.

[9] Definitions from UN Regulations 100, 154 where available/applicable.

Appendix 3. Summary of Changes to Boundary Conditions

Following are the changes to the RWT Annex 1 – Test Procedure[10], Section 5.0 Boundary Conditions for use in the PEV Testing Protocol

Section 5.1 Vehicle Payload and Test Mass

5.1.3 The vehicle's test mass shall be as close as possible to the tare mass of the vehicle plus 370kg (including the driver).
Note: the test mass must not exceed the test vehicle's GVM.

[10] RWT Program ANNEX I – Test Procedure Ver 2.1 Juen 2024