

My Electric Journey with a Nissan Leaf

A classic early-adopter experience.

By Stanton Zeff

FIIFTY-FOUR MONTHS AND TWO BATTERY PACKS LATER, I'M STILL enjoying my first-generation Nissan Leaf battery electric vehicle (BEV)—but with a second-generation battery pack. All batteries (of all types) degrade, but no one, including Nissan, expected the original Leaf battery packs to degrade as rapidly as they did—especially in warm climates. Because of this, Nissan was forced to offer owners of the first-generation 2011/2012 Nissan Leaf this battery capacity warranty: “In addition to the existing lithium-ion battery coverage provided under the Nissan Electric Vehicle Limited Warranty for defects in materials or workmanship, the lithium-ion battery for your 2011/2012 Nissan Leaf is now also warranted against capacity loss below (9) nine bars (or approximately below 70%) as shown on the vehicle’s battery capacity level gauge for a period of 60 months or 60,000 mi, whichever comes first.” Even better, the replacement battery packs featured an improved heat-resistant chemistry along with a small increase in capacity.

WHY I OWN AN ELECTRIC CAR

People often ask me, “Why do you own an electric car?”

When I first began to consider buying an all-electric BEV as opposed to a plug-in hybrid electric vehicle (PHEV), I settled on three basic requirements:

- ▼ more than a two-seater (for family trips)
- ▼ ability to travel > 60 mph (for highway use)
- ▼ range > 75 mi (which would get me to/from my regional airport on a single charge).

At the time (circa 2011), the only BEV that could satisfy all of these conditions was the Nissan Leaf. Of course, things like “being green” and reducing the total cost of ownership (fuel, maintenance, etc.) were also important, but these are topics left for another time. The Nissan Leaf was initially offered to the public on a regional basis (a few states at a time) via a type of lottery: by joining an e-mail list, you waited for notification that you were eligible to reserve and order a Leaf by placing a US\$99 refundable deposit. Within a couple of days of my notification, my order was confirmed, and I took ownership of my Leaf on 1 September 2011—nearly eight months after I had started the purchase process.

For the first couple of years, I enjoyed nearly full range (about 90–100 mi depending on driving habits and conditions) out of my Leaf, but extremely warm climates (like Arizona and Texas) became the proverbial canary in the coal mine for what was to come next. Through social networking and online forums (like www.mynissanleaf.com),

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it became obvious that heat was accelerating battery pack degradation and, therefore, range loss beyond initial projections. For example, instead of retaining 70% battery capacity after ten years (on average), some Leafs were projecting that same capacity in less than half that time. In fact, extreme cases were seeing this degradation in as little as three years! As time progressed, I too began to experience something electric vehicle owners call *range anxiety*: that is, the fear of not having sufficient charge capacity to make it to or from your destination; in other words, the fear of being stranded. Where I was once able to travel over 90 mi on a single charge, I could now barely make 60 mi. Even worse, the normal range hit that accompanies cold temperatures (especially below 40 °F) exacerbated the situation to the point where my cold weather range could easily be less than 50 mi—half of what the battery pack was capable of when new.

COUNTDOWN TO A NEW BATTERY PACK

Something had to give, and that something was the (new) Nissan Leaf capacity warranty as previously described. This isn't something that happens all at once; thanks to the battery capacity gauge Nissan placed in the dash alongside the fuel capacity gauge, owners can follow the degradation of their battery pack bar-by-bar (there are 12 capacity—and fuel—bars total). I dropped my first capacity bar around the two-year mark, the second capacity bar around the three-year mark, and the third and fourth capacity bars in the fourth year; at that point, I qualified for a warranty battery pack replacement. The trip to the dealer for the warranty verification initiated a month-long process whereby a brand new battery pack (with an improved



FIGURE 1. A Nissan Leaf battery pack.

Table 1. Battery pack data.

Battery Pack	Old	New
Volts	391.5 V	393.5 V
Ampere Hours	42.39 Ah	66.14 Ah
Health	43.43%	99.63%

heat-resistant chemistry) was built in Nissan's Knoxville, Tennessee, facility and shipped via flatbed truck to my local dealer, where it was installed in my waiting Leaf (with the old battery pack returned). As shown in Figure 1, the Leaf battery pack is a very large (under the front and rear seat area) and very heavy (over 600 lbs) component with 48 individual modules comprising 192 individual battery cells. You can literally breathe new life into a BEV with a new battery pack. In fact, it's almost like getting a brand new car. Table 1 is data provided by the Leaf's Battery Management System (BMS) for my old (before removal) and new (after installation) battery packs.

The health metric jumps right out at you: the brand new battery pack is nearly 100% (as expected), while the old battery pack had fallen to less than half. A less severe, but more direct, measure of battery pack capacity is the ampere hours (Ah) metric. A brand new 2011/2012 Leaf can "see" a maximum of about 66 Ah; since this battery pack had not been on the shelf very long, it is basically at full capacity. By the time my old battery pack had met the replacement warranty terms (eight capacity bars remaining), I had only about 64% of the original Ah capacity left—far less than the 70% that Nissan stated in the warranty addendum. Finally, even the volts reading of the new battery pack is slightly higher at full charge, which ultimately yields a small increase in driving range. An informal range test performed after a few deep-discharge cycles (which consists of driving the car to very low battery warning and then charging it to full) revealed that my original range of over 90 mi on a single charge had indeed been restored.

BEST KEPT SECRET

Leaf ownership is a classic early-adopter experience: it can be both exhilarating and challenging at the same time. It's exhilarating to own and drive one of the first production BEVs in history, and it's challenging to understand the ramifications and limitations of a new technology. In fact, some used Nissan Leafs offer second-hand owners a rare opportunity: it is possible to buy a used 2011/2012 Leaf at a reduced price and still take advantage of the capacity warranty, as it follows the car, not the owner. In other words, find a Leaf in a warm climate with nine capacity bars remaining that you are confident will drop the final bar before five years or 60,000 mi, at which time you can have the battery pack replaced just as I did. There are web resources available to help you understand the tools and metrics necessary to find just the right used Leaf. Even better, there is almost no additional maintenance required beyond the new battery pack with the exception of things like tire replacement and brake reconditioning. I still feel as though my electric (car) journey has just begun!

ABOUT THE AUTHOR

Stanton Zeff (sdz.zeff@verizon.net) earned a B.S.E.E. degree from the University of Texas at Austin and an M.S. degree in telecommunications from Southern Methodist University. He is a Senior Member of the IEEE and past chair of the Dallas Section of the IEEE Communications and Vehicular Technology Society, where he received an award for Outstanding Service to the Society.

