Toyota/Lexus Hybrids

Efficient driving guide, information and diagnostics

(and more)

Compiled by /u/andy_why

Table of Contents

1. Introduction

This document has been compiled by Reddit user /u/andy_why primarily to help out the users of /r/prius, /r/ct200h and /r/Lexus.

/u/andy_why had owned a 2013 Lexus CT since 2016-2023, a Lexus UX 250h until 2025, and now a Toyota RAV4 Prime/PHEV, and has over 9 years of hybrid driving experience. With a strong technical background and an eye for detail, he has been able to learn the nuances of hybrid vehicle operation in this time which has allowed this guide to be created.

The techniques and information you can learn here can be applied to hybrid and electric vehicles, and some techniques work for non-hybrids too.

For ease of reading, explanations are in normal text and **summarised tips are highlighted in green**.

This guide was written with gen3 Lexus/Toyota hybrid powertrains in mind. Where possible, gen4 is specifically mentioned if something is different with that specific powertrain versus the gen3. However, most advice remains the same between generations.

Disclaimer
All information provided here is used at your own risk. It is provided with no guarantee, and much of the information is generated from personal experience, research online and through the use of AI (ChatGPT). Use common sense when using the suggestions here and never compromise on safety.

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2. Driving Efficiently

Whilst hybrid vehicles can help you save money with better fuel economy over a non-hybrid vehicle, if you know how to drive it more effectively you can maximise your fuel economy with very little effort.

2.1. Efficiency Factors

There are a lot of factors that affect efficiency:

- Weather
    - Outdoor Temperature
    - Cabin Temperature
    - Wind
    - Rain
- Speed
- Acceleration
- Coasting / Gliding
- Braking
- City vs Highway
- Journey Length
- Terrain
- Driving Style
- Maintenance
    - Wheel alignment
    - Binding brakes
    - Poor engine running
    - EGR system
- Forced hybrid battery charging
- Transmission “B” Mode
- Pulse and Glide
- Brake Specific Fuel Consumption (BSFC)
- Tire Pressure
- Hybrid Battery Temperature
- Fuel Grades

2.1.1. Weather

Wind

Windy weather can cause further aerodynamic drag on top of the speed that you're travelling. This acts like increasing your speed which is less efficient.

To maximise fuel economy in high wind you can:

- **Slow down a little to reduce aerodynamic drag.**
- **Take a route with terrain/buildings that would block the wind (although some routes themselves may be less efficient or inconvenient).**

Rain

Driving in rain increases drag on your tires and body aerodynamics. Whilst you can't control the weather, you can adapt to the conditions.

To maximise fuel economy in the rain you can:

- **Slow down a little to reduce drag on the tires and body aerodynamics.**
- **Ensure you use appropriate wet rated tires.**
- **Keep your tires inflated to the proper pressure (never over-inflate).**

2.1.2. Speed

Speed is a large factor in fuel economy thanks to the increase in aerodynamic drag as you increase in speed. This drag requires more energy to overcome resulting in higher fuel consumption.

According to studies backed by the department of energy, the average car will be at its advertised MPG at 55 mph (88 km/h). As the speed increases, efficiency gets worse.

- 3% less efficient at 60 mph (96 km/h)
- 8% less efficient at 65 mph (104 km/h)
- 17% less efficient at 70 mph (112 km/h)
- 23% less efficient at 75 mph (120 km/h)
- 28% less efficient at 80 mph (128 km/h)

Source: https://www.mpgforspeed.com/

The efficiency drop will vary between vehicles, but you can use the above as a rule of thumb.

Speed can also affect when your hybrid system is able to run in electric mode only with the combustion engine turned off. In most Toyota and Lexus hybrids, this is only permissible below 43 mph (69 km/h) except on models featuring a generation 4 hybrid synergy drive which allows the engine to turn off up to around 70 mph (112 km/h).

If you're on a reasonably flat road and travelling at an appropriate speed for your generation of hybrid system, easing off the throttle might allow the car to enter electric (EV) mode and turn the combustion engine off.

You may be able to maintain your speed for a short time using EV mode only, but be aware, you'll only be able to do this for up to 1 mile on a non-plug-in hybrid before the battery is depleted. You should avoid fully depleting the battery to avoid the engine running unnecessarily. Pulse and glide is a much better technique to use.

To maximise fuel economy you can:

- **Stay below the speed limit, but still travel at an appropriate speed for the road type that does not hold up other road users.**
- **On flat roads, ease off the throttle when under 43 mph (69 km/h) to enter EV mode for a short time.**

2.1.3. Acceleration

Any time you accelerate you need to use more energy than when you are cruising to reach your desired speed. You can minimise the energy required by accelerating more gently and getting up to cruising speed more slowly.

Almost all Toyota and Lexus hybrids have a display on the dashboard indicating how much power you're demanding from the hybrid system.

It is split into 3 segments:

- CHG - The braking region where regenerative braking is operating.
- ECO - The region at which the combustion engine operates most efficiently.
- PWR - The power region at which the engine produces more power, but less efficiently.

The ECO region is split into 2 parts, with the lower half indicating where the electric part of the hybrid system can operate alone, and the upper half where the engine will always assist.

By staying in the ECO region as much as possible, you can maximise your fuel economy.

The car will accelerate quite slowly, and it might not be quick enough for some changes in elevation. Try to use the PWR area only when you need to.

To maximise fuel economy when accelerating you can:

- **Always accelerate gently.**
- **Stay in the ECO area of the power display as much as possible.**
- **Try to stay in the lower half of the power display for the first 10 mph when pulling away so that you use electric power only.**
- **Avoid the PWR area of the power display unless needed.**

2.1.4. Coasting / Gliding

Normally coasting would be considered dangerous because you have less control of the vehicle, however, in a Toyota and Lexus hybrid the way the transmission works means that you can coast without the transmission being in neutral.

The Power Split Device (or PSD) is a fancy name for the transmission, and it works by having a planetary gearset connected to two motor-generators (electric motors) called MG1 and MG2, and the combustion engine. By varying the speed and direction of MG1 the speed of the planetary set can change states which can allow the combustion engine to be started, stopped or allow it to generate electricity.

If the throttle pedal is lightly pressed just the right amount it's possible to have zero energy transfer through the transmission. This condition is coasting / gliding. As soon as you apply or release the throttle the transmission will begin to transfer energy again. All other transmissions only achieve a zero energy state by disconnecting it from the engine through a clutch system.

Because there is zero energy transfer when you properly press the throttle, you are at the highest possible efficiency the car can be at other than being turned off. There is no drag from the engine or transmission and no burning of fuel. There is only aerodynamic and tyre drag to contend with. For the duration of coasting / gliding your car will essentially be doing infinite miles per gallon.

Now of course you will slow down over a short time, requiring you to use energy again, but in the duration of coasting your efficiency is at its highest because of reduced drag of engine and transmission components. This drag is otherwise higher than you might expect.

Mastering coasting / gliding takes time. You can use the power meter on the dashboard or the energy flow display on cars equipped with this to help you understand the power flow. Keep the needle or bar as close to the line between CHG and ECO to achieve the best coast / glide. Use ECO mode on the car to make the throttle pedal less sensitive.

A better explanation of the transmission/power split device with a nice interactive diagram is available here: http://eahart.com/prius/psd/

To maximise fuel economy by coasting / gliding, you should:

- **Keep the power meter as close to zero as possible.**
- **Use the energy flow display on equipped cars to understand the flow of power.**
- **Use ECO mode on to make the throttle pedal less sensitive.**

2.1.5. Braking

On a hybrid or electric vehicle, braking needs to become one of your best friends for fuel economy. Unlike a non-hybrid, which will waste all of the kinetic energy of the vehicle moving by converting it into heat in your brake pads, a hybrid vehicle can recapture some of the through regenerative braking.

Regenerative braking is achieved by taking the kinetic energy of the vehicle moving and using the electric motor as a generator to convert it back into electricity. This electricity is stored in your hybrid or EV battery to use again later.

It can take some time to master regenerative braking because it requires forward thinking and analysis of the road ahead. You need to look ahead and anticipate the need to slow down or stop so that you can decide when to begin braking.

Since hybrid vehicles generally don't have particularly strong regenerative braking, you must brake early and lightly to capture as much energy as possible. EVs have stronger regenerative braking so you can brake a little later and still capture most of the energy.

You can help yourself avoid hard braking by keeping a larger than usual gap between you and the vehicles in front of you.

Whenever you are coming to a stop or need to slow down, take note of the power meter on your dashboard. It is split into 3 areas with one of them being "CHG". This stands for "charging" and indicates that power is being put back into the battery as a result of braking.

You need to ensure that you keep the meter *almost* but not quite full to maximise regenerative braking. If the meter gets filled, then friction brakes will start to blend in with the regenerative braking and you will start losing energy to the friction brakes.

As you slow down to under 10mph (16 km/h) the friction brakes will engage automatically anyway when regenerative braking is no longer possible.

Do not be afraid to push the brake pedal harder if you need to stop more quickly. Safety is more important than efficiency.

To maximise fuel economy when braking you should:

- **Look ahead and anticipate the need to slow down or stop.**
- **Keep a larger gap in front of you.**
- **Brake early.**
- **Brake lightly.**
- **Keep the CHG meter almost but not quite full.**

2.1.6. City vs Highway

Driving in the city versus driving on the highway can have a large impact on fuel economy. The reason for this is because general stop-go driving is less efficient than cruising. A hybrid vehicle is able to overcome a lot of this, but only when driven in the correct manner. You can easily get low fuel economy in the city if you don't drive in the correct manner.

The best advice for this is to try to use a route which minimises city driving and keeps you at the most constant speed you can.

City Driving
Any stop and go city traffic means more energy is spent accelerating than you would use if you were cruising at a fixed speed. You should use the techniques learned in other sections of this document around acceleration and braking appropriately to maximise fuel economy in this situation.

If possible, try to use a route that does not require you to stop and go as frequently.

Highway Driving
Whenever you're on the highway, you can maximise fuel economy by staying at a nice cruising speed and using your cruise control.

Avoid making changes to your speed whenever you can, as again, any acceleration requires more energy than cruising. If you have to change speed, try to do it slowly. Use the acceleration and braking techniques from this document.

To maximise fuel economy in the city vs highway you should:

- **Seek the route which allows you to maintain a consistent speed.**
- **In the city, use acceleration and braking techniques learned in this document.**
- **On the highway, use cruise control to maintain a set speed.**
- **Avoid changing speed, and do it slowly if you have to.**

2.1.7. Journey Length

The length of your journey can impact fuel economy because the combustion engine needs time to warm up to get to its operating temperature.

When the combustion engine is not at its operating temperature it operates at a much lower efficiency as the engine requires more fuel. A short journey may not be long enough to allow it to warm up, especially at colder times of the year.

In temperature conditions of around 0°C / 32°F the combustion engine will require 10-15 miles of highway driving (16 to 24 kms) to get to its full operating temperature of 90°C / 194°F.

The car will allow the combustion engine to turn off before it is fully warmed up in the pursuit of efficiency, so you can't rely on this as an indicator that the engine is fully up to temperature.

Short journeys are going to occur regardless, so you should try to combine your short journeys close together so that the combustion engine does not fully cool down.

To maximise fuel economy you should:

- **Combine short journeys close together.**
- **Use all of the other techniques learned in this document.**

2.1.8. Terrain

The terrain on which you drive your hybrid or electric car will impact its fuel economy wildly.

By terrain we mean the type of road surface, the inclines and declines, and the turns in the road experienced on your route. Each of these affects fuel economy.

Road Surface
The road surface impacts fuel economy through drag on your tires. Stick to paved roads rather than loose surfaces to maximise fuel economy.

Inclines
Any change in elevation can positively and negatively affect fuel economy.

An incline will reduce fuel economy as you'll use more energy to go up it. You can minimise energy used by not accelerating up the incline to a higher speed. Try to keep your speed, or even allow your vehicle to slow down a little as you climb it.

For example if you start an incline at 60 mph (96 km/h) and reach the top at 50 mph (80 km/h), this would be an acceptable loss in speed. Try to keep your power meter in the ECO range when possible.

Steep gradients may require you to enter the PWR area. If this happens, hold your speed unless you absolutely have to accelerate.

Declines
A decline will improve fuel economy as you descend it as you'll use less or no energy. You can even recapture some energy through regenerative braking.

Twists and Turns
Twists and turns in the road generate drag on the tires, so avoiding tight turns minimises any loss through tyre drag.

To maximise fuel economy on varying terrain you should:

- **On an incline, avoid accelerating and increasing speed, and keep your power meter in the ECO range when possible.**
- **On a decline, use your regenerative braking to capture some energy to use later.**
- **Avoid tight turns.**

2.1.9. Driving Style

Everyone on the road has a varied driving style that can impact their fuel economy. By driving style we mean everything from:

- The speed you drive
- Your acceleration techniques
- How hard you brake
- Sudden changes in direction
- Your attitude towards other drivers
- … and so much more.

This guide should help you to change your driving style to one that is more focused on maximising fuel economy.

However, to do this, you need to be patient and take your time.

You'll likely not achieve anything from this guide if:

- You're always in a rush or running late.
- You regularly experience road rage or aggression.
- You're not willing to try techniques over a long period of time.

To maximise fuel economy you need to be open to changing your driving style:

- **Take your time**
- **Slow down**
- **Be patient with other road users**
- **Be willing to learn**
- **Drive considerately**

2.1.10. Maintenance

Keeping on top of the maintenance of your vehicle is just as important for a hybrid or electric vehicle as it is for any other car. Some things can cause lower fuel economy.

Wheel alignment
If your wheels are not properly aligned it can cause increased drag on your tires resulting not only in lower fuel economy but excessive tyre wear too.

Binding brakes
A common issue on a lot of hybrids is binding brakes, which is caused by a brake calliper seizing up. This causes the brakes to constantly apply a small force, causing friction on the brake discs and therefore turning energy straight into wasted heat.

You can check for this by jacking up a wheel and spinning it whilst in neutral/with the parking brake off. It should spin freely without binding.

Poor engine running
A poorly running engine can consume more fuel than one that is running well.

There are a lot of reasons why an engine can run badly, but if you suffer any loss in power, have an engine management light on your dashboard, or hear strange sounds, you should have it looked at by a mechanic.

EGR system
On some models of Toyota Prius and Lexus CT200h, typically the 2010-2013 models, there is a known issue with the EGR system clogging up. This is generally considered to happen at around 100,000 miles (160 000 kms), and can happen more easily if your engine burns oil.

A clogged EGR system means that exhaust gases will not be re-burned in the engine and this can negatively affect fuel consumption.

Another unfortunate side effect of this is that it can also cause premature head gasket failure because of the increased combustion temperatures. This leads to engine misfiring/knocking, and requires head gasket replacement, and replacement or cleaning of the EGR pipe, cooler and intake manifold to fix the issue.

Preventative cleaning maintenance or part replacement should be considered for the EGR, EGR cooler and intake manifold every 75,000 miles (120 000 kms) on 2010-2013 Toyota Prius and Lexus CT200h models.

To maximise fuel economy you should regularly service your vehicle and have it checked annually by a mechanic. If you notice any changes to the car's behaviour or notice any unusual noises, have a mechanic check it over.

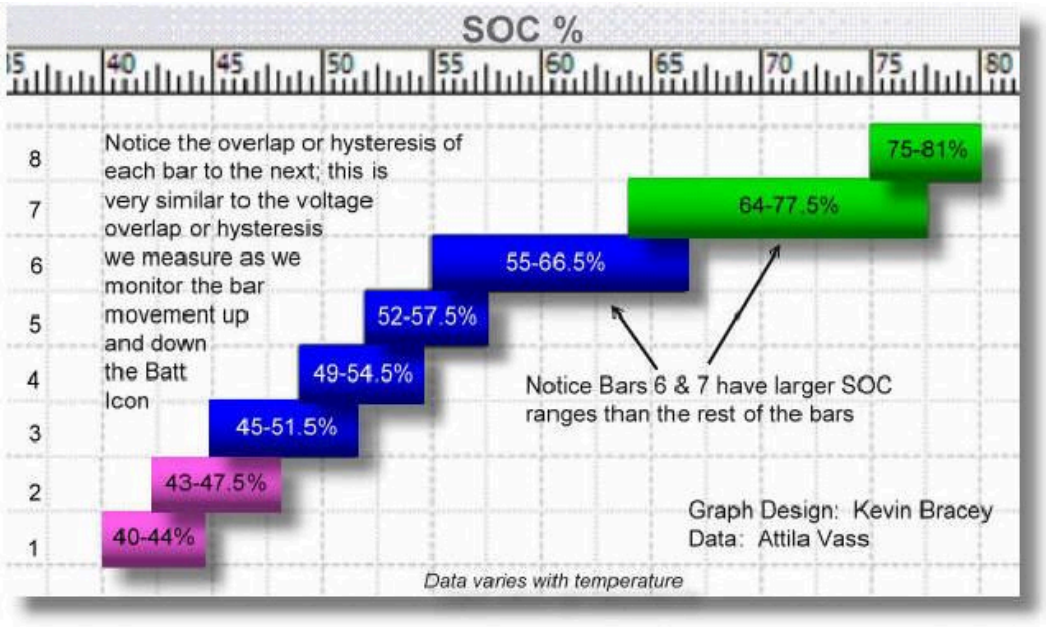
2.1.11. Forced Hybrid Battery Charging

One operation of hybrid systems that is rarely talked about is forced hybrid battery charging. This occurs when the hybrid battery reaches a minimum charge level, and to prevent full depletion the car must forcibly recharge it using the combustion engine.

For the Toyota and Lexus hybrid systems, the battery has an internal percentage value which is converted to display to the driver as follows (varies depending on model):

- **40% (1 bar)** - The battery is empty and will be forcibly recharged to ~50%.
- **50% (4 bars)** - The battery is half charged.
- **60% (6 bars)** - The battery is charged to a normal state. This is where it will normally sit after cruising for a short while. The engine will not normally charge it higher (unless the engine is running to warm it up) but there is space for regenerative braking energy.
- **80% (8 bars)** - The battery is fully charged and to prevent damage it will not take more energy.

You can see how the percentages and bars work in a bit more detail below:



It's important to note that once the force recharging process begins it will forcibly charge the battery until it reaches 47-50% (4 bars), which takes around 2-3 minutes. The only time the engine will shut off during this is if you shut the car off yourself.

Forcibly recharging the hybrid battery requires you to burn fuel to make electricity, and this process is inefficient due to inherent losses through the system. Every time energy is converted from one kind to another, there are losses.

- Fuel burns in the engine at up to 40% maximum efficiency (but typically much lower).
- The engine spinning the generator to make electricity is up to 95% efficient.

- The electricity being stored in the battery is up to 95% efficient.

Knowing these inefficiencies, you would ideally want to recharge the hybrid battery from recaptured regenerative braking energy only, as this power would otherwise be lost in the friction brakes on a non-hybrid. We can almost consider this “free energy”.

Unfortunately, the basic principles of hybrid operation mean that this never happens. Whenever the engine is running it will recharge the hybrid battery until it’s back to 60% (6 bars) in gen1 to gen3 models, and this is a good thing because you’d encounter forced recharging more often if it didn’t do this, causing more inefficiency. Gen4 and higher models do not do this, they recharge only as much as needed until it needs to use the energy again to improve efficiency, so it will sit at a much lower charge level most of the time. You may encounter more frequent forced charging events in gen4 and higher models.

By being aware of the issue, you can attempt to prevent forced recharging of your hybrid battery using the following tips:

- When the battery is low, accelerate at a rate which keeps the power meter above the center of the ECO area, as this is the “engine on” area. This allows the car to be driven and also charges the hybrid battery.
- Capture as much energy as possible when you are slowing down by using the regenerative braking. See the braking section of this guide.
- Turn off your air conditioning. This puts a considerable draw of power on the hybrid battery.
- If you’re stopped for any length of time, turn the car off when possible. Even when parked, if the hybrid system is turned on it will slowly deplete the hybrid battery. You should avoid using accessory mode instead which uses the 12v battery, as this battery is quite small and is easily depleted.
- Use “park” on the transmission when stopped. If you keep the transmission in drive but do not have your foot firmly on the brake, the car will send some energy to the electric motor driving the wheels in anticipation of you moving away to prevent you rolling backwards. You can tell if you have your foot firmly enough on the brake using the power flow screen on cars equipped with this. It will show when power is being used to drive the wheels.

Inevitably, forced recharging of the battery is going to happen sometimes and there is little you can do about it. However, mitigating when possible will save you in the long run.

To avoid forced hybrid battery recharging, you can:

- **Keep the power meter above the halfway mark of the ECO section to force the engine on when the hybrid battery is low.**
- **Maximise your use of regenerative braking.**
- **Turn off your air conditioning.**
- **Turn the car off when stopped for any length of time, or at the very least put it in park.**

2.1.11. Transmission “B” Mode

The transmission on your car has several modes. Normally you would drive in “D” or “Drive”, but Toyota and Lexus hybrids also have a “B” mode.

In short, “B” mode allows engine braking by keeping the engine running unless you’re completely stopped. This is similar to putting your automatic transmission in low or changing to a lower gear in a manual transmission.

Using “B” mode is inefficient and needs to be reserved for special purposes only.

“B” mode is designed for long descents down mountains or hills where regenerative braking alone would fill up your hybrid battery, causing your braking system to switch back to friction brakes only. By using “B” mode you can minimise wear on your brakes by allowing the engine to add drag and help to slow the car down.

“B” mode does slightly increase the default regenerative braking when you take your foot off the throttle, but it also allows engine braking for as long as it is enabled even if your hybrid battery is not yet full.

You need to carefully consider when the best time to use “B” mode is, and the best time is when your hybrid battery is full and is no longer offering braking assistance.

You should switch back to “D” or “Drive” as soon as you finish your descent.

Avoid using “B” mode unless:

- **You’re travelling down a large gradient.**
- **Your hybrid battery is approaching full.**
- **You need the extra braking assistance.**
- **Your descent means your brakes may overheat.**

If you are unsure if you should be using “B” mode on a descent or not, it is better to just use it anyway. Safety is more important than efficiency.

2.2.12. Pulse and Glide

Pulse and glide is the epitome of hybrid driving. If you can master this, then your efficiency will improve drastically given that all other conditions are favourable.

What is pulse and glide?
Pulse and glide is a technique where you get up to your desired speed at a reasonable rate of acceleration, then when you reach it, you “coast” until you lose a little speed and then need to accelerate again.

How does it work?
This technique uses the unique ability of the Toyota and Lexus hybrid transmission to “coast” with the engine off without actually putting the transmission in neutral.

By carefully modulating the throttle pedal you can allow no power to go to the wheels, and no power to be put back into the battery. The car just “glides” on the existing kinetic energy.

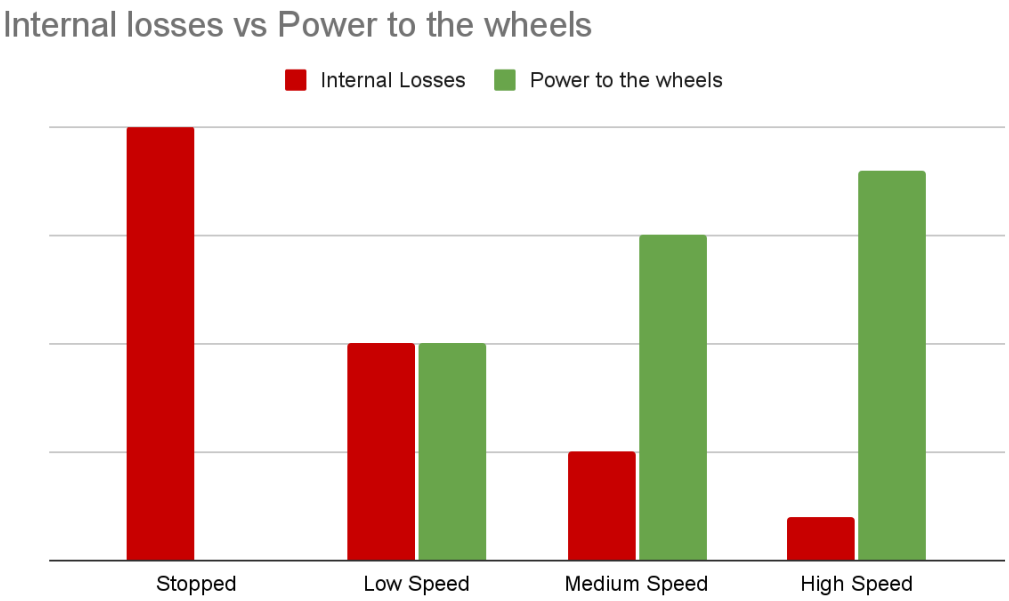
How do you do it?

1. At speeds up to 42 mph (67 km/h), and on relatively flat roads, accelerate up to the desired speed using no more than the upper part of the ECO section of the power meter.
2. Release the throttle pedal almost entirely. The EV light will illuminate to show you’re in electric only mode with the engine off.
3. Lightly press the throttle pedal just enough that the power meter sits as close to zero as possible.
4. When you lose enough speed, repeat the process.

Why does this work?
Pulse and glide works because the ratio of energy lost to moving the combustion engine's internal parts versus how much energy is put to the wheels is higher.

By accelerating modestly, this ratio of energy lost to internal parts versus power put to the wheels is significantly lowered. Then, when you’re up to speed, allowing the engine to stop means no losses at all for a short time, rather than returning to a higher ratio of internal losses than power put to the wheels.

To try and explain this visually, below is an example of what these losses might look like based on vehicle speed:


Internal losses vs Power to the wheels
Internal Losses
Power to the wheels
Stopped
Low Speed
Medium Speed
High Speed

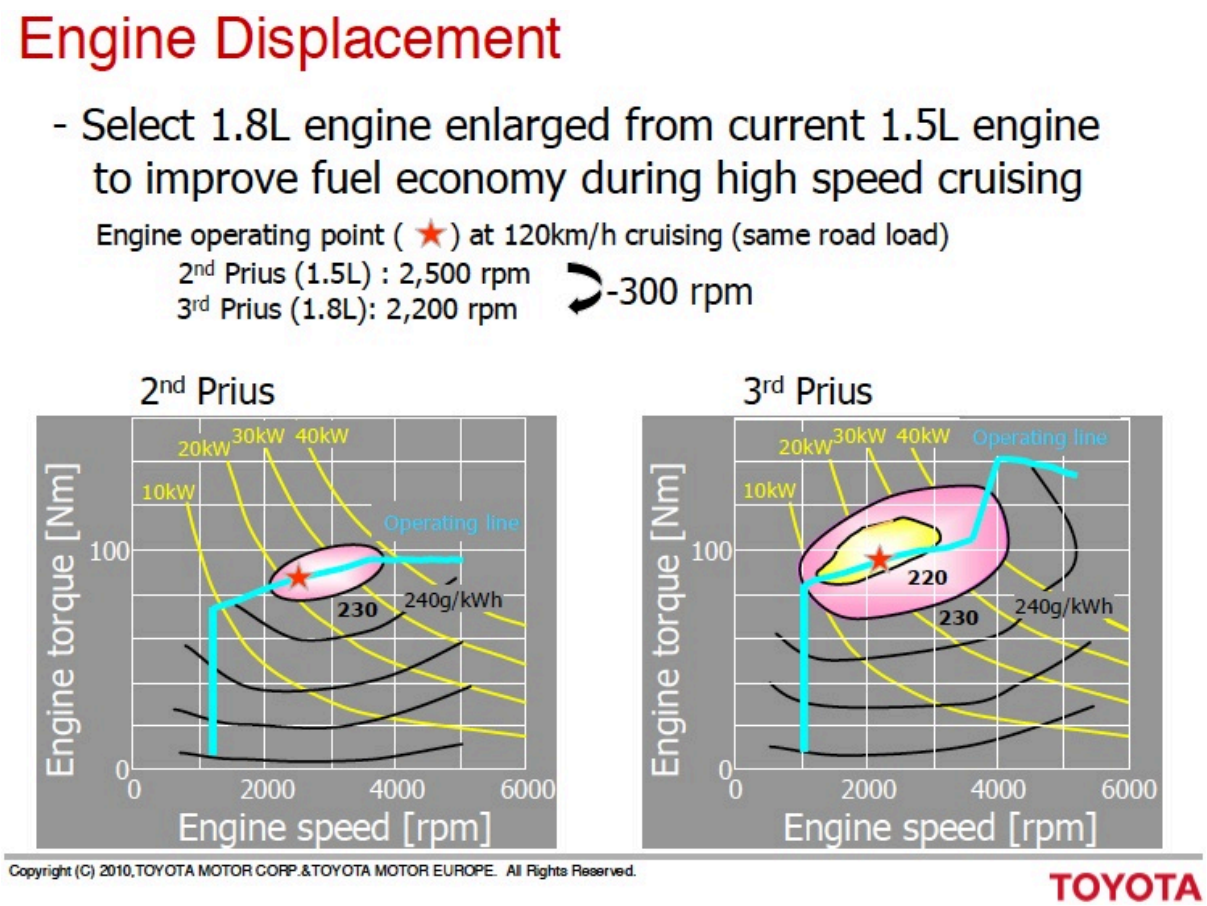
2.2.13. Brake Specific Fuel Consumption (BSFC)

Brake Specific Fuel Consumption, or BSFC, is the name given to the amount of fuel consumed at a given engine load and power output.

It's possible for an engine to produce the same amount of power at different load levels and result in a different fuel consumption.

The eCVT (electronic continuously variable transmission) in Toyota and Lexus hybrids are designed to try and maximise the amount of time that the engine operates at the best BSFC point for the required power output. This is something that a manual and standard automatic transmission can't do because of their set gear ratios.

Below are diagrams of the BSFC maps for the 2nd and 3rd generation Prius engines.



Controlling BSFC is next to impossible. Engine load varies due to a lot of conditions that are outside of your control, including speed, aerodynamics, road surface, temperature and more. The engine management system will always do its best to hunt for the best BSFC point that it can within the limitations of its programming.

There are ways in which you can help with this, and Toyota and Lexus give you an easy way to do it - the dashboard power meter.

By staying within the upper part of the ECO area of the power meter you will allow the engine management system to stay as close to the best BSFC point as possible.

However, there is a massive caveat. Note that the graph above says that the best point to be at is 2200-2500 rpm at 120km/h (75 mph) cruising speed. This is true, but it can result in higher fuel consumption than driving a bit slower at a less efficient BSFC point.

The reason for this is because you need more energy to drive faster thanks to additional aerodynamic drag. So whilst the engine might burn fuel more efficiently at a higher load when you drive faster, you're still using more fuel than you need to. Slowing down will use a lot less fuel than you lose in fuel burn efficiency. This is true until you slow down too much (below around 40 mph - 64 km/h) and then your engine efficiency will drop and the benefits are lost.

BSFC tends to be poor at slower speeds because it's not possible to put enough load on the engine to bring it up into an efficient region.

The car's engine management system will always do its best to get efficiency to the best BSFC point as often as it can, but ultimately, without a constant load on the engine, BSFC will never be at its best all (or much) of the time.

So what do you as a driver need to do?

- **Stick to within the upper ECO area of the power meter.**
- **Continue to use the other methods outlined in this guide.**

2.2.14. Tire Pressure

Tire pressure can have a small impact on your fuel efficiency, especially if they're under-inflated.

You should always ensure that your tires are properly inflated to the correct PSI. Check them regularly and don't ignore your car's TPMS system if it gives you a tire pressure warning.

You can find the proper tire pressure for your car either on a label on the body panel when you open the driver's door, or in your car's handbook.

Over-inflation
There are many people out there who like to over-inflate their tire pressure by a few PSI. Whilst this can result in better fuel economy, it does so because it reduces the amount of tire rubber in contact with the road. In turn, this reduces the amount of grip the tire can give. If you have to brake or steer sharply you will have reduced response from your steering and brakes.

You should never over-inflate your tires because this can reduce road grip and steering stability.

Under-inflation
Under-inflation is not great for fuel economy. Whilst it tends not to cause any issues for road grip and stability unless you're more than 10 PSI (0.6 bar) under the recommended pressure, it will cause excessive and improper tire wear, along with poorer fuel efficiency. This is because more rubber is in contact with the road surface and it adds more drag.

Ensure you inflate your tires to the right pressure and check them regularly.

For maximum safety and great fuel economy you should:

- **Inflate your tires to the proper PSI given in the car's handbook.**
- **Never over-inflate your tires.**
- **Check your tire pressure regularly.**

2.2.15. Temperature, Air Conditioning & Cabin Heating

Hybrids are particularly sensitive to temperature. It affects the efficiency of both engine and hybrid components alike, but there are things you can do to help overall efficiency.

Outdoor and Cabin Temperature
The outdoor temperature can impact fuel economy by forcing the combustion engine to run more frequently.

Most hybrids get cabin heating from the engine coolant, which is sometimes supplemented by a small amount of electric heating to make up for the lack of heat from the internal combustion engine's higher efficiency. Plug-in hybrids may use a heat pump to avoid the engine running except at extremely cold temperatures.

As a result you'll find that when outdoor temperatures drop below around 12°C/53°F the combustion engine will need to run more often until the coolant is up to a temperature that can supply cabin heating. The engine will be allowed to turn off once it reaches around 60°C/140°F.

However, the combustion engine is considered to be at operating temperature when the coolant hits 90°C/194°F. If you're demanding heat to heat up the cabin, this will come from the engine coolant and it may not get up to operating temperature very quickly. This will lower engine operating efficiency and result in more fuel burned.

You can help to overcome this by:

- Turning the heat down by a few degrees.
- Using heated seats (direct contact heating is more effective than heating the air around you).
- Turning off the HVAC entirely (but avoid doing this if it compromises safety, such as demisting).
- Turn off ECO drive mode! Ironically, ECO mode disables the supplemental electric heating system (if equipped) which can be highly beneficial in winter at keeping the engine off for longer.

Air Conditioning
On a hot day, you'll no doubt rely on air conditioning to keep you cool. The compressor in most hybrids are electrically driven and uses power from the hybrid battery.

Under high load conditions, such as when you first start the car and it is heat-soaked, the compressor can use a lot of power - over 3kW. This will eventually settle to under 1kW, and often nearer 0.4kW once the cabin is down to temperature.

This consumption can quickly use up a lot of hybrid battery power if the combustion engine is not running. You'll sometimes find that your hybrid battery discharges from full to empty in under 10 minutes even when you're not moving.

You can reduce the amount of power your air conditioning requires by:

- Opening windows for a few minutes and using non-recirculate mode first if the car's interior is heat-soaked.
- Use recirculate mode when the cabin cools down to the point that the interior temperature is equal to or lower than the outside temperature, so that you are cooling already cooled air and not hotter outside air.
- Turn the temperature up so you don't need to cool the air as much.
- Turn ECO mode on, which will reduce air conditioning power and fan speed at the expense of taking longer to cool the cabin. (This may not be preferable on very hot days).
- Turning off front defrost/demist mode when it's no longer needed as this will force the engine to run more and it turns the air conditioning on for some models. However, air conditioning is beneficial to keep humidity down and stop the glass from misting/fogging up so there is some benefit to using this mode.

To maximise fuel economy, you need to allow the engine to stop. You can do this by:

- **In colder weather:**
  - **Not using ECO mode. Ironically, using ECO mode disables the supplemental electric heating which can cause the engine to run more often.**
  - **Reducing the cabin heating demand by turning off the HVAC or lowering the temperature.**
  - **Use heated seats. Direct contact heating is more effective than warming the air around you.**
- **In warmer weather:**
  - **Increasing the cabin temperature by a few degrees.**
  - **Opening the windows and using non-recirculate mode for the first few minutes if the cabin is heat soaked.**
  - **Use recirculate mode once the cabin is equal to or cooler than the outside temperature.**
  - **Turn on ECO mode to reduce air conditioning power and fan speed.**

2.2.16. Hybrid Battery Temperature

All batteries have a temperature range at which they're designed to operate most efficiently and effectively.

This temperature varies by chemistry, but typically it's between 20°C/68°F and 35°C/95°F.

- If the battery is too cold, it will not output as much power and its efficiency will be reduced.
- If the battery is too hot, it will start to damage it. The car will restrict or cut its use if it gets too hot.

As a battery is charged and discharged it will slowly heat up. This happens because all batteries have a small internal resistance which means it wastes some energy coming into or out of it as heat. The more power you put into or out of the battery the more waste heat that is generated.

The hybrid battery heats up most as you use regenerative braking, as this puts the most amount of power into the battery. Ohm's law comes into play and we can work out the maximum amount of heat that may be put into the battery at a maximum regenerative braking level of about 22kW (gen3) and a cell resistance of 0.22 ohms (this will vary with each drivetrain generation and battery age. I am using a 10 year old gen3 hybrid battery as an example).

$$V = I \times R = 100A \times 0.22\Omega = 22V$$
$$P = V \times I = 22V \times 100A = 2200W$$

The above equation results in 2200W (2.2kW) of heat being generated inside the battery cells at a maximum of ~22kW regenerative braking for the gen3 drivetrain. This is the same heat as 2 space heaters. If you do a lot of regen braking you will find that the battery heats up significantly and this may result in it approaching temperatures where the cooling can't keep up.

As the hybrid batteries in most cars are air cooled by a fan using air from the car's cabin, you can ensure that the battery is receiving the right amount of cooling by ensuring that the hybrid battery vent is free from dust and debris, clean the filter annually if it has one, and make sure that you use the air conditioning on hot days.

As a general rule of thumb, if you're at a comfortable temperature in the car's cabin then your hybrid battery should be comfortable too.

The car will always do its best to manage the battery temperature, and if it approaches a dangerous level it will restrict or cut use of the hybrid battery until it cools down, and will go back to relying on the combustion engine.

To manage the hybrid battery temperature you should:

- **Use the air conditioning to keep the cabin cool.**
- **Ensure that the hybrid battery fan vent is clear of dust and debris and that the filter is clean.**

2.2.17. Fuel Grades

Not all cars are designed to run properly on the lowest grade of fuel so you should review the owners manual for your car and engine.

Generally you should not operate on the lowest grade fuel as this tends to result in lower fuel economy and lower engine power output on most engines. It will rarely cause harm to the engine unless it's a high performance engine that demands higher grade fuel.

Always follow the owner's manual recommendation on which grade to use.

Using a higher than recommended grade fuel
Using a lower fuel grade than recommended can lower fuel economy and power, but using a higher grade than recommended does not necessarily improve the fuel economy and power further than the recommended grade would.

Higher grades are recommended for high performance engines. The characteristics of higher grade fuel doesn't benefit a regular engine so using it would just result in wasted money.

For best fuel economy:

- **Use the recommended grade fuel for your car's engine. This can be found in the user's manual.**

3. General Hybrid Information

3.1. Battery Types

Two types of batteries are generally in use with hybrid vehicles as traction batteries:

- Ni-MH (Nickel Metal Hydride)
- Lithium

The car will also feature a standard 12v lead acid battery like any other car to run the 12v systems.

3.1.1. Ni-MH (Nickel Metal Hydride)

- Used in generation 1, 2 and 3 Toyota and Lexus hybrid systems (except the plug-in versions).
- Used in some generation 4 Toyota and Lexus hybrid systems depending on the year and country climate.

Advantages

- Reliable
- Safe
- Cheap
- Does not require active balancing
- Proven lifespan (10+ years)
- Can be charged below freezing temperatures

Disadvantages

- Power output falls when below freezing
- Higher internal resistance (more heat build up).
- Larger per unit of energy
- Heavier per unit of energy

3.1.2. Lithium

- Used in some generation 4 Toyota and Lexus hybrid systems depending on the year and country climate.
- Used in all plug-in Toyota and Lexus hybrid vehicles.

Advantages

- Reliable
- Lower internal resistance (less heat build up)
- Smaller per unit of energy
- Lighter per unit of energy
- Higher power output

Disadvantages

- More expensive than Ni-MH
- Can't be charged below freezing temperatures
- Unproven lifespan (too new to say how long they'll last)
- Requires active balancing
- Unsafe if mis-managed

3.2. Warm Up Stages

When you first turn on the car, there is a sequence of stages that the car runs through before it reaches "normal" operation. These are the warm-up stages and they're triggered by either engine coolant temperature or time since the car was turned on.

The stages are designed to protect engine components from wear, and if you pay enough attention you will eventually be able to predict which stage you're currently in.

This following information comes from personal observations and an analysis found on: http://techno-fandom.org/~hobbit/cars/five-stages.txt

I have attempted to simplify the stages for ease of reading, but you can find more detailed observations on the link above.

As far as I am aware, these stages apply to generations 1, 2 and 3 of the Toyota and Lexus hybrid systems. Generation 4 does appear to act a little differently in some stages, but there is no specific information about this available yet and I have not been able to gather it myself.

- **Stage 1a**
  - Occurs when the engine and catalytic convertor are cold.
  - The car will try to use battery power only until the engine has been running for at least 50 seconds.
  - You can enter manual EV mode if you do so before the engine starts.
- **Stage 1b**
  - Occurs when the warm-up period in 1a has been completed.
- **Stage 2**
  - Occurs when engine coolant reaches 40°C (104 °F).
  - The engine can turn off if not needed to provide power, battery charging, and you are not demanding cabin heat.
  - You can enter manual EV mode if the engine turns off.
- **Stage 3**
  - Occurs when engine coolant reaches 73°C (163 °F)
  - In this stage the engine is almost up to temperature and needs to do an "idle check". It will continue to run even when you think it may drop into EV mode

until you drop below 26 mph (41 km/h) for 5-15 seconds to complete the check.

- **Stage 4**
    - This is normal operating mode where the car is most efficient.
    - This stage is only reached after the “idle check” or if the car is restarted and the coolant is above 60°C (140 °F)
    - The engine will almost always turn off when in the lower half of the ECO band of the power meter unless the hybrid battery is low or is forcibly recharging, or you’re moving too quickly (above 42 mph - 67 km/h).

This information, whilst not particularly useful, helps you to understand the operation of the car and the situations at which it will or will not enter EV mode.

3.3. Engine On Triggers

The combustion engine can turn on for a large number of reasons, including:

- The engine is in a warm-up stage.
- You’re moving above 42mph (67 km/h) gen3, or 84mph (135 km/h) gen4.
- You’re using transmission “B” or braking mode for engine braking.
- You’re using manual gear selection mode on applicable models.
- You have selected transmission “N” or neutral mode whilst the engine is running (it cannot start or stop, it will maintain the current state).
- You’re demanding cabin heat and the engine coolant temperature is too low.
- You have the front demister turned on and engine coolant temperature is too low.
- The hybrid battery is empty or is forcibly recharging.
- The hybrid battery is too cold.
- The hybrid battery is too hot.
- The hybrid battery can’t supply enough power on its own.
- The hybrid battery is full (engine is spinning without fuel to burn off excess power).
- The hybrid battery is malfunctioning (you should have a dashboard warning light).

With enough careful observations you should be able to tell the reason why the engine is running at any time.

4. Troubleshooting, diagnostics and known issues

4.1. 12v Battery

4.1.1. 12v Battery Functions

The 12v battery in a Toyota or Lexus hybrid does not start the engine. Engine starting is powered by the hybrid battery.

The 12v battery is however used to start the car's computers, which when running will then connect the hybrid battery to the inverter allowing the car to move and start its engine. This is a safety feature so that high voltage is not present on the car's wiring when the car is turned off.

A weak 12v battery can prevent the car from starting even if the hybrid battery is absolutely fine. This is one of the most common reasons a Toyota or Lexus hybrid breaks down.

On a non-hybrid you can usually tell when a 12v battery is getting weak by slower turning of the engine when it is starting, which worsens over time. As the 12v battery does not start the engine it is not possible to use this method. You should be aware of the symptoms of a weakening, failing or failed 12v battery.

4.1.2. Symptoms of a weak or failing 12v battery

- The car will enter READY mode but only after several attempts and power cycling the car.
- Lights are dimmer than usual and significantly change intensity with load on the battery.
- The car is experiencing multiple electrical malfunctions at the same time.
- The brake accumulator pump runs slower than normal when you open the door.
- You cannot leave the car more than a few days without requiring a jump start.

4.1.3. Symptoms of a dead or failed 12v battery

- There is no power to the car.
- The dash lights up but the car will not enter READY mode at all.
- The dash lights flicker and the car will not enter READY mode at all.
- Lights are very dim.
- You need a jump start every day.

Related reading: *5.5. Can I jump start another vehicle with my hybrid?*

4.1.4. Replacement Recommendation

It has generally been suggested that the 12v battery in Toyota and Lexus hybrids only lasts around 3-6 years depending on how it has been treated and the climate in which the car is driven. You may want to preventatively replace the battery before this time period is up.

Hot climates will weaken a 12v battery quickly and it may need replacing every 2-3 years.

Cold climates will reveal a weakening 12v battery more easily with the above symptoms.

If you have a gen4 or gen5 hybrid system, be sure to read section 4.1.6 as this may apply to you. It is becoming common for modern Toyota/Lexus vehicles made after 2018 to see the 12v battery fail every 1-2 years.

4.1.5. Infrequent Driving

The 12v battery in Toyota and Lexus hybrids is relatively small, usually only around 38-45Ah compared with 65-115Ah of non-hybrid vehicles. With loads such as alarms, keyless entry, powered lift gates and digital dashboards putting a drain on the battery when the car is off, it is easy to significantly discharge it if it's not driven enough to replenish the used power.

This can result in the 12v battery being in a partially discharged state on a regular basis. This partial state of discharge is actually damaging to a 12v AGM or lead acid battery through a chemical process known as sulfation. Sulfation essentially "blocks" capacity of the battery from being used. The more discharged the battery is, the faster it damages it, and the longer it is left in a partial discharged state the more damage occurs.

Some sulfation is reversible if the battery is fully recharged soon after being discharged, but extended periods of partial discharge states or under-charging results in the sulfation hardening into irreversible damage. Such damage takes only days to begin and eventually the remaining usable capacity gets so low that the battery can't do its job and it fails.

A healthy battery is expected to last only a few weeks before it is discharged if the car is not driven, and this time will drop as the battery ages and its capacity diminishes.

To ensure you don't have a state of partial discharge, be sure to have the car in 'READY' mode or drive at least 2 hours per week and at least 15 minutes per journey to keep it sufficiently charged. The more driving you do each week the healthier your 12v battery should remain (however, see 4.1.6 for situations where this may not apply due to a possible design issue in the 12v charging system of gen4/5 vehicles).

4.1.6. Incorrect Charging (a likely deliberate design issue)

I believe that, through personal observation and reports from other owners, that Gen4/5 Toyota and Lexus 12v batteries do not get properly recharged, for reasons that I have detailed below.

Summarised

- The 12v battery in gen4/5 vehicles does not appear to receive a proper charge.
- It charges at 14.4v for 90 minutes then drops to 12.4-12.6v, a state of discharge.
- It should drop to 13.5-13.8v to float charge.
- This is important because dropping to 12.4-12.6v is a discharging state, down to approximately 75% state of charge.
- Any state of charge below 100% on a lead acid or AGM battery damages it through plate sulfation which permanently reduces the batteries ability to hold a charge over time as the sulfation solidifies.
- This worsens the more discharged a battery is and the longer it remains in this state.
- This leads to eventual premature battery failure within 1-2 years for most.
- I believe this happens because of “emissions” laws trying to cut carbon emissions by reducing energy going into the 12v battery the same way smart alternators operate.
- A potential solution to this is to disconnect the battery sensor on the negative terminal of the 12v battery. This forces charging at 14.0-14.1v continuously (no time limits) which is healthier than putting the battery into a discharging state, and is a good compromise on charging voltage.
- This is safe because it’s a built in fail-safe voltage which is used if the sensor is faulty or disconnected.

The full story in detail

I personally have discovered what I believe to be a design issue with Toyota/Lexus Gen4 and Gen5 vehicle 12v charging regime, which causes the 12v battery to be incorrectly charged, and as a result, it drastically reduces its lifetime and increases the risk of a dead 12v battery.

Most modern vehicles use a sensor on the negative terminal of the battery. This allows the car to monitor voltage, current and temperature at the battery itself. In theory this is a sound idea, allowing careful control of how the battery is managed. However, if the software that controls this is not correct then it will result in a battery that is mismanaged.

My tests across my own vehicles and evidence sourced from other owners' experiences [1] [2] leads me to believe that the Toyota and Lexus vehicles do not have the correct software configuration to correctly charge the 12v battery.

Under normal testing everything appears to be normal. The battery charges at around 14.4v as you would expect, and this is how a battery should be charged during its “bulk/absorption” phase of charging (the stages that do most of the charging). This stage is supposed to last until around 1/50th of the battery capacity in charge current is observed. For a 45Ah battery

that's about 0.9amps. After this the charge voltage should drop to around 13.7v, which is known as a "float" voltage to maintain the battery charge.

During my observations using an OBD dongle and the Dr Prius app, and finding evidence online, this is not what is happening. Initially the battery is charging at around 14.4v, until 90 minutes into a single driving session. At this point the battery voltage drops to around 12.4v, which in lead acid battery terms is discharging the battery. A fully charged voltage at the terminals when open circuit is 12.8-13.2v, so anything less than this is discharging it.

12.4v is considered to be around 75% state of charge, which for a lead acid/AGM is extremely detrimental. Any state of charge under 100% is actually causing chemical damage to the battery through sulfation of the lead plates. Sulfation essentially "blocks" capacity of the battery from being used. The more discharged the battery is, the faster it damages it. Some sulfation is reversible if the battery is recharged soon after being discharged, but extended periods of under-charging results in the sulfation hardening into irreversible damage. Such damage takes only days to begin.

If someone drives long distances regularly without a stop every 90 minutes, they are the most likely to encounter problems from this design issue. This is especially true if a long journey of over 90 minutes is regularly performed in one go and then the car is stopped and left for a period of time, as this will allow hardened sulfation to set in due to the moderate discharge on the battery.

Equally so, anyone who does not drive their vehicle often enough or for long enough is going to encounter a similar scenario of under-charging. Under-charging and sulfation is what kills most lead acid batteries, and I believe this is why we're seeing a significant number of brand new hybrid vehicles from Toyota and Lexus having so many 12v battery issues.

So why does this happen?

My belief on why this happens is simple. Carbon emissions.

Some "smart" people thought they could save on carbon emissions by not always applying a charge to the 12v battery, but instead, choosing to do "smart charging" whereby the 12v battery is charged when there is essentially free power available when slowing the vehicle down. This caught the attention of some people in the government and a requirement was brought in for modern vehicles to have this implemented.

Most non-hybrid vehicle smart alternators work this way, by allowing the 12v battery to discharge to around 75% (12.4v), and then when the vehicle is slowing down they apply an over-voltage (often as high as 15.5-16.0v) to dump high current into the lead acid battery for a short time, recuperating some tiny fraction of the energy that would otherwise be lost from braking. It's similar to what a hybrid does when using regen brakes but on a much smaller scale (a few hundred watts versus 10's of kilowatts).

Doing this requires you to have sufficient space in the battery to put the energy, so the 12v battery is kept in a partially discharged state to allow for it. This process, and stop-start technology keeping the battery partially discharged, is what kills these batteries very quickly

(in 1-2 years) because they're in a constant state of under-charge allowing continuous formation of sulfation.

But why is this present on a Toyota/Lexus hybrid? The same reason. Carbon emissions. Whilst it doesn't do the same current dumping as a non-hybrid, it serves the same purpose by not applying a charge to the battery constantly, which would waste some energy as heat. It's a particularly stupid solution to a problem that never existed and actually creates a new problem of low battery longevity. This requires more frequent replacements and thus likely undos any carbon emissions that were saved.

There is a very simple solution to this problem that you can do yourself.

It's as easy as disconnecting the sensor on the negative terminal of the 12v battery that was mentioned at the beginning of this section. By doing this you force the DC-DC convertor to put out a **continuous** fixed voltage of around 14.0v which is sufficient enough to charge the 12v battery but not so much that it results in an over or under-charge condition.

Having worked with lead acid batteries and charging systems for a long time (over 15 years) I have plenty of experience in charging lead acid batteries to know that this approach is safe. In addition to this, older vehicle alternators would usually put out a fixed voltage of around 14.5v continuously and this did not result in any failed batteries in this time.

Most modern hybrids do often use AGM lead acid batteries which are less tolerant to this high of a voltage (14.5v) continuously, but 14.0v is acceptable for continuous charging of an AGM. We also know this because the Toyota engineers set this as the fail-safe voltage should the battery sensor fail.

This is a largely unnecessary solution as many people will just deal with replacing their batteries every couple of years if they're affected, but in my eyes it taints the Toyota and Lexus brand reliability. Who wants a car that suddenly won't start one day every 1-2 years because software mis-managed their 12v battery? Not me. I like to take care of my vehicles and batteries. I believe it was because of this exact issue that I suffered my first dead battery after 19 years of driving.

I have personally disconnected the sensor (in March 2025) and I will be observing how this affects the life of my battery over the coming years. I have full faith that this will result in a healthy 12v battery for the life of my ownership of the car.

4.1.7. How to avoid a dead 12v battery

- Drive at least 2 hours per week, and at least 15 minutes per journey.
- Don’t use AUX mode (ignition on only) to run the radio or power devices from the 12v AUX socket, etc. Always use READY mode so that the 12v battery is charging.
- Turn your lights off when the car is off. Some vehicles keep the lights on if you turn the car off and remain inside without opening a door. Be aware of this.
- Keep doors closed or turn off interior lights if doors are left open for a long period of time.
- Avoid repeatedly opening and closing electric lift gates or sliding doors.
- Disable keyless entry if your key is to be kept close to the car, such as when camping.
- Ensure the car is locked when you don’t need it to be open. Keeping it unlocked can stop the car’s computers from fully turning off.
- Do not leave a dash cam running when the car is off. This is the quickest way to kill your 12v battery. Ensure it turns off when the car is turned off.
- If you go away for a week or more, consider disconnecting the 12v battery, or use a battery tender or solar panel (if kept outdoors) to keep it charged.

Even if you do all of these things, everyone gets a dead 12v battery eventually. Ensure you also carry your own jump cables so you can ask someone for help, or carry a jump box.

For hybrids, any jump box will usually do the job because the car requires very little power to start. The engine starts from the hybrid battery.

4.2. Gen 4 poor Ni-MH hybrid battery cooling performance

During my 18 months of Lexus UX ownership I have found that the car has issues with hybrid battery cooling performance. This also applies to other Lexus and Toyota models, specifically the Toyota RAV4.

The reason for this, I believe, is caused by a software issue which is not making the hybrid battery fan run at the proper speed when the battery reaches its temperature limits.

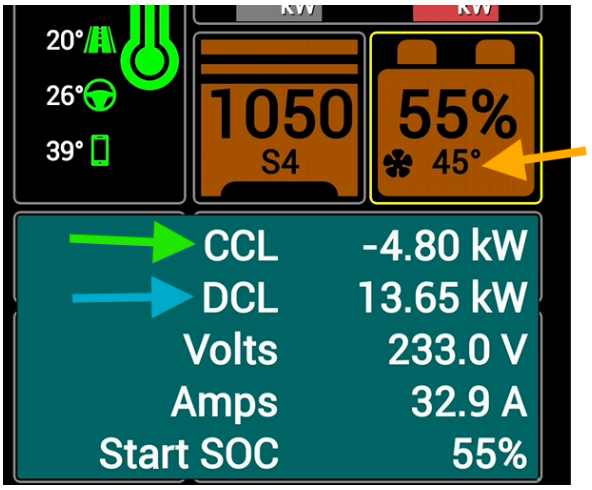
The Ni-MH hybrid battery will heat up during use, specifically during heavy charging (regen) and discharging (regular driving). It has a temperature limit of 45°C, at which point the hybrid battery ECU will begin to restrict battery usage. It will pull back the maximum charge and discharge power to ensure that it is used as minimally as possible so that heat generation is minimised.

As a result of these limits the car reverts back to a micro-hybrid state whereby the engine will stop only when you are fully stopped, and will immediately start again when you press the throttle. All propulsion power is coming from the engine at all speeds rather than from the hybrid battery at low speed, there is no battery assistance under full throttle, and regen braking is also almost completely disabled (a minimal amount is allowed so the battery charge level can be maintained).

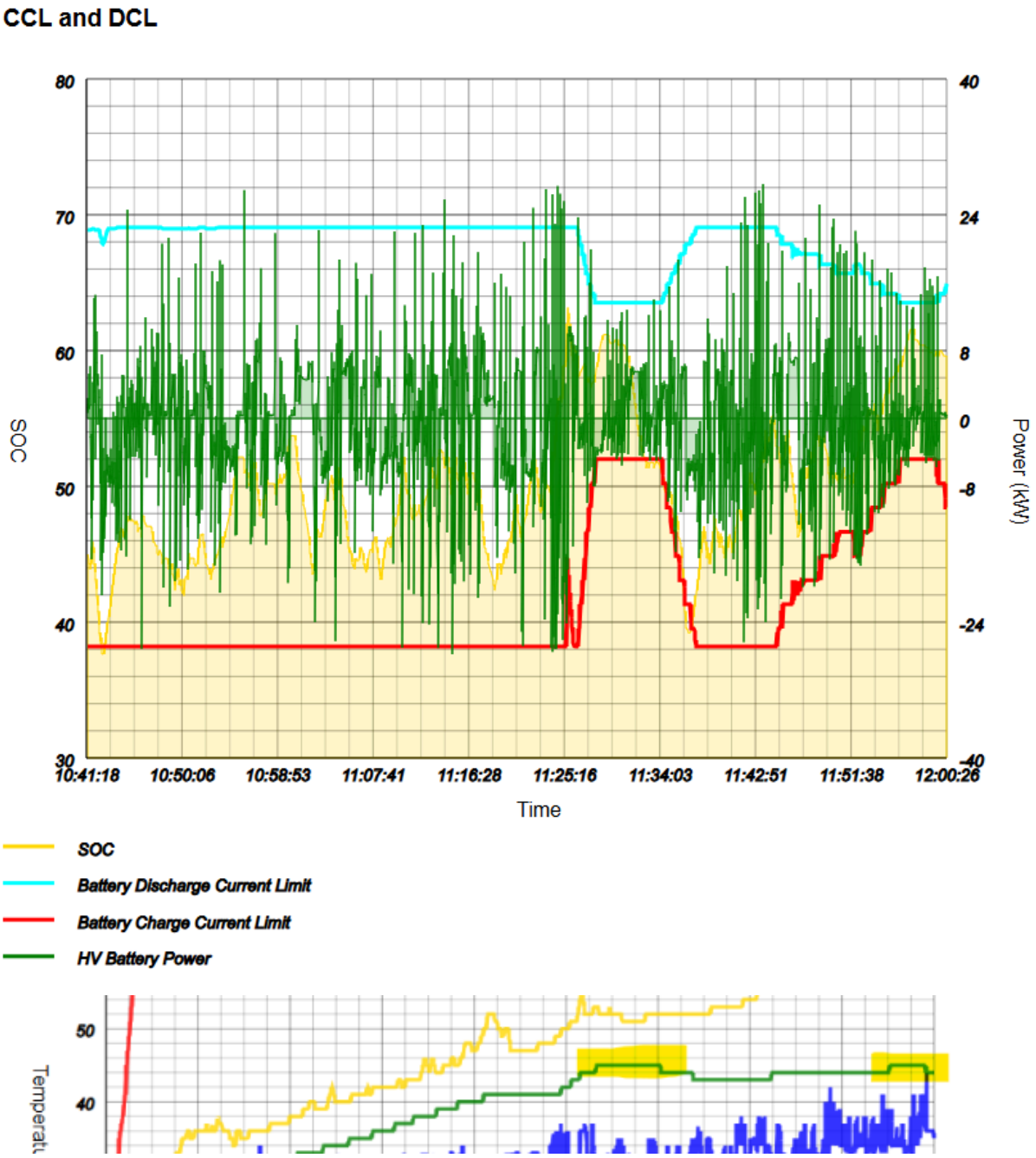
When the battery reaches 45°C the hybrid battery fan is running, but not at full speed. It is suspected that it's to keep noise levels to a minimum (because the car is "luxury"). In this condition any noise should be acceptable to maintain battery health.

In the Hybrid Assistant app you can see the following information which shows us the exact values.

- **Orange arrow** is battery temperature (max limit is 45°C where the battery is considered overheating and the car fully restricts power).
- **Green arrow** is the battery charge power limit (normal is around -26kW).
- **Blue arrow** is the battery discharge power limit (normal is around 22.5kW).
- Not shown is the hybrid battery fan speed which is "4" but with no maximum known value.



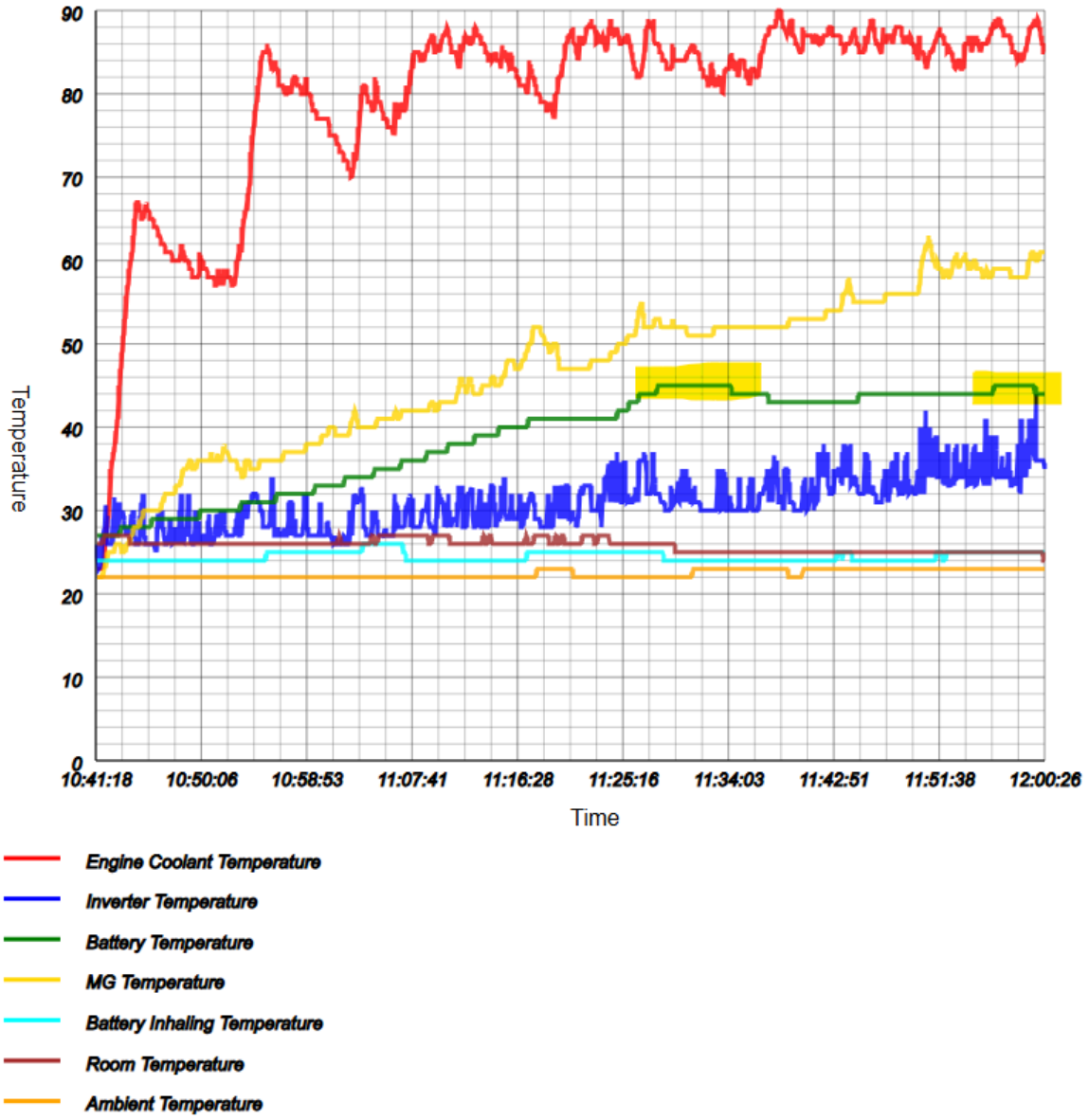
This data can also be observed over time on graphs taken from Hybrid Assistant:



The top graph shows the battery charge and discharge limits. The second partial graph (of which the full one is below) shows the hybrid battery temperature in green with the yellow highlight showing the section we're interested in. This matches up with the first graph on time.

We can see that as the hybrid battery temperature approaches 45°C the limits begin to creep in. This happens very quickly and within a 1°C change.

Powertrain Temperature



I have personally evidenced this to Lexus and they believe there is no fault because the car does not provide any fault codes or messages on the displays. They have ignored my evidence where the car stops using the hybrid battery, has limits that come from the car, etc. because the data does not come from their own diagnostic tools.

It should be noted that this issue does not stop the car from functioning, but it does reduce functionality of the hybrid system. It has been built in a way that protects the battery and lets you continue on engine power alone, but it reduces total performance because 30HP comes from the hybrid battery at full throttle, and it almost completely disables regenerative braking, all of which eventually impacts fuel economy.

It is possible to overcome this issue with the Dr Prius app to force the hybrid battery fan to run faster when it gets too hot. However, this clearly should not be required for basic

operation of the vehicle. It requires you to know about the issue, understand the symptoms, buy an expensive OBD adapter and run an app on your phone whenever you drive. The average person is not going to know about this issue so long as the car keeps driving (which it does).

In some weather conditions the battery is already close to overheating temperature when it's left in the sun for a few hours so these limits can apply almost immediately upon starting the car in hot weather.

I have to use the app regularly in summer to prevent hybrid battery overheating or to get it out of an overheating state. If I don't I suffer reduced performance, particularly on a journey of over 1 hour where a lot of regen braking is used. Regen braking heats up the battery significantly due to the amount of power flow.

Sitting at a high temperature does make me concerned for the hybrid battery longevity since 45°C is an upper limit for charging it. However, my vehicle and its hybrid battery are still under warranty. Should it fail it will be replaced for free. For those which are not warrantied the battery replacement cost could be prohibitive.

If you have this issue I encourage you to bring it up with the dealer and to post on reddit (and share with me so that I can document it here). It's possible that if there are enough complaints we can get them to issue a software update.

In the meantime you can use the Dr Prius app with an OBD dongle to overcome the issue.

References:

1. https://priuschat.com/threads/hybrid-battery-temperature-and-fan-speed-hybrid-assistant.249434/
2. https://www.reddit.com/r/Lexus/comments/1k7tj9t/temperature_hybrid_battery/

4.3. Unusual Engine Revving

The engine in Toyota and Lexus hybrids do like to rev higher than most non-hybrid engines. This is because of the engine and hybrid system design and the way it is linked in with the eCVT transmission. As a result, some newer drivers tend to think that perhaps the clutch or transmission is “slipping” when this is not the case.

As you get to know the car you’ll know what is normal and what isn’t, so when something unusual happens you’ll be able to identify it.

The engine may rev higher than unusual under some conditions, which is normal:

- The hybrid battery is not fully charged. The extra engine RPM is so that it can generate power to charge the battery.

- You’re using “B” mode on the transmission. When you let off the throttle the engine will increase in RPM to create drag that slows you down. It will decrease slowly as your speed decreases. Switch back to “D” or “Drive” to resolve this.

- You’re going up a steep incline. An incline requires more engine power so the engine will increase in RPM to generate more power.

- The transmission is in “Park” and you’re pushing the throttle. The engine RPM will increase slightly to at most around 2500 RPM.

- You’re using the sports mode and/or manual gear selection and have selected a low gear that increases engine RPM and allows for engine braking. Switch back to “D” or “Drive” to resolve this.

If your engine is high in RPM when you hit the throttle but the car does not move appreciably then there may be a problem with the hybrid system. The car should alert you with a master warning light, but it has been known for this not to happen if the car goes in “limp” mode. If this is the case, pull over safely and turn the car off, then back on. This may resolve the problem. If it reoccurs, book a service with your local dealer or hybrid specialist.

4.4. Hybrid Battery Depletes/Charges Quickly

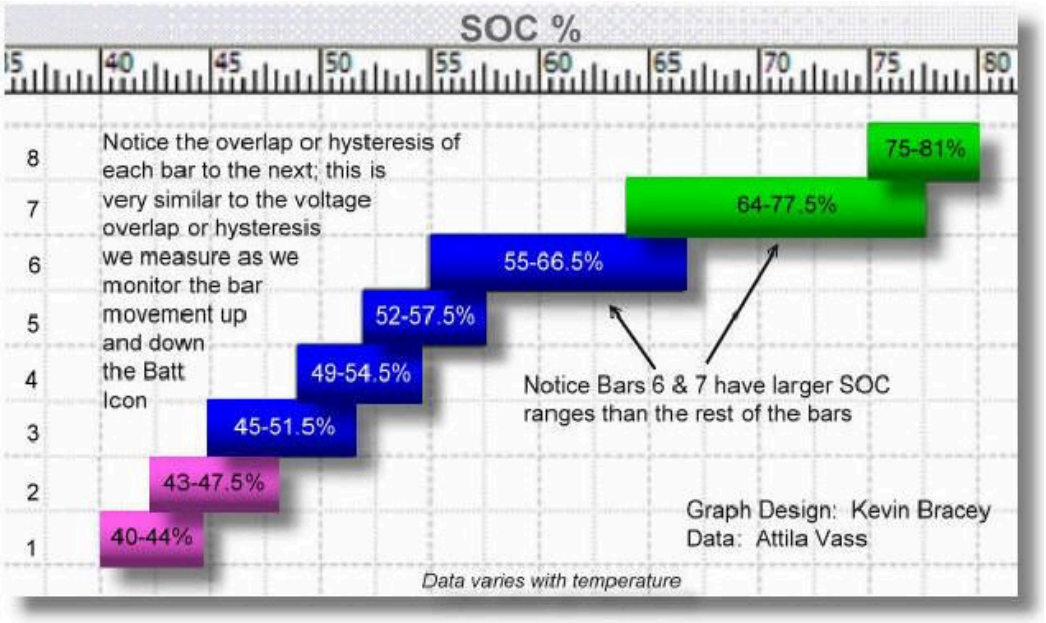
The hybrid battery is carefully managed by the car's computers, and most of the time you can let it do its thing and just drive the car care-free. If you're observant, you may like to keep track of your hybrid battery level.

There are a number of reasons why the hybrid battery might deplete quickly. Some are normal and some are not:

Normal Operation:

- You're using a lot of high power electrical loads such as your air conditioner as well as driving in EV mode. The hybrid battery is small and the air conditioner can use up to 3kW of power, and EV mode driving can use up to 8kW of power in gen3 or up to 14kW in gen4. The hybrid battery allows only around 300Wh (0.3kWh) of its capacity to be used so 11kW of load can use that in just 2 minutes! A typical air conditioning load of 800w (0.8kW) would use this up in just 15-20 minutes on its own.

- The hybrid battery is in the lower 50% of its charge level. The battery indicator is not linear so the lower bars fall off more quickly than the top bars do because the percentage range that they show is smaller, as shown in the below diagram.



Abnormal Operation:

- If the battery goes from full to empty in a short distance driving in EV mode, this may indicate that your hybrid battery is failing.

- If the hybrid battery charges to 8 out of 8 bars quickly this may indicate that your hybrid battery is failing.

- If the hybrid battery charge level changes by more than 1 bar between turning the car off and back on then this may indicate that your hybrid battery is failing.

4.5. Hybrid Battery Rarely Fully Charges

By “fully charged” this refers to 6 out of 8 bars.

In gen3 vehicles and earlier:

- It’s normal to see 6 out of 8 bars of charge after driving for around 5 minutes at a constant speed.

- It’s **not normal** to see the battery at a low state of charge after holding a constant speed for over 5 minutes.

- It’s normal to see lower charge when you’re city driving with regular start-stop situations.

- It’s normal to see more than 6 out of 8 bars when the temperature is cold and the engine is running for cabin heat. It will charge the battery to put a load on the engine to bring it up to operating temperature quicker.

In gen4 and gen5 vehicles:

- It’s normal to see the charge between 2-6 out of 8 bars at all times (city and highway) as these hybrid systems use the battery to propel the vehicle in more situations than gen3 and earlier.

- It’s normal to see lower charge when you’re city driving with regular start-stop situations.

- It’s normal to see more than 6 out of 8 bars when the temperature is cold and the engine is running for cabin heat. It will charge the battery to put a load on the engine to bring it up to operating temperature quicker.

4.6. Hybrid Battery Diagnostics with the Dr Prius App

There are always a lot of questions and answers about how to use the Dr Prius app for hybrid battery diagnostics, but there are no tutorials on what the proper method is or any tutorials showing how to do it.

This section will provide a step by step guide on how to use Dr Prius to diagnose your hybrid battery.

For this test you will need the Dr Prius App, which is available on the Google Play and Apple App Store.

You will also need a compatible Bluetooth OBD Dongle. Visit https://priusapp.com/ and select the “OBD2 To Buy” tab to see a recommended selection of dongles that are supported (and a list of those that are not supported).

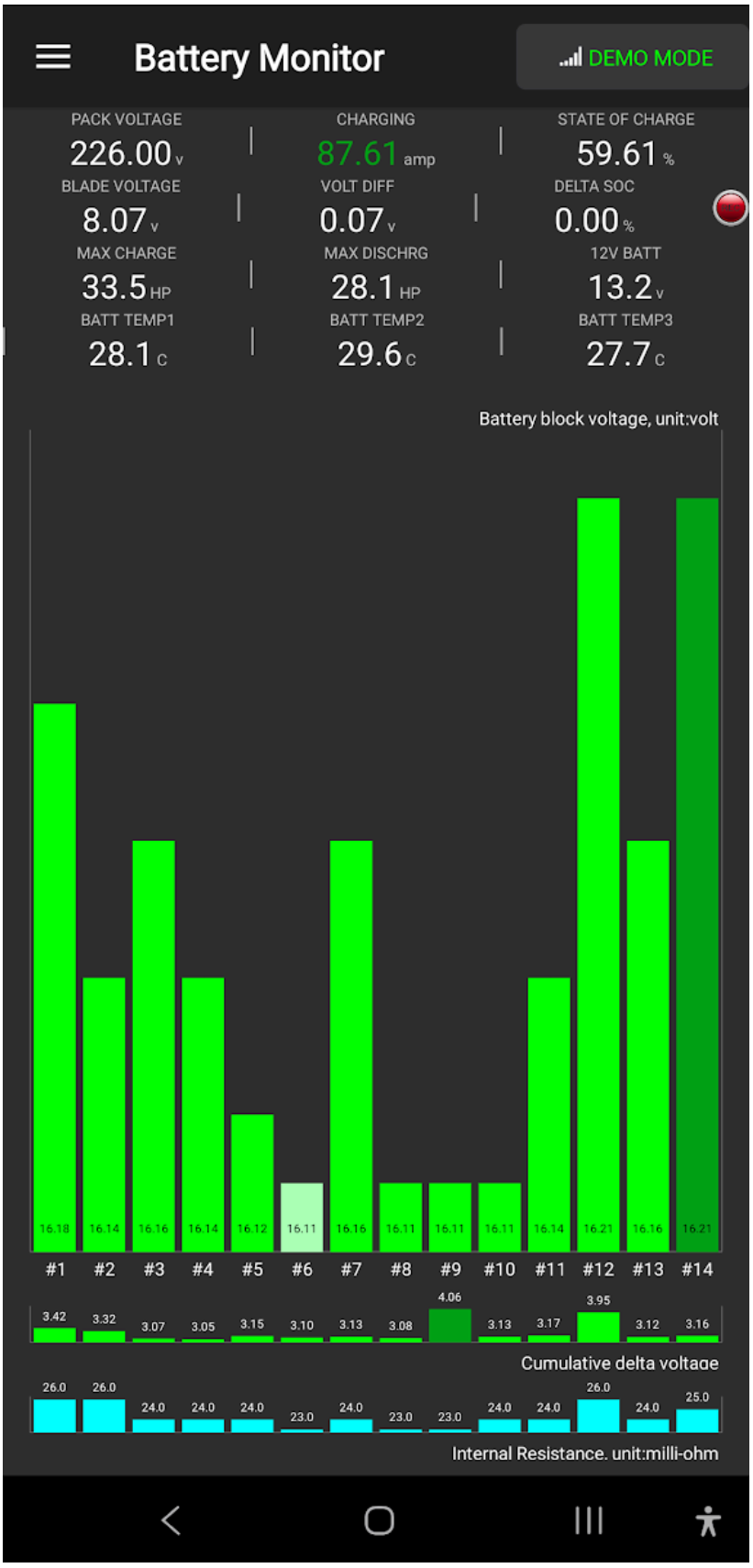
I personally use the “vLinker FD+ OBD2 Bluetooth” which looks like this:

Available on:
Amazon UK
Amazon.com

Don’t worry, no affiliate links on these!

There are cheaper alternative OBD dongles but the above is one I know to work. As compatibility varies, you are purchasing at your own risk. Amazon’s returns policy tends to be quite good so it’s usually a safe place to order from if you’re unsure.

4.6.1. The app interface and what everything means



The Dr Prius app interface looks complicated if you don't understand what everything represents, so below is a breakdown so you can understand it more easily.

- **Pack Voltage**
  The total voltage of all the modules in your hybrid battery added together.

- **Charging / Discharging** (The label changes depending on the current state)
  The charging or discharging current going into or out of the hybrid battery in amps.

- **State of Charge**
  The current state of charge of the hybrid battery in percent. Typically this will vary between 35-75% with a nominal state between 40-60%.

- **Blade Voltage**
  The average voltage of the individual modules in the hybrid battery.

- **Volt Diff**
  The voltage difference between the lowest voltage module and the highest voltage module in your hybrid battery.

- **Delta SOC**
  The percentage difference between the best and the worst module. Typically this should read 0% otherwise it may indicate a hybrid battery issue.

- **Max Charge**
  The maximum hybrid battery charging power in horsepower (divide by 1.341 for kilowatts). This will decrease if your hybrid battery is too hot or too cold.

- **Max Dischrg (Discharge)**
  The maximum hybrid battery discharge power in horsepower (divide by 1.341 for kilowatts). This will decrease if your hybrid battery is too hot or too cold.

- **12v Batt**
  The voltage of your 12v battery as measured by your OBD module. This can be slightly inaccurate depending on the quality of your module. A healthy range when the car is turned on and in READY mode is 13.5-15.0v.

- **Batt Temp 1 / 2 / 3**
  The temperature of the hybrid battery in each zone.
  Zone 1 is closest to the cooling fan.
  Zone 2 is in the middle. This tends to be the hottest zone and the hybrid battery fan uses this value to determine how fast to run.
  Zone 3 is the opposite end of the cooling fan.

- **Large Green Bar Graph**
  The voltage of each pair of modules in your hybrid battery in Ni-MH batteries, or individual cells in Lithium batteries.

- **Small Green Bar Graph**
  The cumulative voltage difference of each module or cell (highest voltage - lowest voltage). This tells you how much the cell or module has varied in voltage. A cell/module that is significantly higher than the rest may indicate a weak or failing cell/module.

- **Small Aqua Bar Graph**
  The internal resistance of each cell/module in milli-ohms. A higher reading than other cells/modules may indicate a weak or failing cell/module.

Data Recording
It is possible to record data from the app into a CSV file so that it can be reviewed later. Simply tap the red circle with REC in it to begin, and tap it again to stop. When you stop recording you will be prompted to save it or share it.

4.6.2. How to check the health of your hybrid battery

The health of your hybrid battery can generally be determined by carrying out a few tests. Any one of them alone ***can possibly*** diagnose a failing hybrid battery, ***but it is not always clear cut***.

- Resting Voltage Balance
- Internal Resistance
- Low Speed Voltage Drop
- High Acceleration Voltage Drop
- Scan for fault codes

Note that even after completing these tests the data you receive may falsely lead you to believe the battery is failing when it may be something else causing it, such as an electrical connection issue, faulty ECU, faulty/mis-interpreted readings, or a test carried out improperly.

By following these instructions you accept that the information revealed by doing these tests may lead to an inaccurate conclusion, is carried out at your own risk, and any actions you take based on this are your own decision.

Each test is detailed below.

4.6.2.1. Resting Voltage Balance

The resting balance test checks if your battery modules are balanced with one another when not under load. This test typically reveals the weakest batteries most easily.

1. Discharge the hybrid battery to between 42% and 45% state of charge (the lower the better, but the engine will forcibly turn on at 40% so stay above this) by driving around in EV mode at below 20mph. Don't allow the engine to start by keeping below the first half of the eco portion on the power meter.
2. When stopped and in park with the engine not running (but the car still on), monitor the volt diff value and compare with the table below.

Volt Diff (Ni-MH)	Volt Diff (Lithium)	Health
<0.1v	TBD	Likely healthy
0.1v - 0.2v	TBD	Likely healthy
0.2v - 0.3v	TBD	Likely Weakening
0.3v - 0.5v	TBD	Likely Weak
0.5v+	TBD	Likely Failed

3. If you have a volt diff of a value other than one in green it is likely that one of the modules is getting weak or has failed.

4.6.2.2. Internal Resistance Test

The internal resistance test checks if any of your battery modules have an internal issue. A high internal resistance could indicate a failed cell.

1. Open the Dr Prius app and connect to the car whilst it is in READY mode.
2. Look at the aqua coloured bar graph near the bottom of the app.

3. Note the internal resistances of each module and check the table below.

Internal Resistance (Ni-MH)	Internal Resistance (Lithium)	Health
<30 milli-ohms	TBD	Likely healthy
>30 milli-ohms	TBD	Likely Weak or Failing

This applies only when the battery is at a normal temperature of around 25°C / 77°F. Resistances are higher when the battery is hot and lower when the battery is cold.

4. Note the difference in internal resistance between the highest and lowest modules and check the table below.

Internal Resistance Difference (Ni-MH)	Internal Resistance Difference (Lithium)	Health
<3 milli-ohms	TBD	Likely healthy
3-5 milli-ohms	TBD	Likely Weakening
5-10 milli-ohms	TBD	Likely Failing
10+ milli-ohms	TBD	Almost Certainly Failed

When you compare any two of your modules and they have a difference in internal resistance that is a value in red then you may have a failing module.

4.6.2.3. Low Speed Voltage Drop Test

The low speed voltage drop test checks if any one of your modules has an inability to sustain a moderate load placed on it at a low state of charge. It is designed to find modules which can't hold as much energy as the other modules.

For safety reasons, get help from a friend or family member. One of you will need to drive and the other monitor the app. If you can't get help then screen recording the app would be helpful so that you can review it afterwards when you're safely stopped.

1. Discharge the hybrid battery to around 45% state of charge by driving around in EV mode at below 20mph. Don't allow the engine to start by keeping below the first half of the eco portion on the power meter.
2. Monitor the **volt diff** value whilst you continue to drive around at below 20mph without the engine coming on.
3. Check if the **volt diff** rises above 0.3v (Ni-MH) at any time.
    a. If the value does rise above 0.3v (Ni-MH), note the cell number with the lowest bar on the large graph. Modules with a severe voltage difference will change from green to yellow or red.
4. At 40% state of charge the engine should then turn on to recharge the battery. The test is finished.

Volt Diff (NI-MH)	Volt Diff (Lithium)	Health
<0.1v	TBD	Likely healthy
0.1v - 0.2v	TBD	Likely healthy
0.2v - 0.3v	TBD	Likely Weakening
0.3v - 0.5v	TBD	Likely Weak
0.5v - 1.0v	TBD	Likely Failed
1.0v+	TBD	Almost Certainly Failed

If at any time the volt diff value rises above 0.3v for more than a brief period then it may indicate that one or more of your modules is not holding as much capacity as other modules.

The larger this number the worse the problem is. Above 0.5v volt diff it is likely that the car has already triggered a "P0A80 - Replace hybrid battery" code.

4.6.2.4. High Acceleration Voltage Drop Test

The high acceleration voltage drop test checks if any one of your modules has an inability to sustain a high load placed on it. It is designed to find modules which can't output as much energy as the other modules.

For safety reasons, get help from a friend or family member. One of you will need to drive and the other monitor the app. If you can't get help then screen recording the app would be helpful so that you can review it afterwards when you're safely stopped.

1. Find an open unused road where you can safely accelerate from a stop at full throttle for up to 5 seconds.
2. Discharge the hybrid battery to around 45% state of charge by driving around in EV mode at below 20mph. Don't allow the engine to start by keeping below the first half of the eco portion on the power meter.
3. From a stop, accelerate at full throttle for at least 5 seconds and monitor the volt diff.
4. Check if the **volt diff** rises above 0.3v (Ni-MH) at any time whilst accelerating.
    a. If the value does rise above 0.3v (Ni-MH), note the cell number with the lowest bar on the large graph. Modules with a severe voltage difference will change from green to yellow or red.

Volt Diff (Ni-MH)	Volt Diff (Lithium)	Health
<0.1v	TBD	Likely healthy
0.1v - 0.2v	TBD	Likely healthy
0.2v - 0.3v	TBD	Likely Weakening
0.3v - 0.5v	TBD	Likely Weak
0.5v - 1.0v	TBD	Likely Failed
1.0v+	TBD	Almost Certainly Failed

5. Once you have taken your reading the test is finished.

If at any time the volt diff value rises above 0.3v (Ni-MH) for more than a brief period then it may indicate that one or more of your modules is not holding as much capacity as other modules.

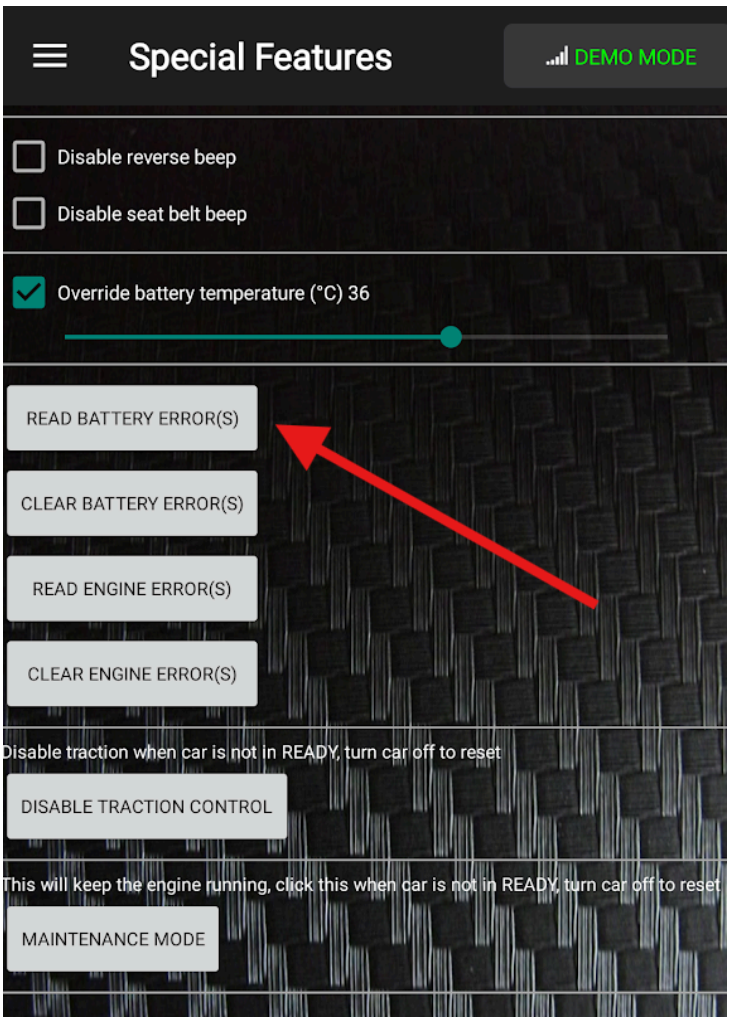
The larger this number the worse the problem is. Above 0.5v (Ni-MH) volt diff it is likely that the car has already triggered a "P0A80 - Replace hybrid battery" code.

4.6.2.5. Scan for Fault Codes

The Dr Prius app allows you to scan for hybrid battery error codes stored in the ECU.

Such codes are typically accompanied by the master warning light  and the message “CHECK HYBRID SYSTEM” on the dashboard.

You can check for codes by going to the “Special Features” menu in Dr Prius and hitting the “Read battery error(s)” button.



The “P0A80 - Replace hybrid battery” is the most common and indicates when the hybrid battery metrics are detected as being out of specification.

You will usually get this code as soon as the tests you can run manually enter a failed state, which can render the vehicle undriveable or unreliable.

You can often predict failure earlier with the manual tests.

4.6.2.6. Reading the results

You ***may*** have a failing hybrid battery if you find any metric or test tells you the following:

- The **volt diff** value is:
    - Above 0.3v (Ni-MH)
- The **internal resistance** of a module is:
    - Above 30 milli-ohms (Ni-MH)
- The **internal resistance between modules** is:
    - Greater than 3 milli-ohms (Ni-MH)
- The Delta SOC is above 0%.
- You have already received a ”P0A80 - Replace hybrid battery” fault code.

The more metrics that show a failure the greater the chance that the hybrid battery is actually failing.

However…

You may also ***not*** have a failing hybrid battery.

The symptoms you find during the tests could also be caused by:

- Corrosion on busbars
- Loose connections
- Damaged cables
- A failing ECU
- Or something else

High resistance connections caused by corroded, loose or failing cabling or busbars in the hybrid battery can contribute to the symptoms of a failing hybrid battery even though the modules themselves are actually fine.

Corrosion, loose connections or damaged cabling themselves ***are*** an issue and do need addressing (it can cause a fire if you don’t), but it may be a simpler fix if that’s the only issue.

It’s very easy to jump to conclusions that the modules are failing when it could quite easily be something else. You won’t know until the battery is removed, inspected and the modules individually tested.

You should not attempt to remove or disassemble the hybrid battery unless you are proficient with working on high voltage DC power and have the proper safety equipment. High voltage DC power is significantly more dangerous than AC power.

5. Technical Questions Answered

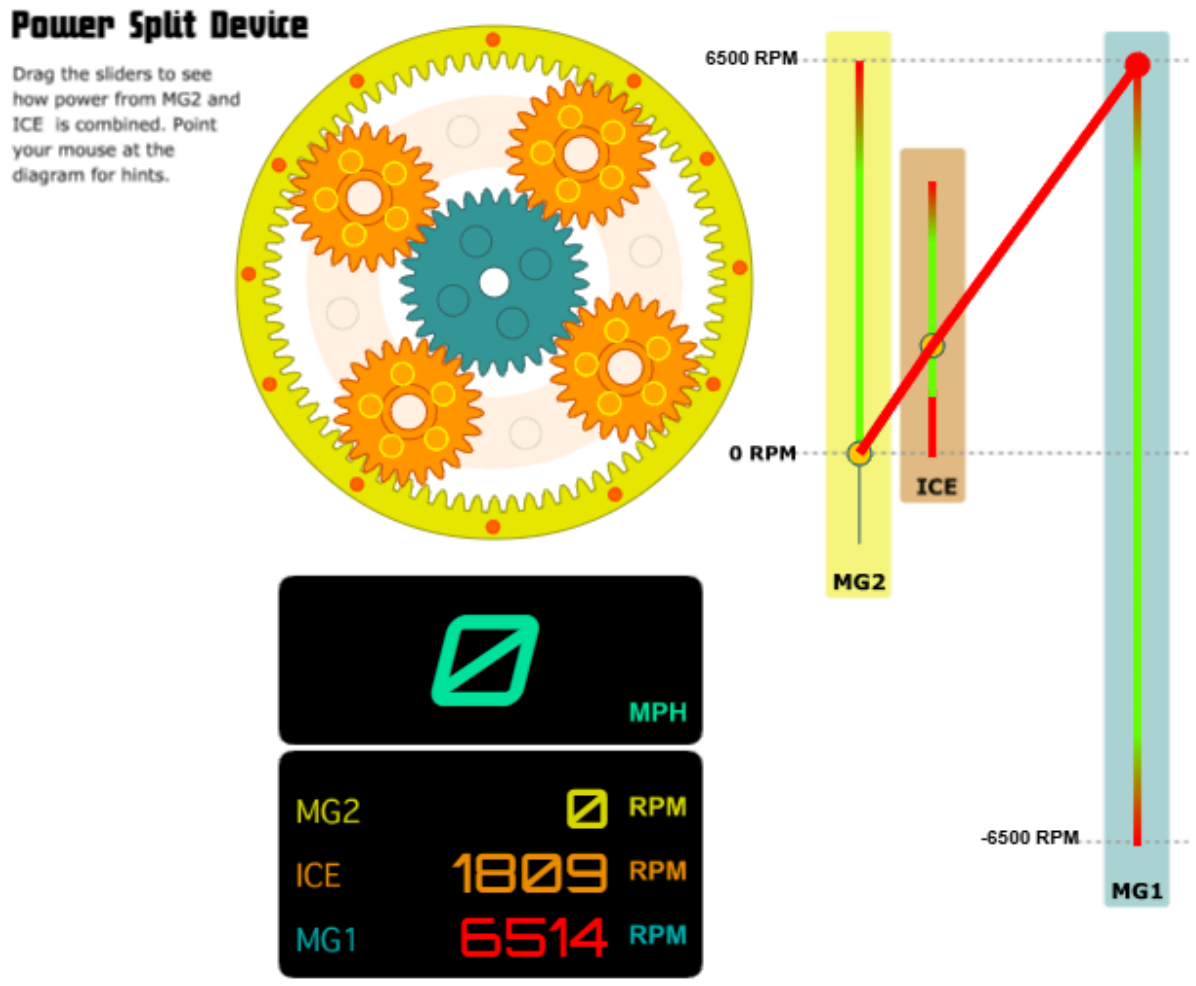
All answers are based on my own knowledge and research. I cannot guarantee their accuracy.

5.1. Why does the engine RPM not go to maximum when launching the car even though it has an eCVT?

The eCVT, despite being variable, still has limits on the amount of variance it can provide. The main reason for this is the motor-generator (MG1) which has a maximum RPM that it is able to rotate before it would break itself apart, as well as technical reasons such as back-EMF.

To demonstrate this, below are screenshots from this very handy tool which interactively shows you how the eCVT operates by allowing you to change the MG1, ICE (engine) and MG2 speeds. I believe this is based off of an early eCVT generation but the principle is the same, with different limits between generations: https://eahart.com/prius/psd/

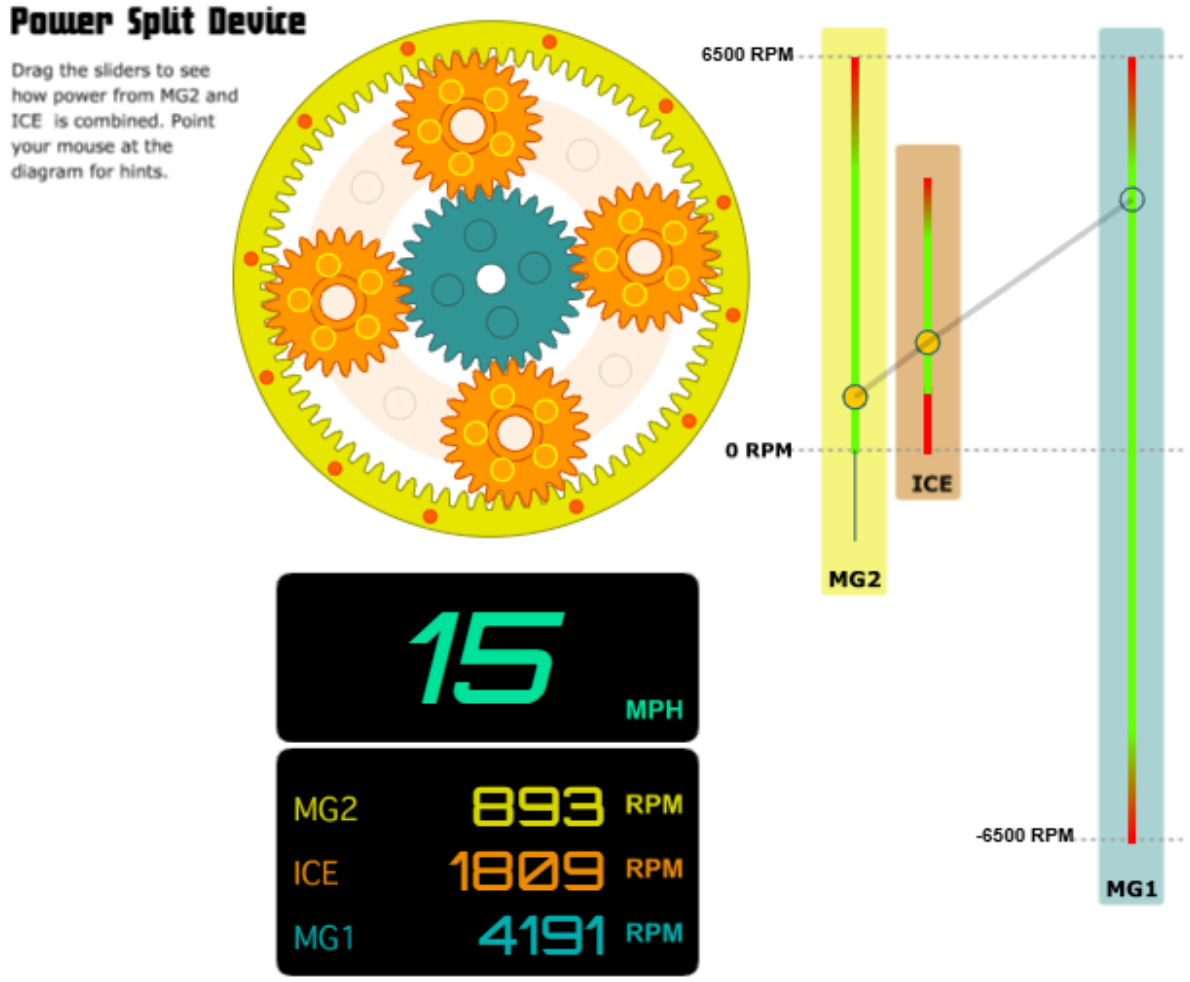
The line drawn between the MG2, ICE and MG1 sliders must always be straight otherwise it is leaving the allowed constraints. Red shows that a constraint is being broken.



When at a standstill and the RPM of the engine increases, MG1 must spin faster to counteract the effect of the engine's RPM increasing. It has to do this because if it didn't then this would mean a transfer of torque through the planetary gearset to the wheels (MG2) and this isn't always desirable (such as when in park or coasting).

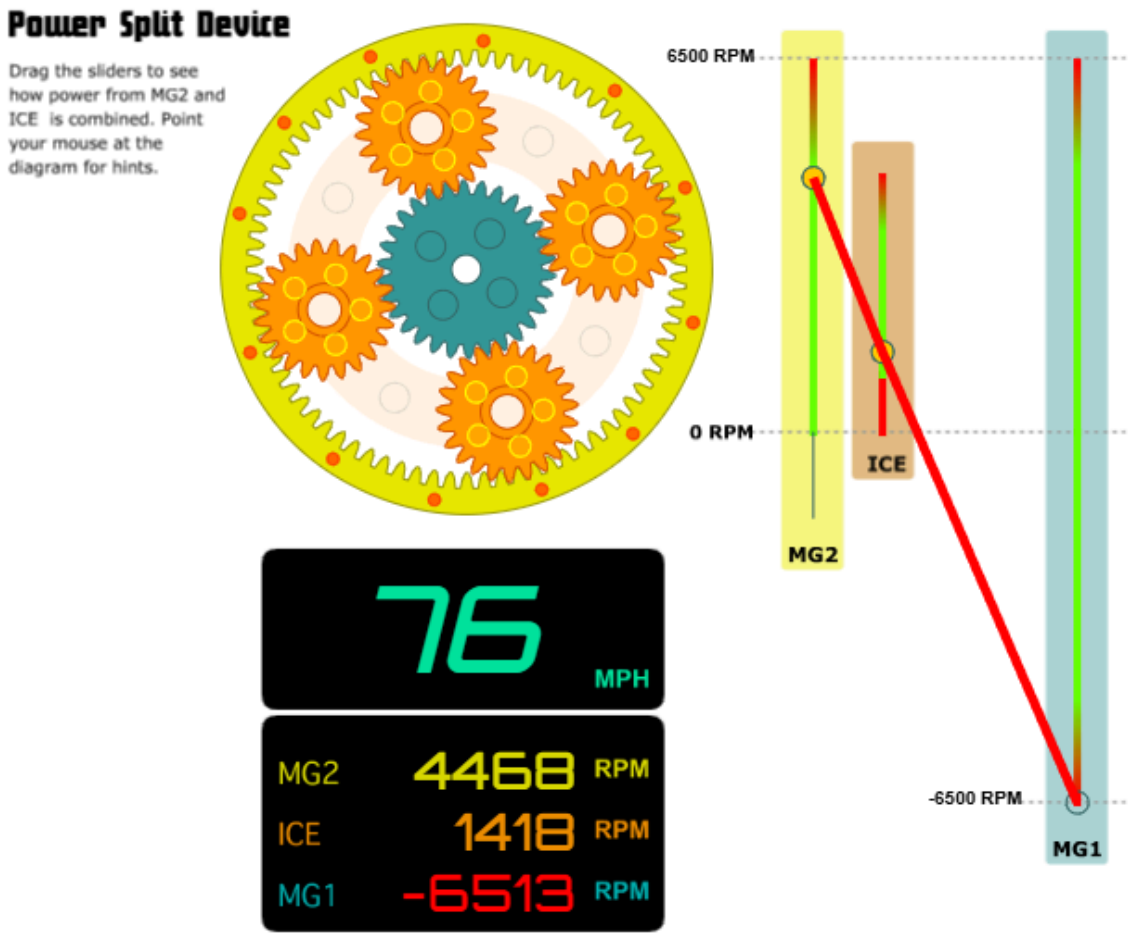
MG1 has an upper RPM limit which prevents the engine from being able to spin faster when you're at a standstill as it would result in MG1 breaking itself apart if it did.

If we increase the vehicle speed slightly you can see that MG1's RPM drops as MG2's RPM increases, bringing it back within allowed limits. This means that the engine RPM could now increase, and MG1 RPM can also increase and stay within limits.



A similar limit applies when the vehicle is moving at higher speeds and is the reason why the engine is not always able to turn off.

At higher vehicle speeds, MG1 has to reverse direction but it still has the RPM limit. Because of this the ICE must stay running at a higher RPM than idle to avoid an overspeed of MG1.



This is why the engine RPM can't always be at the RPM we might want or expect depending on the vehicle's speed.

Based on my research (which may be incorrect), here are the applicable limits/data. Max speed is observed evidence by other drivers posting online (reddit/priuschat):

Generation	MG1 RPM Limit	Planetary Gearset Gear Ratio	Max Engine Off Vehicle Speed
Gen 1 (1997-2003)	~6,500 RPM	2.6:1	42mph (67km/h)
Gen 2 (2004-2009)	~10,000 RPM	2.6:1	42mph (67km/h)
Gen 3 (2010-2015)	~13,500 RPM	3.6:1	42mph (67km/h)
Gen 4 (2016+)	~17,000 RPM	2.636:1	84mph (135km/h)
Gen 5 (2022+)	~17,000 RPM	2.636:1	84mph (135km/h)

There are also software limits in place to protect the inverter and motor components because of back-EMF. This occurs when the motors spin too quickly and there is nowhere for the power to go. This creates high voltages and this can damage the inverter components and motor windings. To avoid this, MG1 may have lower RPM limits under no-load conditions.

5.2. Why do we not get the full engine power and hybrid electric motor power at the same time?

Using a gen3 prius as an example, where the engine has a maximum output of 98hp and the hybrid system has a maximum capability of 80hp, why do we only get 134hp total power output instead of 178hp?

There are 2 reasons for this:

1. **The hybrid battery is not powerful enough**
   The hybrid battery can't supply 80hp (60kW) of power. It's limited to around 27kW (36hp) due to its small capacity, and only when it has a high state of charge and is within temperature limits.

2. **eCVT power split limits**
   At all times the engine is running the eCVT planetary gear set splits the power from the engine into two.

   Due to its gear ratio, approximately 2/3rds of the power goes directly through it to the wheels and the other 1/3rd is used by MG1 to generate power which is then sent to MG2 to drive the wheels or to charge the hybrid battery.

   Note that transfer of engine power to the wheels only happens if MG1 is actually generating power otherwise no power is transferred through the planetary gear set.

   This means that at maximum engine output, around 32hp of the engine's power is being used to generate power which is then sent to MG2. This leaves 66hp of engine power remaining. Another 36hp (maximum) is then sent from the battery to MG2, totalling 68hp.

   The 66hp remaining from the engine and the 68hp sent to MG2 gives you a total of 134hp.

   The remaining 12hp of electric motor capacity likely exists purely as a safety overhead.

5.3. Why can’t the hybrid battery charge in “N” or “Neutral”?

In all Toyota and Lexus hybrids you will find an eCVT transmission. In these transmissions there is always a physical connection to the wheels through the gearbox to the engine. It can’t be disconnected by any means.

Neutral is a software state which permits zero energy transfer through the transmission. If energy were to transfer through the transmission it would actually make the vehicle move as a side effect of the way the transmission works.

Since neutral must be a state of zero energy transfer, hybrid battery charging is not allowed in neutral because it requires energy transfer.

This also means that the engine is also not allowed to change states in neutral - if it is stopped it cannot start, and if it is running it cannot stop. Doing so would cause a momentary transfer of energy through the transmission.

You should not leave the vehicle in neutral for longer than a few minutes to avoid discharging the hybrid battery to a state that may not allow the engine to start. The car will do its best to protect the battery by warning you to shift to park or drive, and then shutting down the car when it gets dangerously low. The car may not restart if this happens and it will require a visit to the dealer to have the hybrid battery recharged.

You should also avoid car washes that require you to be in neutral to move you along automatically.

5.4. Why does the engine start when I turn the car on even when I have a full hybrid battery?

The engine will start even when the hybrid battery is full when you start the car because:

- It needs to warm up the catalytic converter to be compliant with emissions laws.
- It warms the engine up to a minimum safe level ready for you to use without incurring damage.
- The ambient temperature may be cold and you have the cabin heat turned on. All heat comes from engine coolant (except in plug-in hybrid variants which may use a heat pump as well).
- The hybrid battery is too hot to be used (can happen if the ambient temperature is very hot or the car is in direct intense sunlight for a prolonged period).

5.5. Can I jump start another vehicle with my hybrid?

No, but also yes, if done properly, but you do so at your own risk.

The 12v system on a normal car is powered by an alternator which is generally very robust and can handle a lot of abuse such as high current jump starting.

Hybrids use an electronic DC-DC converter in the hybrid inverter that converts your hybrid battery voltage (more than 200v) down to around 14v. They're less robust at handling abuse such as high current from jump starting. They're not designed for it and electronics are typically more sensitive to abuse than a mechanical alternator.

However, it is possible to use a hybrid to jump start another vehicle if you follow a procedure that minimises the risk to the hybrid system.

This procedure protects the hybrid system by **ensuring the hybrid system is turned off when the dead car is being started**. This ensures that the DC-DC converter does not see high current spikes which could damage it. Turning off the hybrid vehicle when starting the dead vehicle is the most important part of this process. **Do not skip step 5.**

It is not recommended to jump start any vehicle with a hybrid vehicle. Use this guide at your own risk. You accept responsibility for any damage through attempting this process.

1. Ensure both vehicles are completely turned off.
2. Connect the jump cables normally - positive to positive, negative of the hybrid vehicle to a grounded part of the chassis on the dead vehicle.
3. Start the donor hybrid vehicle.
4. Wait 5-10 minutes for the hybrid vehicle to charge the dead vehicle battery.
   Do NOT try to start the dead vehicle at any point when the hybrid vehicle is turned on.

Do not skip this step.

5. After 5-10 minutes, **turn OFF the donor hybrid vehicle**.
   This is the most important step which protects the hybrid system.

Do not skip this step.

6. Attempt to start the dead vehicle **ONCE** whilst the hybrid vehicle is turned off.
7. Repeat from step 3 if the dead vehicle does not start. After a few failed attempts you should stop and call for roadside assistance.
8. If the dead vehicle starts, disconnect the jump cables, negative first.

Note that the hybrid vehicle 12v battery is small and low capacity. It can be easily discharged if you attempt to start the dead car more than once between charging. If you have a weak 12v battery already then attempting this at all may result in the hybrid vehicle not starting again.

5.6. I need a new hybrid battery. What are my options?

If you have identified that your hybrid battery needs replacing then you do have several options to choose from depending on your requirements and budget.

OEM Replacement

An OEM battery is the same kind of battery your car came out of the factory with, and the same kind a dealer would replace it with if you took it to them.

When to consider

- You want reliability
- You want a dependable warranty
- Budget is not a concern
- You intend to keep your vehicle long term (several years)

The part will come from a dealer so you know you're getting new parts, reliability and a dependable warranty.

They are more expensive, but the cost justifies the new part.

Expected cost: Varies by vehicle model

Vehicle Model	USA (USD)	Europe (EUR)	UK (GBP)
Toyota Prius Gen 2	$2,300–$2,600	€2,100–€2,400	£1,750–£4,000
Toyota Prius Gen 3	$2,300–$2,600	€2,100–€2,400	£1,800–£6,000
Toyota Camry Hybrid	$3,500–$4,000	€3,200–€3,700	£2,500–£4,000
Toyota RAV4 Hybrid	$3,500–$4,000	€3,200–€3,700	£1,500–£2,500
Toyota Auris Hybrid	$3,000–$4,000	€2,800–€3,700	£1,800–£3,600
Toyota Yaris Hybrid	$2,500–$3,500	€2,300–€3,200	£1,000–£1,500
Toyota Highlander Hybrid	$4,000–$4,500	€3,700–€4,200	£2,800–£4,000
Lexus CT 200h	$3,000–$4,000	€2,800–€3,700	£1,795–£2,500
Lexus RX 450h	$3,000–$6,000	€2,800–€5,600	£2,000–£5,000
Lexus NX 300h/350h	$3,500–$5,000	€3,200–€4,700	£2,500–£4,000
Lexus ES 300h	$5,000–$7,000	€4,700–€6,600	£3,500–£6,000

Estimated replacement cost data sourced via ChatGPT, May 2025

3rd Party / Remanufactured / Refurbished Replacement

A 3rd party, remanufactured and refurbished batteries are most often just batteries which have been rebuilt using known good but used cells into a usable battery.

When to consider

- You have limited budget
- You're not concerned about having a warranty
- You just need to get the car back on the road
- You don't intend to keep the car too much longer

These should be considered a stop gap replacement to get you back on the road, or if you have a limited budget.

They often fail within a short period of time (1-2 years, sometimes less) because the cells are used and not properly matched for age, resistance or capacity. This stresses the weakest, oldest cells more than the others and expedites their failure.

They often don't have a proper warranty. Most will claim to replace at no extra cost if it goes wrong, and they're often difficult to get in touch with those companies to get this carried out after the initial install.

Expected cost: Varies by vehicle model and chosen supplier.

Self Repair

You can opt to repair the battery yourself if you have sufficient knowledge on how to do so. This should not be attempted by anyone that does not have sufficient knowledge and protective equipment for working with high voltage DC.

When to consider

- You have sufficient knowledge to work with high voltage DC
- You understand how hybrid batteries work
- You're a DIYer
- You have the proper equipment to check and balance cells

The self repair option is used by a lot of people, but it's only as good as the 3rd party option if you're using used cells. If you can source new cells then this is a great alternative to buying a brand new dealer sourced battery.

Depending on the quality of your rebuild, matching of cells, etc. you can expect to get several months to many years out of a self repair.

Expected cost: Varies depending on using new or used cells and the quantity needed, and also if you need to source additional equipment.