

Program version: V12

These plotted curves show, from various perspectives, the battery range of a 2018 Tesla Model 3 LR RWD.

The data for these was obtained by driving the car back and forth on a fairly flat road multiple times, at different speeds, and recording the energy usage per distance as shown by the car in watt-hours per unit distance travelled. This data is shown on one of the plots. Also, certain data was found on the internet, such as vehicle weight.

Many plots show curves for a much wider range of speeds than those used in the testing described above. This was done by fitting a 3rd-order polynomial to the power curve obtained from the testing. From that polynomial power curve, the coefficients of rolling resistance and drag and the baseline power were estimated. From those, the rolling power and drag power were estimated for speeds from near 0 to quite fast. The total power is then the sum of the baseline power, rolling power and drag power. Finally, that total power estimate at different speeds is used to compute the curves for most of the plots.

Some plots take into account battery degradation. This was obtained for the car described above as follows: Ran Tesla battery test in hidden service menu.

If you would like curves plotted for another car and can provide the necessary energy data, contact me and we'll see if we can arrange it.

If you have questions or concerns about any of the plots, you can contact me on various online groups or at ted@tedtoal.net

The R code used to produce these plots is available on GitHub at:
<https://github.com/tedtoal/EV-battery-and-range-plots>

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Power consumption and estimates of rolling and drag coefficients

This shows points computed from raw data and a 3rd-order approximation.

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: batt degraded 12% for 66kWh capacity

D: 100% SOC is 66kWh

E: 3rd-order approx for Total Power $\sim .000009S^3 + .06S + .61$ (S = speed)

F: Est. Rolling Coef $\sim 1000 \times \text{speed_coef} \times \text{convert_mps_to_xxph} \times \text{eff} / \text{vehicleWeight_N}$

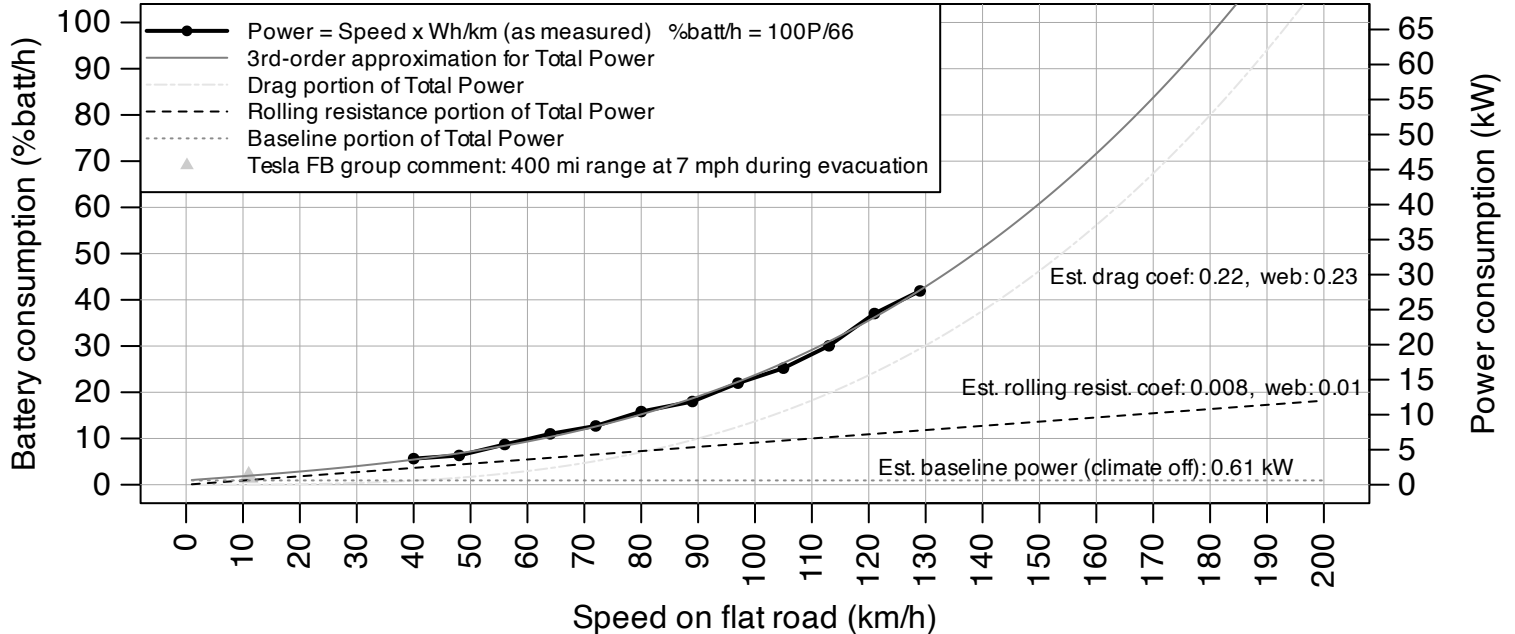
G: Est. Drag Coef $\sim 1000 \times \text{speed_cubed_coef} \times \text{convert_mps_to_xxph}^3 \times 2 \times \text{eff} / \text{air_density} / \text{frontal_area}$

H: Est. Baseline Power $\sim \text{constant_term_coef}$

I: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power}$

J: Rolling Power $= S \times \text{coefRolling} \times \text{vehicleWeight_N} / \text{eff} / 1000$ (S=speed, mps)

K: Drag Power $= SC \times SA^2 \times \text{coefDrag} \times \text{airDens} \times \text{area} \times (SA \geq 0 ? 1/\text{eff} : -\text{regenEff}) / 2000$ (SC=car, SA=air speeds, mps)



Estimated range at various speeds

This shows points computed from raw data, and includes linear and derived approximations.

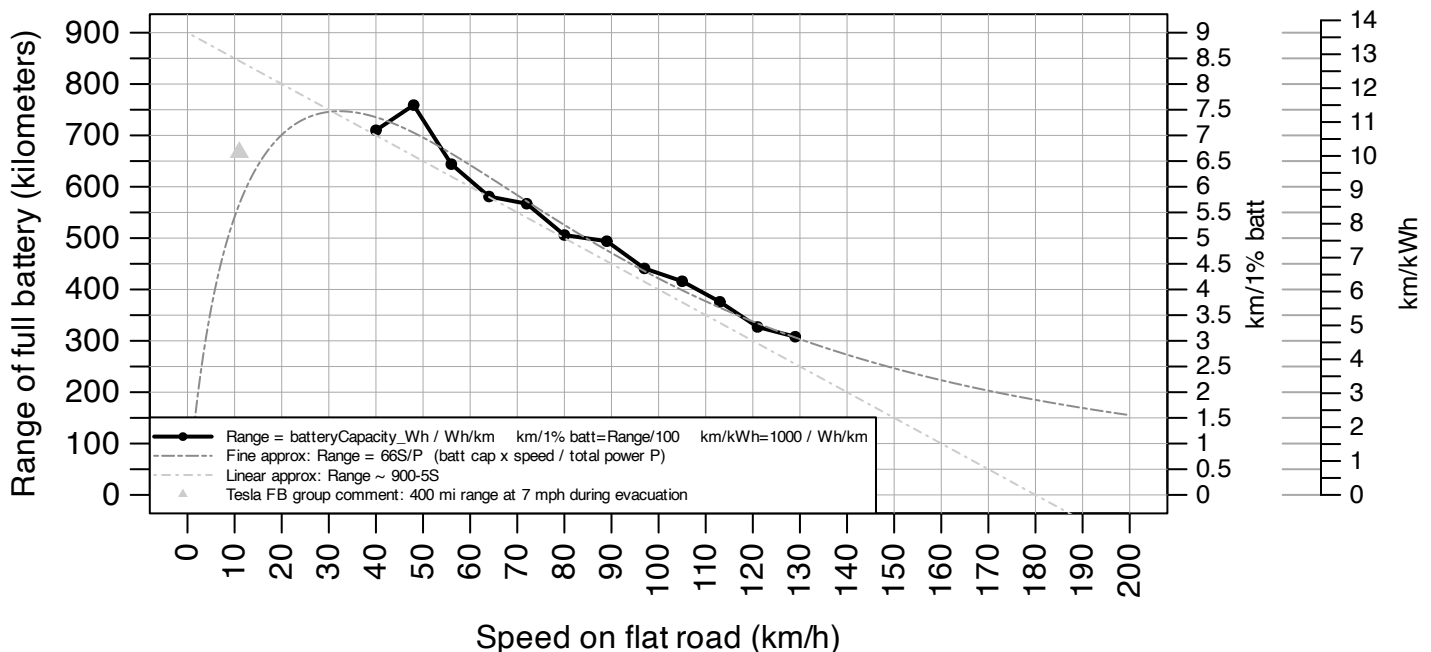
Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: batt degraded 12% for 66kWh capacity

D: 100% SOC is 66kWh

E: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power}$



Energy used per kilometer at various speeds

This shows raw (measured) data and an approximation curve.

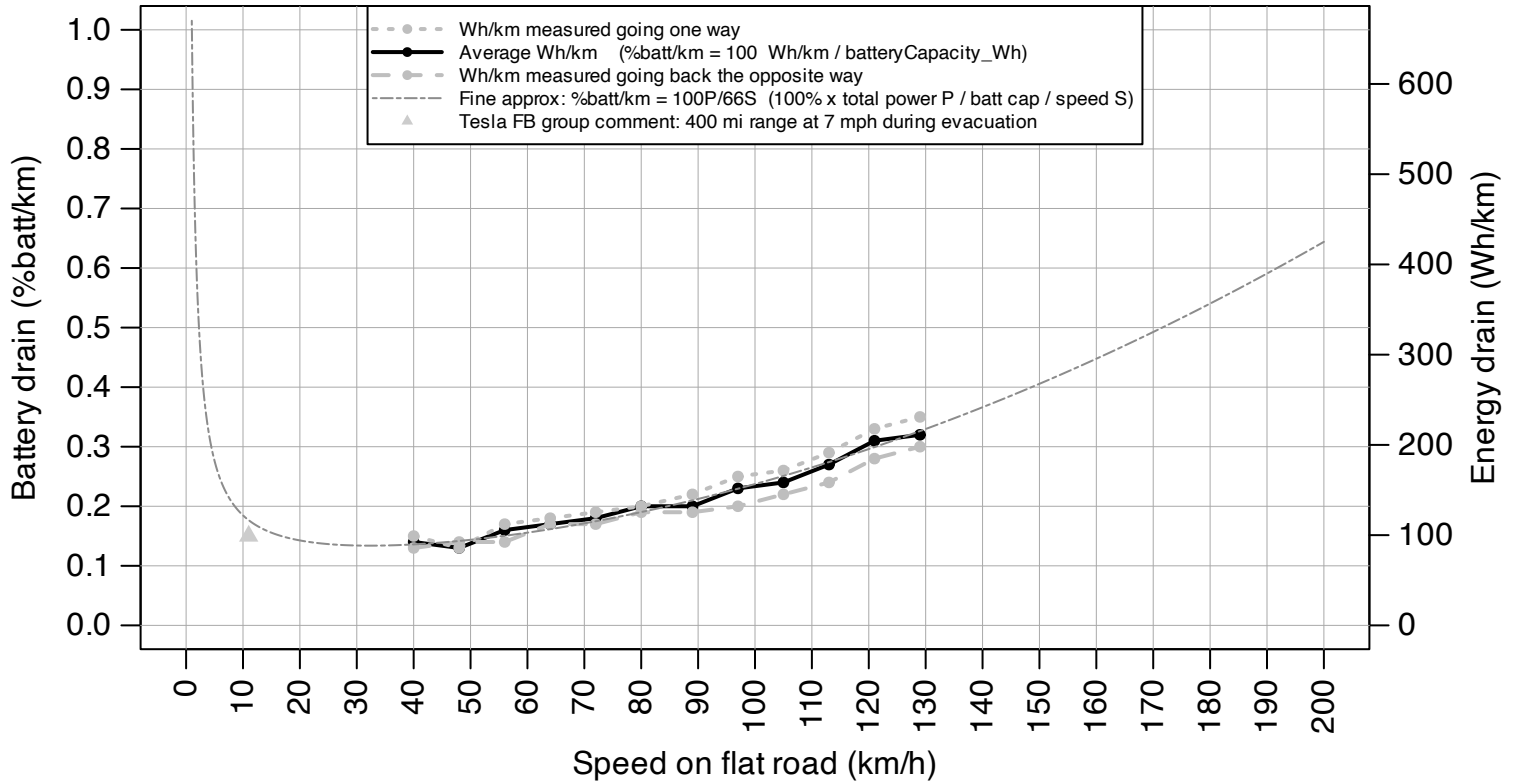
Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: batt degraded 12% for 66kWh capacity

D: 100% SOC is 66kWh

E: Est. Total Power P = baseline+rolling+drag power



Kilometers per euro at various speeds compared to fuel vehicle

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: batt degraded 12% for 66kWh capacity

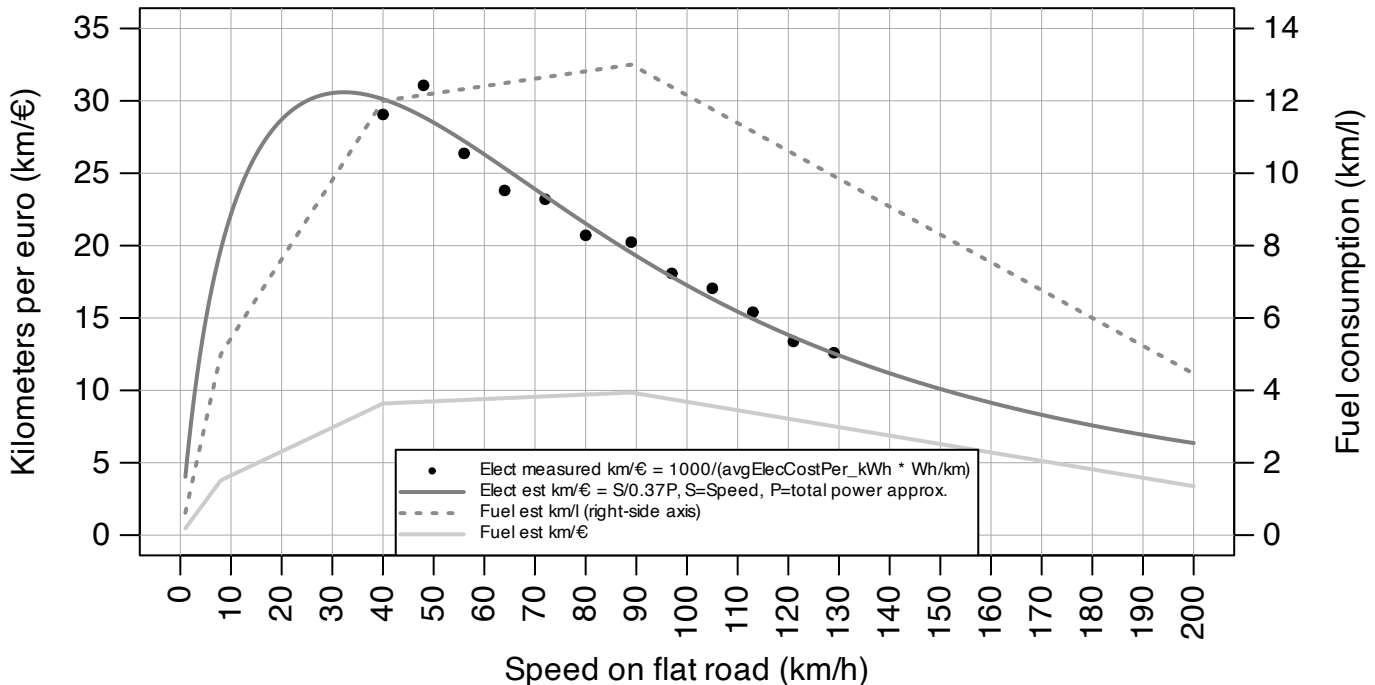
D: 100% SOC is 66kWh

E: electricity cost €0.37/kWh (charging eff. excl.)

F: fuel cost €1.32/liter

G: fuel efficiency as shown by dotted line with right-axis scale

H: Est. Total Power P = baseline+rolling+drag power



Euros per kilometer at various speeds compared to fuel vehicle

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: batt degraded 12% for 66kWh capacity

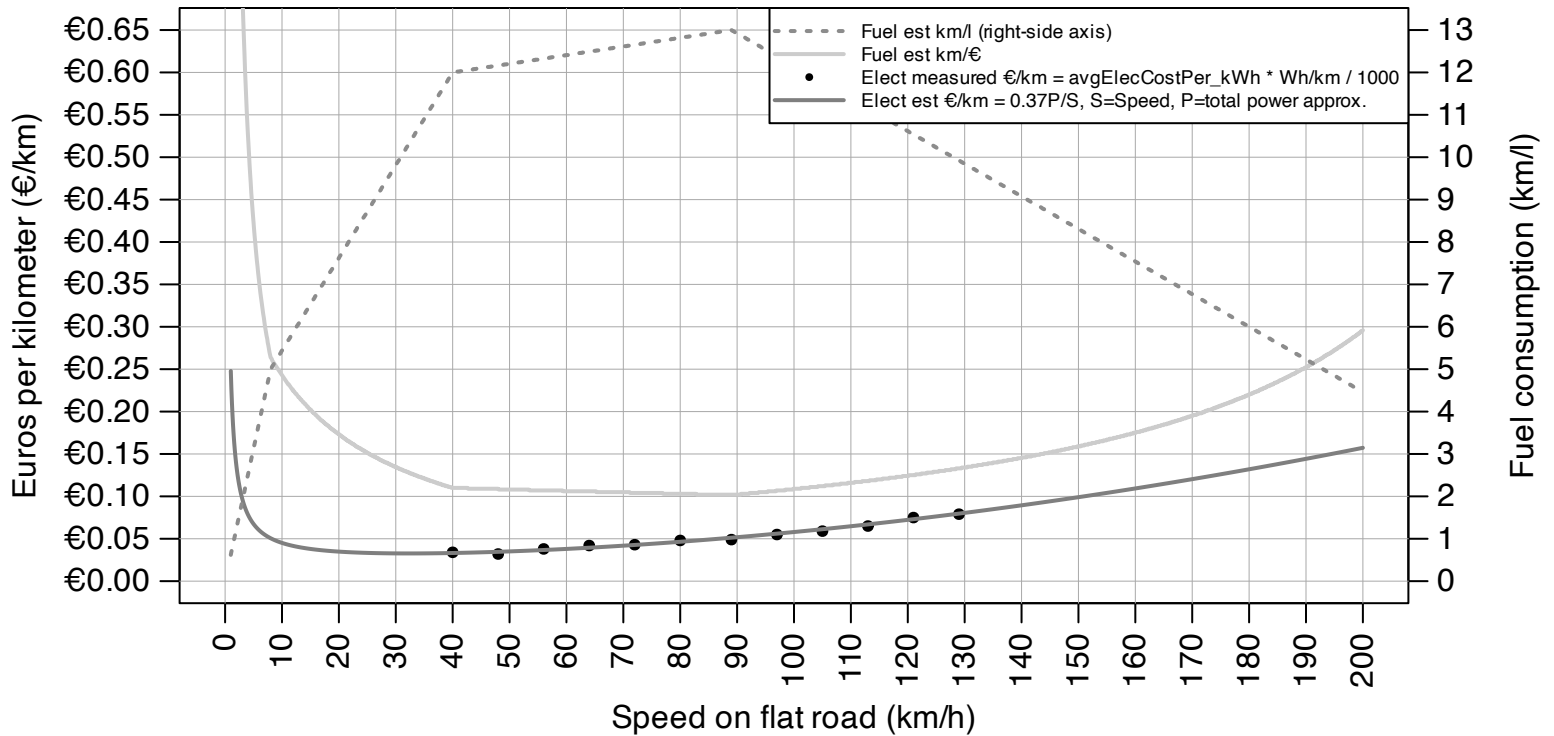
D: 100% SOC is 66kWh

E: electricity cost €0.37/kWh (charging eff. excl.)

F: fuel cost €1.32/liter

G: fuel efficiency as shown by dotted line with right-axis scale

H: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power}$



Cost in euros per 100 km or driving hour at various speeds compared to fuel vehicle

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: batt degraded 12% for 66kWh capacity

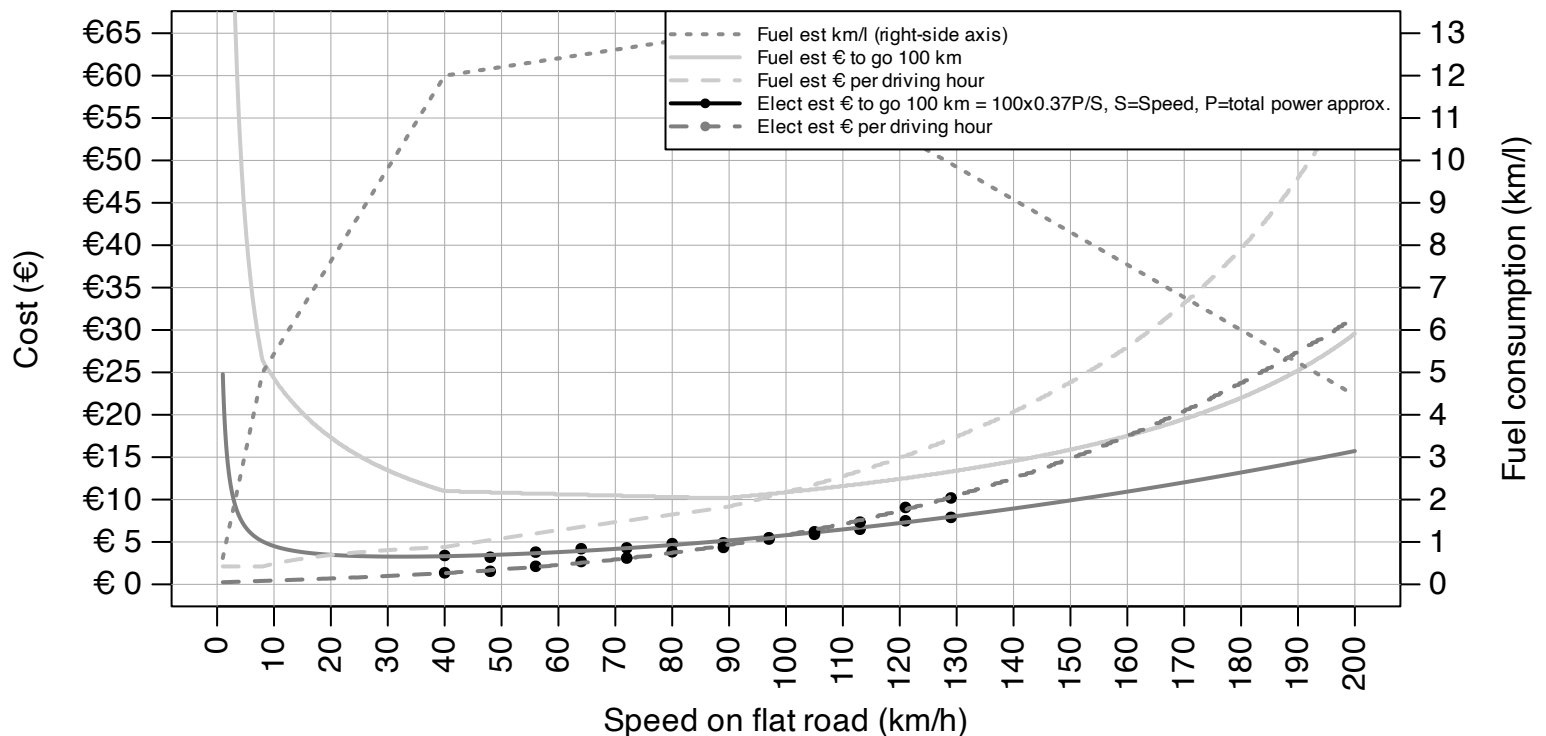
D: 100% SOC is 66kWh

E: electricity cost €0.37/kWh (charging eff. excl.)

F: fuel cost €1.32/liter

G: fuel efficiency as shown by dotted line with right-axis scale

H: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power}$



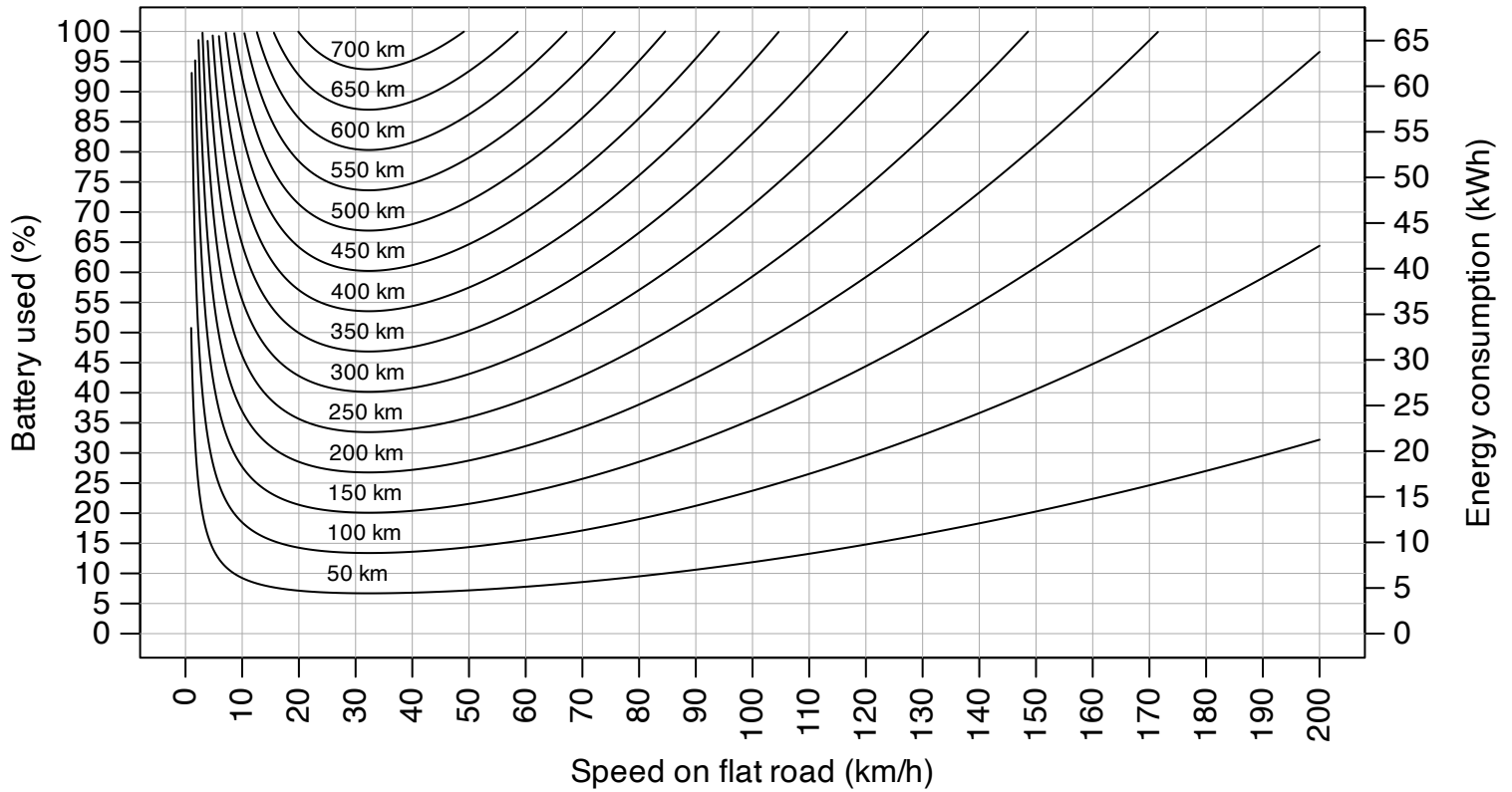
Energy used at various speeds and distances

Assumptions: A: batt degraded 12% for 66kWh capacity

B: 100% SOC is 66kWh

C: Fine approx: %batt/km = 100P/66S

D: Est. Total Power P = baseline+rolling+drag power



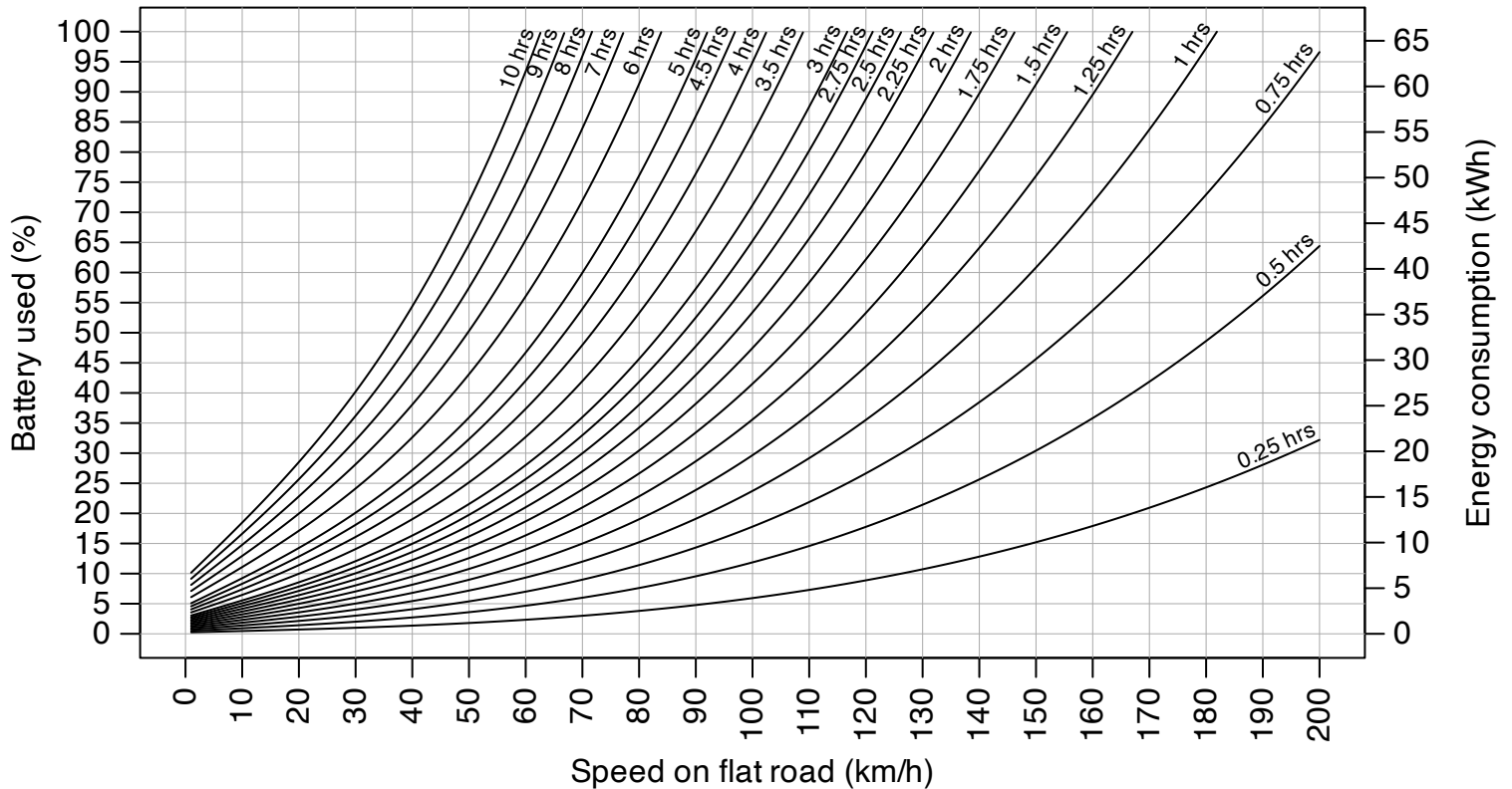
Energy used at various speeds and times

Assumptions: A: batt degraded 12% for 66kWh capacity

B: 100% SOC is 66kWh

C: Fine approx: %batt/h = 100P/66

D: Est. Total Power P = baseline+rolling+drag power



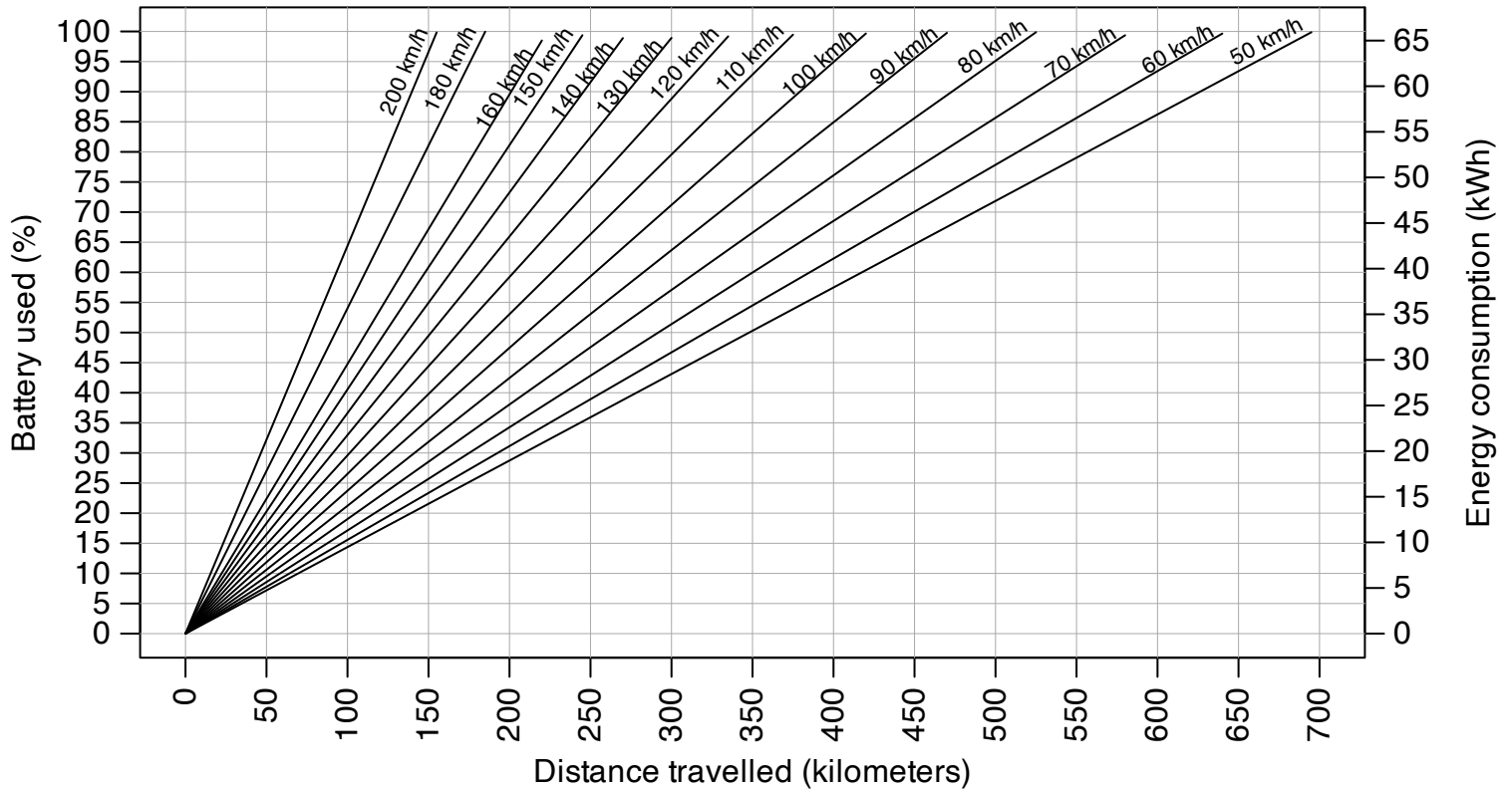
Energy used at various distances and speeds

Assumptions: A: batt degraded 12% for 66kWh capacity

B: 100% SOC is 66kWh

C: Fine approx: %batt/km = 100P/66S

D: Est. Total Power P = baseline+rolling+drag power



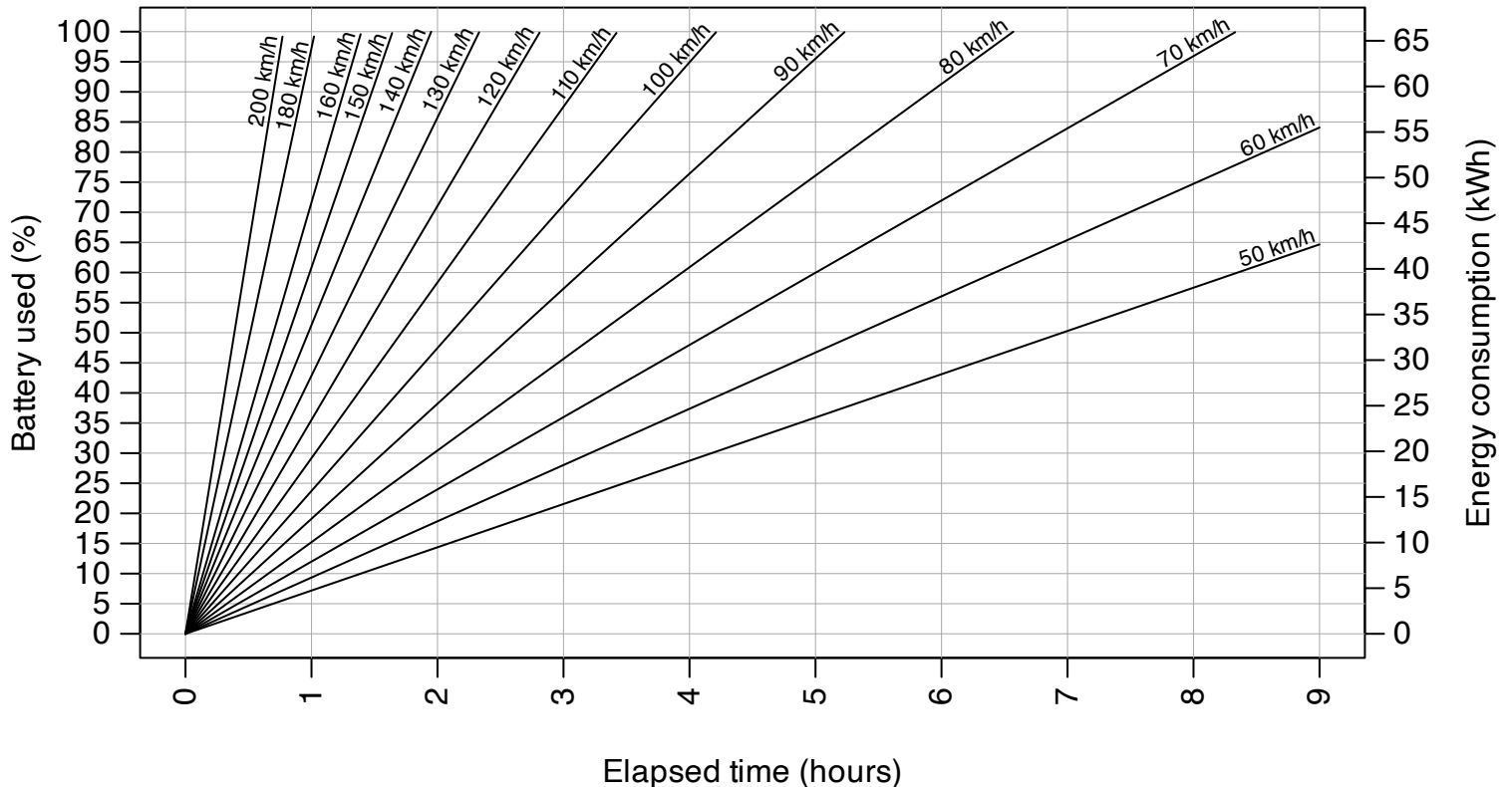
Energy used at various times and speeds

Assumptions: A: batt degraded 12% for 66kWh capacity

B: 100% SOC is 66kWh

C: Fine approx: %batt/h = 100P/66S

D: Est. Total Power P = baseline+rolling+drag power



Estimated range at various speeds and baseline power levels

Assumptions: A: 2018 Tesla Model 3 LR RWD

C: weight 1928kg (with 113kg passengers)

E: batt degraded 12% for 66kWh capacity

G: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

H: range = batt. cap. x speed / total power

J: Rolling Power = $S \times \text{coefRolling} \times \text{vehicleWeight_N} / \text{eff} / 1000$ (S=speed, mps)

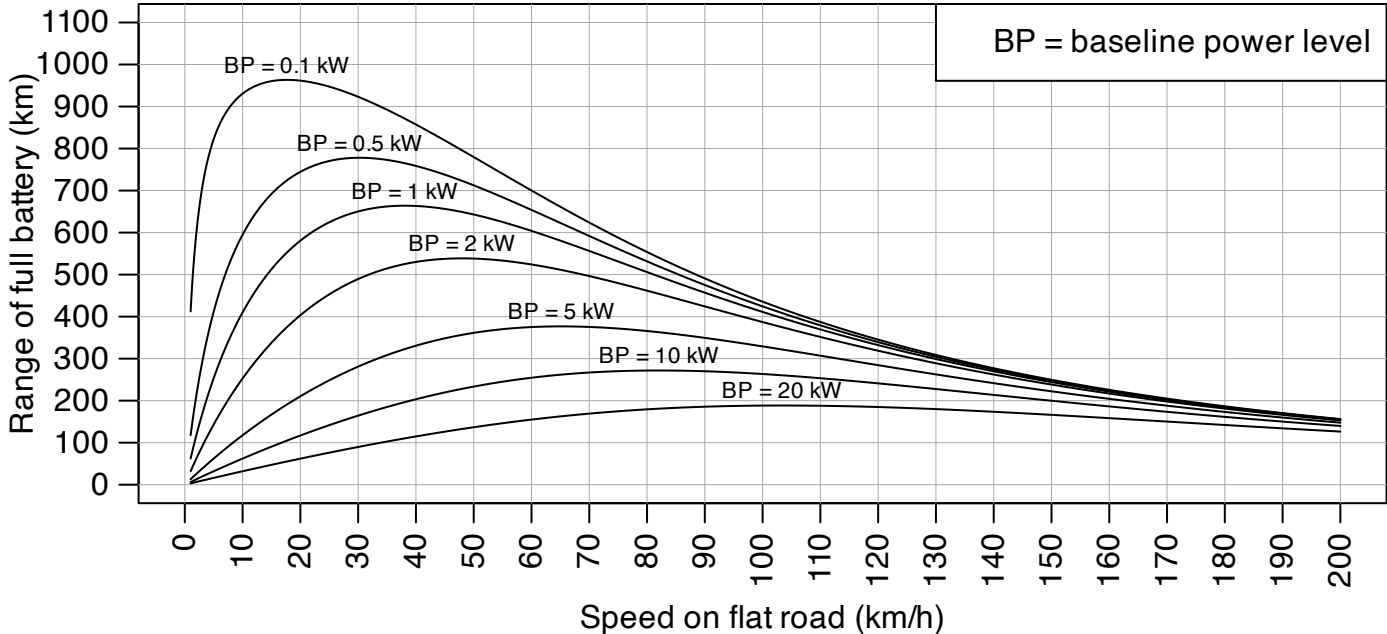
K: Drag Power = $SC \times SA^2 \times \text{coefDrag} \times \text{airDens} \times \text{area} \times (SA \geq 0 ? 1/\text{eff} : -\text{regenEff}) / 2000$ (SC=car, SA=air speeds, mps)

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

D: drag coef 0.22, roll coef 0.008

F: air density computed using density altitude

I: total power = baseline+rolling+drag power



Estimated maximum range at speed with changing baseline power level

Assumptions: A: 2018 Tesla Model 3 LR RWD

C: weight 1928kg (with 113kg passengers)

E: batt degraded 12% for 66kWh capacity

G: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

H: range = batt. cap. x speed / total power

J: Rolling Power = $S \times \text{coefRolling} \times \text{vehicleWeight_N} / \text{eff} / 1000$ (S=speed, mps)

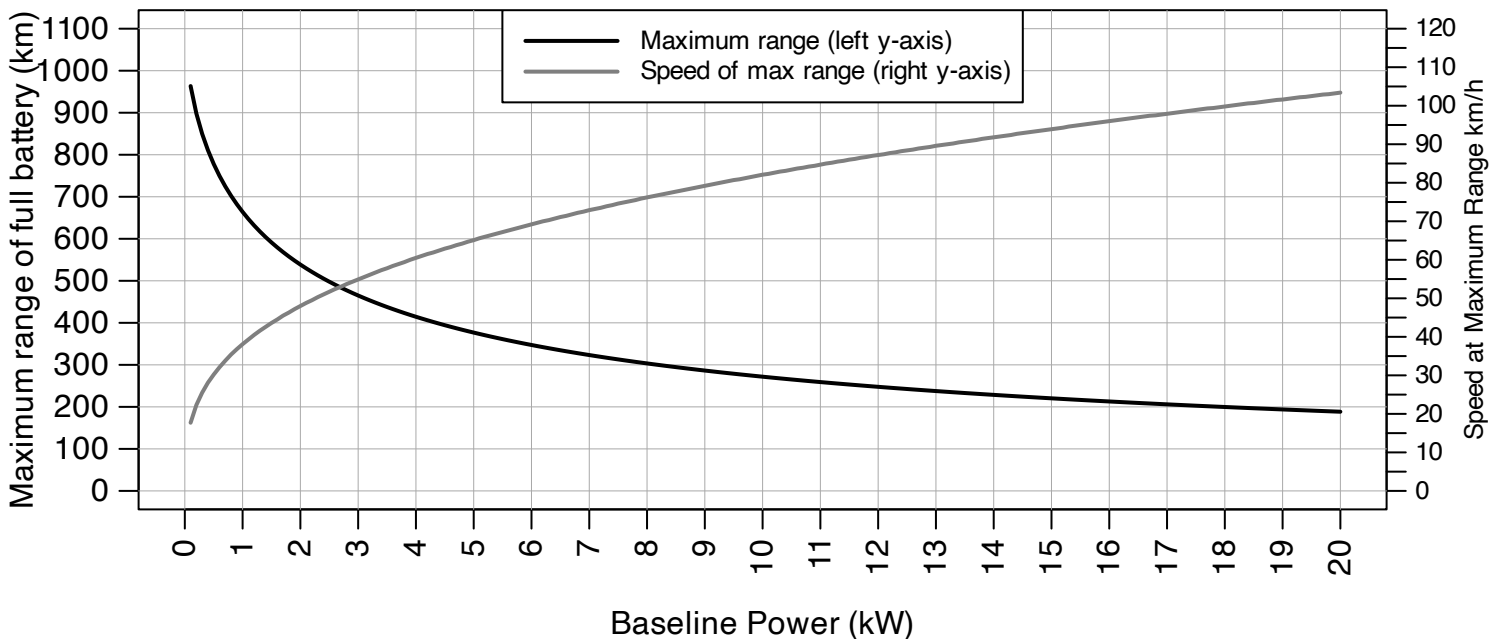
K: Drag Power = $SC \times SA^2 \times \text{coefDrag} \times \text{airDens} \times \text{area} \times (SA \geq 0 ? 1/\text{eff} : -\text{regenEff}) / 2000$ (SC=car, SA=air speeds, mps)

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

D: drag coef 0.22, roll coef 0.008

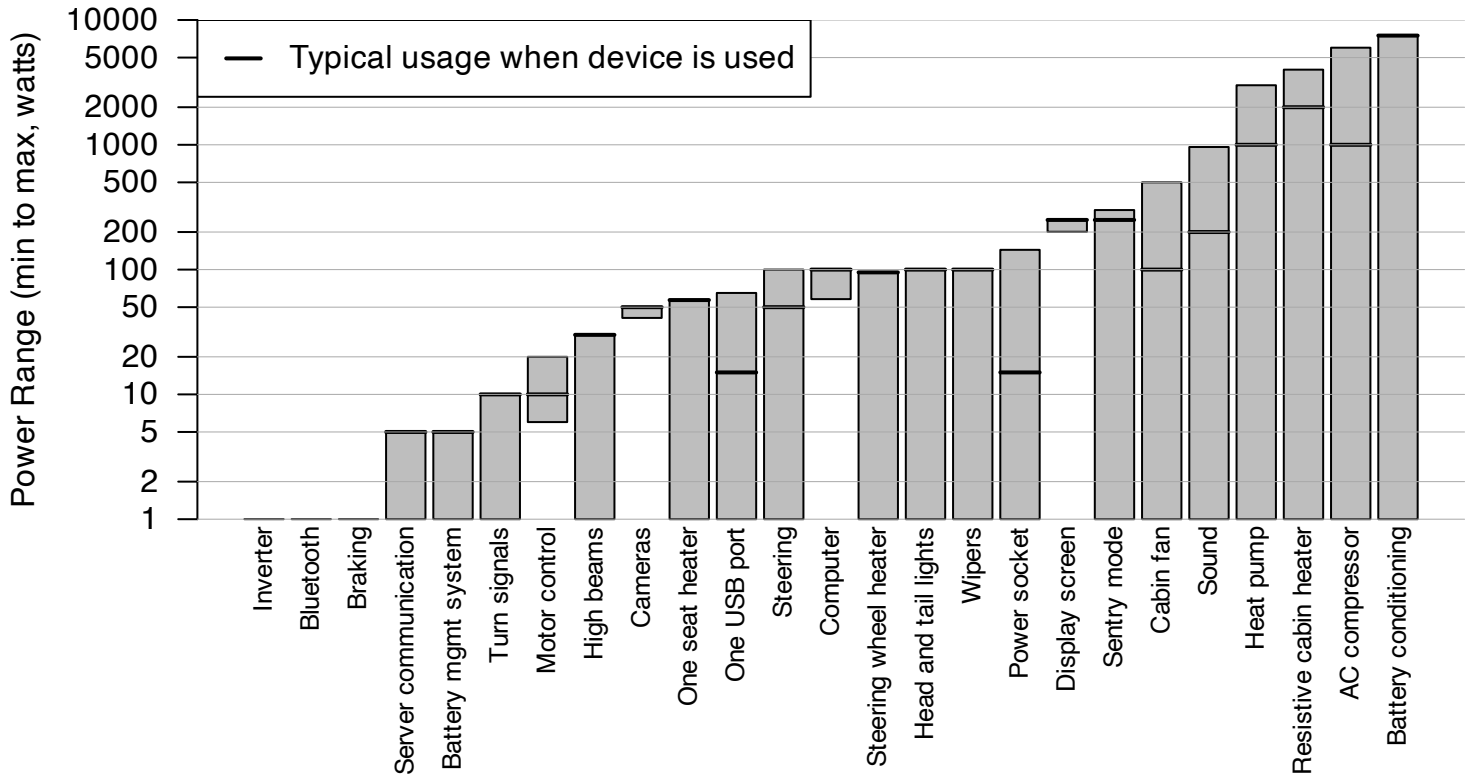
F: air density computed using density altitude

I: total power = baseline+rolling+drag power



Estimated power consumption by accessories

2018 Tesla Model 3 LR RWD



Drag battery/power consumption at various speeds

Assumptions: A: 2018 Tesla Model 3 LR RWD

C: weight 1928kg (with 113kg passengers)

E: frontal area 2.22sq. m.

G: batt degraded 12% for 66kWh capacity

I: 70% energy eff factor applied to compute drag, rolling, and baseline power

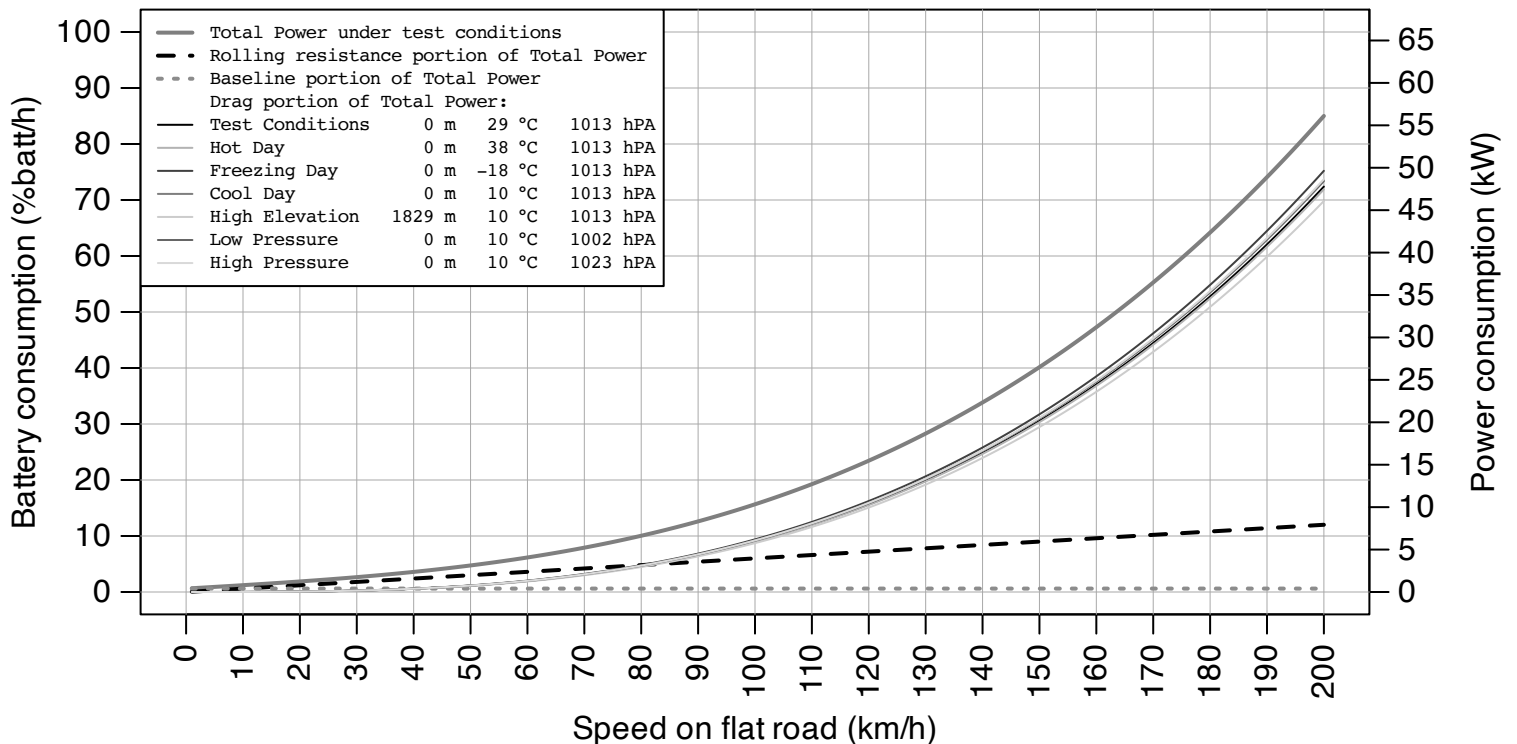
J: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power (test cond)}$

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

D: drag coef 0.22, roll coef 0.008, base power 0.61kW

F: air density computed using density altitude

H: 100% SOC is 66kWh



Estimated range on uphill and downhill grades at various speeds

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: weight 1928kg (with 113kg passengers)

D: batt degraded 12% for 66kWh capacity

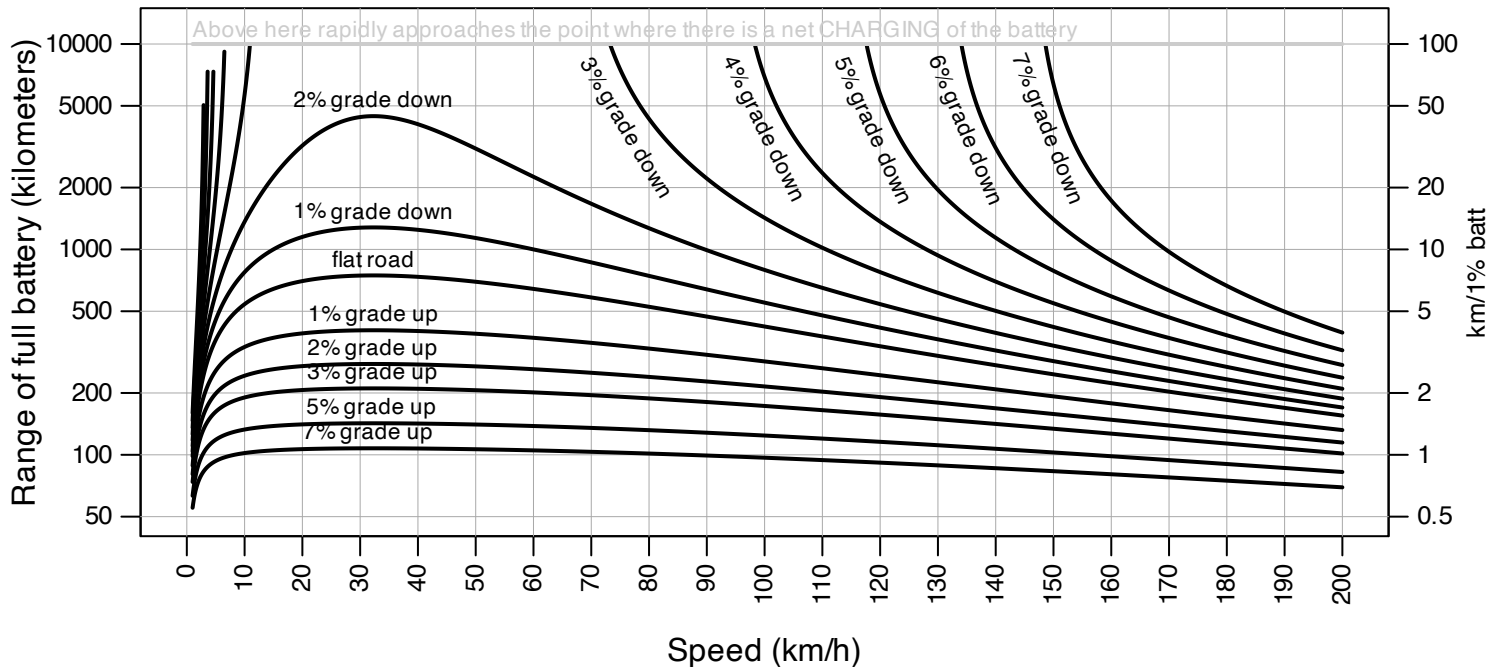
E: 100% SOC is 66kWh

F: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

G: Range = Speed x batteryCapacity_kWh / (Flat Road Power + Lift Power)

H: Lift Power = vehicleWeight_kg x N_per_kg x Speed_kmps x fracGrade x energyEfficiencyFactor

I: Flat Road Power = Est. Total Power P = baseline+rolling+drag power



Estimated range with uphill and downhill elevation changes at various speeds

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: weight 1928kg (with 113kg passengers)

D: batt degraded 12% for 66kWh capacity

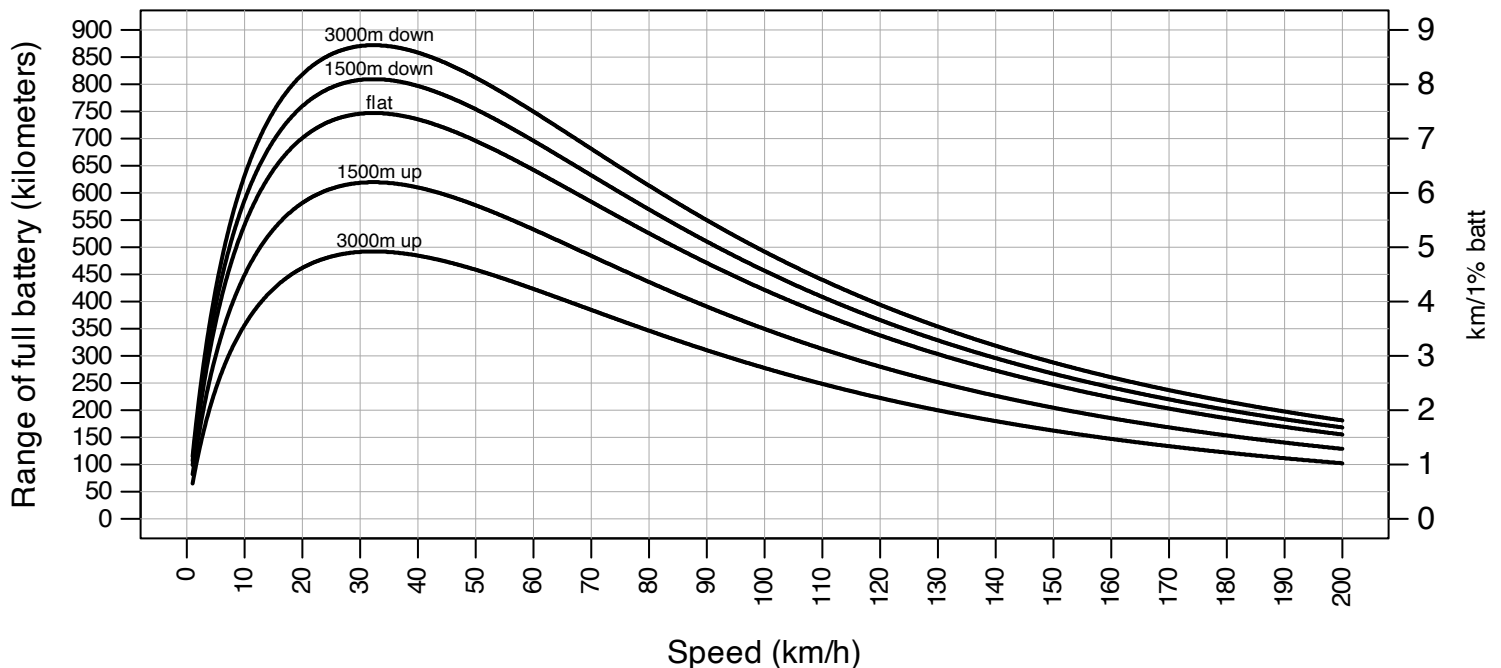
E: 100% SOC is 66kWh

F: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

G: Range = Speed x (batteryCapacity_kWh - Lift Energy) / Flat Road Power

H: Lift Energy = vehicleWeight_kg x N_per_kg x ElevChg_m x kWh_per_Nm x energyEfficiencyFactor

I: Flat Road Power = Est. Total Power P = baseline+rolling+drag power



Power consumption at various car and wind speeds

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: weight 1928kg (with 113kg passengers)

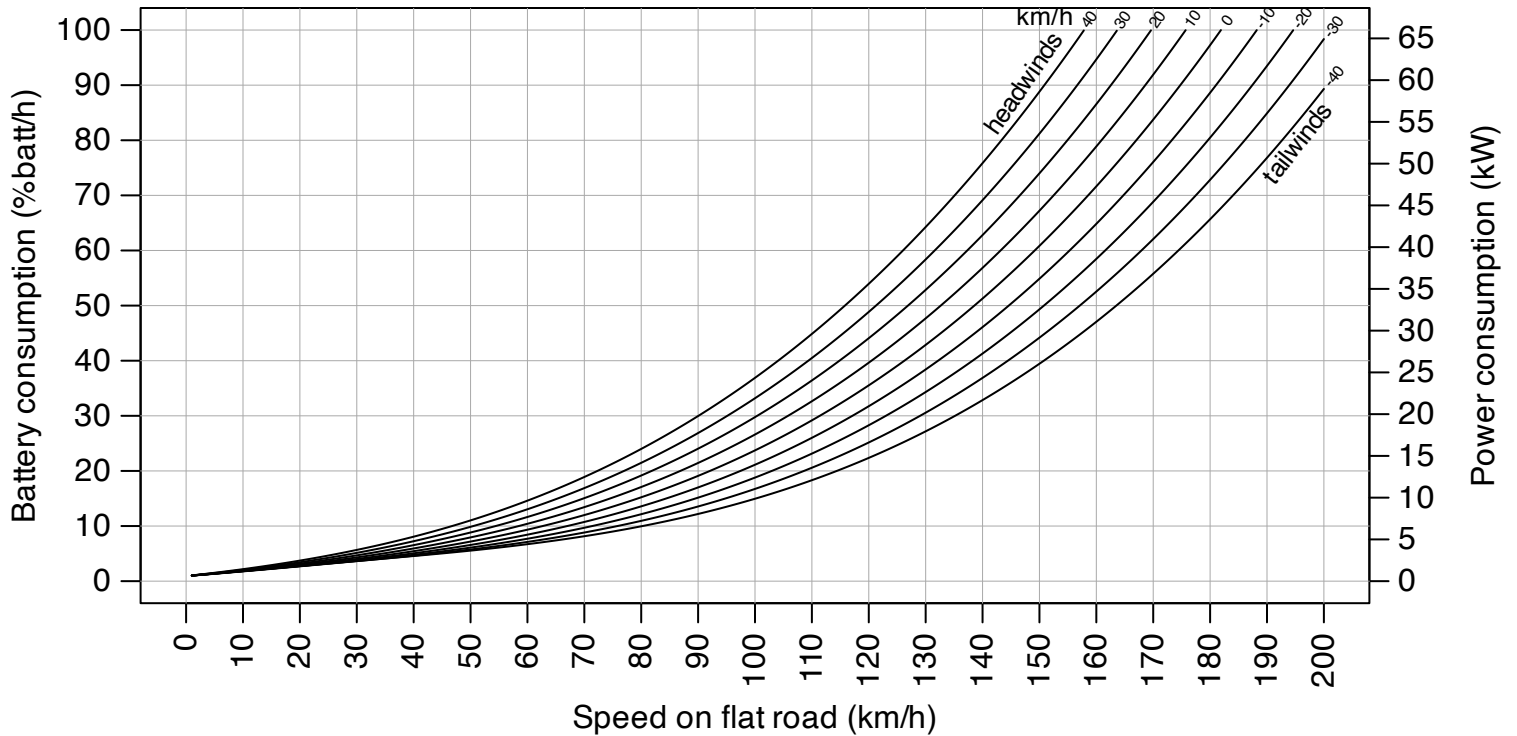
D: drag coef 0.22, roll coef 0.008, base power 0.61kW

E: batt degraded 12% for 66kWh capacity

F: air density computed using density altitude

G: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

H: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power (flat road)}$



Energy used per kilometer at various car and wind speeds

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: weight 1928kg (with 113kg passengers)

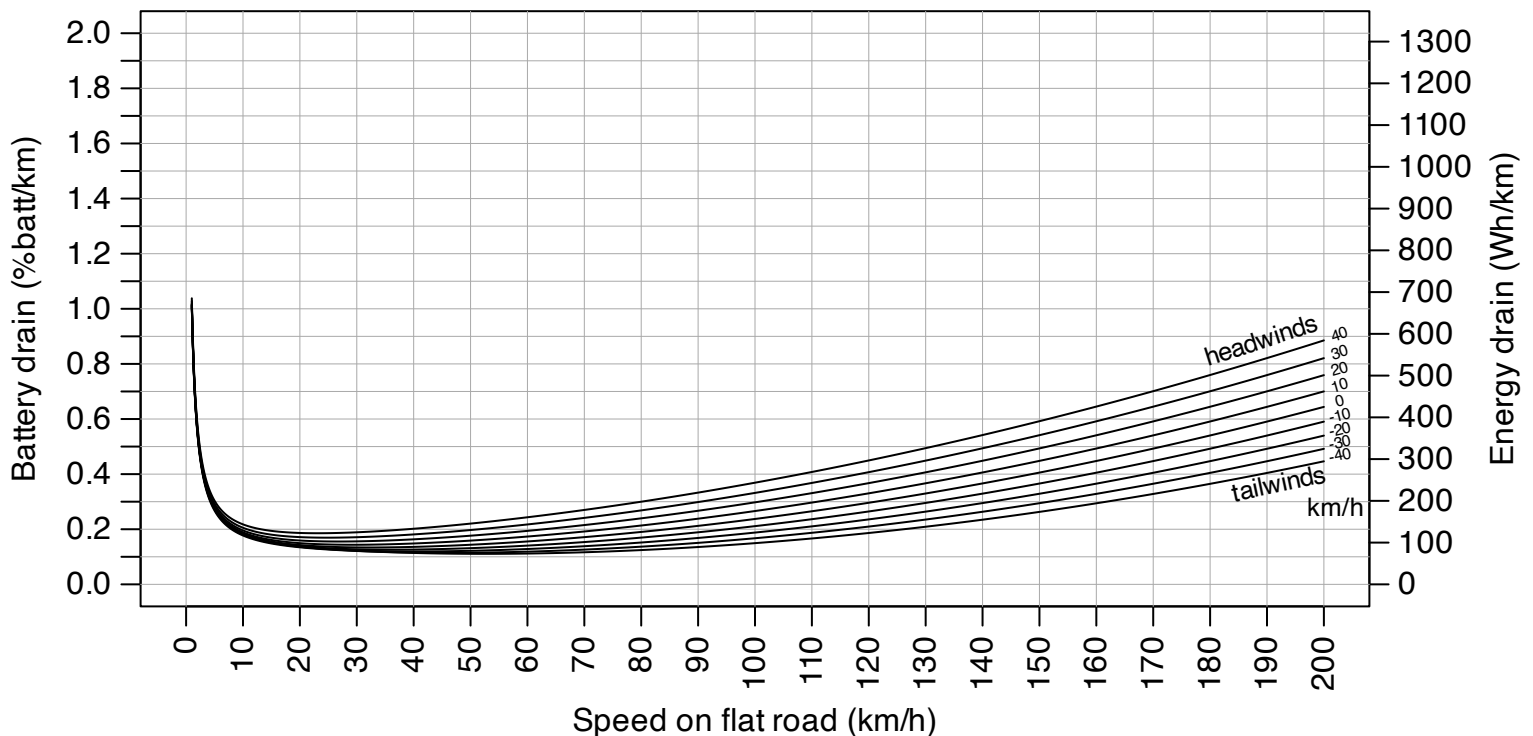
D: drag coef 0.22, roll coef 0.008, base power 0.61kW

E: batt degraded 12% for 66kWh capacity

F: air density computed using density altitude

G: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

H: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power (flat road)}$



Estimated range at various car and wind speeds

Assumptions: A: 2018 Tesla Model 3 LR RWD

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

C: weight 1928kg (with 113kg passengers)

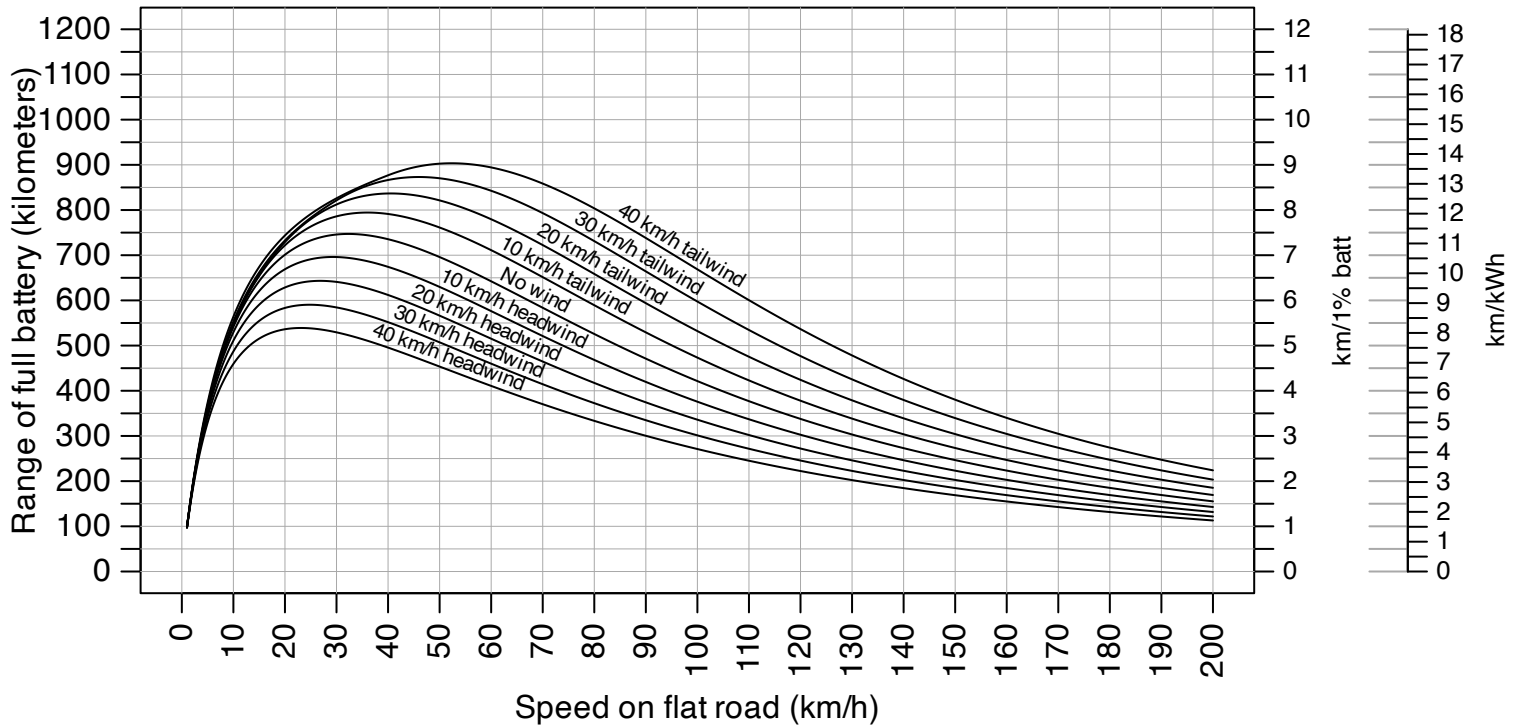
D: drag coef 0.22, roll coef 0.008, base power 0.61kW

E: batt degraded 12% for 66kWh capacity

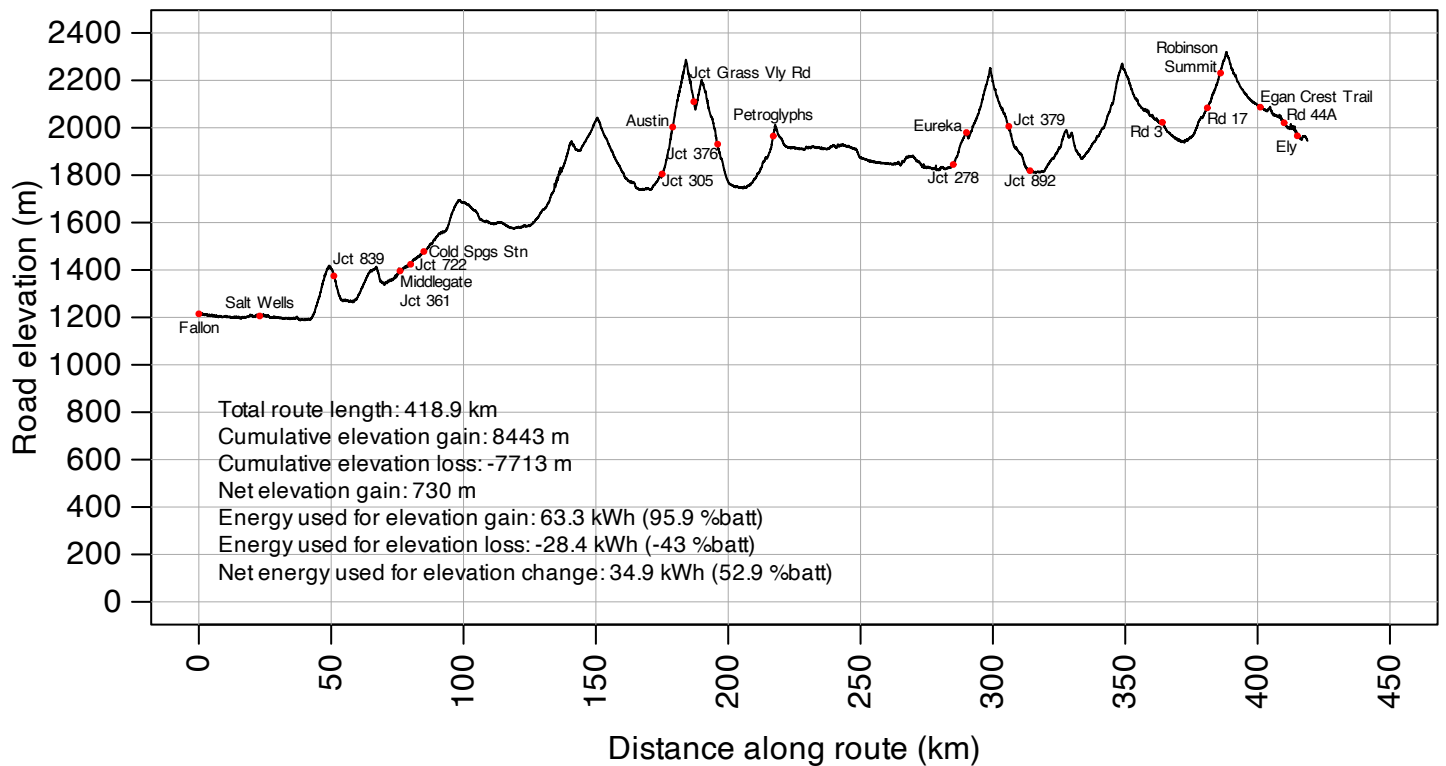
F: air density computed using density altitude

G: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

H: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power (flat road)}$



Elevation profile of Highway 50, Fallon to Ely, NV



Energy used to travel route at various car and wind speeds

Assumptions: A: 2018 Tesla Model 3 LR RWD

C: weight 1928kg (with 113kg passengers)

E: frontal area 2.22sq. m.

G: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

H: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power (flat road)}$

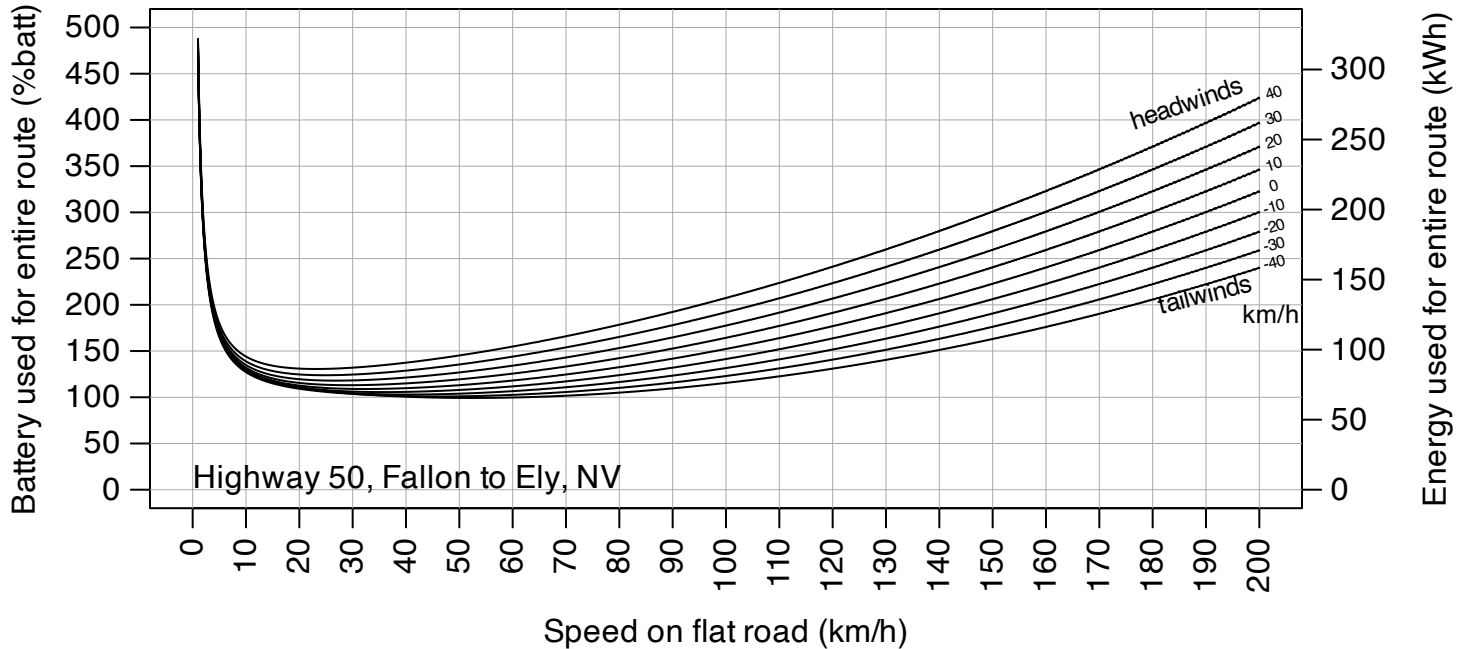
I: Lift Energy = vehicleWeight_kg x N_per_kg x elev_change_m x energyEfficiencyFactor

J: Route Energy = Flat Road Power x travel_time + Lift Energy

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

D: drag coef 0.22, roll coef 0.008 base power 0.61kW

F: batt degraded 12% for 66kWh capacity



Energy usage along travel route at various car speeds

Assumptions: A: 2018 Tesla Model 3 LR RWD

C: weight 1928kg (with 113kg passengers)

E: frontal area 2.22sq. m.

G: 70% net energy efficiency upon increased load, 70% regen energy recapture efficiency

H: Est. Total Power $P = \text{baseline} + \text{rolling} + \text{drag power (flat road)}$

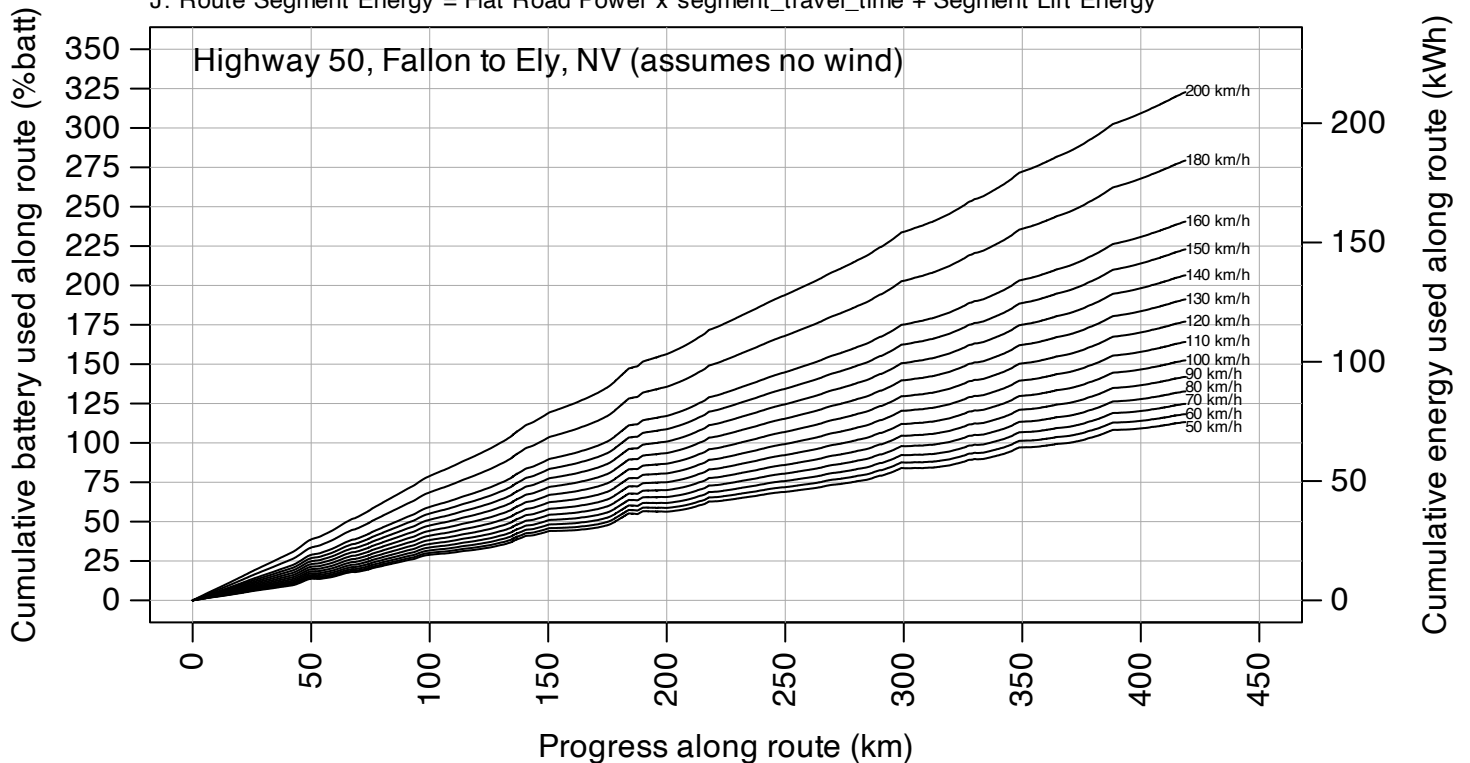
I: Segment Lift Energy = vehicleWeight_kg x N_per_kg x segment_elev_change_m x energyEfficiencyFactor

J: Route Segment Energy = Flat Road Power x segment_travel_time + Segment Lift Energy

B: Testing: flat road, 29°C, elev 0 m, 1013 hPA, wind 0 km/h

D: drag coef 0.22, roll coef 0.008 base power 0.61kW

F: batt degraded 12% for 66kWh capacity

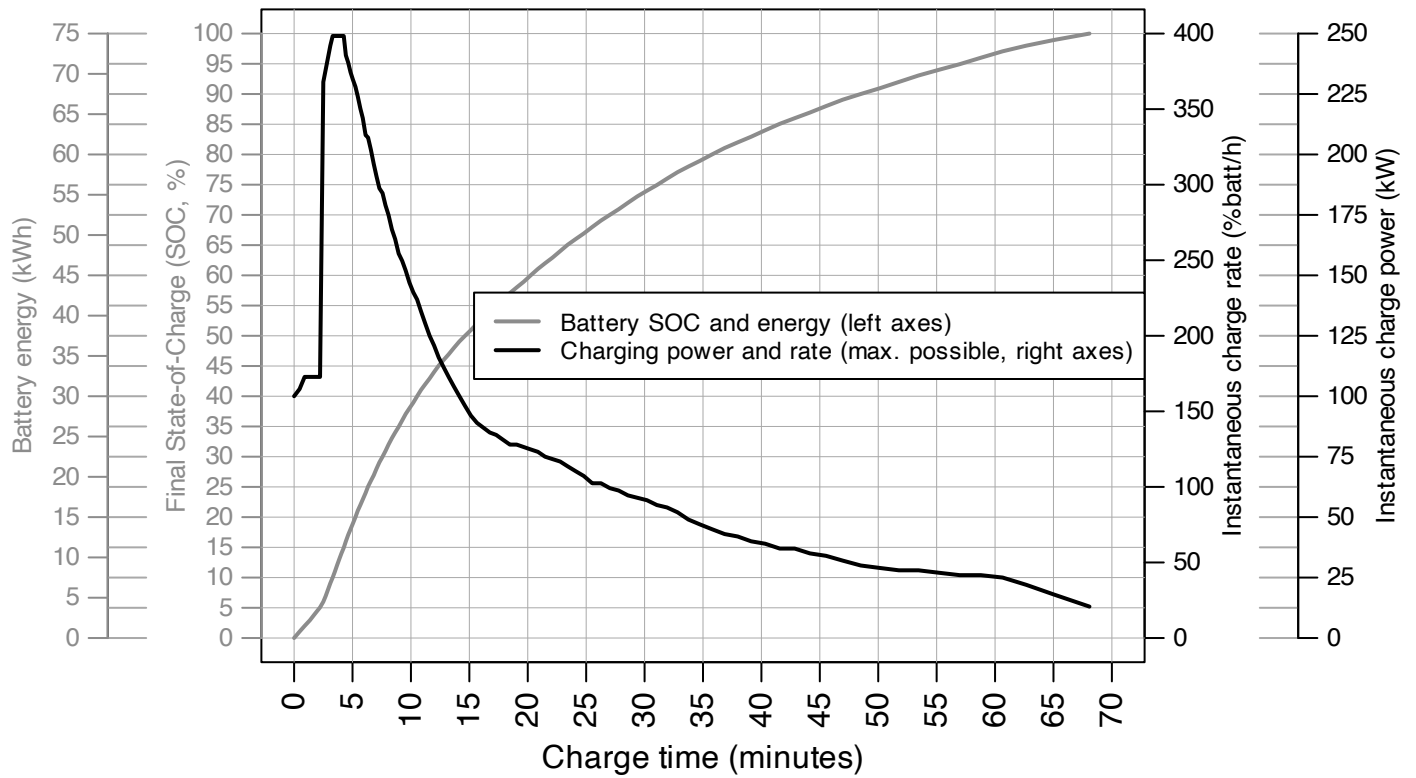


Instantaneous power, final SOC from 0% after charging X minutes at max charge power

Data is for maximum charge rate curve for Tesla Model 3 with 75 kWh battery, no degradation

(from https://evkx.net/models/tesla/model_3/model_3_long_range/chargingcurve)

(Assume charging is done at the maximum possible rate equal to the charging power shown on the right axis)

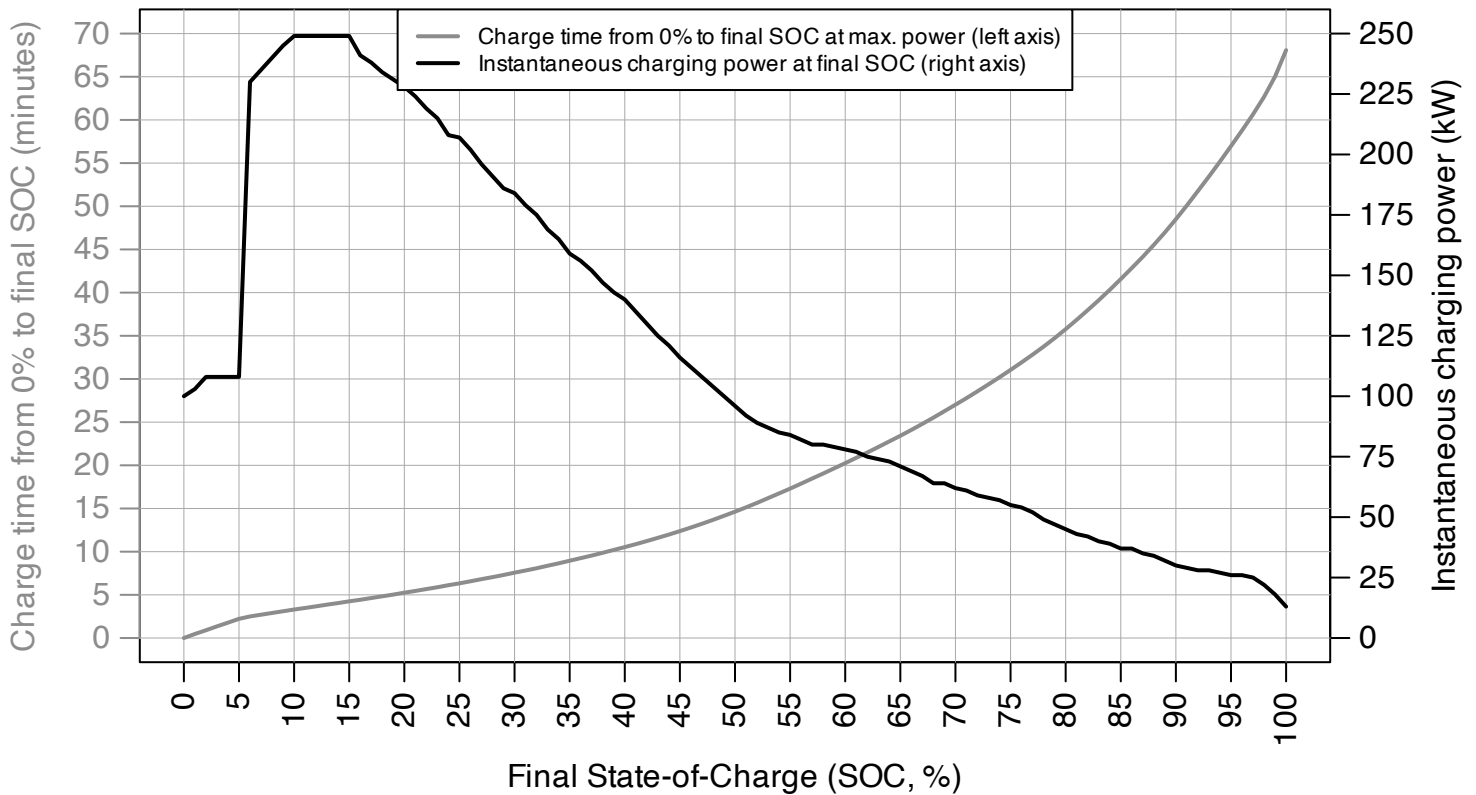


Instantaneous power, charge time from 0% to final SOC at max charge power

Data is for maximum charge rate curve for Tesla Model 3 with 75 kWh battery, no degradation

(from https://evkx.net/models/tesla/model_3/model_3_long_range/chargingcurve)

(Assume charging is done at the maximum possible rate equal to the charging power shown on the right axis)



Charge time from 0% to final SOC at various maximum charge powers

Data is for maximum charge rate curve for Tesla Model 3 with 75 kWh battery, no degradation

(from https://evkx.net/models/tesla/model_3/model_3_long_range/chargingcurve)

