

2014 BMW i3 with Range Extender (REx)

Advanced Vehicle Testing – Baseline Vehicle Testing Results



VEHICLE SPECIFICATIONS¹

Vehicle Features

VIN: WBY1Z4C5XEV274162
 Class: Compact
 Seatbelt Positions: 4
 Type: PHEV²
 CARB³: LEV II SULEV
 EPA Fuel Economy: 117 MPGe
 (Charge-Depleting Mode,
 Combined); 39 MPG (Charge-
 Sustaining Mode, Combined)
 On-Board Charger: 7.4 kW⁴

Electric Motor

Type: PM AC Synchronous
 Maximum Power: 125 kW
 Maximum Torque: 250 Nm

Engine

Model: DOHC – 8 Valve I-2
 Output: 25 kW/55Nm @ 4,300 rpm
 Displacement: 0.647 L
 Fuel Tank Capacity: 1.9 gal
 Fuel Type: Regular Unleaded

Battery

Manufacturer: Samsung SDI
 Type: Lithium-Ion
 Cathode Material: NCM (Nickel-
 Cobalt-Manganese)
 Number of Cells: 96
 Cell Configuration: 8 Modules, 12
 Cells Per Module, Connected In
 Series
 Nominal Cell Voltage: 3.7 V
 Nominal System Voltage: 355.2 V
 Rated Pack Capacity: 60 Ah
 Rated Pack Energy: 18.8 kWh
 Weight of Pack: 235 kg
 Pack Specific Energy: 79.8 Wh/kg
 Pack Energy Density: 98.5 Wh/L
 (Approximate)
 Pack Location: Underneath
 Vehicle Center
 Thermal Management: Active –
 Refrigerant

Weights

Design Curb Weight: 3,064 lb
 Delivered Curb Weight: 3,130 lb
 Distribution F/R: 45%/55%
 GVWR: 3,815 lb
 GAWR F/R: 1,785 lb/2,205 lb
 Maximum Payload: 751 lb

Dimensions

Wheelbase: 101.2 in
 Track F/R: 61.9 in/62.0 in
 Length/Width: 157.4 in/80.3 in
 Height: 62.1 in

Tires

Manufacturer: Bridgestone
 Model: Ecopia EP600
 Size F|R: 155/70 R19|175/60 R19
 Pressure F/R: 33 psi/41 psi
 Spare Installed: N/A - Tire Sealant
 and Inflator

Transmission

Type: Single Speed

NOTES:

1. Vehicle specifications were supplied by the manufacturer, measured, or derived from a literature review.
2. This vehicle is classified as a PHEV since it is a hybrid vehicle that can accept off-board electrical energy, and it has charge-depleting and charge-sustaining modes. However, due to the limited size of the fuel tank, this vehicle has been designated as a BEV for this program.
3. The vehicle was classified as a PZEV by the California Air Resources Board (CARB).
4. The on-board charger capability is listed; however, during the testing that was prior to a vehicle software update, the max. rate was 3.6 kW.

CHARGE-DEPLETING PERFORMANCE STATISTICS¹

TRACK TESTING ²	DYNAMOMETER TESTING ⁷																																																																						
<p><u>Acceleration 0-60 mph³</u> Measured Time: 7.8 s Performance Goal: ≤13.5 s Peak DC Power from Battery: 138.4 kW</p> <p><u>Maximum Speed</u> At ¼ Mile: 84.4 mph Maximum Speed⁴: 91.1 mph Performance Goal: ≥90 mph at 1-mile mark</p> <p><u>Braking from 60-0 mph at 100% SOC⁵</u> Measured Time: 3.0 s Distance: 122 ft Peak DC Power into Battery: 22.6 kW</p> <p><u>Braking from 60-0 mph at 50% SOC⁵</u> Measured Time: 3.4 s Distance: 117 ft Peak DC Power into Battery: 26.0 kW</p> <p><u>Deceleration 60-10 mph⁶</u> Measured Time: 13.1 s Distance: 663 ft Peak DC Power into Battery: 54.8 kW Total DC Energy into Battery: 126.5 Wh</p>	<p><u>Cycle Results⁸</u></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">72 °F</th> <th style="text-align: center;">20 °F</th> <th style="text-align: center;">95°F + 850 W/m²</th> </tr> </thead> <tbody> <tr> <td>UDDS (Cold Start)</td> <td style="text-align: center;">203.7 Wh/mi</td> <td style="text-align: center;">528.1 Wh/mi</td> <td style="text-align: center;">259.7 Wh/mi</td> </tr> <tr> <td>UDDS</td> <td style="text-align: center;">190.3 Wh/mi</td> <td style="text-align: center;">281.3 Wh/mi</td> <td style="text-align: center;">252.7 Wh/mi</td> </tr> <tr> <td>HWFET</td> <td style="text-align: center;">227.1 Wh/mi</td> <td style="text-align: center;">354.0 Wh/mi</td> <td style="text-align: center;">244.4 Wh/mi</td> </tr> <tr> <td>US06</td> <td style="text-align: center;">307.8 Wh/mi</td> <td style="text-align: center;">414.0 Wh/mi</td> <td style="text-align: center;">348.8 Wh/mi</td> </tr> <tr> <td>SC03</td> <td></td> <td></td> <td style="text-align: center;">303.2 Wh/mi</td> </tr> </tbody> </table> <p><u>Fuel Economy at Steady-State Speed, 0% Grade</u></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;"></th> <th style="width: 25%;"></th> <th style="width: 25%;"></th> <th style="width: 25%;"></th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">10 mph</td> <td style="text-align: center;">113.5 Wh/mi</td> <td style="text-align: center;">50 mph</td> <td style="text-align: center;">223.6 Wh/mi</td> </tr> <tr> <td style="text-align: center;">20 mph</td> <td style="text-align: center;">116.8 Wh/mi</td> <td style="text-align: center;">60 mph</td> <td style="text-align: center;">265.4 Wh/mi</td> </tr> <tr> <td style="text-align: center;">30 mph</td> <td style="text-align: center;">144.9 Wh/mi</td> <td style="text-align: center;">70 mph</td> <td style="text-align: center;">319.6 Wh/mi</td> </tr> <tr> <td style="text-align: center;">40 mph</td> <td style="text-align: center;">175.5 Wh/mi</td> <td style="text-align: center;">80 mph</td> <td style="text-align: center;">387.5 Wh/mi</td> </tr> </tbody> </table> <p><u>Duration of Passing Maneuver at Grade⁹</u></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 30%;"></th> <th style="width: 25%;"></th> <th style="width: 25%;"></th> <th style="width: 20%;"></th> </tr> </thead> <tbody> <tr> <td></td> <td style="text-align: center;">0% Grade</td> <td style="text-align: center;">3% Grade</td> <td style="text-align: center;">6% Grade</td> </tr> <tr> <td style="text-align: center;">35-55 mph</td> <td style="text-align: center;">3.1 s</td> <td style="text-align: center;">3.3 s</td> <td style="text-align: center;">4.0 s</td> </tr> <tr> <td style="text-align: center;">55-65 mph</td> <td style="text-align: center;">2.6 s</td> <td style="text-align: center;">2.9 s</td> <td style="text-align: center;">3.5 s</td> </tr> <tr> <td style="text-align: center;">35-70 mph</td> <td style="text-align: center;">6.7 s</td> <td style="text-align: center;">7.7 s</td> <td style="text-align: center;">9.8 s</td> </tr> <tr> <td style="text-align: center;">55-80 mph</td> <td style="text-align: center;">7.3 s</td> <td style="text-align: center;">9.2 s</td> <td style="text-align: center;">13.4 s</td> </tr> </tbody> </table> <p style="text-align: center;">Maximum Speed at 25% Grade from Stop: 49.2 mph</p>				72 °F	20 °F	95°F + 850 W/m ²	UDDS (Cold Start)	203.7 Wh/mi	528.1 Wh/mi	259.7 Wh/mi	UDDS	190.3 Wh/mi	281.3 Wh/mi	252.7 Wh/mi	HWFET	227.1 Wh/mi	354.0 Wh/mi	244.4 Wh/mi	US06	307.8 Wh/mi	414.0 Wh/mi	348.8 Wh/mi	SC03			303.2 Wh/mi					10 mph	113.5 Wh/mi	50 mph	223.6 Wh/mi	20 mph	116.8 Wh/mi	60 mph	265.4 Wh/mi	30 mph	144.9 Wh/mi	70 mph	319.6 Wh/mi	40 mph	175.5 Wh/mi	80 mph	387.5 Wh/mi						0% Grade	3% Grade	6% Grade	35-55 mph	3.1 s	3.3 s	4.0 s	55-65 mph	2.6 s	2.9 s	3.5 s	35-70 mph	6.7 s	7.7 s	9.8 s	55-80 mph	7.3 s	9.2 s	13.4 s
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3. The acceleration is measured from the point at which the vehicle begins to move. The peak power value was taken from a single run.
4. The maximum speed was reached before the one-mile mark.
5. Controlled braking on dry surface. The peak power into the battery value was taken from a single run.
6. Coasting in drive on dry surface. Test run data were cut off when the vehicle reached 10 mph, as vehicle creep speeds are typically below this threshold. The peak power into the battery value and total energy into the battery results were both taken from a single (but different) run.
7. Dynamometer testing occurs after the track testing is complete. Dynamometer testing began on May 8, 2015, with the vehicle odometer reading 4,516 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at <http://www.transportation.anl.gov/D3/>, titled “Chassis Dynamometer Testing Reference Document”. The ABC coefficients derived from track coastdown testing and matched on the dynamometer were A: 23.8171 lb, B: 0.645809 lb/mph, and C: 0.0118864 lb/mph².
8. The Cycle Results table presents the fuel economy achieved by the vehicle on five EPA drive cycles at three different ambient temperatures: (1) 72 °F with vehicle climate-control off, (2) 20 °F with vehicle climate-control set to 72 °F Auto, and (3) 95 °F with vehicle climate-control set to 72 °F Auto. The vehicle is also subjected to 850 W/m² of solar load at 95 °F to simulate direct sunlight. The drive cycles include a hot start unless otherwise indicated. The conversion for Wh/mi to miles-per-gallon-of-gasoline-equivalent (MPGe) is to divide 33,700 Wh/gallon-of-gasoline-equivalent by the Wh/mi value.
9. The passing maneuver value indicates the amount of time required for the vehicle to transition from the first to the second speed, at the specified grade.

Values in red indicate that the Performance Goal was not met.

CONSTANT-SPEED RANGE AND CHARGE TESTING IN CHARGE-DEPLETING MODE¹

	45 mph Test ²	60 mph Test ³	70 mph Test ⁴
Average DC power out of battery at speed (kW):	8.2	15.2	22.5
(A) DC energy out of battery at set speed (kWh) ^{5,7,9} :	17.5	17.3	16.4
(A+) Total DC energy out of battery (kWh) ^{5,7,9} :	17.7	18.0	17.3
Battery capacity discharge at set speed (Ah):	47.6	47.5	45.4
(B) Range at set speed (mi) ^{6,8,10} :	95.7	67.8	51.2
(C) Post-test charge AC energy from EVSE @ 240 V to onboard charger (kWh):	21.1	21.6	21.7
(D) Post-test charge DC energy into battery from onboard charger (kWh):	19.6	19.9	19.7
Post-test charge duration (HH:MM):	07:15	07:35	07:29
AC electricity consumption rate (Wh/mi) ¹¹ :	218	306	402
DC electricity consumption rate (Wh/mi) ¹² :	183	255	320
(A+/D) Battery Roundtrip Efficiency ¹³ :	90%	91%	88%
(D/C) On-Board Charger Efficiency ¹⁴ :	93%	92%	91%
(A+/C) Overall Trip Efficiency ¹⁵ :	84%	83%	80%

NOTES:

- See Note 1 and Note 2 on page 2. The vehicle is accelerated to the desired speed and then cruise control is used to maintain the speed. Range is considered reached when either (1) the vehicle transitions from charge-depleting (CD) mode to charge-sustaining (CS) mode or (2) the engine turns on, whichever occurs first. Battery temperature data were not collected for this vehicle.
- During the 45 mph range test, the average ambient temperature was 74 °F (23 °C). During the post-test charge, the average ambient temperature was 65 °F (18 °C).
- During the 60 mph range test, the average ambient temperature was 75 °F (24 °C). During the post-test charge, the average ambient temperature was 72 °F (22 °C).
- During the 70 mph range test, the average ambient temperature was 76 °F (24 °C). During the post-test charge, the average ambient temperature was 70 °F (21 °C).
- In addition to the energy discharged from the battery during the 45 mph test, energy was discharged during the drive from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 45 mph was completed, there is still ESS energy throughput during the drive to return the vehicle to the test prep area and the EVSE unit for the post-test charge. The pre-test drive required 0.28 kWh while the post-test drive returned 0.09 kWh, and these energy inputs can be added to the energy consumed during the range test (A) to obtain the total output from the battery (17.74 kWh, denoted as (A+)) that is used in the calculations discussed in Notes 13-15.
- In addition to the range measured for the 45 mph test, the pre-test drive required 1.17 miles from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 45 mph was completed, the post-test drive required an additional drive of 6.09 miles to return to the test prep area and the EVSE unit for the post-test charge. These distances can be added to the distance traveled during the range test (B) to obtain the total distance traveled (102.96 miles). However, the energy consumption values consider only the distance traveled during the test at the specified speed, or value (B).
- In addition to the energy discharged from the battery during the 60 mph test, energy was discharged during the drive from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 60 mph was completed, there is still ESS energy throughput during the drive to return the vehicle to the test prep area and the EVSE unit for the post-test charge. The pre-test drive required 0.43 kWh while the post-test drive required 0.19 kWh, and these energy inputs can be added to the energy consumed during the range test (A) to obtain the total output from the battery (17.96 kWh, denoted as (A+)) that is used in the calculations discussed in Notes 13-15.
- In addition to the range measured for the 60 mph test, the pre-test drive required 1.38 miles from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 60 mph was completed, the post-test drive required an additional drive of 6.15 miles to return to the test prep area and the EVSE unit for the post-test charge. These distances can be added to the distance traveled during the range test (B) to obtain the total distance traveled (75.32 miles). However, the energy consumption values consider only the distance traveled during the test at the specified speed, or value (B).
- In addition to the energy discharged from the battery during the 70 mph test, energy was discharged during the drive from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 70 mph was completed, there is still ESS energy throughput during the drive to return the vehicle to the test prep area and the EVSE unit for the post-test charge. The pre-test drive required 0.65 kWh while the post-test drive required 0.22 kWh, and these energy inputs can be added to the energy consumed during the range test (A) to obtain the total output from the battery (17.25 kWh, denoted as (A+)) that is used in the calculations discussed in Notes 13-15.
- In addition to the range measured for the 70 mph test, the pre-test drive required 1.80 miles from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 70 mph was completed, the post-test drive required an additional drive of 7.22 miles to return to the test prep area and the EVSE unit for the post-test charge. These distances can be added to the distance traveled during the range test (B) to obtain the total distance traveled (60.25 miles). However, the energy consumption values consider only the distance traveled during the test at the specified speed, or value (B).
- The AC electricity consumption rate is calculated by dividing the DC electricity consumption rate (in Wh/mi) by the Overall Trip Efficiency for that particular speed.
- The DC electricity consumption rate is calculated by dividing the DC energy from the battery as the set speed (A) by the range at the set speed (B).
- Battery Roundtrip Efficiency is calculated by dividing the DC energy out of the battery (A+) by the DC energy from the on-board charger into the battery (D).
- On-Board Charger Efficiency is calculated by dividing the DC energy from the on-board charger into the battery (D) by the AC energy from the EVSE (C).
- Overall Vehicle Efficiency is calculated by dividing the DC energy out of the battery (A+) by the AC energy from the EVSE (C).

CHARGE-SUSTAINING PERFORMANCE STATISTICS¹

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<p><u>Acceleration 0-60 mph³</u> Measured Time: 9.2 s Performance Goal: ≤13.5 s Peak DC Power from Battery: 118.7 kW</p> <p><u>Maximum Speed</u> At ¼ Mile: 80.4 mph Maximum Speed⁴: 88.5 mph Performance Goal: ≥90 mph at 1-mile mark</p> <p><u>Braking from 60-0 mph</u> Measured Time: 3.5 s Distance: 116.1 ft Peak DC Power into Battery: 67.6 kW</p> <p><u>Deceleration 60-10 mph⁶</u> Measured Time: 13.1 s Distance: 661.6 ft Peak DC Power into Battery: 77.1 kW Total DC Energy into Battery: 166.8 Wh</p>	<p><u>Cycle Results⁸</u></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">72 °F</th> <th style="text-align: center;">20 °F</th> <th style="text-align: center;">°F + 850 W/m²</th> </tr> </thead> <tbody> <tr> <td>UDDS (Cold Start)</td> <td style="text-align: center;">-28.2 Wh/mi 45.0 mpg</td> <td style="text-align: center;">14.2 Wh/mi 26.1 mpg</td> <td style="text-align: center;">-11.9 Wh/mi 39.5 mpg</td> </tr> <tr> <td>UDDS</td> <td style="text-align: center;">-7.9 Wh/mi 51.6 mpg</td> <td style="text-align: center;">-48.3 Wh/mi 27.7 mpg</td> <td style="text-align: center;">-22.6 Wh/mi 39.0 mpg</td> </tr> <tr> <td>HWFET</td> <td style="text-align: center;">-3.0 Wh/mi 50.4 mpg</td> <td style="text-align: center;">-11.0 Wh/mi 38.3 mpg</td> <td style="text-align: center;">-4.9 Wh/mi 47.4 mpg</td> </tr> <tr> <td>US06</td> <td style="text-align: center;">-22.7 Wh/mi 36.4 mpg</td> <td style="text-align: center;">-46.5 Wh/mi 27.1 mpg</td> <td style="text-align: center;">-15.2 Wh/mi 29.8 mpg</td> </tr> <tr> <td>SC03</td> <td></td> <td></td> <td style="text-align: center;">-79.4 Wh/mi 29.0 mpg</td> </tr> </tbody> </table> <p><u>Fuel Economy at Steady-State Speed, 0% Grade</u></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="text-align: center;">15 mph</td> <td style="text-align: center;">3.1 Wh/mi, 88.8 mpg</td> <td style="text-align: center;">60 mph</td> <td style="text-align: center;">6.2 Wh/mi, 44.2 mpg</td> </tr> <tr> <td style="text-align: center;">30 mph</td> <td style="text-align: center;">5.7 Wh/mi, 48.4 mpg</td> <td style="text-align: center;">70 mph</td> <td style="text-align: center;">8.7 Wh/mi, 31.7 mpg</td> </tr> <tr> <td style="text-align: center;">45 mph</td> <td style="text-align: center;">5.0 Wh/mi, 55.1 mpg</td> <td></td> <td></td> </tr> </tbody> </table> <p><u>Duration of Passing Maneuver at Grade^{9,10}</u></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">0% Grade</th> <th style="text-align: center;">3% Grade</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">35-55 mph</td> <td style="text-align: center;">3.4 s</td> <td style="text-align: center;">3.8 s</td> </tr> <tr> <td style="text-align: center;">55-65 mph</td> <td style="text-align: center;">2.6 s</td> <td style="text-align: center;">3.0 s</td> </tr> <tr> <td style="text-align: center;">35-70 mph</td> <td style="text-align: center;">7.5 s</td> <td style="text-align: center;">8.7 s</td> </tr> <tr> <td style="text-align: center;">55-80 mph</td> <td style="text-align: center;">8.1 s</td> <td style="text-align: center;">10.7 s</td> </tr> </tbody> </table> <p style="text-align: center;">Maximum Speed at 25% Grade from Stop: 45.9 mph</p>					72 °F	20 °F	°F + 850 W/m ²	UDDS (Cold Start)	-28.2 Wh/mi 45.0 mpg	14.2 Wh/mi 26.1 mpg	-11.9 Wh/mi 39.5 mpg	UDDS	-7.9 Wh/mi 51.6 mpg	-48.3 Wh/mi 27.7 mpg	-22.6 Wh/mi 39.0 mpg	HWFET	-3.0 Wh/mi 50.4 mpg	-11.0 Wh/mi 38.3 mpg	-4.9 Wh/mi 47.4 mpg	US06	-22.7 Wh/mi 36.4 mpg	-46.5 Wh/mi 27.1 mpg	-15.2 Wh/mi 29.8 mpg	SC03			-79.4 Wh/mi 29.0 mpg	15 mph	3.1 Wh/mi, 88.8 mpg	60 mph	6.2 Wh/mi, 44.2 mpg	30 mph	5.7 Wh/mi, 48.4 mpg	70 mph	8.7 Wh/mi, 31.7 mpg	45 mph	5.0 Wh/mi, 55.1 mpg				0% Grade	3% Grade	35-55 mph	3.4 s	3.8 s	55-65 mph	2.6 s	3.0 s	35-70 mph	7.5 s	8.7 s	55-80 mph	8.1 s	10.7 s
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6. Coasting in drive on dry surface. Test run data were cut off when the vehicle reached 10 mph, as vehicle creep speeds are typically below this threshold. The peak power into the battery value and total energy into the battery results were both taken from a single (but different) run.
7. Dynamometer testing occurs after the track testing is complete. Dynamometer testing began on May 8, 2015, with the vehicle odometer reading 4,516 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at <http://www.transportation.anl.gov/D3/>, titled “Chassis Dynamometer Testing Reference Document”. The ABC coefficients derived from track coastdown testing and matched on the dynamometer were A: 23.8171 lb, B: 0.645809 lb/mph, and C: 0.0118864 lb/mph².
8. The Cycle Results table presents the fuel economy achieved by the vehicle on five EPA drive cycles at three different ambient temperatures: (1) 72 °F with vehicle climate-control off, (2) 20 °F with vehicle climate-control set to 72 °F Auto, and (3) 95 °F with vehicle climate-control set to 72 °F Auto. The vehicle is also subjected to 850 W/m² of solar load at 95 °F to simulate direct sunlight. The drive cycles include a hot start unless otherwise indicated. The conversion for Wh/mi to miles-per-gallon-of-gasoline-equivalent (MPGe) is to divide 33,700 Wh/gallon-of-gasoline-equivalent by the Wh/mi value.
9. The passing maneuver value indicates the amount of time required for the vehicle to transition from the first to the second speed, at the specified grade.
10. Vehicle unable to complete passing maneuver at 6% grade due to lack of available power

Values in red indicate that the Performance Goal was not met.

As a production vehicle, this vehicle is assumed to meet all Federal Motor Vehicle Safety Standards (FMVSS) for Battery Electric Vehicles.

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