Toyota Hybrid Technology & Experience

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2018 Toyota Highlander Hybrid Owner

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Background

Have a 2010 Subaru Outback

- Very happy with it
  - All Wheel Drive
- A little small for longer trips
- Over 100K miles

Intrigued by the new 2018 Subaru Ascent

- Wanted to like it
- Very Disappointed at 2018 Minneapolis Auto Show

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The Dealership Question

What dealership did I want to buy from?

- Honda: Bought a 2001 Odyssey from Buerkle Honda
  - Not always happy with the Service Department
  - Nothing terribly positive to say about the Sales Department
- Subaru: Bought a 2010 Outback from White Bear Subaru
  - OK Dealership
  - 2018 Ascent's unavailable
    - Could reserve 2018
    - No dates; no deals
    - Little choice of options
    - Only engine option was a 4 Cylinder (OK) Turbocharged Engine (I don't like turbos)

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What Vehicle Type?

SUV:

- Car like vs. Van like
- AWD readily available, especially in Minnesota
- Want some “Luxury” this (first) time

Minivan:

- More space
- AWD not so readily available
- Image/comfort

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Maplewood Toyota?!

Bad experience with 1981 Toyota Corolla:

- Swore I'd never buy another Toyota
  - The bad experience was because of the ***dealership*** (now defunct)
  - Vehicle experience was good

Maplewood Toyota

- Dealership has an outstanding reputation: Service, Customer Support
- Have a friend that works there:
  - No special deals, but trusted advice

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Highlander vs. Highlander Hybrid

Sat down with my friend to talk vehicles:

- Strong/affirming recommendation for Highlander
- Asked a question: What's the price differential for a Hybrid?
  - Called a trusted salesman; Answer: ~$1500, significantly lower than expected
- Fuel economy (EPA City/Highway/Comb: Conventional 21/27/23; Hybrid 29/27/28):
  - Significantly better for Hybrid "in city" (29 vs 21)
  - Equivalent for Hybrid "on the highway" (27)
  - Significantly better for Hybrid combined (28 vs 23)
  - Range is an important factor for me, on trips. Hybrid range is longer!

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2018 Toyota Highlander Hybrid Limited

What, I thought, I wanted:

- Highlander Hybrid Limited
- Ooh La La Red
- Saddle Tan Leather Upholstery
- No other specific packages

But:

- Saddle Tan Leather looked good in brochure; ugly in person!

What I bought:

- Highlander Hybrid Limited
- Shoreline Blue Pearl
- Ash Perforated Leather Upholstery
- Protection Package

Because:

- Red wasn't available: Blue paint w/Ash interior were our second, and acceptable, choices
- Protection Package added desirable features; came from the factory - cost too much

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Power Trains

Conventional:

- 3.5 Liter V6 Engine, 295hp
- Direct Shift-8AT (8-speed Automatic Transmission)

Hybrid:

- 3.5 Liter V6 Engine, 306 hp
- eCVT (electronic Continuously Variable Transmission, Toyota Synergy Drive)
- 2 Electric Motors (Front)
- 1 Electric Motor (Rear)

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The Hybrid Powertrain, In My Mind

- A V6 Engine – Nothing new here. Or is there?
  - Engine bonus: No drive belts:
    - Timing chain – long life, no scheduled maintenance, no belt replacement/breaks
    - No fan belts, electric fans
    - No water pump belt, electric pump
    - No power steering belt, electric power steering
- A CVT – OK, so it's an **e**CVT, like my Subaru, right?
- Two Electric Motors Up Front – No big deal, electric motors are everywhere. 'Gotta drive those wheels somehow when the engine isn't driving 'em.
- An Electric Motor in the back – 'Gotta drive those wheels too, wire's easier to run than a driveshaft.

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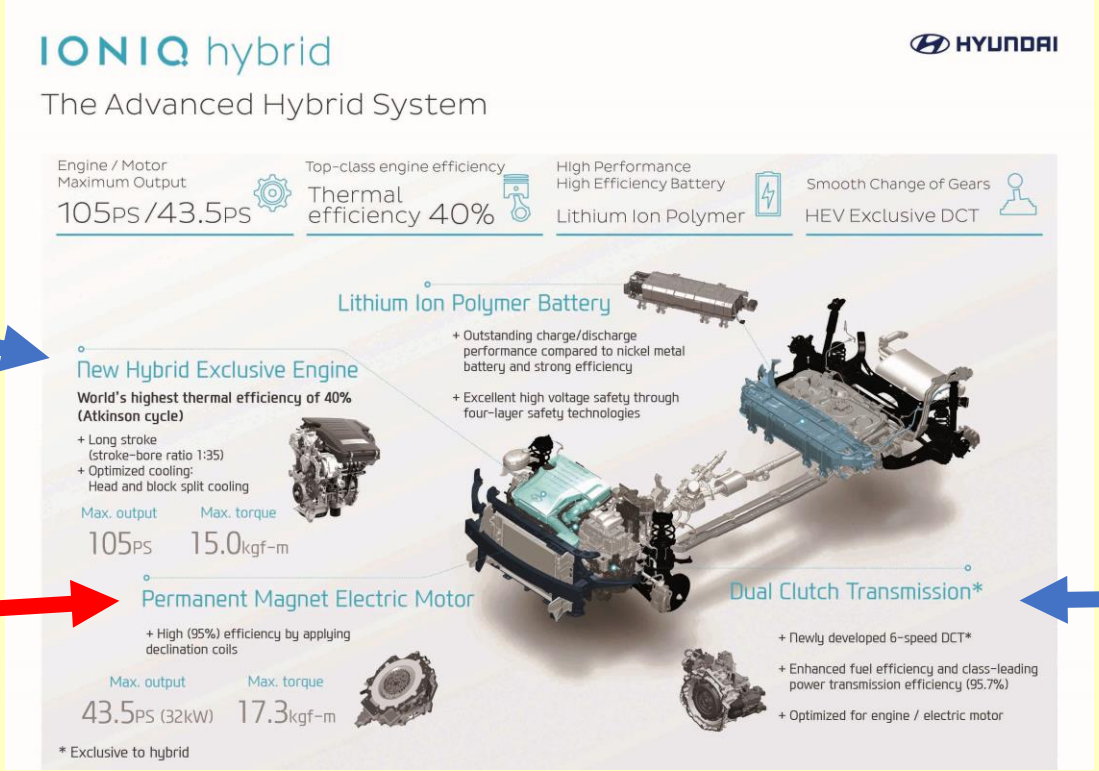
The Picture In My Mind - Before

Take a V6 engine, couple it to an eCVT, hang a couple of electric motors on it. Now I've got it. Maybe something like this Hyundai implementation:

Engine



Notice that the Electric Motor is separate from the Engine and Transmission

Transmission

http://autoworld.com.my/news/2016/01/11/hyundai-ioniq-toyota-prius-killer/hyundai-ioniq-infographic_the-advanced-hybrid-system/

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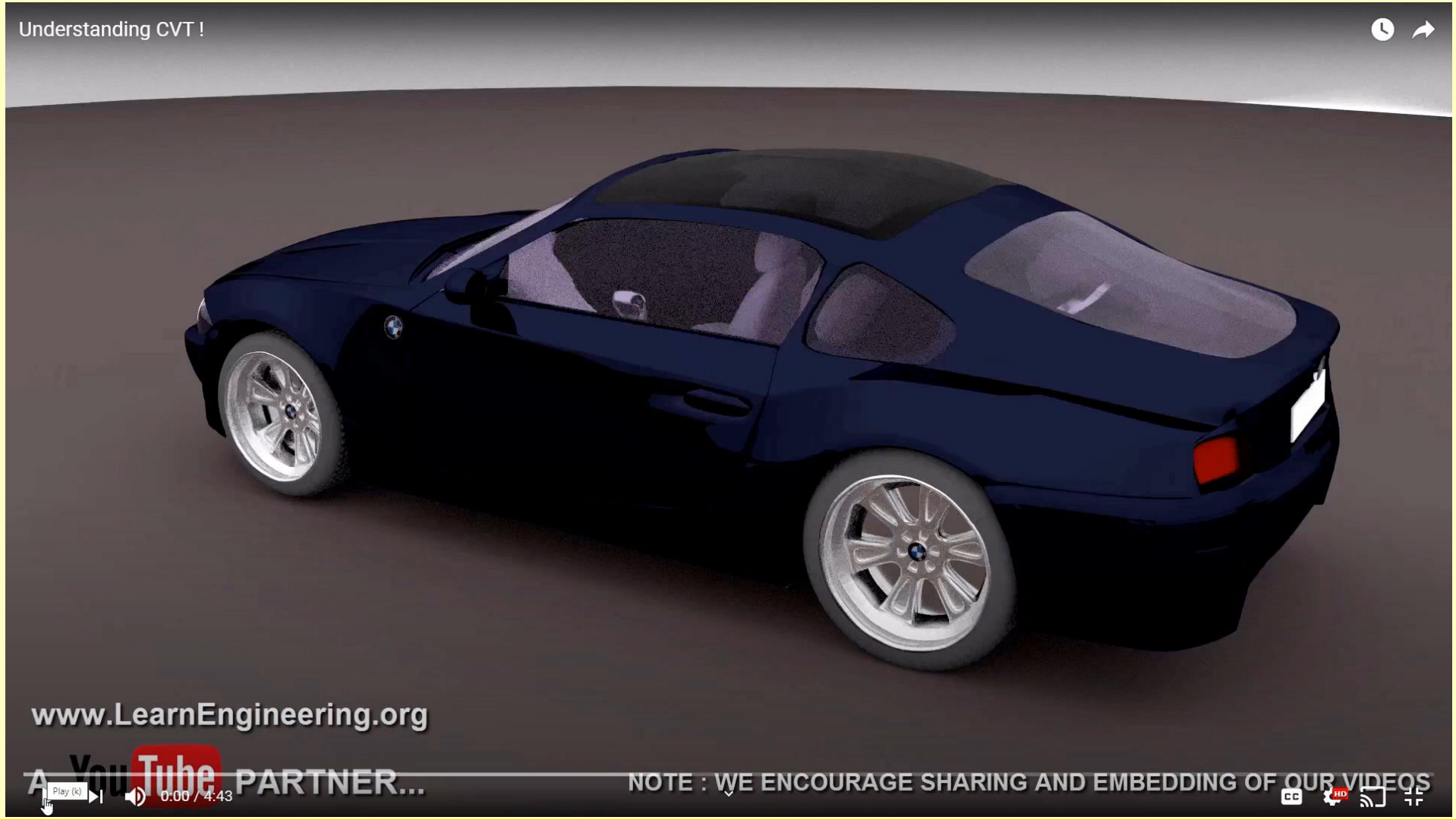
Conventional CVT Operation



https://youtu.be/PEq5_b4LWNY

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Misconception 1: Just a CVT

Toyota eCVT, Toyota Hybrid Synergy Drive, is a completely different design:

- No Torque Converter (clutch function)
  - Common in virtually all conventional automatic transmissions
- No Variable Pulleys
- No Drive Belt

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Toyota Hybrid Synergy Drive

Power Split Device

- Allows power to flow to and from Engine, MG1 and MG2

MG1, Motor Generator 1 (Smaller MG):

- Generator for Drive (HV) Batteries
- Engine Starter Motor
- Supplements MG2 to drive the vehicle, some models

•MG2, Motor Generator 2 (Larger MG):

- Primary Drive Motor

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Transaxle Genius!

- **No** hydraulic servos, clutches, bands, etc., as in conventional automatic transmissions
- All gears are always engaged, i.e., planetary gears and drive/counter gears
- Electronic control of MG1 and MG2 determine gear ratio and direction
- MG1, MG2, and MGR are 3-phase AC motors
- Reference: 3rd Generation Prius Transaxle - P410 Quick Look (too long to view here)
  https://www.youtube.com/watch?v=w_mc17CoyJs
  Also, other WeberAuto YouTube videos

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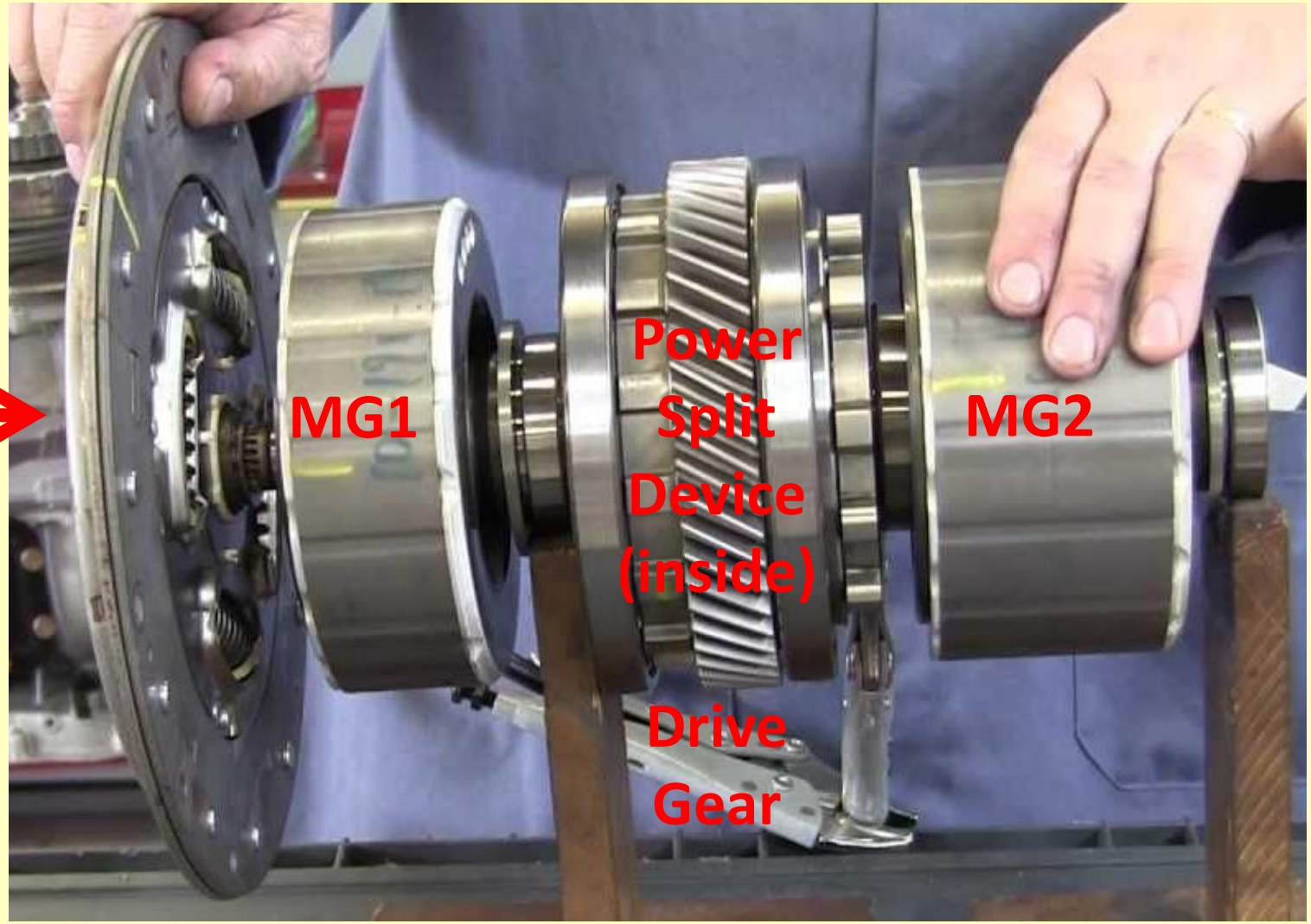
Hybrid Synergy Drive



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4WD vs. *AWD-i*

- 4WD: Four Wheel Drive, all 4 wheels are driven, as necessary, at all times
  - Subaru's implementation: Start with 50/50 front/rear switch to 90/10 at higher speeds
- AWD-i: All wheels are driven at low speeds under most conditions
  - Low speeds, e.g., starting, are when AWD is most useful
  - I haven't determined the max speed for AWD, guess ~ 18-20MPH
  - NOT designed as an off road vehicle

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Misconception 2: Engine Type

Conventional Engines are Otto Cycle engines; Hybrid Engines are Atkinson Cycle engines.

Cycle	Otto Cycle		Atkinson Cycle	
	Intake	Exhaust	Intake	Exhaust
Suck (Intake)	Open	Closed	Open	Closed
Squeeze (Compession)	Closed	Closed	Open at the beginning of the stroke; then closed, less fuel!	Closed
Bang (Power)	Closed	Closed	Closed	Closed
Blow (Exhaust)	Closed	Open	Closed	Open
Result:	More Power, Less Efficient		Less Power, More Efficient, Add'l power from Electric Motor, if needed	

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Regenerative Braking

Capture Kinetic Energy of Vehicle's Motion to:

- Slow the vehicle, before the service (regular) brakes
- Charge the Drive (HV) Battery

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Toyota Safety Sense™ P

- Pre-Collision System w/Pedestrian Detection
- Land Departure Alert w/Steering Assist
  - Above ~32MPH
- Automatic High Beams
  - Above 20MPH
- Dynamic Radar Cruise Control
  - Above ~28MPH

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Other Safety Features

- Backup Camera with Projected Path
  - Backup Cameras are standard on cars model year 2018, and later
  - Project Path and Straight Back guide lines may be Toyota feature
- Blind Spot Monitor and Rear Cross Traffic Alert
  - Blind Spot Monitor is very useful, indicators in mirrors
  - Rear Cross Traffic Alert very useful backing out of parking spaces

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Driving Experience

- Fuel Economy: Published spec, or better
- Dynamic Radar Cruise Control: A Favorite Feature!
  - Great driver stress reliever, especially in traffic
    - Slows you down when you approach slower traffic
    - Maintains distance automatically (choice of intervals)
    - Highly appreciated in highway construction areas
    - Reacts quickly if another vehicle cuts in front of you at equal or lower speed
  - A couple of idiosyncrasies/unexpected consequences
    - May detect the bottom of a hill as traffic
    - May get slowed down coming out of construction zones/behind slower cars

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Driving Differences

- No mandatory changes in driving. Drive it just like a conventional car.
- Very quiet, especially in Electric Vehicle Mode in parking lots. Pedestrians may not hear you!
- Braking from Highway Speeds, e.g., off ramps
  - Conventional car: Let car coast to lower speed then apply brakes
  - Regenerative braking: Apply brakes lightly at high speed to maximize energy capture, apply service brakes at slow speed.

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Other Notes

Generally a very quite car, unless the sunroof is open

- Engine RPM is much lower at highway speeds than other cars, typically 1050-1300 cruising vs. ~2000
- The engine NEVER idles! If there is no demand for energy the engine STOPS!
  - I don't find the Start/Stop system annoying

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