‘EV101’ and The Realities of Vehicle-Integrated PV: An EV Owner’s Perspective

John Rodriguez

School of Photovoltaics and Renewable Energy Engineering,
The University of New South Wales, Sydney, Australia

April 11, 2025

UNSW SYDNEY

AC DC
Artificial intelligence | Characterisation
Defects | Contacts

My Professional Background

- Bachelor of Engineering, Photovoltaic (PV) & Renewable Energy Engineering, UNSW
- Doctor of Philosophy, PV Engineering, UNSW
- Team Leader, Solar Energy Research Institute of Singapore, National University of Singapore
- Master of Business Administration, Quantic School of Business and Technology
- Group Manager, ACDC Research Group, UNSW (Current)

LinkedIn

... So, why Electric Vehicles (EVs)?

So, Why EVs?...

- Battery technology developments from EVs and energy storage complements intermittency of PV and other renewables
- Content Writer, Solar Choice News, 2014–2015
  - ‘UNSW adds **fast chargers**, **Tesla Model S** and BMW i3 to **EV** arsenal’, Jun 2015: link
  - ‘**Tesla** Energy launch shakes up the energy industry’, May 2015: link
  - ‘Levelised cost of storage: A better way to compare **battery** value’, May 2015: link
  - ‘Super-fast charging for new **lithium-ion battery**’, Oct 2014: link
  - ‘Cheaper and lighter **battery** design a win-win for storage’, Sep 2014: link
  - ‘UNSW **solar car** sets new speed record’, Aug 2014: link
  - ‘Sunpower and KB Homes partnership offers **PV with battery storage**’, Jul 2014: link
- I’ve owned an EV for 2 years, and it’s been great!

Contents

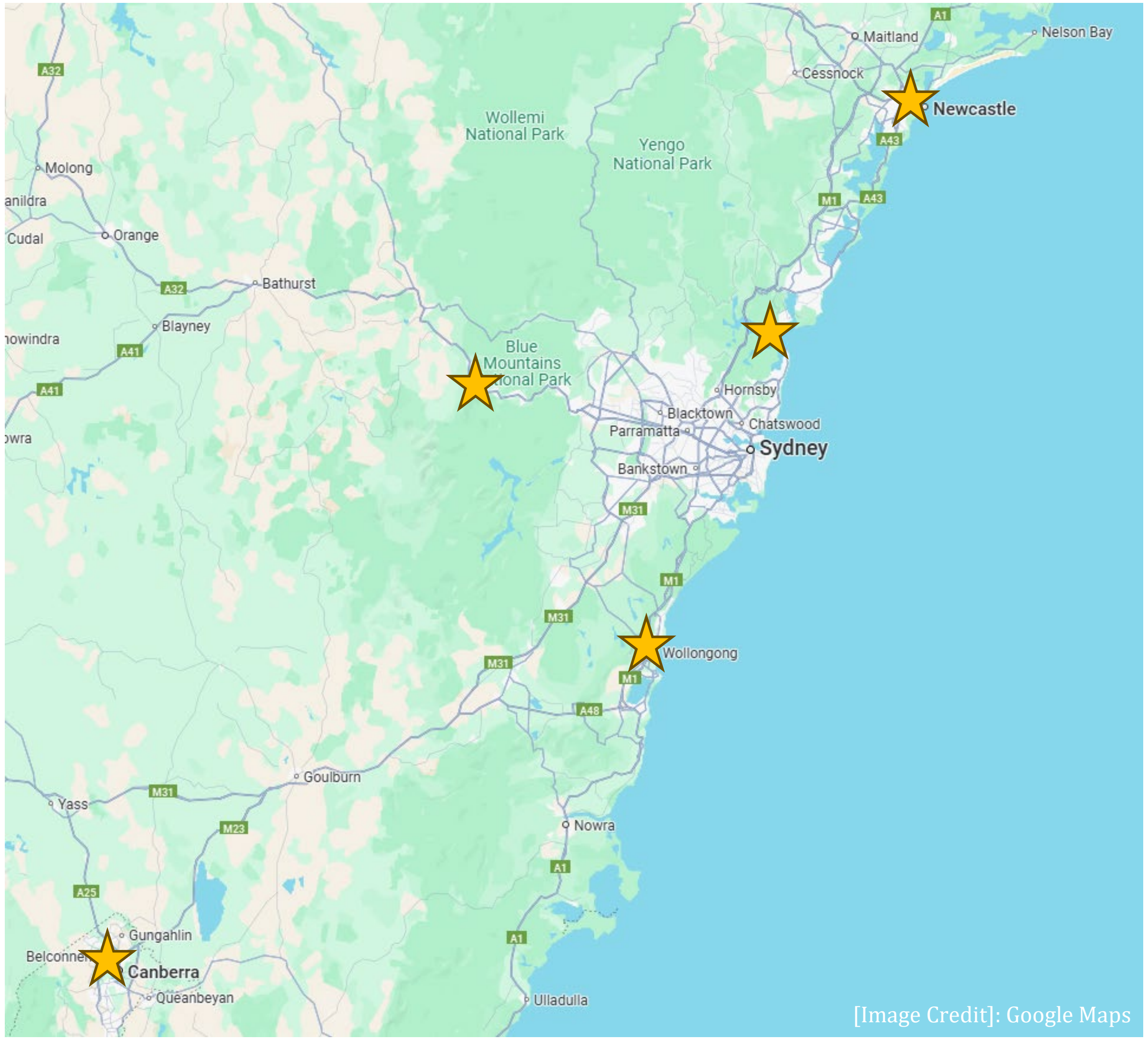

Budget EV Case Study

[EV Case Study] 2015 Gen-1 Nissan LEAF

- LEAF: <u>L</u>ow-<u>E</u>mission, <u>A</u>ffordable <u>F</u>amily car
- First released in Dec 2010!
  - 2011 World Car of the Year
  - Formerly the highest selling EV worldwide[1], with over 400,000 units sold before Tesla Models 3&Y
- 80 kW-107 hp electric motor, more than enough for freeway speeds
- Original lithium-ion battery, 24 kWh nominal capacity
  - Currently at ~ 70% State of Health (SOH) with 17 kWh usable
  - Inner city driving range of ~ 115 km, rises to ~ 140 km on highways
- Second-worst EV available in Aus*, can now be purchased for $5,000(!) and up, depending on odometer and battery SOH.

Range Anxiety is Overemphasised

- Highway range of ~ 140 km
- Locations driven to-and-back:
  - Mooney Mooney, 65 km N
  - Katoomba, 110 km W
  - Wollongong, 80 km S
  - Newcastle, 170 km N
  - Canberra, 290 km SW!
  - What's next? Wagga? Melbourne?



[Image Credit]: Google Maps

Energy Economy, ϵ_{EV}

1) Highway driving: 9.0 km/kWh*
2) Inner-city stop-start average: 6.5 ± 0.5 km/kWh*, compared to brand new Australian EVs:

Make & Base Model	WLTP^ Range [km]	Battery Size [kWh]	Energy Econ. [km/kWh]	Approx. Price [AU$k]
Tesla Model 3	513	62.3	8.2	60
Tesla Model Y	455	62	7.3	61.2
Polestar 2	546 (skeptical)	69	7.9	68.5
BYD Seal	460	61	7.5	53
MG 4	350	51	6.9	35 **(27 EoY sales)**
BYD Atto 3	345	50	6.9	47.2
MG ZS EV	320	51	6.3	35

Source: Australian Electric Vehicle Association (AEVA), New BEV Fact Sheet, Mar 2025

UNSW SYDNEY

* The energy economy values shown are calculated based on energy use from the LEAF battery and does not account for ~ 1–5% charging losses.

^ As per AEVA advice: *"Worldwide Harmonized Light vehicles Test Procedure (WLTP) range is ~ 30% lower than overoptimistic 'NEDC' protocol but ~ 10% higher than US 'EPA'. WLTP standardised cycle: 57% urban routes, 25% peri-urban routes, 18% motorway routes."*

Fuel Efficiency Comparisons

Petrol vehicles are assessed in terms of 'fuel efficiency', μ_{ICE}, in L per 100 km:

$$\mu_{ICE} = \frac{100 \cdot V_f}{d}$$

The running cost of a petrol car, C_{ICE}, in \$ per 100 km is:

$$C_{ICE} = p_{fuel} \cdot \mu_{ICE}$$

Ave. ~ \$22.2 per 100 km

Where:

- V_f = Litres of fuel consumed (L)
- d = Distance driven (km)
- p_{fuel} = Price of petrol (\$/L), AU\$2 as of Oct 2024
- Average μ_{ICE} is 11.1 L/100 km in latest FY2019–2020 Australian Bureau of Statistics (ABS) survey[2]

Like-for-like comparison for consumers

EVs are assessed in terms of 'driving efficiency', μ_{EV}, kWh per 100 km:

$$\mu_{EV} = \frac{100 \cdot E}{d \cdot \gamma} = \frac{100}{\epsilon_{EV} \cdot \gamma}$$

The running cost of an EV, C_{EV}, in \$ per 100 km is:

$$C_{EV} = p_{elec} \cdot \mu_{EV}$$

\$2.9–3.8 per 100 km

Where:

- E = Energy consumed from EV battery (kWh)
- d = Distance driven (km)
- γ = Charging efficiency of ~ 0.95 at 240V AC and ~ 0.99 at > 400V DC
- ϵ_{EV} = 'Energy economy' (km/kWh), 6.3–8.2 km/kWh
- p_{elec} = Price of electricity (\$/kWh), 23 c/kWh offpeak on carbon-neutral Powershop plan at time of writing

[2] *Survey of Motor Vehicle Use* (12-months-ended-30-june-2020), Australian Bureau of Statistics, Australia, ABS Website, accessed 17 June 2024.

Fuel Efficiency Comparisons on MG 'ZS' Platform

Petrol vehicles are assessed in terms of 'fuel efficiency', μ_{ICE}, in L per 100 km:

$$\mu_{ICE} = \frac{100 \cdot V_f}{d}$$

The running cost of a petrol car, C_{ICE}, in \$ per 100 km is:

$$C_{ICE} = p_{fuel} \cdot \mu_{ICE}$$

$13.4 per 100 km

Where:

- V_f = Litres of fuel consumed (L)
- d = Distance driven (km)
- p_{fuel} = Price of petrol (\$/L), AU\$2 as of Oct 2024
- The WLTP μ_{ICE} of a 2022 MG 'ZS' is 6.7 L/100 km.

Like-for-like comparison for consumers

EVs are assessed in terms of 'driving efficiency', μ_{EV}, kWh per 100 km:

$$\mu_{EV} = \frac{100 \cdot E}{d \cdot \gamma} = \frac{100}{\epsilon_{EV} \cdot \gamma}$$

The running cost of an EV, C_{EV}, in \$ per 100 km is:

$$C_{EV} = p_{elec} \cdot \mu_{EV}$$

$3.8 per 100 km, 71% cheaper per km!

Where:

- E = Energy consumed from EV battery (kWh)
- d = Distance driven (km)
- γ = Charging efficiency of $\sim$ 0.95 at 240V AC and $\sim$ 0.99 at > 400V DC
- ϵ_{MG_ZSEV} = 6.3 km/kWh
- p_{elec} = Price of electricity (\$/kWh), 23 c/kWh off-peak on carbon-neutral Powershop plan at time of writing

Fuel Efficiency Comparisons

EVs are assessed in terms of 'driving efficiency', μ_{EV}, kWh per 100 km:

$$\boxed{\mu_{EV} = \frac{100 \cdot E}{d \cdot \gamma} = \frac{100}{\epsilon_{EV} \cdot \gamma}}$$

The running cost of an EV, C_{EV}, in \$ per 100 km is:

$$\boxed{C_{EV} = p_{elec} \cdot \mu_{EV}}$$

$2.9–3.8 per 100 km

What about rooftop solar energy?!?

p_{elec} from rooftop solar in Sydney is ~ 5–10 c/kWh (depending on financing), meaning C_{EV} can be
< $1 per 100 km!!!

Where:

- E = Energy consumed from EV battery (kWh)
- d = Distance driven (km)
- γ = Charging efficiency of ~ 0.95 at 240V AC and ~ 0.99 at > 400V DC
- ϵ_{EV} = 'Energy economy' (km/kWh), 6.3–8.2 km/kWh
- p_{elec} = Price of electricity (\$/kWh), 23 c/kWh off-peak on carbon-neutral Powershop plan at time of writing

EV Charging

My Typical Charging Stats

[Key Point 1] You can treat your EV like your mobile phone or laptop: plug in when you get home and take it with you when you leave. You'll rarely need to visit a petrol station!

[Key Point 2] Most consumers with a parking spot and 240V outlet don't need a fast charger!

- The LEAF is charged mostly overnight at home with a 240V charger (~ 80–90%)
  - Consider the range an overnight charge can provide, d_c, compared to the ~ 30 km daily driving average*:

$$d_c = P_c \cdot t_c \cdot \gamma \cdot \epsilon_{EV} = 100 \cdot P_c \cdot t_c \cdot \gamma / \mu_{EV}$$

Where:

  - P_c = Power supplied by the charger (1.8 kW at 7.5 A);
  - t_c = Charging time (hr, assumed 7pm to 7am);
  - γ = Charging efficiency of ~ 0.95 at 240V AC;
  - ϵ_{EV} = 6.3–8.2 km/kWh ($\epsilon_{EV} = 100/\mu_{EV}$); and
  - d_c = 129–168 km.
- The much smaller remaining portion is split evenly between 'Type 2' AC charging while running errands and 'Type 3' DC charging on longer journeys.

UNSW SYDNEY

* Australian Bureau of Statistics (12-months-ended-30-june-2020), Survey of Motor Vehicle Use, Australia, ABS Website, accessed 17 June 2024.

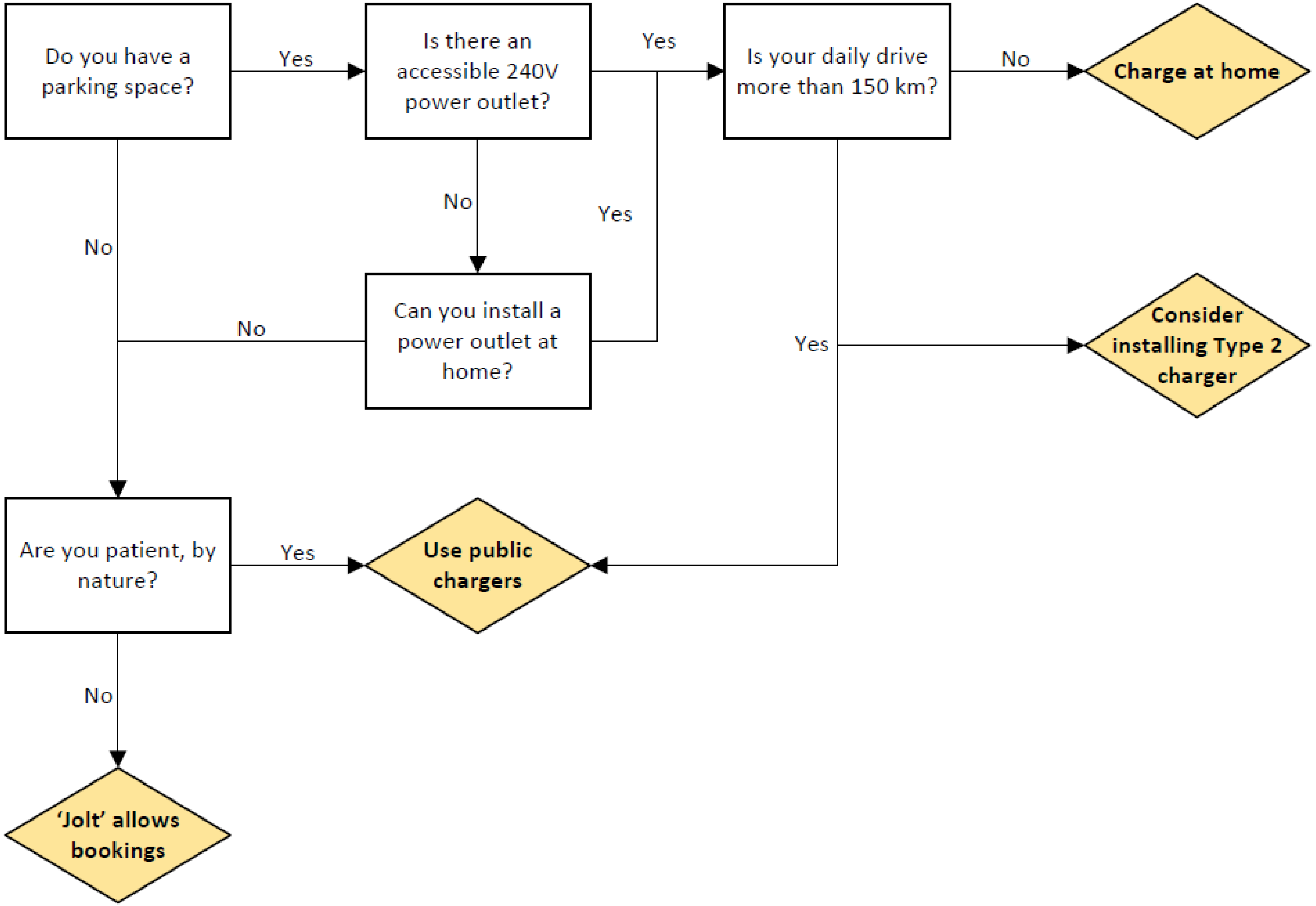
AC DC Artificial Intelligence | Characterisation Defects | Contacts

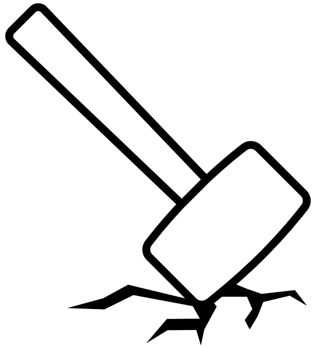
EV Charging Categories

	Power	Voltage	Current	Phase	Price	Plug Types	Free Charging?
	kW	**V**	**A**	**#**	**c/kWh**		
Type 1 (T1): overnight charger	1.8–3.6, AC	240	≤ 15	1	5*–25 off peak	BYO 3-pin 240V-to-T2 or 240V-to-T1	
Type 2 (T2)	3.6–22, AC	240	≤ 32	1, 3	25–50	Mostly BYO, T2-to-T2 or T2-to-T1	Yes, see 'PlugShare' app: shopping centres, carparks, RSLs, community centres, etc.
Type 3 (T3): fast charger	20–150+, DC	400, 800, 1k	> 100	n/a	Up to 70	T2 CCS, Tesla, Chademo	Yes, refer to 'Jolt' app.

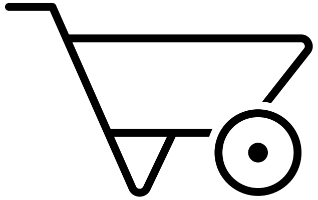
* In addition to charging your EV with panels on your roof, some electricity retailers offer EV plans with greatly reduced off peak and overnight rates.

EV Charging Cheat Sheet



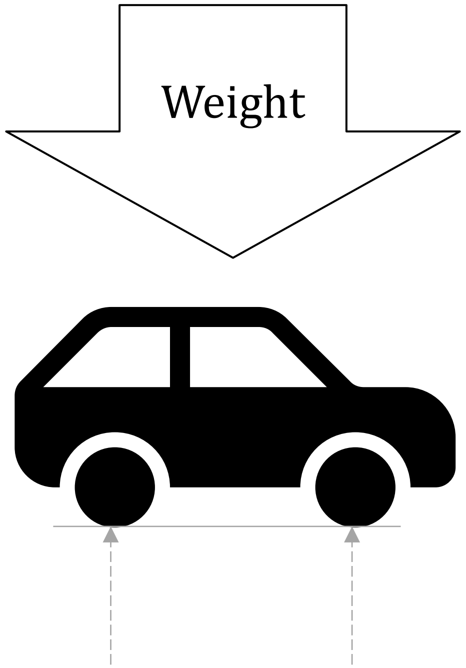


Forces and Work



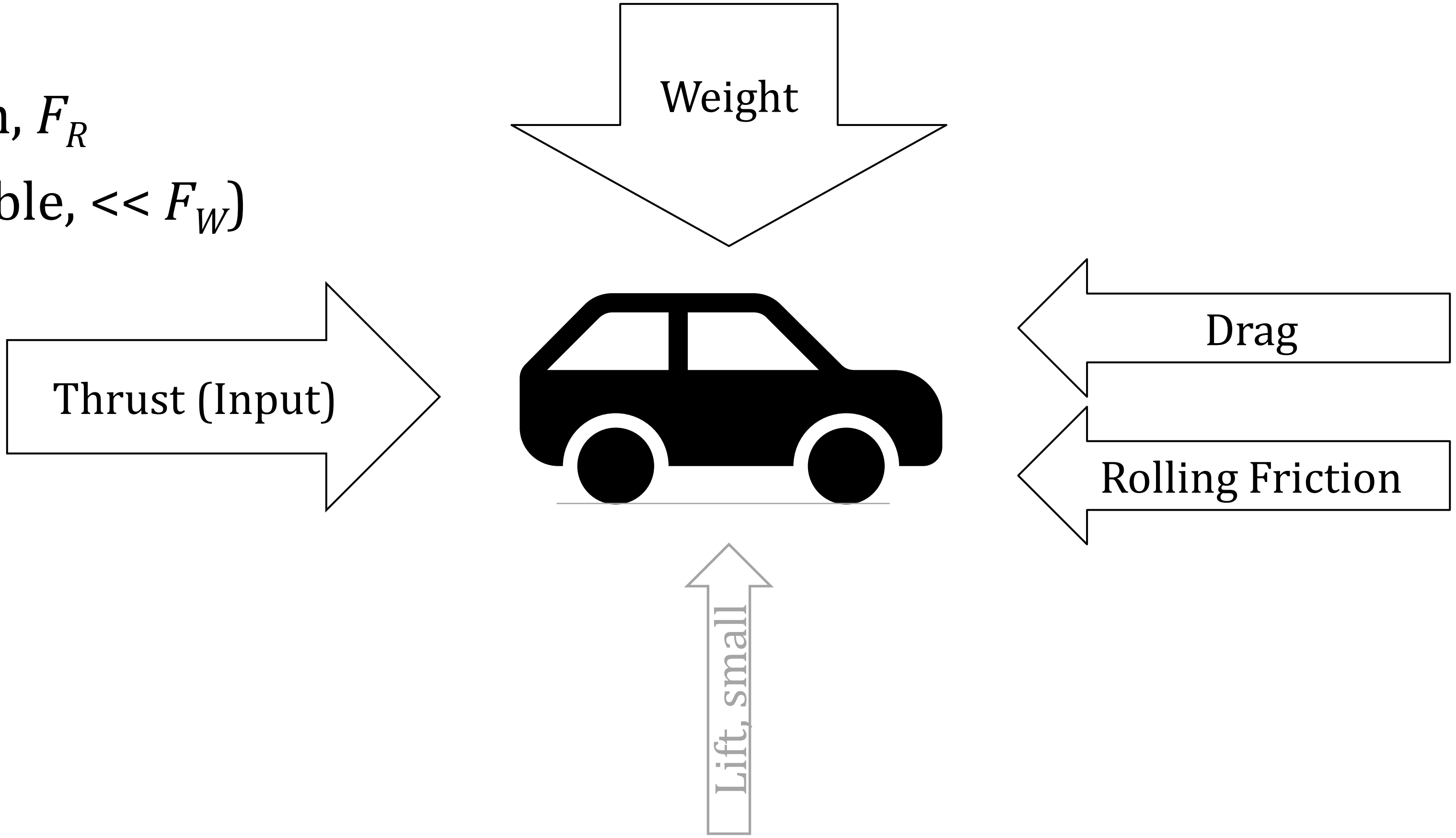
Forces at Rest

- Weight, F_W [N]



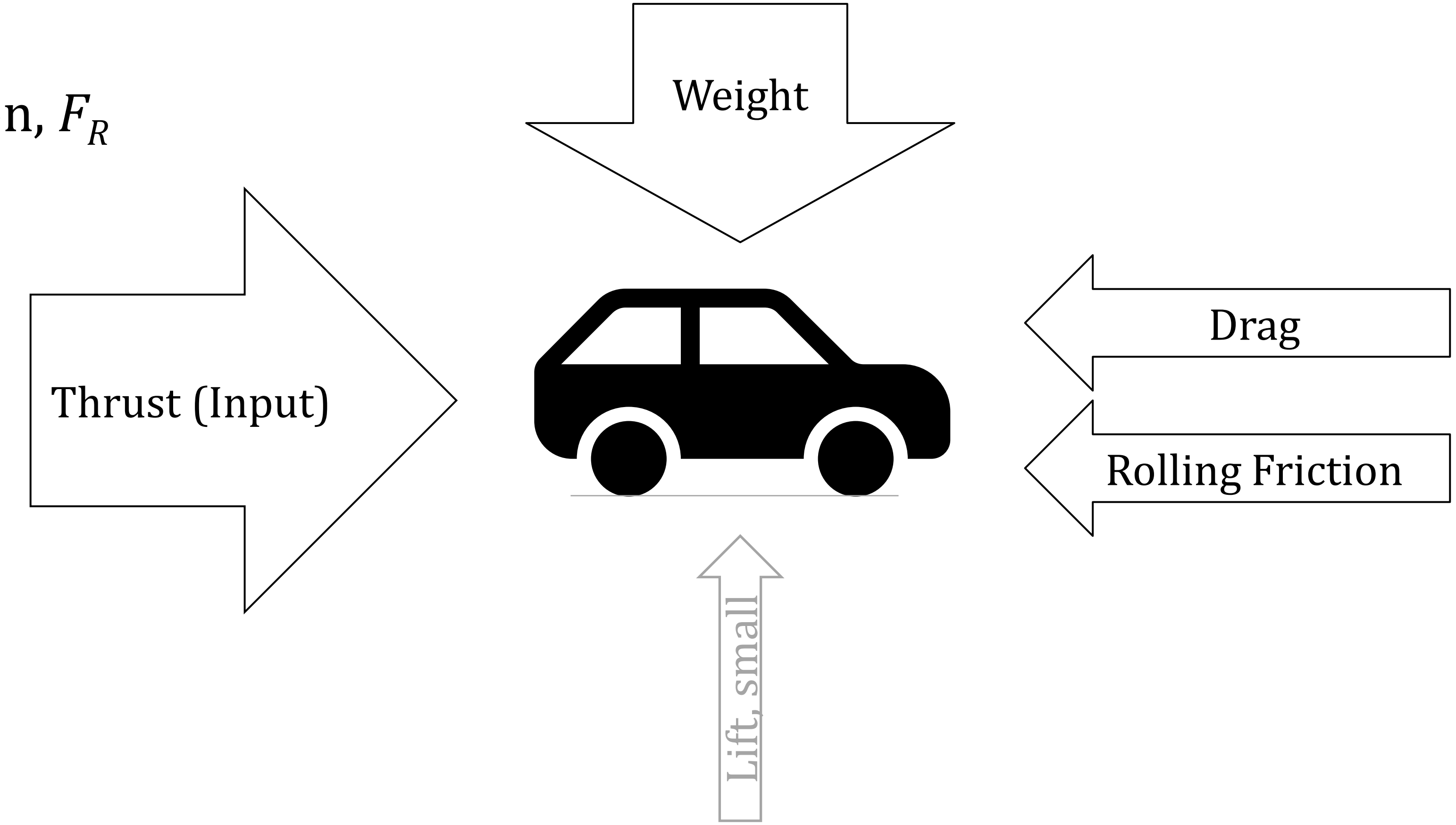
Forces at Constant Velocity

- Weight, F_W [N]
- Thrust, F_{T_bal} (if = F_D + F_R)
- Drag, F_D
- Rolling Friction, F_R
- Lift, F_L (negligible, << F_W)



Forces During Acceleration

- Weight, F_W [N]
- Thrust, F_T (if > $F_D + F_R$)
- Drag, F_D
- Rolling Friction, F_R

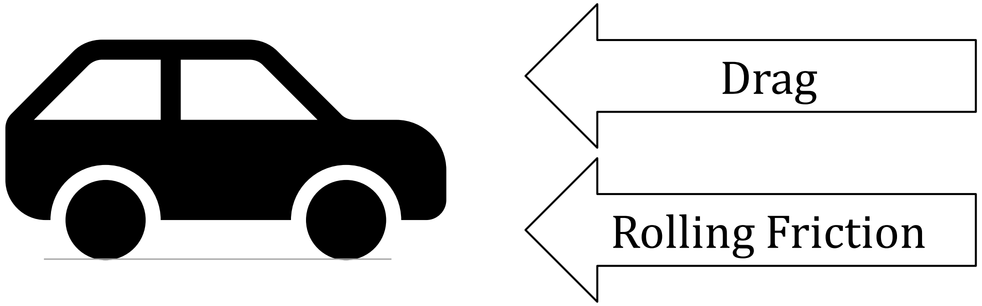


Forces Opposing Motion

- Drag, F_D [N]:

$$F_D = \frac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot (v - v_{wind})^2$$

Where:
- ρ is the density of air [assume 1.2 kg·m^3]
- A is the cross-sectional area of the car perpendicular to motion [m^2]
- C_D is the drag coefficient [Gen-1 Nissan LEAF = 0.28]
- v_{wind} is the wind velocity [assume 0 m·s^{-1}]
- F_L, follows the same format with C_D replaced with the lift coefficient, C_L



- Rolling Friction, F_R [N]:

$$F_R = \mu_R \cdot m \cdot g$$

Where:
- μ_R is the coefficient of rolling friction [assume 0.01][3]
- m is the mass of the car [kg]
- g is the acceleration due to gravity [assume 9.8 m·s^{-2}]

[3] Assumption is for an ordinary car driving on concrete and asphalt. More [sophisticated approximations of CRF] that consider *v* and tyre pressure can be used.

'*Physics For Scientists and Engineers with Modern Physics*', 5th Ed, Serway & Beichner.

Energy Use Calculations

- Distance travelled by the car ('displacement'), x [m], in time, t [s]

- Velocity, v [m·s^{-1}]: $v = \frac{dx}{dt} \leftrightarrow dx = v \cdot dt$

- For constant acceleration, a [m·s^{-2}]: $v = v_0 + a \cdot t$

- Work done by a force, E_w [J, N·m]:

  For constant F: $E_w = F \cdot x$

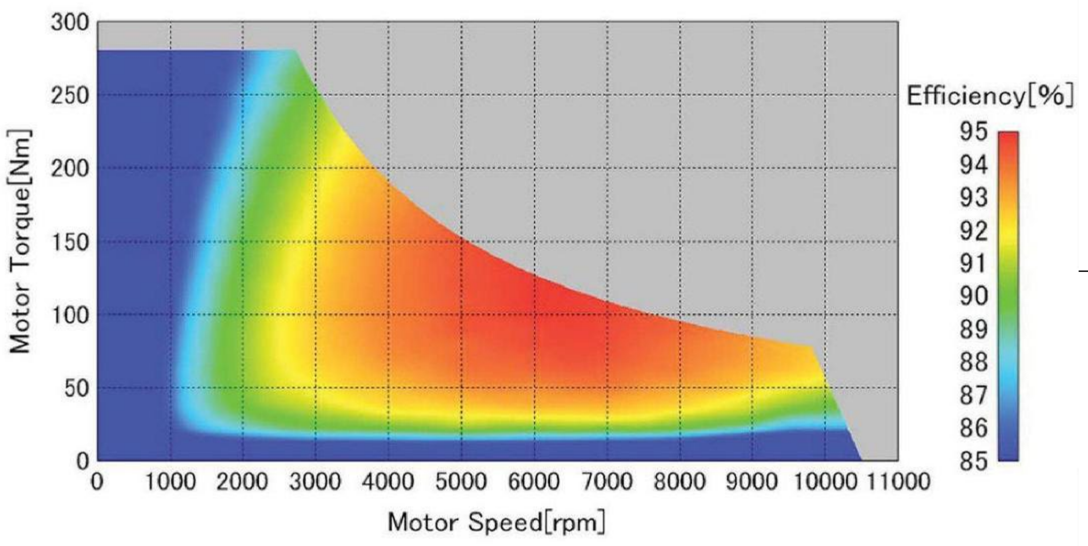
  For $F(x)$: $dE_w = F \cdot dx$

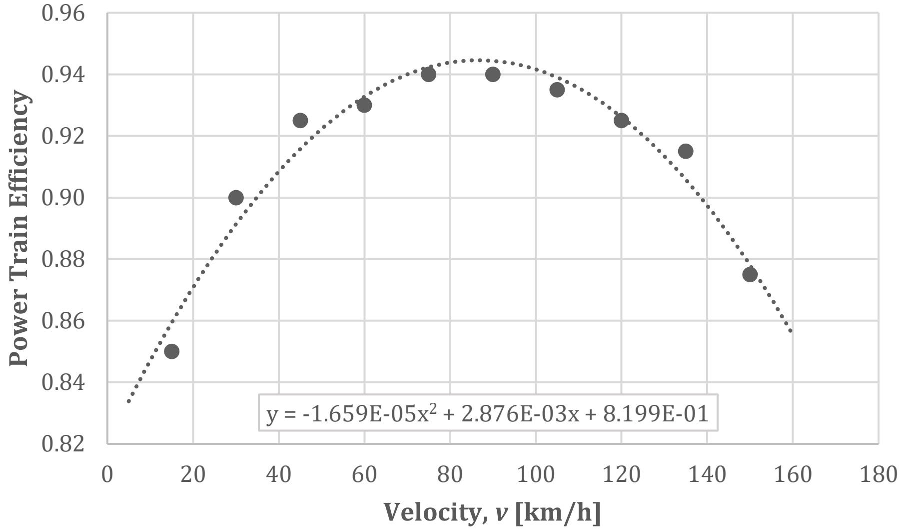
  $E_w = \int F \cdot dx$

- Power, P [W, N·m·s^{-1}]: $P = F \cdot v$

Energy Use Calculations – Losses

- Mechanical: LEAF ‘EM57’ Power Train Efficiency[4], η_{mech}





  - U.S. Department of Energy: EVs convert on average 87–91% of input energy to energy at the wheels[5].

- Electrical[5]: losses due to EV ‘accessories and auxiliary electrical’ (no AC) are small and in the range of ~ 2 %, with corresponding factor η_{elec} = 0.98.

[4] https://www.electricvehiclewiki.com/drivetrain-d1/

[5] ‘*Where the Energy Goes: Electric Cars*’, Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, accessed 15 Oct 2024.

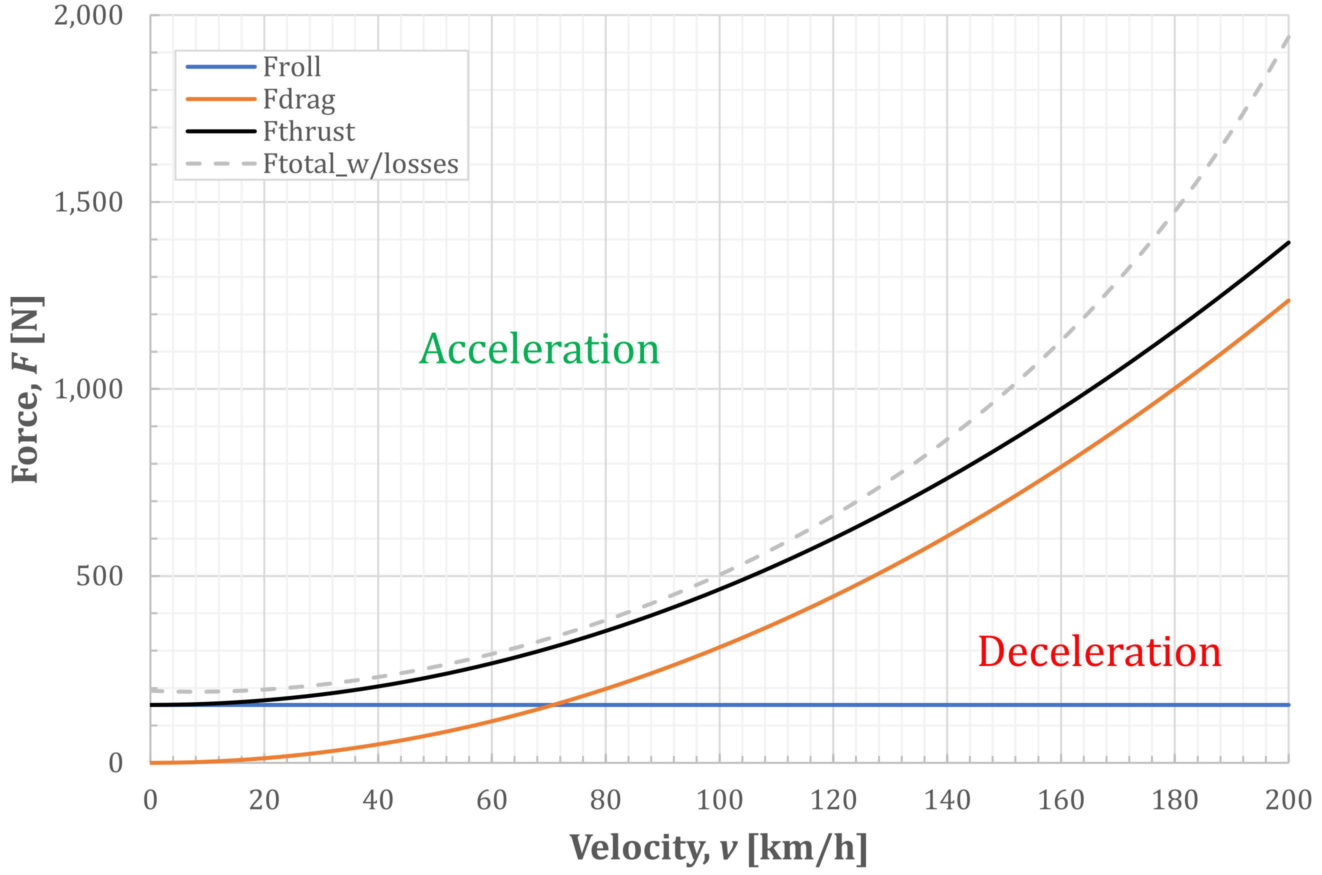
Forces Opposing Motion

For given v:

$$F_{T\_bal} = F_D + F_R$$
$$= \frac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot v^2 + \mu_R \cdot m \cdot g$$

Where:

- ρ = 1.2 kg·m^3
- A_{LEAF} = 2.385 m^2
- C_D = 0.28
- μ_R = 0.01
- m = 1581 kg (curb weight and 1 passenger)
- g = 9.8 m·s^{-2}
- $\eta_{mech}(v)$ and η_{elec} (0.98) overlaid to visualise the effect of losses



Nissan LEAF Power Draw

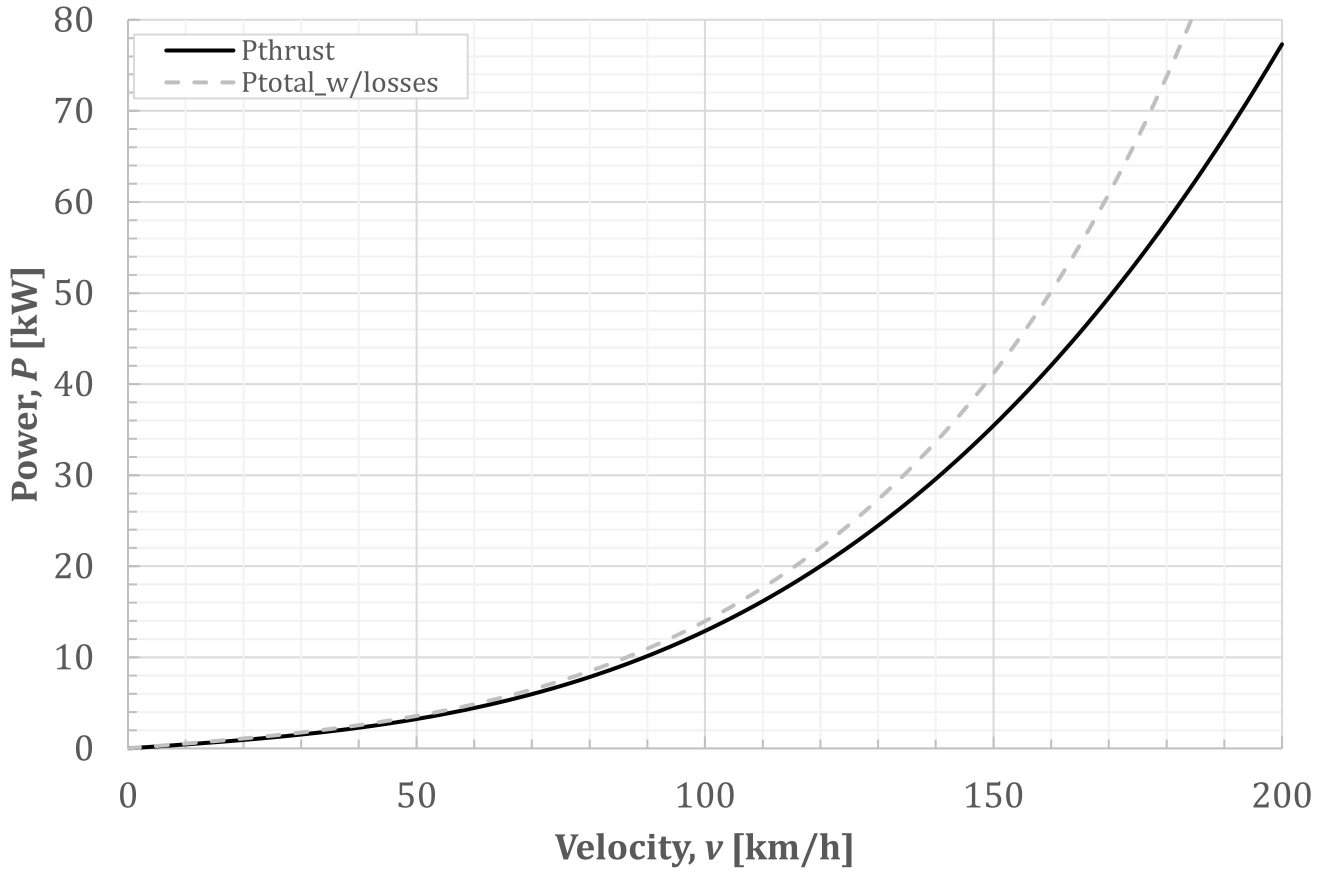
For given *v:*

$$P_{T\_bal} = F_{T\_bal} \cdot v$$

$$= \left(\frac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot v^2 + \mu_R \cdot m \cdot g\right) \cdot v$$

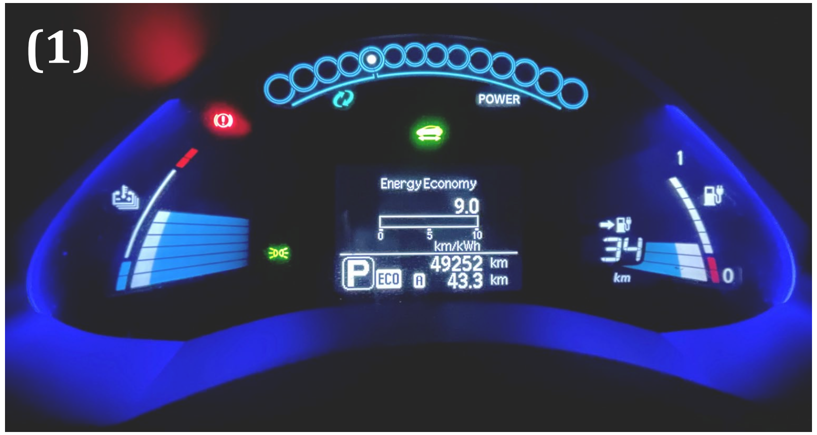
Where:

- ρ = 1.2 kg·m^3
- A_{LEAF} = 2.385 m^2
- C_D = 0.28
- μ_R = 0.01
- m = 1581 kg (curb weight and 1 passenger)
- g = 9.8 m·s^{-2}
- $\eta_{mech}(v)$ and η_{elec} (0.98) losses overlaid



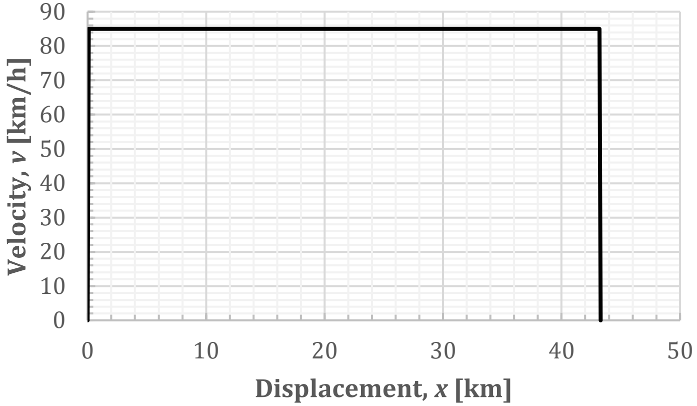
[ϵ_{EV} Scenario 1] Highway Cruising

- Simplifying assumptions:
  - 43.3 km journey to UNSW, with minimal change in elevation
  - Toll roads and highways for vast majority journey i.e., no stops along the way
  - Drove at approx. average speed of 85 km·h^{-1}
  - The work needed to accelerate the car from rest to cruising speed (0.14 kWh) is small compared to total energy use
  - The impact of regenerative braking is small: (i) the LEAF's generator is capped to 30 kW; and (ii) braking is 'rapid' such that vehicle kinetic energy is lost as heat.



$$E_w = \int F_T(v) \cdot dx$$

$$\cong F_{T\_bal}(v = 85) \cdot x$$



[ϵ_{EV} Scenario 1] Highway Cruising

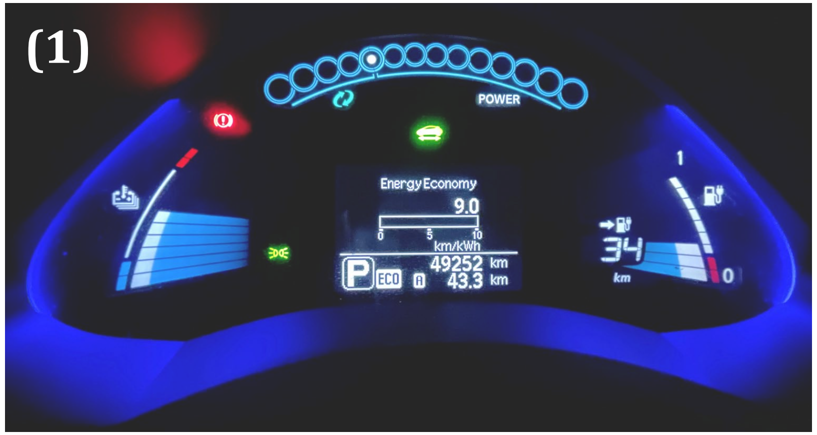
$$E_{battery} = E_w / \eta_{losses}$$

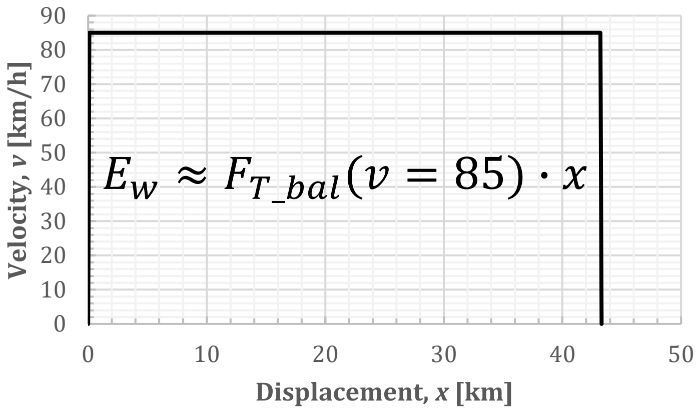
$$\approx \frac{F_{T\_bal}(v = 85) \cdot x}{\eta_{mech}(v = 85) \cdot \eta_{elec}}$$

$$= 17.697\ MJ \ \leftrightarrow 4.916\ kWh\ (3\ d.p.)\ [1\ kWh = 3.6\ MJ]$$

$$\epsilon_{highway} = \frac{x}{E_{battery}} = \frac{43.3\ km}{4.916\ kWh}$$

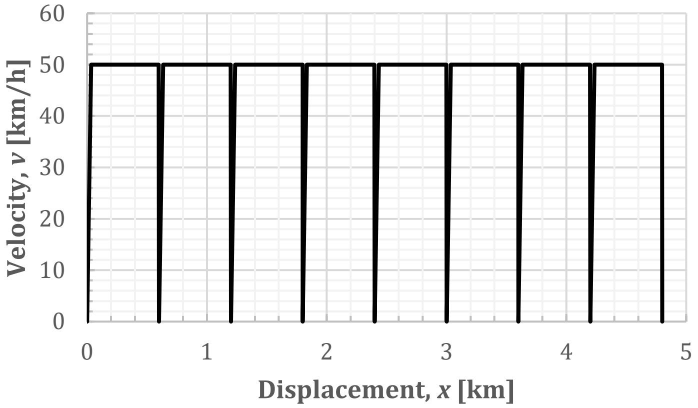
$$= 8.8\ km \cdot kWh^{-1}$$

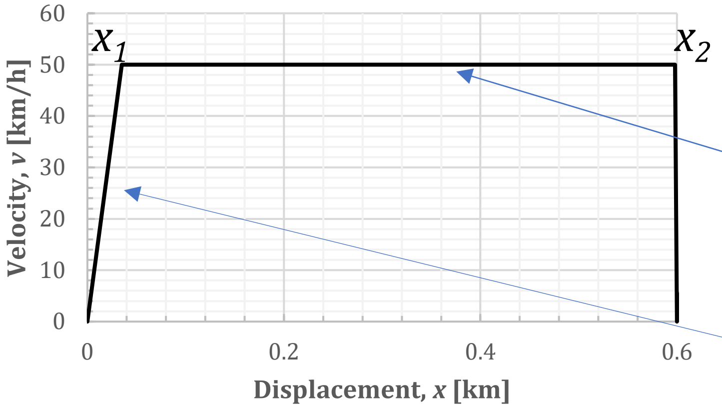




[ϵ_{EV} Scenario 2] Inner City Stop-Start

- My Drive to Work:
  - 4.8 km journey to UNSW, with minimal change in elevation
  - Eight stops along the way: stop signs, roundabouts, traffic lights, on average every 600 m
  - Steady speed of 50 km·h^{-1} after constant acceleration of 10 km·h^{-1} ·s^{-1}
  - The impact of regenerative braking is small (refer to Slide 19)





3 Work against F_D and F_R at constant v.

2 Work against F_D and F_R while accelerating.

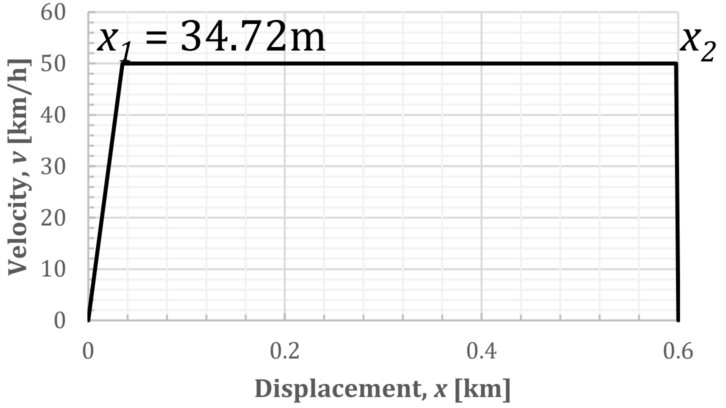
1 Accelerate object to 50 km·h^{-1}from rest.

$$E_w = \underbrace{\int_0^{x_1} F_a \cdot dx}_{1} + \underbrace{\int_0^{x_1} (F_D(v) + F_R) \cdot dx}_{2} + \underbrace{\int_{x_1}^{x_2} (F_D(v = 50) + F_R) \cdot dx}_{3}$$

[ϵ_{EV} Scenario 2] Inner City Stop-Start

$$
\begin{aligned}
E_w &= \int_0^{x_1} F_a \cdot dx + \int_0^{x_1} (F_D(v) + F_R) \cdot dx + \int_{x_1}^{x_2} (F_D(v=50) + F_R) \cdot dx \\
&= (m \cdot a) \cdot x_1 + \int_0^{x_1} \left(\tfrac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot v^2 + \mu_R \cdot m \cdot g\right) \cdot dx + F_{T\_bal}(v=50) \cdot (x_2 - x_1) \\
&= 152{,}488\, J + \int_0^{x_1} \left(\tfrac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot v^2 + \mu_R \cdot m \cdot g\right) \cdot dx + 145{,}178\, J
\end{aligned}
$$

$$
\begin{aligned}
\int_0^{x_1} \left(\tfrac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot v^2 + \mu_R \cdot m \cdot g\right) \cdot dx &= \int_0^{t_1=5} \left(\tfrac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot v^2 + \mu_R \cdot m \cdot g\right) \cdot (v \cdot dt) \\
&= \int_0^{t_1=5} \left(\tfrac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot (a \cdot t)^3 + \mu_R \cdot m \cdot g\,(a \cdot t)\right) \cdot dt \\
&= \left[\frac{\rho \cdot A \cdot C_D \cdot a^3 \cdot t^4}{8} + \frac{\mu_R \cdot m \cdot g \cdot a \cdot t^2}{2}\right]_0^5 \\
&= 6{,}722\, J
\end{aligned}
$$



$$
E_{battery} \approx \frac{(m \cdot a) \cdot x_1 + \int_0^{x_1} (F_D(v) + F_R) \cdot dx}{\eta_{mech_{ave}} *\cdot\, \eta_{elec}} + \frac{\int_{x_1}^{x_2} (F_D(v=50) + F_R) \cdot dx}{\eta_{mech}(v=50) \cdot \eta_{elec}} = 0.0965\, kWh \ (4\ d.p.)
$$

$$
\therefore \epsilon_{city} = \frac{0.6\, km}{0.0965\, kWh} = 6.2\, km \cdot kWh^{-1}
$$

UNSW SYDNEY

* The average power train efficiency between 0 and 50 km/h is used (0.87).

'*Physics For Scientists and Engineers with Modern Physics*', 5th Ed, Serway & Beichner. For constant a, $x_b - x_a = (v_b + v_a) \cdot t/2$

AC DC Artificial Intelligence | Characterisation Defects | Contacts


Can I Run My Car With Solar Panels?

LEAF PV Sizing

- As an upper limit, consider module record efficiencies for non-concentrator modules[6]:
  - Silicon (dominant technology, relatively low cost): 24.9%, Maxeon, 2024
  - III-V (very $$$): 32.65%, Sharp, 2022
  - For comparison, Sunswift 7 modules: ~ 22% silicon modules from Sunpower, 4.8 m^2
- Assume **ideal** conditions:
  - Standard test conditions (STC) of 1,000 $W \cdot m^{-2}$ irradiance, G, at 25 °C
  - No shading from clouds or surrounding structures
  - Perfectly flat horizontal surfaces to mount the PV modules
- Available horizontal space on LEAF: 2.3 m^2
  - Roof: 1.7 m × 0.9 m
  - Hood: 0.9 m × 0.9 m
- Two scenarios:
  A. Power EV with PV modules only, no energy from the battery
  B. Use PV plus the battery to store energy for use later *

[6] Green MA, *et al*. 'Solar cell efficiency tables (Version 64)'. Prog Photovolt Res Appl. 2024; 32(7): 425-441. doi:10.1002/pip.3831

* I'll leave this for you to figure out. Consider an average of ~ 4–5 Peak Sun Hours, PSH, for a horizontal surface in Sydney (equivalent to 4–5 hours in STC).

100% Solar Powered LEAF?

PV power generation, P_{PV}:

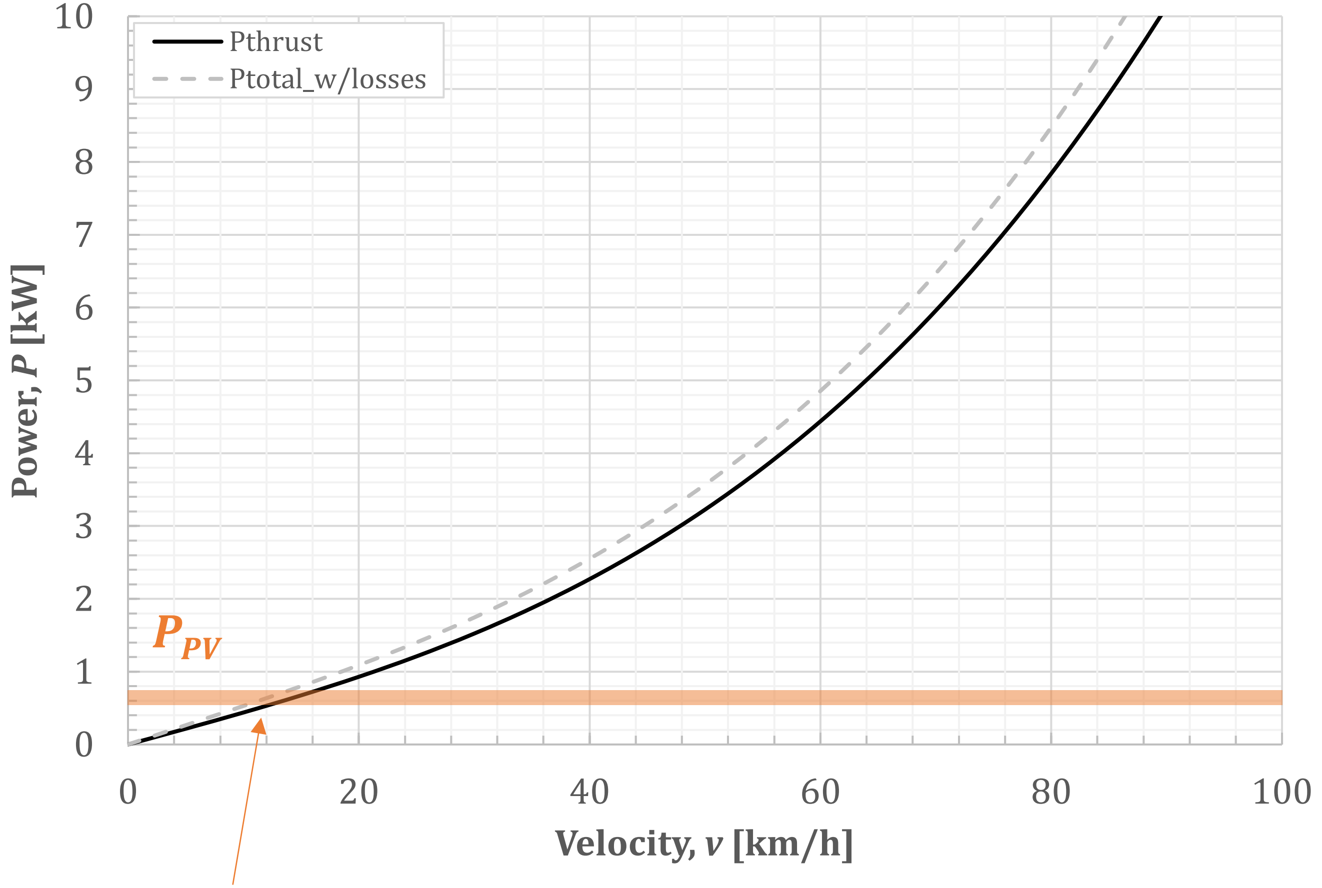
$$P_{PV} = A_{PV} \cdot G_{STC} \cdot \eta_{PV} \approx 600\text{–}800\ W$$

Where:

- A_{PV} = 2.3 m^2
- G_{STC} = 1000 W·m^{-2}
- η_{PV} = 24.9–32.65% for record modules

[NOTE] For non-ideal conditions (shading, PV on curved surfaces, vertical mounting on side/rear), G will decrease on average and reduce P_{PV} further:

$$P_{PV} \propto G$$



v_{max} ~ 10–15 km·h^{-1}

But What About Sunswift?

[Image Credit]: UNSW Sydney

[Sunswift] How Do They Do It?

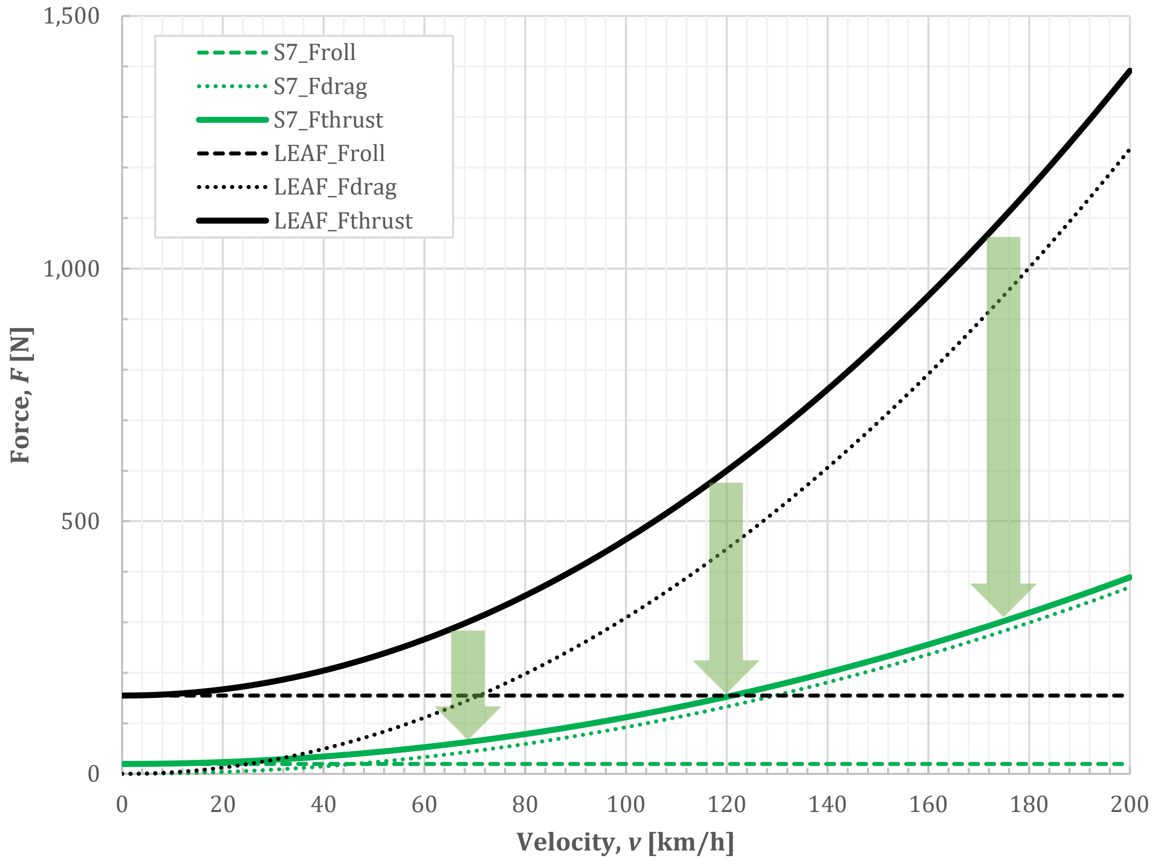
$$E_w \approx F_T \cdot x$$

$$F_{T\_bal} = F_D + F_R$$
$$= \frac{1}{2} \cdot \rho \cdot A \cdot C_D \cdot v^2 + \mu_R \cdot m \cdot g$$

Where:

- ρ = 1.2 kg·m^3
- g = 9.8 m·s^{-2}

	LEAF	Sunswift
A [m^2]	2.385	~ 2.1
C_D	0.28	0.095
μ_R	0.01	0.004
m_{curb} [kg]	1481	500
ϵ [km·kWh^{-1}]	6.5	≳ 20–30



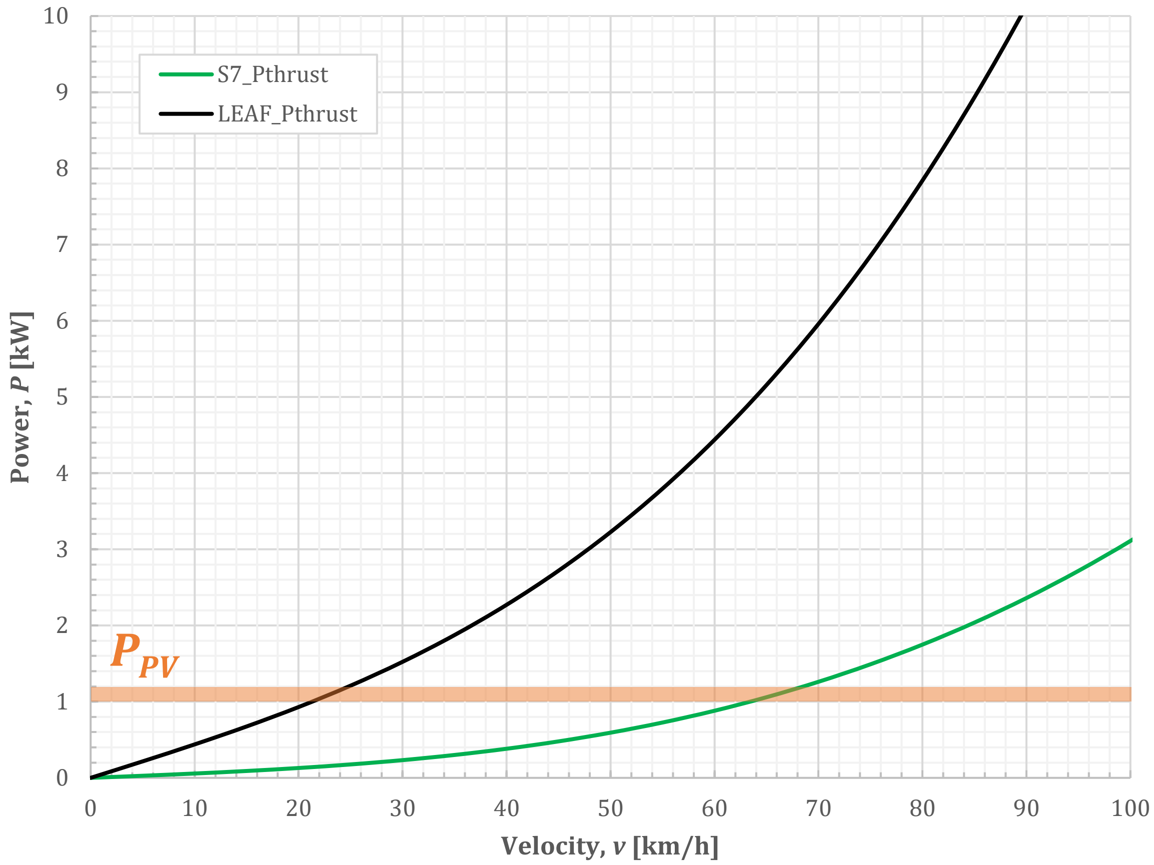
[Sunswift] How Do They Do It?

$$P_{PV} = A_{PV} \cdot G_{STC} \cdot \eta_{PV\_STC} \approx 1\ kW$$

Where:

- A_{PV} = 4.8 m^2
- G_{STC} = 1000 W·m^{-2}
- η_{PV_STC} = 22% *

	LEAF	Sunswift
A_{EV} [m^2]	2.385	~ 2.1
C_D	0.28	0.095
μ_R	0.01	0.004
m_{curb} [kg]	1481	500
ϵ [km·kWh^{-1}]	6.5	$\gtrsim$ 20–30
A_{PV} [m^2]	2.4	4.8



* Sunswift 7 published efficiency of ~ 22%.

Let's Recap

$$
\begin{tikzcd}
\boxed{\$/100\ \text{km}} & \boxed{\epsilon_{EV}} \arrow[l] & \boxed{E_{work}} \arrow[l] & \boxed{P,\ F_{thrust}} \arrow[l] & \boxed{C_{drag},\ \mu_{Roll},\ m,\ A} \arrow[l] \\
\boxed{\$/\text{kWh}} \arrow[u] & & & \boxed{P_{PV}} \arrow[u] & \boxed{\mu_{PV},\ A_{PV}} \arrow[l]
\end{tikzcd}
$$

Summary

- EVs are now very affordable, especially when bought second-hand
- Average EV running costs are ~ 70–80% less per 100 km than ICE vehicles when charged at home, and still significantly cheaper when using public fast chargers
- The now-standard 300+ km range of new EVs is PLENTY for the average driver
- What's next for the LEAF?
  - Continue saving up to $2k–4k p.a. on fuel costs;
  - Keep driving it until the battery SOH drops to an impractical range; after which
  - There are battery pack replacement options available to keep it on the road for (hopefully) decades more; and
  - Options to repurpose or recycle the old battery pack.

UNSW SYDNEY

ARENA

Australian Government

Australian Renewable Energy Agency

ACAP

AC DC

Artificial intelligence | Characterisation

Defects | Contacts

Thank you!

John Rodriguez
john.rodriguez@unsw.edu.au