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Dynamometer and Road Testing of Advanced Electric Vehicles and Projections of Future Range Capability

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Abstract

Chassis dynamometer test data for three electric vehicles - the Ford/GE ETX-II, the AC Propulsion CRX, and the Solectria Force - are presented. Each of the vehicles uses an advanced ac motor and three-phase electronic controller. Tests were performed using sealed lead-acid, nickel-cadmium, nickel-metal hydride, and sodium sulfur batteries. The net energy consumption of the small passenger cars on the all-electric driving cycle (FUDS plus FHWTS) was 85-100Wh/km, which was in good agreement with simulation results obtained using the SIMPLEV computer program. Improvements in both vehicle and battery characteristics compared to the vehicles tested were projected and the energy consumption and range of the advanced vehicles predicted using SIMPLEV. The calculations indicated for the small passenger cars, 83Wh/km and a range of up to 500km (nickel-metal hydride batteries) and for minivans, 160Wh/km and a range of up to 390km (sodium sulfur batteries).

Introduction

In recent years, there have been significant advancements in motors, electronics, and batteries for electric vehicles. There have been many reports and papers (References 1–6) discussing the design and testing of these advanced components, but little data in the open (non–proprietary) literature on tests of vehicles that incorporate them into their drivelines. The advanced components include AC induction and brushless DC permanent magnetic motors and the associated electronic three–phase inverters and batteries having much higher energy density than lead–acid batteries (nickel–cadmium, nickel–metal–hydride, and sodium sulfur). In this paper, the results of a series of tests of vehicles using advanced driveline components are reported and analyzed and used as the basis for projecting the performance (primarily range)of future electric vehicles. These tests were performed at the Idaho National Engineering Laboratory (INEL) and at the California Air Resources Board (CARB) facility in El Monte, California as part of the CRADA between CARB and US. Department of Energy (DOE) to evaluate electric vehicle technology prior to the mandated manufacture of electric vehicles for sale in California in 1998. Most of the tests were done on the chassis dynamometer, but some testing was done on the road using an on–board data acquisition system (VDAS, Reference 7).

Advanced Electric Vehicles

Three electric vehicles were tested. These were the Ford/General Electric ETX–II, the AC Propulsion (Coconni) CRX, and the Solectria Force. All of these vehicles utilize AC motors and three–phase inverters and are claimed to have very efficient drivelines. The ETX–II (Reference 8) has a two–speed, automatic transaxle and the CRX and the Force have a single–speed gear reduction between the motor and the wheels. By past standards, all the vehicles have relatively high power drivelines ranging from 37.5 kW in the Force to 100 kW in the CRX. For all three vehicles, the drivelines were mounted in a chassis designed to be used with a conventional internal combustion engine (ICE). Hence the vehicle weights and road load characteristics were not particularly low and in all cases, there was considerable room for improvement in future vehicle designs using the same driveline components. The characteristics of the vehicles and their drivelines are summarized in Table 1.

Vehicles were tested using sealed lead–acid, nickel– cadmium, nickel–metal–hydride, and sodium sulfur batteries. The lead–acid and nickel–cadmium batteries are commercially available and the nickel–metal–hydride and sodium sulfur batteries are experimental models being developed under DOE and USABC programs. The characteristics of the batteries are summarized in Table 2. The energy densities range from about 30 to 75 Wh/kg and the batteries in all cases have sufficiently high power density(W/kg) to meet the power requirements of the motor/electronics in the vehicles in which they were tested. In these studies, battery life and cost were not an issue. Only battery performance was important.

Test Procedures

Dynamometer Setup

In all cases, the dynamometer setup was based on coast–down data. In the case of the CRX and the Force, the vehicles were coasted down (in both directions) on a flat portion of a public road in Idaho Falls, Idaho near INEL. For both vehicles, the half–shafts were connected to the driveline and the motor was turning during the coast–down. The CdA and rolling resistance coefficient for each vehicle were determined from the measured coast–down curves using the recommended SAE procedure (Reference 9) and the SIMPLEV vehicle simulation program (Reference 10,11). Corrections were made in both methods for the non–standard altitude (4700 ft) of Idaho Falls. The two approaches yielded essentially the same values for the road load characteristics–CdA and rolling resistance. Those values were then used in SIMPLEV to calculate the coast–down curve (speed vs. time) for sea–level, which was used to setup the electromechanical dynamometers at INEL and CARB. The road load parameters (A,B,C) for the dynamometer were adjusted until the measured coast–down times on the dynamometer matched the calculated coast down curve to a fraction of a second. For both the CRX and the Force the road load parameters determined from the INEL coast–down data resulted in higher road loads than claimed by the vehicle developers.

In the case of the ETX–II, the coast–down curve was calculated using the SAE Procedure from coastdown data supplied to INEL by Ford. The road load characteristics of the ETX–II were then calculated to be consistent with the vehicle's coastdown curve. The road load parameters shown in Table 1 for all the vehicles are based on coast–down data.

Instrumentation and Data Acquisition

For the dynamometer tests, the vehicles were instrumented primarily to determine the current, voltage, and power at the main battery pack. The voltage and current to and from the DC–DC converter were also measured. Vehicle speed was determined from the dynamometer roll speed encorder. The data were transferred to a PC hard–drive every second using the Autonet data acquisition system. The battery currents were measured using either a bar shunt or a Lem Hall effect current transducer. Voltage was taken directly off the battery pack using a voltage divider. The voltage and current signals were input into a Xitron Technologies Power Analyzer (Model 2500 series) for processing with the output signals for battery voltage, current, and power being sent to the Autonet data acquisition system. Battery Wh and Ah in and out of the battery and DC–DC converter were integrated sec–by–sec by a channel of the Autonet system. In the ETX–II tests, bar shunts were used for current measurement and in the CRX and Force tests the Lem Hall effect transducers were used. In all cases, no attempt was made to measure separately the phase currents and powers in and out of the AC inverter to the motor. Battery parameters were also measured and recorded during battery charging with the wall–plug kWh being measured by an AC watt meter.

For the CRX and Force tests, the vehicles were instrumented with the VDAS (Reference 7) system and associated sensors for battery voltage, current, and power and vehicle speed. Battery temperatures were also measured using temperature transducers. Battery current was measured using bar shunts and the power inferred using a DC power transducer. In the VDAS, the data is recorded sec–by–sec on a 2.8 Mbyte floppy disk drive for analysis and plotting off–line on a portable computer. The VDAS system was the primary data acquisition system for the dynamometer tests at CARB and all road testing. In the dynamometer tests at INEL, data were taken using the VDAS primarily as a means of validating the system and sensors for AC drivelines and the relatively high levels of noise associated with those systems. It was determined from those tests that the DC power transducer did not function satisfactorily in the AC environment so that battery power for all tests using the VDAS was determined from integrating with time the product of battery voltage and current.

Driving Cycles

The vehicles were tested at constant speeds between 40 and 105 km/h and on the following driving cycles: the Federal Urban Driving Schedule (FUDS), the Federal Highway Driving Schedule (FHWDS), the all-electric (FUDS + FHWDS), and the LA–92 (Reference 12). Maximum effort acceleration tests were also performed.

Review of the Test Data

The test data for each of the three vehicles have been presented and discussed in previously published reports from the INEL (References 13–15) and CARB (References 16). In this paper, the test data will be reviewed and used as a basis for comparing the energy consumption and performance characteristics of the vehicles and projecting the characteristics of similar size vehicles in the future.

AC Propulsion (Coconni) CRX

The characteristics of the AC Propulsion CRX are given in Table 1. The values shown for the road load parameters were based on coast–down tests at the INEL. The weight was determined by weighing the vehicle prior to the tests. The Optima 800S batteries used in the INEL tests were badly degraded in Ah capacity, but they were capable of providing sufficiently high power to meet the vehicle power requirements for the INEL tests. The batteries were replaced with new Optima batteries prior to the testing at CARB.

The energy economy test results for the CRX are summarized in Table 3. Results are shown for constant speeds between 40 and 105 km/h and for the FUDS, FHWTS, LA–92, and all-electric (combined FUDS and FHWTS) driving cycles. Also shown in Table 3 for the constant speeds are calculated driveline efficiencies (battery to the wheels) obtained by dividing the road load power (calculated from the coast–down curve using SIMPLEV) and the measured power out of the battery. The test data indicate that for an electric vehicle having a test weight of over 1450 kg, the net energy consumption of the CRX is quite low being about 100 Wh/km for the federal urban and highway driving cycles and at a constant speed of 85–90 km/h. The range of the vehicle depends on the energy storage capacity of the battery. For a lead–acid battery storing 15 kWh, the range would be about 150 km (93 miles). The test data also indicate that about 25% of the gross energy out of the battery is returned during regenerative braking on the FUDS and LA–92 driving cycles. This is the largest fraction measured for a vehicle at INEL to date. The acceleration characteristics of the CRX are also shown in Table 3. The 0–96 km/h acceleration time of 10 seconds is the best to date at INEL and results from the use of the 100 kW motor in the vehicle. Comparisons of the test results for energy consumption and maximum effort acceleration times and calculated values obtained using SIMPLEV are given in Table 4. In all cases, the test data and calculated values agree to within 10% and in most instances much closer.

Testing of the CRX on the road was done at CARB using the VDAS as the on-board data acquisition system. In all instances, the road data were consistent with the dynamometer data, but it was not possible to get data on the road of sufficient repeatability for detailed comparisons with the dynamometer data. The CRX did exhibit a range of 150–200 km on the road with new Optima 800S batteries depending on the traffic conditions.

Solectria Force

Solectria Force vehicles were tested at both INEL and CARB. Two different vehicles were involved in the testing. Both vehicles were equipped with dual 18 kW, induction motors mounted on the same shaft with a single speed reduction from the motor output shaft to the input to the transaxle. The vehicle tested at INEL used Saft nickel–cadmium batteries and the vehicle at CARB used the experimental nickel–metal–hydride (NiMH) batteries from the Ovonic Battery Co. As shown in Table 1, the test weights and dynamometer setups for the two vehicles were different.

For each vehicle, special care was taken to verify that the battery powers at various constant speeds were the same on the dynamometer and the road.

The energy consumption data for the two Solectria Force vehicles for constant speeds and the various driving cycles are given in Tables 5 and 6. Also shown are acceleration characteristics of the vehicles. Note that the energy consumption of the Force vehicle tested at CARB was 80–90 Wh/km and that of the Force tested at INEL was 110–120 Wh/kM. These differences of 20–40% are due to the lower weight, lower CdA, and lower rolling resistance of the Force tested at CARB. The differences in energy consumption of the two vehicles were predicted with good accuracy by the SIMPLEV simulation program. This is a good example of the large effect on vehicle energy consumption that can result from the use of a smaller pack of higher energy density batteries, lower road loads from reducing aerodynamic drag and rolling resistance, and improvements in regenerative braking. The Solectria Force tested at CARB with the Ovonics nickel–metal–hydride batteries has a calculated range of 200–240 km based on a measured battery capacity of 18.9 kWh at the C/3 rate and the measured energy consumption values for the various driving cycles. Range results for the Force tested at the INEL were not meaningful, because the discharge capacity of the NiCd batteries during the tests was much less than the 140 Ah rated capacity of the batteries. With batteries at rated capacity, the estimated range of the Force with NiCd batteries would be about 145 km (90 miles) on the all–electric driving cycle.

The acceleration characteristics of the two Force vehicles are essentially the same as would be expected since they both use the same motor and controller. Both vehicles had adequate, but not outstanding, acceleration characteristics (0–48 km/h in 6 sec and 0–80 km/h in 15 sec) because the combined power of the two motors in the vehicles was only about 40 kW.

Ford/General Electric ETX–II

The ETX–II was tested on the chassis dynamometer at the INEL in late 1991 and early 1992 as part of the DOE program to evaluate electric vehicles using advanced driveline components (Reference 8). As shown in Table 1, the ETX–II driveline consisted of a 52.5 kW interior permanent magnetic synchronous motor, three–phase transistor inverter and a microprocessor–based inverter/motor controller with the motor and two–speed, automatic transaxle on a single shaft mounted as part of the rear axle of the vehicle. The traction battery in the ETX–II was an experimental 60 kWh, sodium–sulfur (NaS) battery developed by Chloride Silent Power (CSPL) of the United Kingdom. The battery was extensively tested at INEL as reported in References (17,18). The NaS battery was nearing the end of its calendar life at the time the ETX–II testing was started and the tests were completed using sealed lead–acid batteries. The tests of the ETX–II with the NaS battery did show a measured range of 194 km (120 miles) on the dynamometer at 88 km/h with discharge energy of 40kWh.

The energy consumption data for the ETX–II are summarized in Table 8. On the FUDS cycle, the ETX–II had an energy consumption of 212 Wh/km and at 88 km/hr (55 mph), the energy consumption was 218 Wh/km. Neither of these energy consumption values includes the effect of heat loss from the battery. The ETX–II was not tested on the highway and all– electric cycles. The relatively high energy consumption of the ETX–II is due primarily to its weight (2045 kg) and road load characteristics (CdA=1.08 m2, Fr=.0095). As indicated in Table 8, the efficiency of the driveline is 70–85% except at low power (less than 6kW). As would be expected, the energy consumption of the vehicle was essentially the same with the NaS and lead–acid batteries. As with the other vehicles, SIMPLEV simulation results for the ETX–II were in good agreement with the test data.

Future Performance of Electric Vehicles

The performance (energy consumption, range, and acceleration) of electric vehicles can be expected to improve significantly in the future due primarily to improvements in vehicle characteristics (weight and road load) and battery energy and power densities (Wh/kg,W/kg). Projections of the magnitude of these improvements in performance for small passenger cars, similar to the CRX and the Force, and minivans will be made based on SIMPLEV calculations. The vehicle designs and battery characteristics (lead–acid, nickel–metal–hydride, and sodium sulfur) assumed in the simulations are considered to be achievable in the near–term or by 1998–

2000. The starting point for the projections are the characteristics of the vehicles and batteries whose tests were discussed in the previous section of the paper. The drivelines for the small passenger cars consisted of components scaled from those in the CRX (much like those in the GM Impact) and those in the minivans were scaled from the MEVP components (Reference 19) being used by Ford in the Ecostar.

The performance improvement results will be discussed in two parts. First, the effect of reduced weight and road load will be presented using batteries like those in the vehicles tested at INEL and CARB and second, the effect of improved batteries combined with the improved vehicle characteristics will be shown and discussed. Vehicle range is the performance parameter of primary interest in the projections as satisfactory vehicle acceleration (0–96 km/h in 10–13 seconds) has been demonstrated in both types of vehicles using all the batteries being considered in this paper.

Improved Vehicle Characteristics

The characteristics of the present and improved vehicles are shown in Table 9. Modest improvements in vehicle weight, aerodynamic drag, rolling resistance, and regenerative braking have been assumed. SIMPLEV calculations were made for both the present and improved vehicles for batteries that are presently commercially available off the shelf or are experimental, but available from the developer for testing in vehicles. The battery characteristics and their source are shown in Table 10. The results of the SIMPLEV calculations for small passenger cars and minivans on the all–electric driving cycle are given in Table 11. The battery weight was fixed for each vehicle type. Improving the vehicle characteristics decreased the energy consumption and increased the range by about 25% for all types of batteries. All the vehicles used efficient ac drivelines of sufficient maximum power to give good acceleration characteristics.

Improved Batteries

The battery improvements assumed were given in Table 10. The key battery parameter listed in the table is energy density Wh/kg, but each of the batteries was modeled in detail in SIMPLEV (Reference 10) in terms of module weight, Ah capacity, and open circuit voltage and resistance as a function of state–of–charge. The battery for each vehicle was sized (Ah capacity) to yield the battery weight required (fixed) for that vehicle with battery resistance being scaled by SIMPLEV to reflect the capacity change from the reference cell for that battery type. Calculations were made for present and improved batteries in the improved vehicle designs (small passenger cars and minivans). The results are given in Table 12. Range improvements of 35–60% are projected when the improved batteries become available with ranges of 325– 485 km (200–300 miles) being possible for small passenger cars and 240–325 km (150–200 miles) projected for minivans. The range results for the various battery types are summarized in Table 13. The ranges shown correspond to 100% discharge of the batteries so that the useful range of the vehicles is 80–90% of the values in the tables. All the batteries included in the simulations are currently in an advanced state–of–development and can be considered near–term battery candidates.

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Table 1: Characteristics of Electric Vehicles Tested at INEL and CARB

Vehicle	Test Weight kg	C_D	A_F m²	Rolling Resistance	Motor Type	Maximum Motor Power (kW)	Transmission
Ford/GE ETX-II	2050	.37	2.92	.0095	dc brushless permanent magnetic	52.5	2-speed automatic
AC Propulsion CRX	1477	.30	1.77	.0067	ac induction	100	single speed reduction
Solectria Force -INEL	1236	.30	1.79	.0125	ac induction	37	single speed reduction
Solectria Force -CARB	1164	.30	1.67	.0065	ac induction	42	single speed reduction

Table 2: Characteristics of the Batteries in the Vehicles Tested at INEL and CARB

Vehicle	Battery Type	Battery Manufacturer	Pack Voltage	Pack Weight (kg)	Module Voltage/Ah	Energy Density (Wh/kg)
Ford/GE ETX-II	sodium sulfur	Chloride Silent Power	200	750	8V/300Ah	75
AC Propulsion CRX	sealed lead-acid	Optima	336	490	12V/45Ah	28
Solectria Force -INEL	flooded nickel-cadmium	Saft	126	382	6V/140Ah	46
Solectria Force -CARB	sealed nickel-metal hydride	Ovonic	164	280	12V/130Ah	67

Table 3: Summary of Test Data for the AC Propulsion CRX

Test Cycle	$(Wh/km)_{net}$	$(Wh/km)_{gross}$	% Regeneration
FUDS	101	136	25.7
LA92	127	165	23.0
Highway	97	100	3.0
All-electric	100	115 (estimated)	13.0 (estimated)

Constant Speed

Speed (km/h)	P_{AV}(kW)	Wh/km	Efficiency (%) Bat - Wheels
40	2.2	55	69
48	2.8	58	74
56	3.6	64	78
64	4.5	70	84
72	5.6	78	86
80	7.0	87	88
88	8.5	97	90
96	10.2	106	91

Acceleration Time

	Time (sec)
0 - 48km/h	5.6
0 - 80km/h	8.4
0 - 96km/h	10.4

Table 4: Comparison of Test Data and SIMPLEV Calculations for the AC Propulsion CRX

	Wh/km			
	Test		SIMPLEV	
Driving Cycle	Net	Gross	Net	Gross
FUDS	101	136	109	143
Highway	96	100	100	112
LA92	127	167	129	175

Constant Speed

	Wh/km	
Speed (km/h)	Test	SIMPLEV
40	55	55
48	58	59
56	64	66
64	70	75
72	78	83
80	87	95
88	97	106
96	106	118

Acceleration Time

	Time (sec)	
	Test	SIMPLEV
0 - 48km/h	5.6	4.2
0 - 80km/h	8.4	7.6
0 - 96km/h	10.4	10.0

Table 5: Summary of Test Data for the Solectria Force - INEL (NiCd)

Test Cycle	$(Wh/km)_{net}$	$(Wh/km)_{gross}$	% Regeneration
FUDS	108	138	21.7
LA 92	137	170	19.4
Highway	122	125	2.4
All-electric	114	129	11.6

Constant Speed

Speed (km/h)	PAV(kW)	Wh/km	Efficiency (%) Battery-to-wheels
40	2.8	69	78
48	3.6	74	80
56	4.4	79	84
64	5.6	88	82
72	6.9	96	84
80	8.5	106	85
88	10.3	117	85
96	13.3	139	80

Acceleration Time (sec)

0 - 48km/h	6.2
0 - 80km/h	23.1
0 - 96km/h	-

Table 6: Summary of Test Data for the Solectria Force - CARB (NiMH)

Test Cycle	$(Wh/km)_{net}$	$(Wh/km)_{gross}$	% Regeneration
FUDS	92	114	19.2
LA 92	-	-	-
Highway	80	86	6.8
All-electric	86	99	13.0

Constant Speed

Speed (km/h)	P_{AV}(kW)	Wh/km	Efficiency (%) Battery-to-wheels
40	-	-	-
48	2.9	60	66
56	-	-	-
64	4.0	63	77
72	-	-	-
80	6.5	81	76
88	-	-	-
96	9.4	98	82

Acceleration Time (sec)

0 - 48km/h	6.5
0 - 80km/h	15
0 - 96km/h	22

Table 7: Comparison of Test Data and SIMPLEV Calculations for the Solectria Force - CARB (NiMH)

	Wh/km			
	Test		SIMPLEV	
Driving Cycle	Net	Gross	Net	Gross
FUDS	92	114	91	115
Highway	80	86	82	90
All-electric	86	99	85	100

Constant Speed

	Wh/km	
Speed (km/h)	Test	SIMPLEV
40	-	-
48	60	52
56	-	-
64	63	62
72	-	-
80	81	78
88	-	-
96	98	97

Acceleration Time

	Time (sec)	
	Test	SIMPLEV
0 - 48km/h	6.5	8.2
0 - 80km/h	15	14.9
0 - 96km/h	22	20

Table 8: Test Data and SIMPLEV Calculations for the ETX-II (Data Taken from Reference 13)

	Wh/km			
	Test		SIMPLEV	
Driving Cycle[1]	Net	Gross	Net	Gross
SAE J227a C	196	218	225	237
FUDS	212	233	238	251

Constant Speed[2]

	Wh/km		
Speed (km/h)	Test	SIMPLEV	Effic. Bat-wheels[3]
48	155	158	61
56	159	165	68
72	172	203	83
80	200	227	81
88	218[4]	253	85
96	242	279	-

(1) Driving cycle tests were performed with sealed lead-acid batteries.

(2) Constant speed tests were performed with the CSPL sodium-sulfur battery.

(3) Efficiency (battery-to-wheels) was calculated from the measured battery power and calculated road load based on the dynamometer coastdown curve.

(4) Measured range of 185km with the sodium sulfur battery (40kWh capacity).

Table 9: Characteristics of Present and Improved Vehicle Designs

Vehicle	Test Weight kg	C_D	$A_F(m^2)$	Rolling Resistance	Maximum Motor Power (kW)	Regen Factor
Small passenger car						
Present	1471	.30	1.75	.0067	100	.70
Improved	1343	.24	1.75	.0055	100	.70
Minivan						
Present	2045	.36	2.9	.008	75	.5
Improved	1809	.32	2.9	.0065	75	.75

Table 10: Characteristics of Present and Improved Batteries of Various Types

	Present (1994)			Improved		
Battery Type[1]	$(Wh/kg)_{cn}$	$(W/kg)_{max}$	Source	$(Wh/kg)_{cn}$	$(W/kg)_{max}$	Source
Sealed lead-acid	28	120	Sonnenschein	45	250	Horizon
Ni Mt. Hydride	65	150	Ovonic	85	200	Ovonics
Sodium Sulfur	75	100	CSPL	105	150	CSPL

(1) All batteries modeled in SIMPLEV in terms of module weight and open-circuit voltage and resistance as a function of state-of-charge.

Table 11: Effect of Vehicle Improvements on Vehicle Performance Using Present Batteries

		Present Vehicles		Improved Vehicles	
Battery Type	Battery Weight (kg)	Wh/km	Range (km)(2)	Wh/km	Range (km)(2)
Small Passenger Cars(1)					
Lead-acid	490	101	148	83	187
Ni Mt Hydride	475	101	300	83	370
Minivans(1)					
Lead-acid	590	192	87	160	110
Ni Mt. Hydride	590	191	198	159	240
Na S	590	192	229	160	274

(1) All vehicles accelerate 0-96km/h in 10-13 seconds.

(2) Range on the all-electric driving cycle (FUDS + FHWTS)

Table 12: Effect of Battery Improvements on the Performance of Vehicles Having Improved Characteristics

		Present Batteries		Improved Batteries	
Battery Type	Battery Weight (kg)	Wh/km	Range (km)(2)	Wh/km	Range (km)(2)
Small Passenger Cars(1)					
Lead-acid	490	83	187	82	296
Ni Mt Hydride	475	83	370	83	517
Minivans(1)					
Lead-acid	590	160	110	160	184
Ni Mt. Hydride	590	159	240	159	320
Sodium Sulfur	590	160	274	160	390

(1) All vehicles accelerate 0-96km/h in 10-13 seconds

(2) Range on the all-electric driving cycle (FUDS + FHWTS)

Table 13: Projected Range and Acceleration for Advanced Electric Vehicles

	Ranges (km)(1)	
Battery Type	Small Passenger Cars(2)	Minivan(3)
Lead-acid	296	184
Ni Mt Hydride	516	320
Sodium Sulfur	–	390

(1) Ranges on the all-electric driving cycles (FUDS + FHWTS)

(2) Acceleration for small passenger cars	0 - 48km/h	3.8 sec
	0 - 80km/h	6.9 sec
	0 - 96km/h	9.0 sec
	maximum motor power	83 kW
	maximum battery power	190 W/kg
(3) Acceleration for minivans	0 - 48km/h	4.3 sec
	0 - 80km/h	9.5 sec
	0 - 96km/h	13.4 sec
	maximum motor power	120 kW
	maximum battery power density	150 W/kg