Project Lithium V2.5
Lexus CT200h Hybrid Battery Retrofit
Platform Validation & Testing Report

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Fennec LLC
FennecConcepts.com

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Disclaimer

The contents of this report is not endorsed, sponsored, or affiliated with NexPower Energy, Project Lithium, Nexcell Battery, or the Dr. Prius App. The Project Lithium battery used in this testing was purchased through the Project Lithium website, without any prior notice made to NexPower Energy that this battery would be used for testing. No additional modifications have been done to the 2ZR-FXE engine or hybrid system on either vehicle beyond the Project Lithium battery retrofit. **NexPower Energy did not receive or review this report before it was released.**

The data collected and presented in this report is being represented to the best of my ability, but it should be acknowledged that while I attempted to control the testing environments, there are still potential variables that are difficult to quantify and control. As such, the data and results presented in this report are for informational use only.

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*For any questions or comments on the contents of this report, feel free to email me at **mfarthi@gmail.com***

Vehicle Selection - Overview & Differences

Overview

The vehicles selected for this testing were a 2012 and 2017 Lexus CT200h. Table 1 highlights the key differences between the 2 selected vehicles.

Vehicle Model	**2012 Lexus CT200h Premium**	**2017 Lexus CT200h F Sport**
Mileage	108262	100033
Battery Type	Original - Nickel–Metal Hydride (NiMH)	Project Lithium - Lithium Iron Phosphate (LiFePO4)
Battery Mileage	108262	3333
Maximum Battery Capacity	69.44%	100%
Tire Information	Kelly Edge A/S 215/45/R17	Michelin Primacy MXM4 215/45/R17
Tire Pressure	36 PSI	36 PSI

Table 1: Vehicle Selection and Key Differences

The vehicles were chosen due to their similar mileage to minimize differences in vehicle age. The Dr. Prius App Life Expectancy Test was performed prior to the test, with the 2012 CT200h showing a maximum reported battery capacity of 69.44% prior to the test. Due to the Project Lithium battery being recently installed in the 2017 CT200h, a life expectancy test was not performed.

Both vehicles were refilled to maximum capacity at the same gas station prior to the start of the testing. 87 Octane was used. Tire pressures were confirmed on all 4 wheels, and filled to correct pressures if they did not match. Both vehicles were driven on the exact same routes in sequential order until all testing was complete. Every test swapped the order in which each vehicle ran the test first, with the first test beginning with the 2012 CT200h. Testing equipment was swapped between vehicles between each test run. Every test was ran in ECO mode unless stated otherwise. The order that the tests are presented in this report is the order they were ran.

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Testing Equipment

Both vehicles used the same recording equipment through the entirety of this report, and was swapped between vehicles prior to the beginning of every test.

- Android Tablet: Samsung Galaxy Tab A9+ 11”
- OBD Scanner: OBDLink MX+ OBD2 Scanner
- Hybrid Battery/Vehicle Monitoring: Dr Prius App Version 6.30
- Performance App: OBD Link App Version 5.38.0
- Vehicle Tablet Mount Base: RAM MOUNTS Tough-Wedge Base
- Tablet Mount: RAM Mounts RAM-HOL-TAB20U Tab-Tite Holder w/ Custom End Caps for Samsung Tablet

Testing Configuration & Layout inside the Lexus CT200h

A very important detail needs to be made. While I attempted to record logs of every test I performed, it was discovered that the recording function in the Dr. Prius App did not behave as expected and did not save the logs after every test. This was discovered after completion of the final test, and when I began writing this report. As a result, there will be less vehicle-recorded data plotted in the report than expected. While this is unfortunate, the data presented below was still recorded immediately following each run and is as accurate and consistent to the best of my ability.

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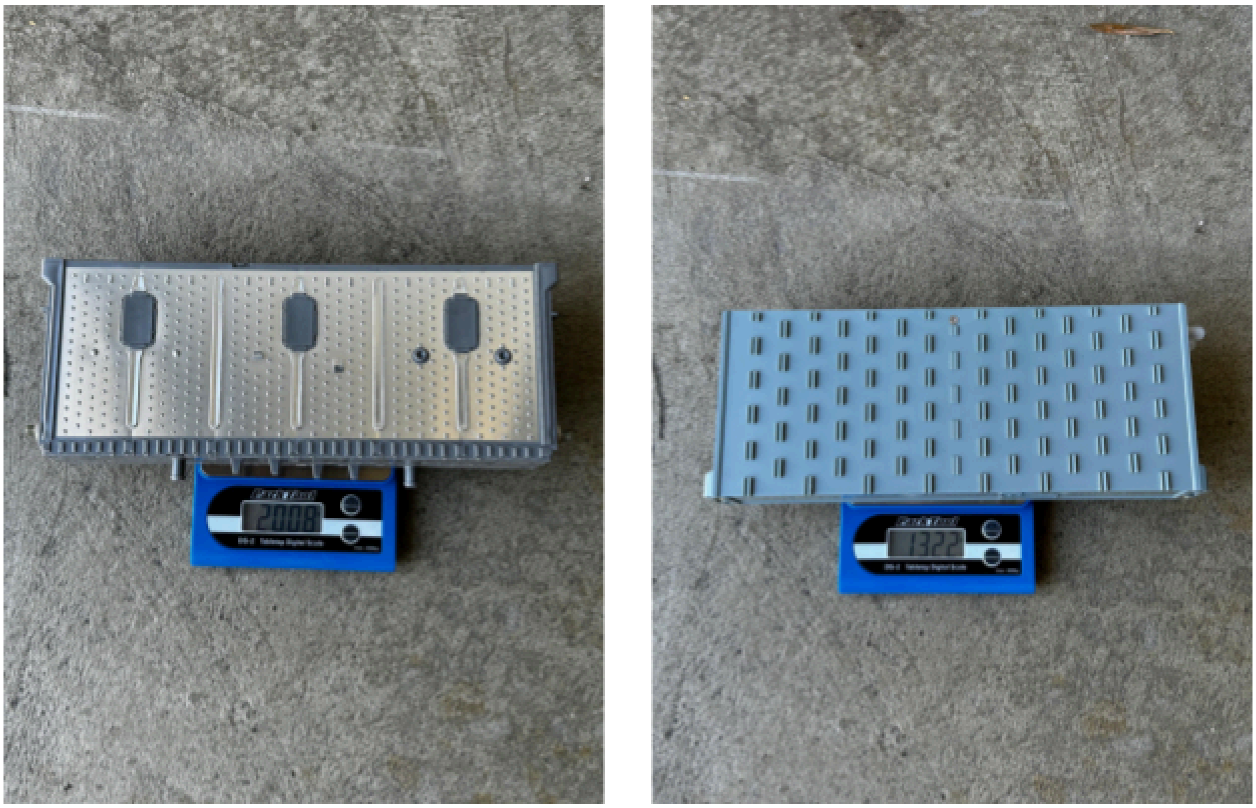
Project Lithium Battery Overview - Weight Differences

This section is to provide a brief overview of the weight differences between the 2 batteries. When I performed the battery retrofit, I weighed the individual cells to test the claim made by NexPower Energy on the weight savings of the pack. The image below shows a screenshot of the weight savings claims made by NexPower energy on the CT200h battery sale page.

1. **1/2 of the weight of the original battery pack** Stock NiMH battery weights 80 lbs! Dr. Prius lithium pack weight less than 35 lbs.

Weight saving claims by NexPower Energy

Each cell was weighed on a Park Tool DS-2 Tabletop Digital Scale. The measured weight is shown in the image below.



Weight difference between the factory NiMH Battery Cell (Left) and Project Lithium V2.5 Cell (Right). Measurement is in grams

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Table 2 shows the total weight of the cells in each battery pack configuration.

	Stock NiMH Battery	Project Lithium Battery
Individual Cell Weight (Grams)	2008g	1322g
Total Cell Weight (Grams)	28112g	18508g
Weight Difference	**9604g**	

Table 2: Weight differences between the NiMH Battery Cell and Project Lithium Cell

The total weight reduction seen by the battery pack is **9604g, or 21.1732lbs**. This is a **34.1633% decrease in cell weight.** While this is an improvement, this is not equal to half the weight of the original battery pack, as claimed by NexPower Energy.

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EV Mode Range Test 1

Test Overview

An EV Mode Range Test is to test the overall improvement in EV Mode Range with a Project Lithium battery. The vehicles were driven on a predetermined route at a targeted fixed speed (20 MPH). With both vehicles being fully charged to 75% SOC, each vehicle was driven in EV mode until the internal combustion engine was restarted to recharge the battery (when 40% SOC was reached). Once the engine is started, the vehicle is brought to a complete stop and data was recorded.

The tachometer in "normal" mode was kept under the "ECO" reading, as going above will trigger the engine to restart. The line to not cross is shown in red in the image below.

The line (in red) on the tachometer that cannot be crossed to keep the vehicle in EV Mode.

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Route Overview

The route was a single direction route through a rural section of Wisconsin. The vehicles started from the same position and drove until the internal combustion engine was activated to recharge the battery. Figure 1 shows the route that the vehicles used during the EV Mode Range Test 1.

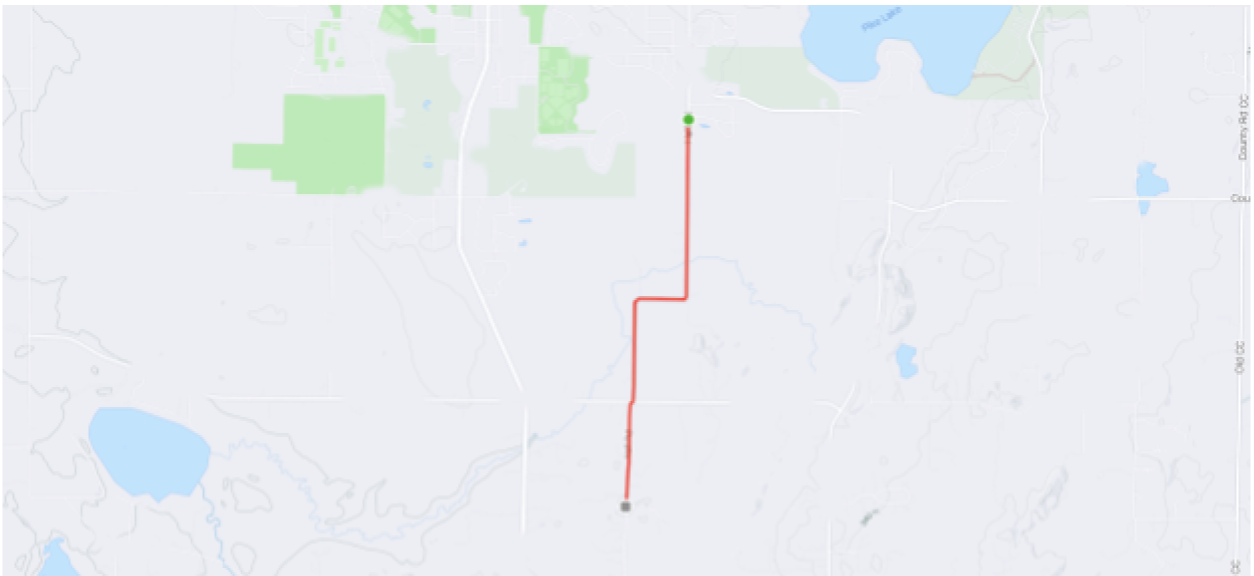

Figure 1: Route used for EV Range Test 1

Figure 2 shows the elevation profile of the route.

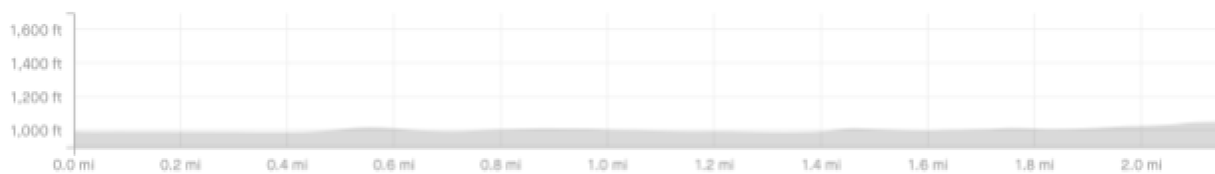

Figure 2: Elevation Profile of EV Mode Range Test 2

Results

The results of the EV Mode Range Test 1 can be seen in Table 3. Definitions for each row are as follows.

- **Starting State of Charge %:** This was the reported high voltage battery State of Charge (SOC) at the beginning of the test.
- **Outside Ambient Temperature**: This was the reported outside temperature reported by the Instrument Panel Cluster at the beginning of the test.
- **HVAC Settings**: These were the settings of the Heating, Ventilation, and Air Conditioning (HVAC) system at the beginning of the test. These settings were not changed throughout the duration of the test to minimize variance in electrical load on the system. The Air Conditioning Compressor is a high voltage component, and relies on the high voltage battery to operate.

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- **Distance Travelled**: This was the total distance recorded by the "TRIP A" trip counter in the Instrument Panel Cluster. This was reset at the beginning of every test.
- **Average Speed:** This was the average speed recorded by the "AVERAGE SPEED" value reported in the Instrument Panel Cluster. This was reset at the beginning of every test.

	Stock NiMH Battery	Project Lithium Battery
Starting State of Charge %	75%	75%
Outside Ambient Temperature	83º F	83º F
HVAC Settings	72 Auto	72 Auto
Distance Travelled	1.4 Miles	2.1 Miles
Average Speed	21 MPH	21 MPH

Table 3: Results of EV Range Test 1

Overall, the Project Lithium Battery saw a **50% increase** in EV Mode Range when compared to the standard NiMH battery pack. It was acknowledged that due to the elevation being more extreme beyond the 1.4 miles the NiMH battery was able to travel, that the test was not representative of the true improvements from the Project Lithium battery. This was retested in EV Mode Range Test 2 later in this report.

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20 Mile Variable Efficiency Test

Test Overview

The goal of this test is to understand the efficiency of the Project Lithium battery on a standard, non-highway route at various speeds. Since the hybrid battery is more utilized by the vehicle at lower speeds, this test was created to quantify these potential efficiency gains. This test is to attempt to validate the claims made in the Project Lithium FAQ on their website. The specific quote is in Figure 3.

Q: What is the MPG gain?

A: It depends on how good you are utilizing the electric power, the customers report back with at least 10% MPG gain in city and highway driving combine. Please check out our EV range test videos to find out the maximum potential.

Figure 3: Project Lithium's Claim on MPG Improvement

The EPA-defined "Combined MPG" is a weighted average of the EPA City Fuel Efficiency Test (55%) and EPA Highway Fuel Efficiency Test (45%). This would be a difficult percentage to quantify (and claim an improvement on) without a controlled environment. The EPA runs their tests in a laboratory on an engine dynamometer (Figure 4) to minimize variability throughout the test.

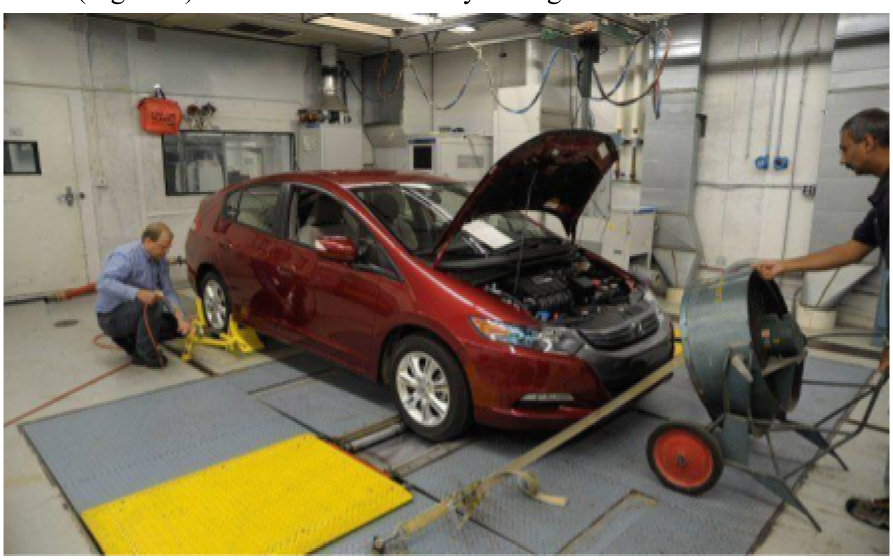

Figure 4: An engine dynamometer, used by the EPA for fuel efficiency tests

During a EPA fuel efficiency test, the vehicle is ran through a pre-programmed "City" profile and a "Highway" profile (Figure 5) to calculate the City and Highway MPG for the vehicle.

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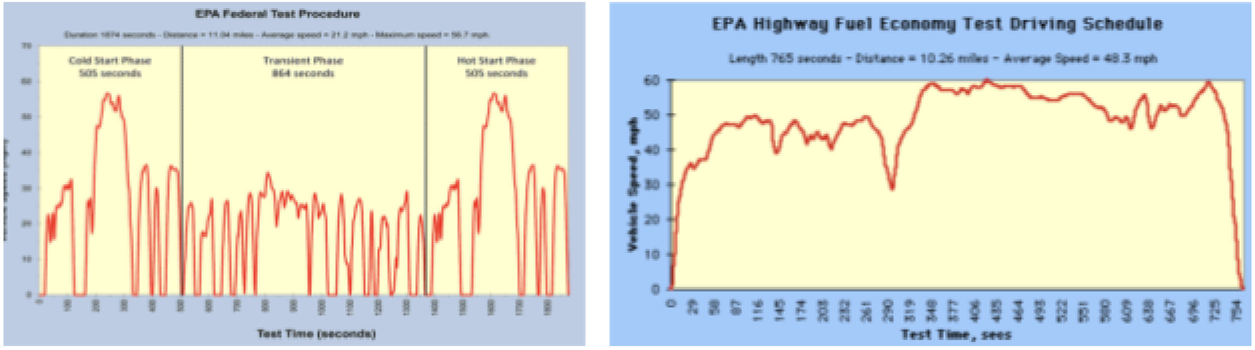

Figure 5: The City (Left) and Highway (Right) test driving profile used by the EPA. City represents urban driving, in which a vehicle is started with the engine cold and driven in stop-and go rush hour traffic. Highway represents a mixture of rural and interstate highway driving with a warmed-up engine, typical of longer trips in free-flowing traffic.

At the time of this report, no data was found showing such a test has been performed on a dynamometer for the Project Lithium Battery. The test I conducted for this report was also not performed on a dynamometer, and was performed on a public road in a pre-defined loop. The loop was designed to attempt to mimic the EPA Highway Fuel Economy Test Profile, with speeds varying between 35 and 55 miles per hour. This is much lower than the speed limits used by most of the United States for their interstates & highways, and therefore a separate interstate driving efficiency test will be performed later in this report. Unlike the EPA test, which is only 10.26 miles long, this test was extended to 20 miles to provide greater exposure to various speed limits on the route. To help ensure consistency between vehicles, the tests were performed back-to-back to limit the variance in traffic. In addition, vehicles were placed in ECO mode, and Cruise Control was used once the vehicle reached the speed limit. Acceleration and braking were smooth and consistent, in an attempt to maximize efficiency for both vehicles.

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Route Overview

The defined route was a 20 mile loop with varying speeds between 25 and 55 MPH. Both vehicles started and finished at the same location, completing the loop in a counter clockwise direction. Figure 6 shows the loop and speed limits on each section of the road.

Figure 6: 20 Mile Efficiency Test Loop

The route contained many rolling hills with 100-200 feet of elevation gain. The descents allow for testing of the increased capacity and regenerative braking capabilities that NexPower Energy claims. Figure 7 shows the elevation profile of the route.

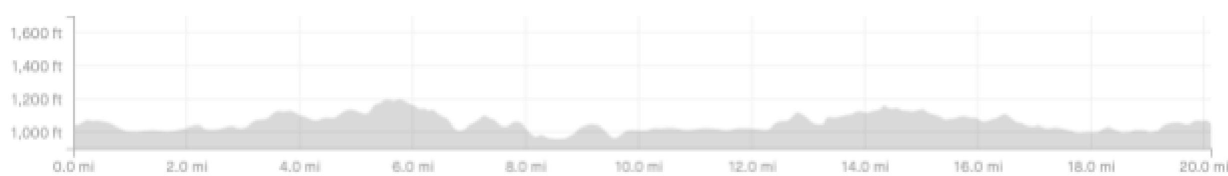

Figure 7: Elevation Profile of the 20 Mile Efficiency Test

Results

Table 4 shows the results of the 20 Mile Variable Efficiency Test. Definitions for each row are as follows:

- **Starting State of Charge %:** This was the reported high voltage battery State of Charge (SOC) at the beginning of the test.
- **Outside Ambient Temperature**: This was the reported outside temperature reported by the Instrument Panel Cluster at the beginning of the test.
- **HVAC Settings**: These were the settings of the Heating, Ventilation, and Air Conditioning (HVAC) system at the beginning of the test. These settings were not changed throughout the

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duration of the test to minimize variance in electrical load on the system. The Air Conditioning Compressor is a high voltage component, and relies on the high voltage battery to operate.

- **Total Trip Time:** This was the total duration of the test, measured by the “TRIP TIME” field in the Instrument Panel Cluster. This was reset at the beginning of every test.
- **Distance Travelled**: This was the total distance recorded by the “TRIP A” trip counter in the Instrument Panel Cluster. This was reset at the beginning of every test.
- **Average Speed:** This was the average speed recorded by the “AVERAGE SPEED” value reported in the Instrument Panel Cluster. This was reset at the beginning of every test.
- **Car Reported MPG.** This was the average Miles Per Gallon (MPG) recorded by the “AVERAGE” page reported in the Instrument Panel Cluster. This value can be reset at any time, and is different from the “AVG” value reported on the “CURRENT” MPG page, which is the average fuel economy since the last full fuel refill. Car Reported MPG was reset at the beginning of every test.

	Stock NiMH Battery	Project Lithium Battery
Starting State of Charge %	75%	75%
Outside Ambient Temperature	85º F	86º F
HVAC Settings	72 Auto	72 Auto
Total Trip Time (Hr:Min)	0:33	0:32
Distance Travelled	20.0 Miles	20.0 Miles
Average Speed	39 MPH	40 MPH
Car Reported MPG:	49.5 MPG	55.6 MPG

Table 4: 20 Mile Efficiency Test Results

Overall, the Project Lithium Battery saw a ***6.1 MPG increase*** when compared to the stock NiMH Battery after completing the 20 Mile Variable Efficiency Test. While the average speed was 9-10 MPH slower than the EPA Highway Fuel Economy Test profile, the test can still be seen as a representative example of a route that can be seen in the Rural Midwest.

Based on these results, **the Project Lithium battery increases medium speed, non-highway driving efficiency by 12.3232%.**

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70 MPH Interstate Efficiency Test

Test Overview

The goal of this test is to understand the efficiency of the Project Lithium battery on a typical, high-speed interstate found in most parts of the United States. Since the hybrid battery is more utilized by the vehicle at lower speeds, and the vehicle is not equipped with a powerful enough motor to provide propulsion at interstate speeds, this test was created with the expectation that there would be little to no difference in fuel efficiency at higher speeds. The test utilized a standard, limited-access interstate, with 2 on-ramp accelerations and 2 exit-ramp decelerations to complete a 24 mile loop.

Route Overview

The defined route is a 24 mile interstate loop with a 70 MPH speed limit. Both vehicles started and finished at the same location. The vehicles drove southbound before exiting the interstate and returning northbound to the starting location. Figure 8 shows the 70 MPH Interstate Efficiency Test route.

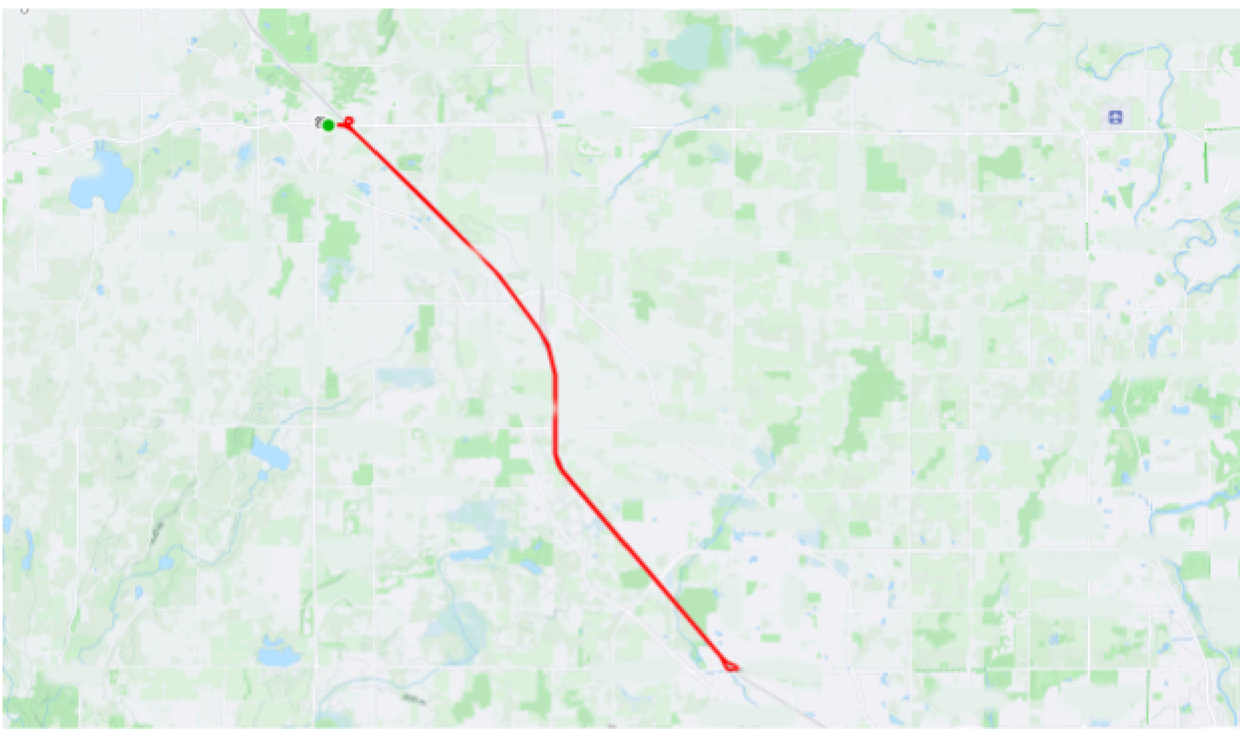

Figure 8: 70 Mile Interstate Efficiency Test Route

The elevation profile of this interstate is shown in Figure 9.

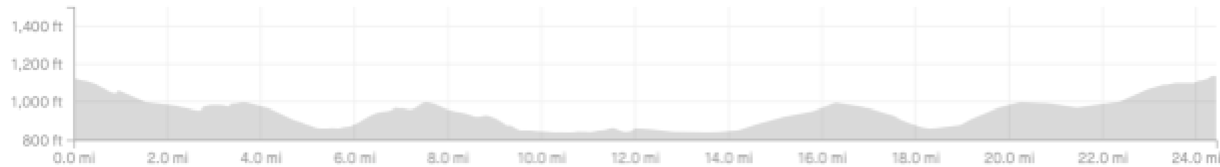

Figure 9: Elevation Profile of the 70 MPH Interstate Efficiency Test

Results

Table 5 shows the results of the 70 MPG Interstate Efficiency Test. Definitions for each row are as follows:

- **Starting State of Charge %:** This was the reported high voltage battery State of Charge (SOC) at the beginning of the test.
- **Outside Ambient Temperature**: This was the reported outside temperature reported by the Instrument Panel Cluster at the beginning of the test.
- **HVAC Settings**: These were the settings of the Heating, Ventilation, and Air Conditioning (HVAC) system at the beginning of the test. These settings were not changed throughout the duration of the test to minimize variance in electrical load on the system. The Air Conditioning Compressor is a high voltage component, and relies on the high voltage battery to operate.
- **Total Trip Time:** This was the total duration of the test, measured by the “TRIP TIME” field in the Instrument Panel Cluster. This was reset at the beginning of every test.
- **Distance Travelled**: This was the total distance recorded by the “TRIP A” trip counter in the Instrument Panel Cluster. This was reset at the beginning of every test.
- **Average Speed:** This was the average speed recorded by the “AVERAGE SPEED” value reported in the Instrument Panel Cluster. This was reset at the beginning of every test.
- **Car Reported MPG.** This was the average Miles Per Gallon (MPG) recorded by the “AVERAGE” page reported in the Instrument Panel Cluster. This value can be reset at any time, and is different from the “AVG” value reported on the “CURRENT” MPG page, which is the average fuel economy since the last full fuel refill. Car Reported MPG was reset at the beginning of every test.

	Stock NiMH Battery	Project Lithium Battery
Starting State of Charge %	75%	75%
Outside Ambient Temperature	84º F	86º F
HVAC Settings	72 Auto	72 Auto
Total Trip Time (Hr:Min)	0:36	0:37
Distance Travelled	24.0 Miles	24.1 Miles
Average Speed	63 MPH	63 MPH
Car Reported MPG:	44.9 MPG	45.2 MPG

Table 5: 70 MPH Interstate Efficiency Test Results

Overall, the Project Lithium Battery saw a ***0.3 MPG increase*** when compared to the stock NiMH Battery after completing the 70 MPH Interstate Efficiency Test.

Based on these results, **the Project Lithium battery saw improved interstate driving efficiency by 0.668151%. However, this is *well* within a margin of error for a non-closed course, not 100% controlled testing environment. The conclusion of this test is that the Project Lithium battery does NOT provide any benefit for interstate or high speed driving.**

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Acceleration Performance Test

Test Overview

The goal of this test is to understand the performance improvements from the Project Lithium Battery through an acceleration test. This test is to validate the claims made in the Project Lithium FAQ on their website. The specific quote we will be testing is in Figure 10.

Q: Can Nexcell lithium improve my 0~60 time?

A: Yes, unlike NiMH, lithium will be able to provide electric motor with more than 30 seconds of peak power at full throttle therefore improve the 0~60 time.

Figure 10: Project Lithium's claim on 0-60 time improvement

It is unknown how Project Lithium was able to test 30 seconds of peak power to the electric motor. According to *FastestLaps.com*, the 0-150 KPH (93.20 MPH) time is 26.8 seconds. The CT200h is electronically governed to a top speed of 113 MPH, so therefore it *could* be possible they tested this through a 0-113 MPH test to measure the 30 seconds of peak power, however based on the previous *70 MPH Interstate Efficiency Test*, it is reasonable to conclude that the CT200h is not utilizing the high voltage battery or electric motor at high speeds.

Regardless, this test aims to provide some real world results for acceleration of a CT200h equipped with a Project Lithium battery pack.

Results

Testing was performed on a flat, straight road. Each vehicle was verified with equal tire pressure prior to the beginning of the test. 3 runs were made with each vehicle to 70 MPH and data was recorded using the OBDLINK Android App via an OBDLink MX+ OBD2 data scanner. Each vehicle started and finished the test from the same location. The data has been consolidated for better comparison in the following charts, with screenshots of each run located in the Appendix for additional review. Table 6 shows the results of each run for the 60ft, 330ft, ⅛ Mile, 1000ft, and ¼ Mile.

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	Stock NiMH Battery		Project Lithium Battery	
	Time (Seconds)	Speed (MPH)	Time (Seconds)	Speed (MPH)
60ft Run 1	2.76	26.7	2.7	24.2
60ft Run 2	2.75	27.3	2.7	24.2
60ft Run 3	2.97	27.3	2.52	24.9
330ft Run 1	7.52	49.7	7.38	47.8
330ft Run 2	7.53	49.7	7.54	47.8
330ft Run 3	7.65	49.1	7.25	47.8
1/8 Mile Run 1	11.5	61.5	11.38	61.5
1/8 Mile Run 2	11.42	61.5	11.49	61.5
1/8 Mile Run 3	11.61	61.5	11.26	61.5
1000ft Run 1	14.93	70.8	14.88	70.8
1000ft Run 2	14.87	70.8	15.07	69.6
1000ft Run 3	15	70.8	14.72	69.6
1/4 Mile Run 1	17.89	76.4	17.78	76.4
1/4 Mile Run 2	17.8	77.1	17.92	75.8
1/4 Mile Run 3	17.97	77.1	17.66	76.4

Table 6: Results of each Acceleration Test

For better comparison, Table 7 shows the best run at each distance for both the stock NiMH battery and Project Lithium battery along with their corresponding differences.

	Stock NiMH Battery	Project Lithium Battery	Difference
60ft Best (s)	2.75	2.52	-0.23
330ft Best (s)	7.52	7.25	-0.27
1/8 Mile Best (s)	11.42	11.26	-0.16
1000ft Best (s)	14.87	14.72	-0.15
1/4 Mile Best (s)	17.8	17.66	-0.14

Table 7: Recorded best times of each battery

Table 8 shows the recorded times at various speeds of each run.

Speed (MPH)	NiMH Run 1	NiMH Run 2	NiMH Run 3	Lithium Run 1	Lithium Run 2	Lithium Run 3
0-10	0.82	0.83	0.95	0.88	1.02	0.72
0-20	2.32	2.17	2.39	1.76	2.03	1.88
0-30	3.65	3.53	3.71	3.21	3.22	3.1
0-40	5.52	5.55	5.67	5.01	5.74	4.86
0-50	7.85	7.86	7.97	7.86	7.89	7.73
0-60	10.62	10.63	10.74	10.68	10.65	10.51
0-70	14.81	14.27	14.88	14.84	15.07	14.72

Table 8: Various 0-XX Test Results

For better comparison, Table 9 shows the best run of each speed for both the stock NiMH battery and Project Lithium battery, along with their corresponding differences.

Speed (MPH)	Stock NiMH	Project Lithium	Difference
0-10 Best	0.82	0.72	-0.1
0-20 Best	2.17	1.76	-0.41
0-30 Best	3.53	3.1	-0.43
0-40 Best	5.52	4.86	-0.66
0-50 Best	7.85	7.73	-0.12
0-60 Best	10.62	10.51	-0.11
0-70 Best	14.27	14.72	0.45

Table 9: Best recorded times for each battery

Overall, the results **suggest up to a 0.14 second improvement in the ¼ Mile when equipped with a Project Lithium Battery, a 0.43 second improvement in 0-30 time, and 0.11 second improvement in 0-60 time.**

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EV Mode Range Test 2

Test Overview

To conclude this testing, a final EV Mode range test was performed in the late afternoon after the engine and battery had been used throughout the day. This was mainly due to the nature of the route used in EV Mode Range Test 1. Since Test 1 used a one way route instead of a loop, this resulted in the better performing battery to experience a different hill profile on the trip, which potentially limited the range of EV Mode. As a result, a second EV Mode Range Test was created. The test is the same as previous, except the vehicles were driven in a loop to minimize elevation profile influence. With both vehicles being fully charged to 75% SOC, each vehicle was driven in EV mode until the internal combustion engine was restarted to recharge the battery (when 40% SOC was reached). Once the engine is started, the vehicle is brought to a complete stop and data was recorded.

Route Overview

The route was a 0.64 mile loop with approximately 30 feet of elevation gain per loop. To minimize variance, a target speed of 16 MPH was used throughout the test. Coasting was performed on the small, downhill section of the loop. Figure 11 outlines the route used in the EV Mode Range Test 2.

Figure 11: EV Range Test 2 Route

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Figure 12 shows the elevation profile of a single loop of the route.

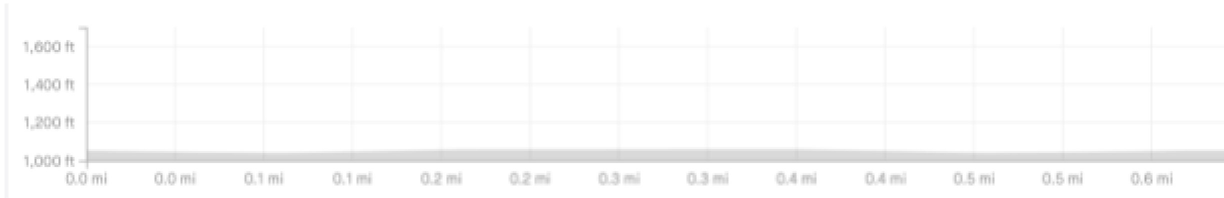

Figure 12: Elevation Profile of EV Range Test 2

Results

The results of the EV Mode Range Test 2 can be seen in Table 10. Definitions for each row are as follows.

- **Starting State of Charge %:** This was the reported high voltage battery State of Charge (SOC) at the beginning of the test.
- **Outside Ambient Temperature**: This was the reported outside temperature reported by the Instrument Panel Cluster at the beginning of the test.
- **HVAC Settings**: These were the settings of the Heating, Ventilation, and Air Conditioning (HVAC) system at the beginning of the test. These settings were not changed throughout the duration of the test to minimize variance in electrical load on the system. The Air Conditioning Compressor is a high voltage component, and relies on the high voltage battery to operate.
- **Distance Travelled**: This was the total distance recorded by the "TRIP A" trip counter in the Instrument Panel Cluster. This was reset at the beginning of every test.
- **Average Speed:** This was the average speed recorded by the "AVERAGE SPEED" value reported in the Instrument Panel Cluster. This was reset at the beginning of every test.

	Stock NiMH Battery	Project Lithium Battery
Starting State of Charge %	75%	75%
Outside Ambient Temperature	80° F	80° F
HVAC Settings	72 Auto	72 Auto
Distance Travelled	1.50 Miles	3.05 Miles
Average Speed	16 MPH	16 MPH

Table 10: Results of EV Range Test 2

Overall, the Project Lithium Battery saw a **103% increase** in EV Mode Range when compared to the standard NiMH battery pack. This is an improvement over EV Mode Range Test 1, and is likely due to the elimination of the additional hills that the Project Lithium battery saw later in Test 1's route.

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Summary & Retrospective

To summarize the data contained in this report, the following statements can be made:

- The individual Project Lithium battery cells are **34.163% lighter**.
- The total weight reduction from switching to Project Lithium is approximately **21 lbs**.
- EV-Only testing saw a **103% improvement in EV-only range**
- Variable speed (35 - 55 MPH) roads saw a **12.3232% increase in Fuel Efficiency**
- Highway speeds (70 MPH) saw a **0.66% increase in Fuel Efficiency**
- 0-30 Acceleration times saw a **12% improvement in performance**
- 0-60 Acceleration times saw a **1% improvement in performance**

Once factoring in that the brand-new, Project Lithium battery was being compared to a 108,000 mile, original NiMH battery with only 70% of its battery capacity remaining, the improvements seen from the Project Lithium battery become questionable. Is the battery an overall improvement in fuel efficiency? Or just better in efficiency and performance because it is fresher/newer? Due to the Dr. Prius App not saving the logs of each run, I was not able to fully quantify the temperature improvements seen during this testing. However, it was observed that the Project Lithium battery consistently ran 20ºF to 30ºF cooler than the NiMH battery, which resulted in never hearing the battery fan turn on for the Project Lithium equipped Ct200h, a nice improvement in cabin comfort and noise.

The conclusion from this testing is the following:

While the Project Lithium battery is lighter than the stock NiMH battery and has improved thermal performance and EV range, it has negligible real-world efficiency and performance improvements when compared to a OEM hybrid battery supplied by Toyota/Lexus, especially if driving primarily on interstates.

The Project Lithium battery appears to be a cost-effective replacement to a standard OEM battery, and you should expect similar performance for a slightly lower price.

Retrospective

I have spent the last 10 years in the world of automotive performance and validation testing, and will be the first to admit that while testing is always a good way to generate conclusions, it also requires tight and careful control of the input variables to generate 100% accurate results. While I attempted to the best of my ability to do a 1:1 comparison between the NiMH battery and Project Lithium battery, I would still like to acknowledge the lack of control in some variables in this testing. Here is a few of them, in no particular order:

- No access to a dynamometer, this results in driving to be done by a test operator (me). While I consider myself a fairly consistent driver due to performing platform validation for the last 10 years, I'm still not as consistent as a robot, so some variance in driving behavior between tests is expected.
- This was not performed on a closed course, and while vehicle/traffic light interactions were minimal, they were not identical on every run. The route's I selected kept the variance minimized

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(as shown by the test durations length being within seconds of each other on every run), however the number of cars and time waiting at traffic lights between vehicles was marginally different (and outside my control).

- This testing was done with a 2012 and 2017 CT200h. While these vehicles are mostly identical, some changes were allegedly done to the engine to improve reliability after 2014. This has never been quantified to any sort of efficiency improvements.
- The mileage of these vehicles is very similar (100k vs 108k), but were driven in very different environments throughout their lives. The 2017 was mainly driven in the summers, and only a few winters, with the last 25,000 miles driven in the California San Francisco Bay Area. The 2012 has spent most of its life in Michigan and Wisconsin, and has been exposed to much more extreme cold temperatures.
- The service history of both vehicles is different. The 2017 has only been serviced by Lexus dealerships since bought new, and the 2012 has been serviced through a variety of dealerships through its life. The 2017 has had every mileage service performed, with the 2012 receiving oil changes every 5000 miles, with the occasional major service done to it. As a result, this may have marginal impacts on overall engine health.
- While the tire pressures between vehicles are the same, the tires are manufactured by different companies and have different tread profiles. As a result, this may have a slight impact on fuel efficiency.
- And finally, the NiMH battery used for this testing only reported 70% maximum SOC from the life expectancy test via the Dr. Prius App. Therefore, there is a non-quantifiable performance degradation of this battery when compared to a brand-new, lithium battery. As much as I would have loved to do this test with 2 brand new batteries, it was not in the best interest of my wallet.

One piece of testing you may have noticed being omitted from this report is any sort of city driving. Due to this testing taking place in a very rural part of Wisconsin away from any major city, and the increased variability of stop-and-go traffic, I decided to not perform any city fuel efficiency tests, as I did not have the confidence that it would be replicable between vehicles. This may or may not be an area that the Project Lithium battery sees significant improvements, however this will be difficult to quantify without access to a vehicle dynamometer.

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Final Thoughts

At the time of writing this report, the V2.5 Project Lithium pack for the CT200h is listed on the website at $2120. On the Lexus Parts website, the DRIVE MOTOR BATTERY PACK (G951076012) is listed at $2,588.67 MSRP, which contains the cell enclosure and mounting bracket in addition to the NiMH cells.

If you were like me, and purchased this lithium battery to replace a perfectly functional and healthy battery out of pure boredom, you may be asking yourself ***"How much driving will I need to do before this battery is saving me money?"***

The Project Lithium Q&A states that this battery can save you money via its improved efficiency. Let's understand how long it would take for someone like me in a near-perfect scenario to start saving money after installing this battery pack.

- The total cost of the battery after shipping and taxes was **$2390.00**
- There was no installation costs, as I installed the battery myself.

A majority of my driving is done at interstate (70 MPH) speeds, and as shown in the Interstate Efficiency Test, the Project Lithium battery has little to no improvement in fuel efficiency at this speed. Let's say I ***only*** drove the route used in the 20 Mile Variable Efficiency Test for the rest of my life, and saw a lifetime improvement of ***6.1 MPG*** as a result. At the time of this report, the AAA National Average for a gallon of gas is $3.591. We can use this to calculate the cost savings per 1000 miles driven.

- A NiMH equipped CT200h would use 20.202 gallons of fuel per 1000 miles, or cost **$72.54**
- A Project Lithium equipped CT200h would use 17.986 gallons of fuel per 1000 miles, or cost **$64.59**

This means that the Project Lithium battery will save me **$7.95 per 1000 miles** driven, if only driven in this exact route for the remaining lifetime of the vehicle. However, I have to save $2390 before this battery swap ***actually*** saves me any money.

As a result, **I will need to drive 300,628 miles on the Project Lithium battery before I can officially offset the cost of replacing my perfectly healthy NiMH battery.** This, of course, is assuming I never drive a single interstate or any other road ever again…

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Appendix

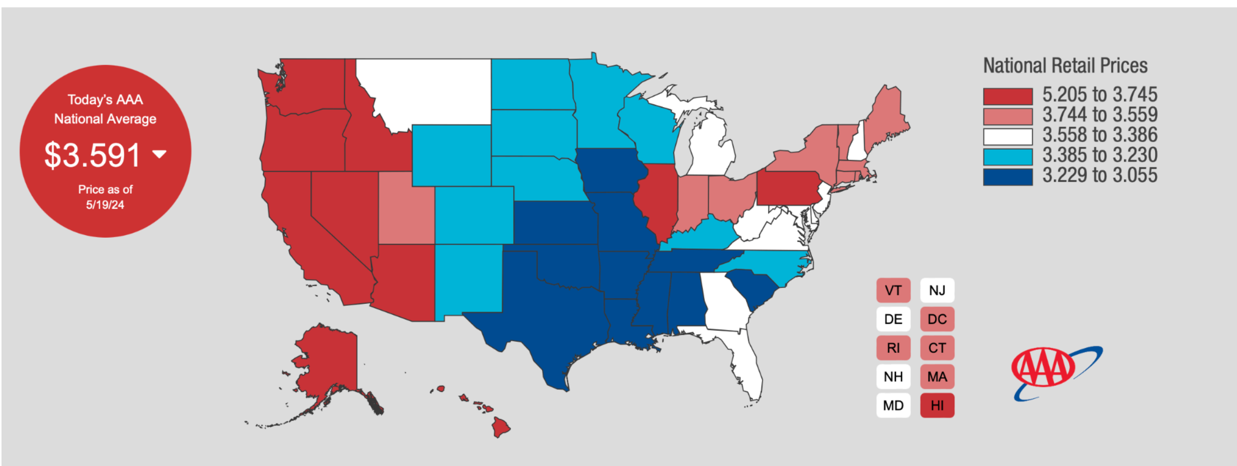
Top Speed:
https://www.ct200hforum.com/threads/top-speed-for-ct.119910/#:~:text=Top%20speed%20is%20specified%20at%20113mph%20or%20180km%2Fph.

0-150KPH Time :https://fastestlaps.com/models/lexus-ct-200h

Project Lithium FAQ Page: https://projectlithium.com/pages/faqs

EPA Website: https://www.fueleconomy.gov/feg/fe_test_schedules.shtml

AAA Fuel Average at the time of this report (https://gasprices.aaa.com/):



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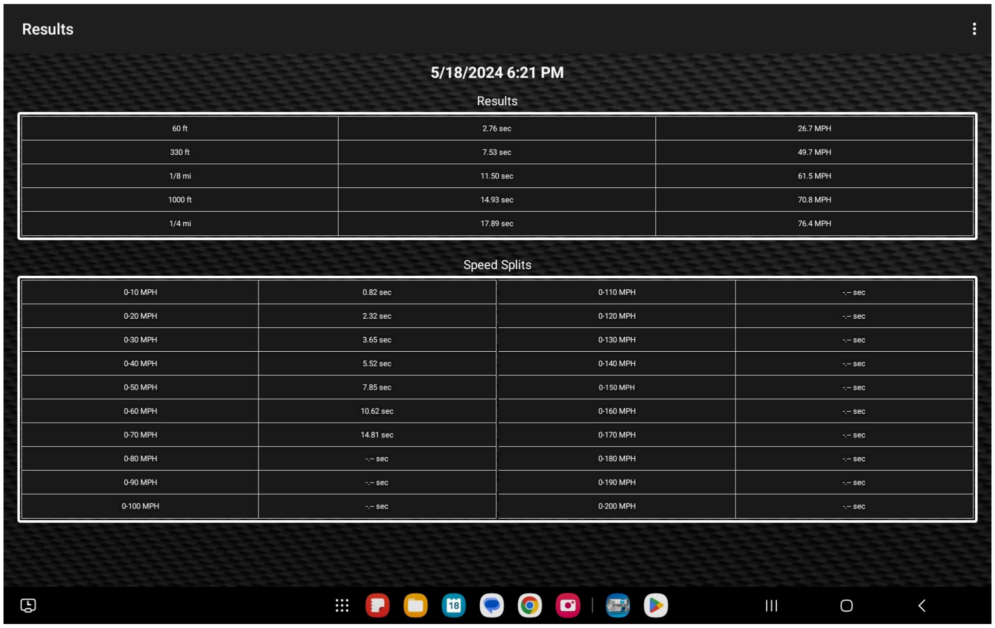
NiMH ¼ Mile Attempt 1:



Results

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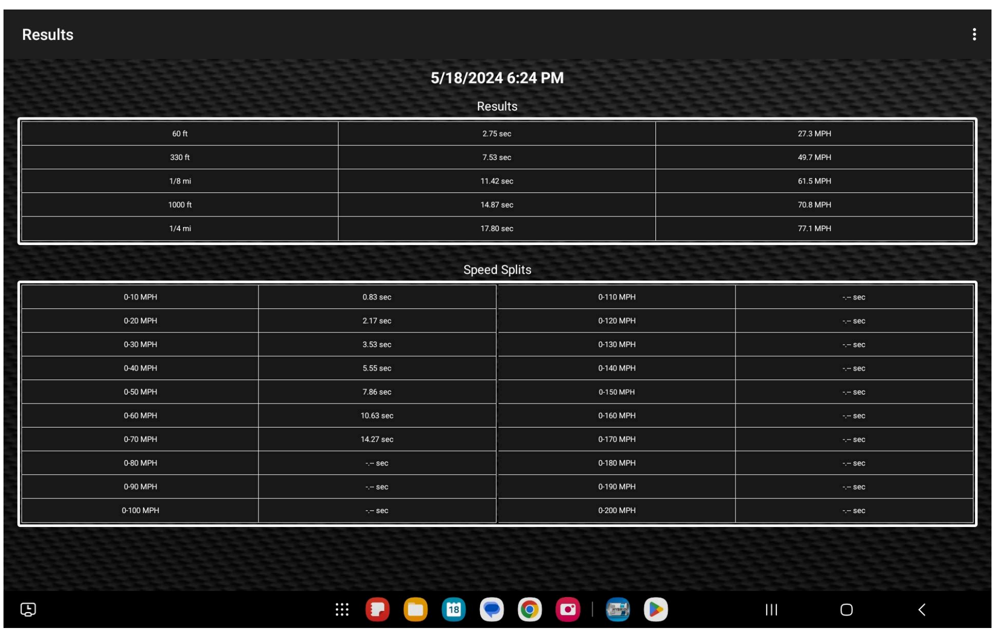
Results

60 ft	2.76 sec	26.7 MPH
330 ft	7.53 sec	49.7 MPH
1/8 mi	11.50 sec	61.5 MPH
1000 ft	14.93 sec	70.8 MPH
1/4 mi	17.89 sec	76.4 MPH

Speed Splits

0-10 MPH	0.82 sec	0-110 MPH	-.-- sec
0-20 MPH	2.32 sec	0-120 MPH	-.-- sec
0-30 MPH	3.65 sec	0-130 MPH	-.-- sec
0-40 MPH	5.52 sec	0-140 MPH	-.-- sec
0-50 MPH	7.85 sec	0-150 MPH	-.-- sec
0-60 MPH	10.62 sec	0-160 MPH	-.-- sec
0-70 MPH	14.81 sec	0-170 MPH	-.-- sec
0-80 MPH	-.-- sec	0-180 MPH	-.-- sec
0-90 MPH	-.-- sec	0-190 MPH	-.-- sec
0-100 MPH	-.-- sec	0-200 MPH	-.-- sec

NiMH ¼ Mile Attempt 2:



Results

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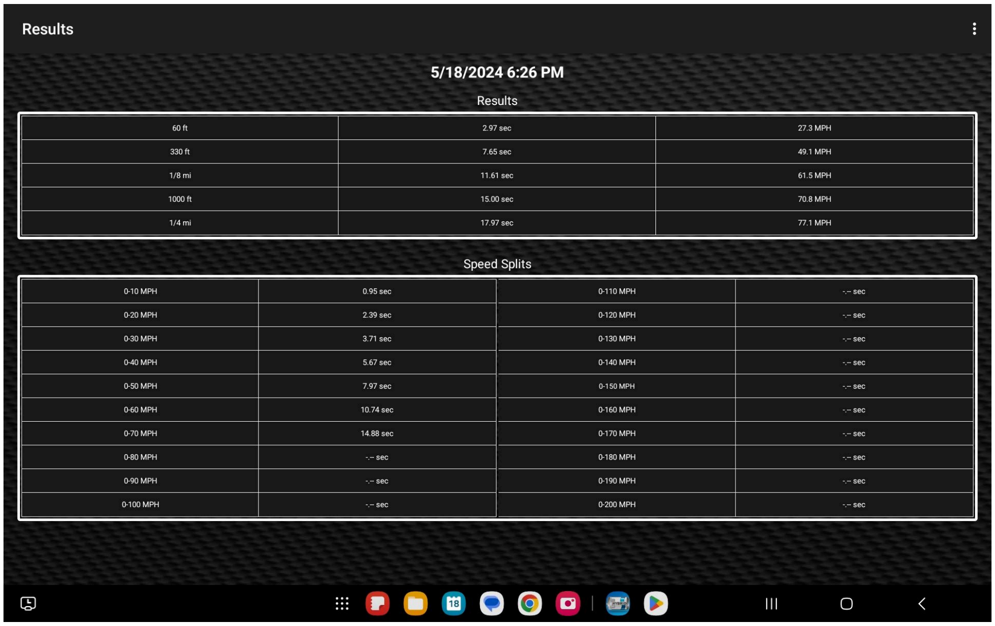
Results

60 ft	2.75 sec	27.3 MPH
330 ft	7.53 sec	49.7 MPH
1/8 mi	11.42 sec	61.5 MPH
1000 ft	14.87 sec	70.8 MPH
1/4 mi	17.80 sec	77.1 MPH

Speed Splits

0-10 MPH	0.83 sec	0-110 MPH	-.-- sec
0-20 MPH	2.17 sec	0-120 MPH	-.-- sec
0-30 MPH	3.53 sec	0-130 MPH	-.-- sec
0-40 MPH	5.55 sec	0-140 MPH	-.-- sec
0-50 MPH	7.86 sec	0-150 MPH	-.-- sec
0-60 MPH	10.63 sec	0-160 MPH	-.-- sec
0-70 MPH	14.27 sec	0-170 MPH	-.-- sec
0-80 MPH	-.-- sec	0-180 MPH	-.-- sec
0-90 MPH	-.-- sec	0-190 MPH	-.-- sec
0-100 MPH	-.-- sec	0-200 MPH	-.-- sec

NiMH ¼ Mile Attempt 3:



Results

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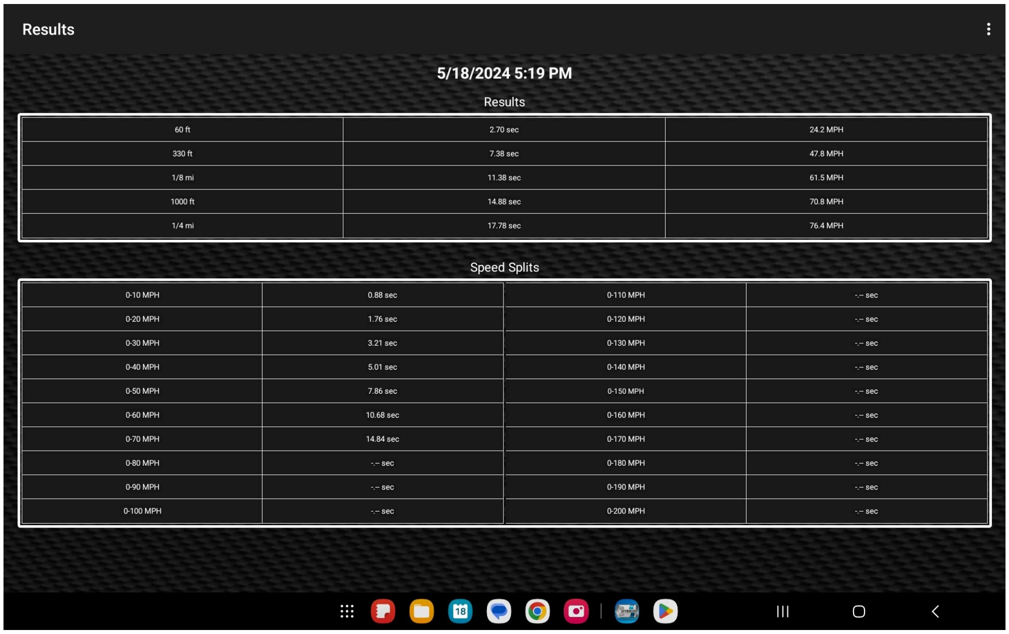
Results

60 ft	2.97 sec	27.3 MPH
330 ft	7.65 sec	49.1 MPH
1/8 mi	11.61 sec	61.5 MPH
1000 ft	15.00 sec	70.8 MPH
1/4 mi	17.97 sec	77.1 MPH

Speed Splits

0-10 MPH	0.95 sec	0-110 MPH	-.-- sec
0-20 MPH	2.39 sec	0-120 MPH	-.-- sec
0-30 MPH	3.71 sec	0-130 MPH	-.-- sec
0-40 MPH	5.67 sec	0-140 MPH	-.-- sec
0-50 MPH	7.97 sec	0-150 MPH	-.-- sec
0-60 MPH	10.74 sec	0-160 MPH	-.-- sec
0-70 MPH	14.88 sec	0-170 MPH	-.-- sec
0-80 MPH	-.-- sec	0-180 MPH	-.-- sec
0-90 MPH	-.-- sec	0-190 MPH	-.-- sec
0-100 MPH	-.-- sec	0-200 MPH	-.-- sec

Project Lithium ¼ Mile Attempt 1:



Results

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Results

60 ft	2.70 sec	24.2 MPH
330 ft	7.38 sec	47.8 MPH
1/8 mi	11.38 sec	61.5 MPH
1000 ft	14.88 sec	70.8 MPH
1/4 mi	17.78 sec	76.4 MPH

Speed Splits

0-10 MPH	0.88 sec	0-110 MPH	-.-- sec
0-20 MPH	1.76 sec	0-120 MPH	-.-- sec
0-30 MPH	3.21 sec	0-130 MPH	-.-- sec
0-40 MPH	5.01 sec	0-140 MPH	-.-- sec
0-50 MPH	7.86 sec	0-150 MPH	-.-- sec
0-60 MPH	10.68 sec	0-160 MPH	-.-- sec
0-70 MPH	14.84 sec	0-170 MPH	-.-- sec
0-80 MPH	-.-- sec	0-180 MPH	-.-- sec
0-90 MPH	-.-- sec	0-190 MPH	-.-- sec
0-100 MPH	-.-- sec	0-200 MPH	-.-- sec

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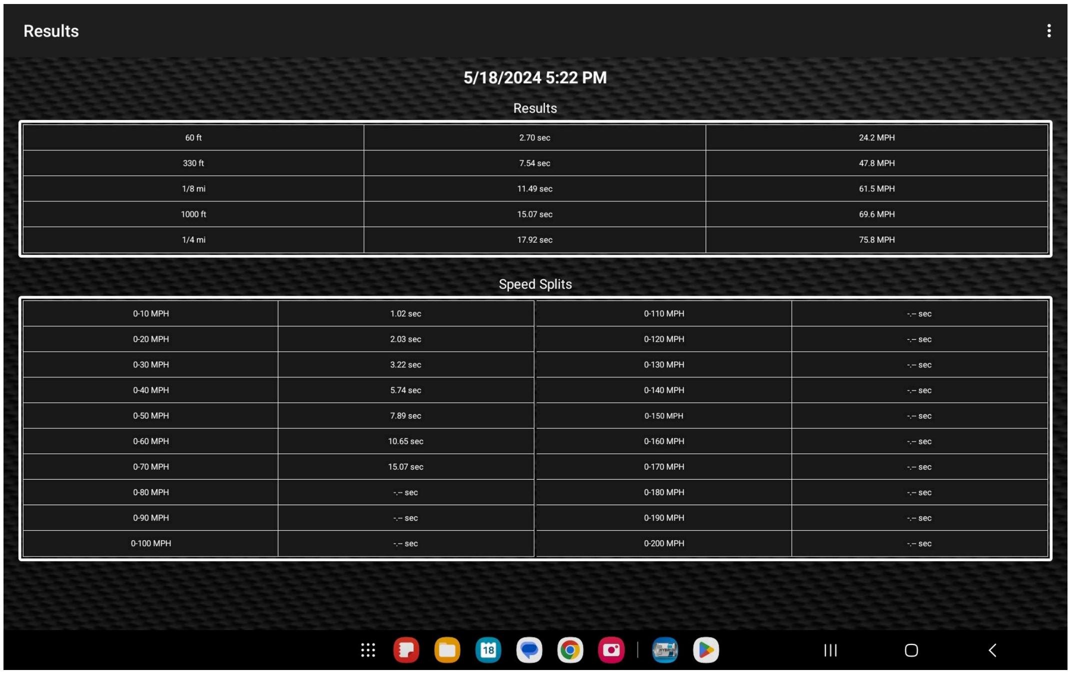
Project Lithium ¼ Mile Attempt 2:



Results

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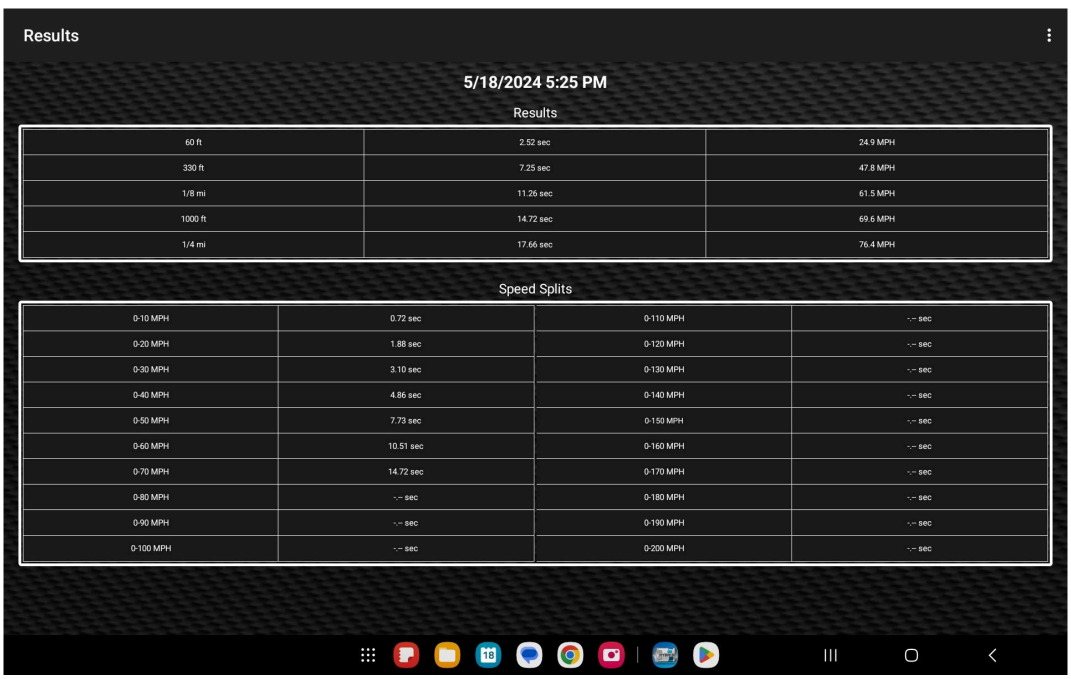
Results

60 ft	2.70 sec	24.2 MPH
330 ft	7.54 sec	47.8 MPH
1/8 mi	11.49 sec	61.5 MPH
1000 ft	15.07 sec	69.6 MPH
1/4 mi	17.92 sec	75.8 MPH

Speed Splits

0-10 MPH	1.02 sec	0-110 MPH	-.-- sec
0-20 MPH	2.03 sec	0-120 MPH	-.-- sec
0-30 MPH	3.22 sec	0-130 MPH	-.-- sec
0-40 MPH	5.74 sec	0-140 MPH	-.-- sec
0-50 MPH	7.89 sec	0-150 MPH	-.-- sec
0-60 MPH	10.65 sec	0-160 MPH	-.-- sec
0-70 MPH	15.07 sec	0-170 MPH	-.-- sec
0-80 MPH	-.-- sec	0-180 MPH	-.-- sec
0-90 MPH	-.-- sec	0-190 MPH	-.-- sec
0-100 MPH	-.-- sec	0-200 MPH	-.-- sec

Project Lithium ¼ Mile Attempt 3:



Results

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Results

60 ft	2.52 sec	24.9 MPH
330 ft	7.25 sec	47.8 MPH
1/8 mi	11.26 sec	61.5 MPH
1000 ft	14.72 sec	69.6 MPH
1/4 mi	17.66 sec	76.4 MPH

Speed Splits

0-10 MPH	0.72 sec	0-110 MPH	-.-- sec
0-20 MPH	1.88 sec	0-120 MPH	-.-- sec
0-30 MPH	3.10 sec	0-130 MPH	-.-- sec
0-40 MPH	4.86 sec	0-140 MPH	-.-- sec
0-50 MPH	7.73 sec	0-150 MPH	-.-- sec
0-60 MPH	10.51 sec	0-160 MPH	-.-- sec
0-70 MPH	14.72 sec	0-170 MPH	-.-- sec
0-80 MPH	-.-- sec	0-180 MPH	-.-- sec
0-90 MPH	-.-- sec	0-190 MPH	-.-- sec
0-100 MPH	-.-- sec	0-200 MPH	-.-- sec

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