Owning a Tesla
Going Electric

January 28th, 2019

Rochester, MN

Outline

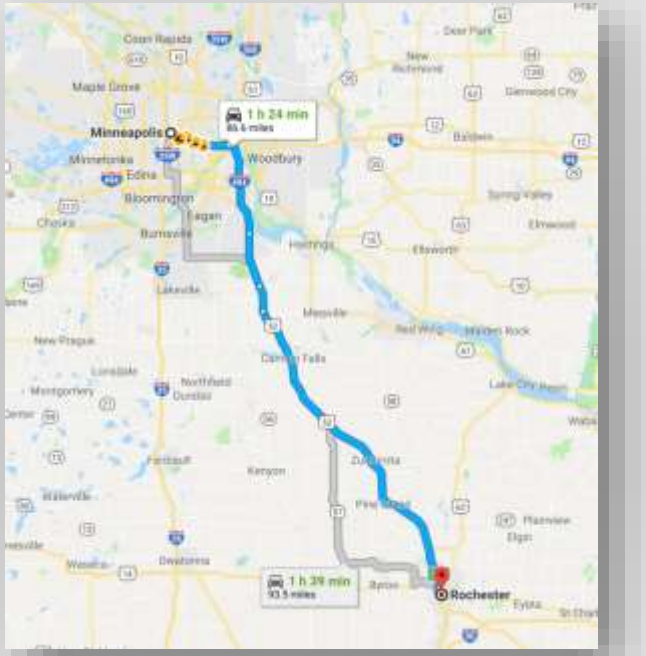
- Who am I
- Tesla Models
- Energy Refresher and Costs
- Theft Rate
- Tesla Supercharger Network
- Side Effects
- Maintenance

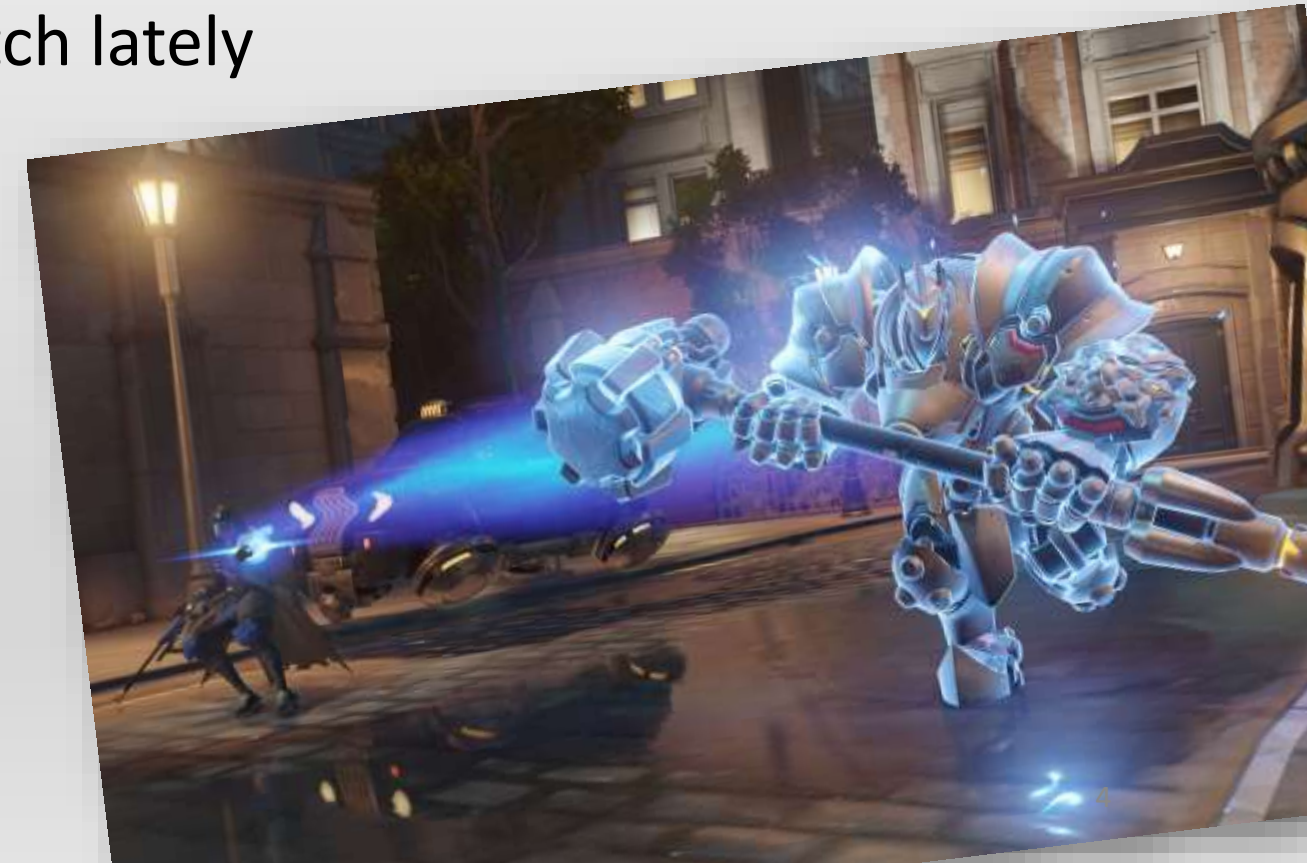
Intro for Eldon

- B.S. and M.S. at the UMN Twin Cities in Electrical Engineering
- Licensed Professional Engineer P.E. – Minnesota #47894
- Current Chair of IEEE Twin Cities Section 2019
- Verification Application Engineer at Synopsys
- Blog https://tenthousandfailures.com
- 6 Published Papers in Verification

Intro for Eldon

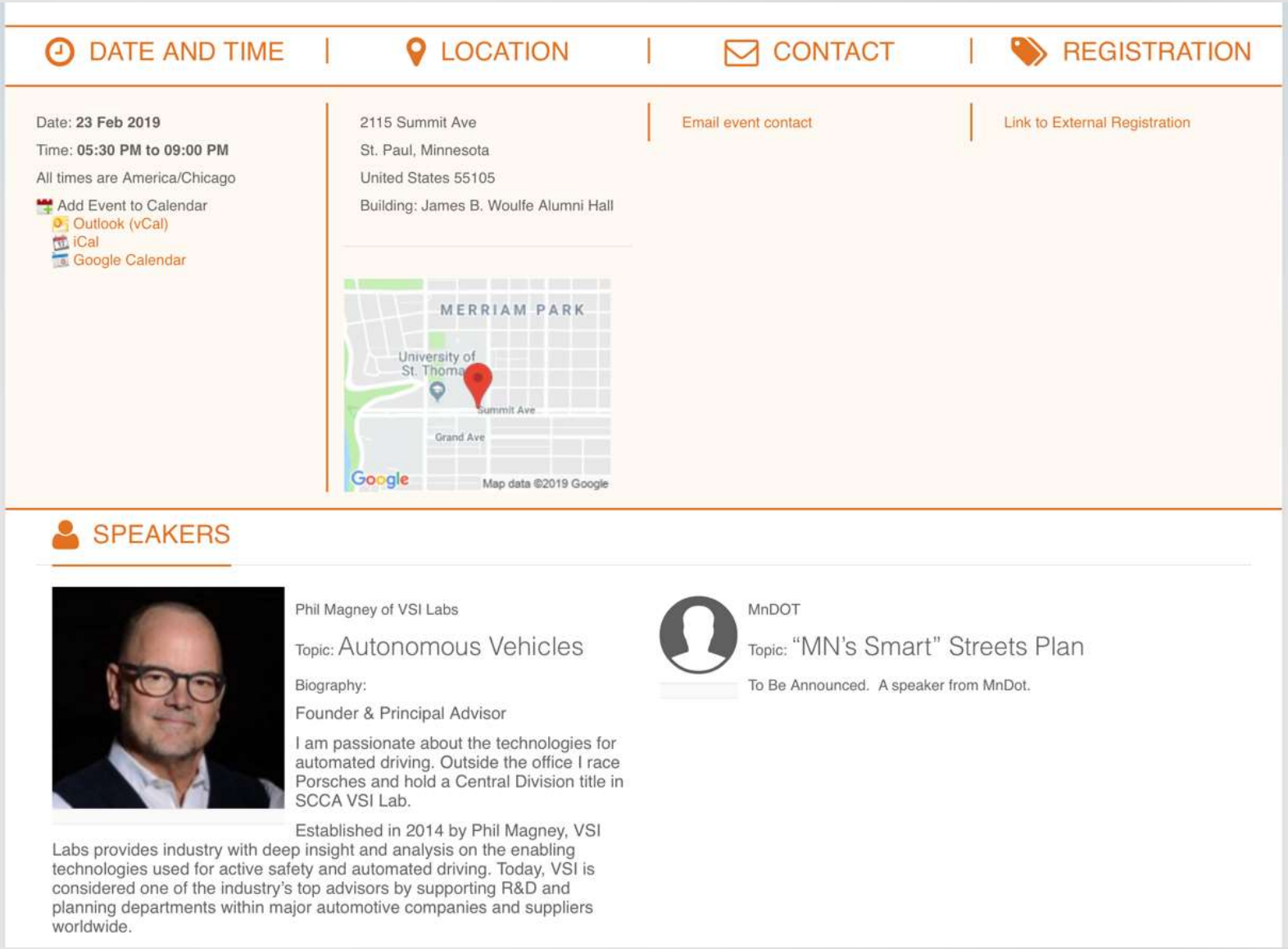
- Commutes about 200 miles round trip 3 times a week from Rochester to the Twin Cities / elsewhere
- Playing a lot of Blizzard's Overwatch lately





Plug for IEEE Twin Cities Banquet

Feb 23rd
At St. Thomas



DATE AND TIME | LOCATION | CONTACT | REGISTRATION

Date: **23 Feb 2019**
Time: **05:30 PM to 09:00 PM**
All times are America/Chicago
Add Event to Calendar
Outlook (vCal)
iCal
Google Calendar

2115 Summit Ave
St. Paul, Minnesota
United States 55105
Building: James B. Woulfe Alumni Hall

Email event contact

Link to External Registration

SPEAKERS

Phil Magney of VSI Labs

Topic: Autonomous Vehicles

Biography:

Founder & Principal Advisor

I am passionate about the technologies for automated driving. Outside the office I race Porsches and hold a Central Division title in SCCA VSI Lab.

Established in 2014 by Phil Magney, VSI Labs provides industry with deep insight and analysis on the enabling technologies used for active safety and automated driving. Today, VSI is considered one of the industry's top advisors by supporting R&D and planning departments within major automotive companies and suppliers worldwide.

MnDOT

Topic: "MN's Smart" Streets Plan

To Be Announced. A speaker from MnDot.

https://tc-ieee.org

My New Car History

2005
Toyota Corolla
29 mpg

2012
Toyota Prius
48 mpg

2018
Tesla Model S
102 mpge

My New Car History

2005
Toyota Corolla
29 mpg

2012
Toyota Prius
48 mpg

2018
Tesla Model S
102 mpge

mpge is dumb

Tesla Model 3
$35k to $64k

Tesla Model X
~~$75k~~ $97k to $128k


Tesla Model S
~~$69k~~ $85k to $123k

Table 1: New Vehicle Sales BMW of North America, LLC, December 2018

	Dec-18	Dec-17	%	Total 2018	Total 2017	%
i3	356	672	-47%	6,117	6,276	-2.5%
i8	97	80	21%	772	488	58.2%
2 Series	718	1,188	-39.6%	9,208	11,737	-21.5%
3 Series	3,184	5,556	-42.7%	44,578	59,449	-25.0%
4 Series	1,916	3,411	-43.8%	31,379	39,634	-20.8%
5 Series	4,756	4,743	0.3%	43,937	40,658	8.1%
6 Series	330	369	-10.6%	3,762	3,355	12.1%
7 Series	983	1,107	-11.2%	8,271	9,276	-10.8%
8 Series	223	0	0.0%	223	0	0.0%
Z4	0	0	0.0%	4	502	-99.2%
X1	3,411	4,454	-23.4%	29,060	30,826	-5.7%
X2	1,454	0	0.0%	16,154	0	0.0%
BMW passenger cars	**17,428**	**21,580**	**-19.20%**	**193,465**	**202,201**	**-4.3%**

BMW X2 below (X3 through X6 are classified as light trucks per BMW)

Tesla Model 3 versus BMW North America

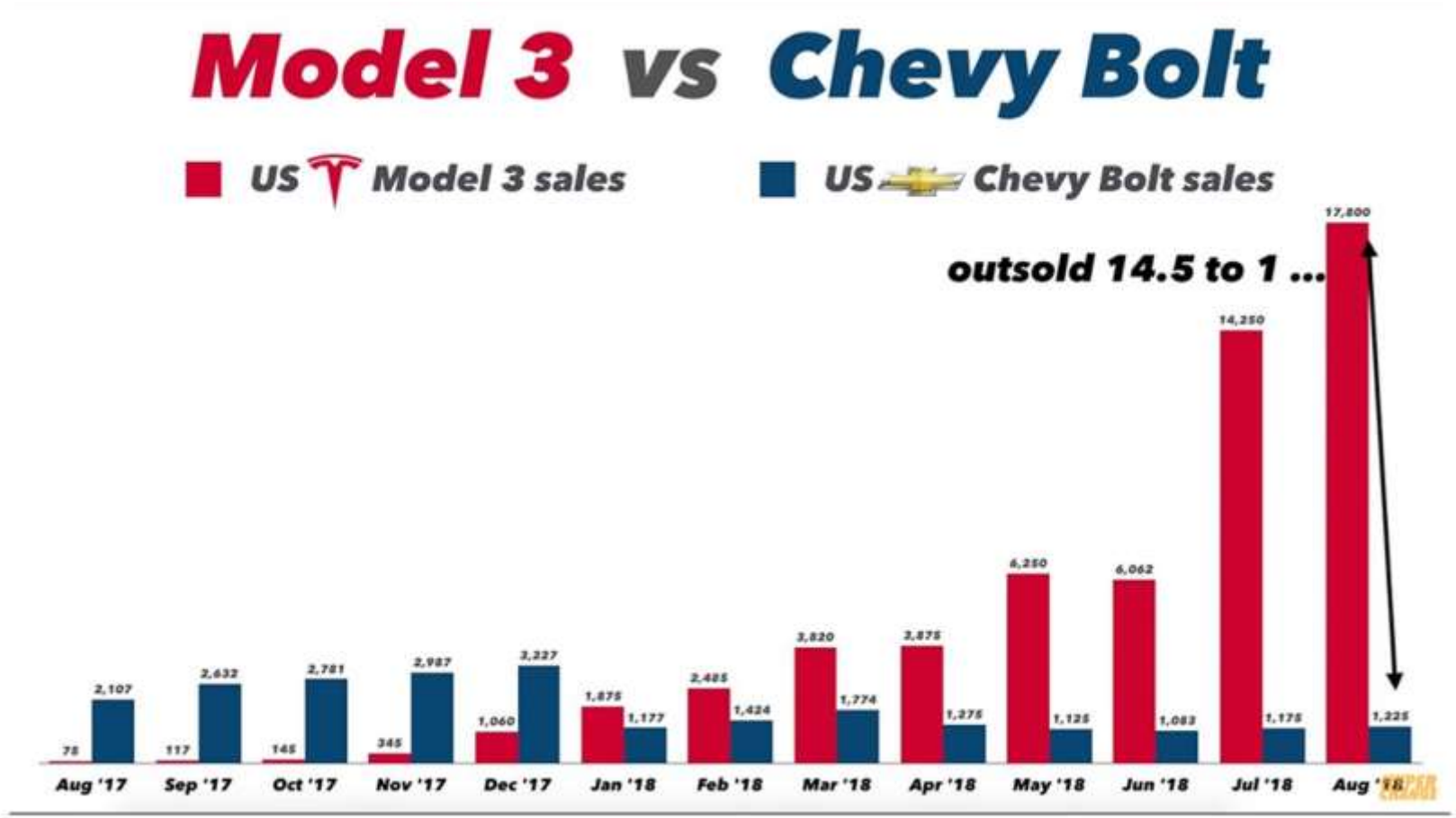
EV Model	January	February	March	April	May	June	July	August	September	October	November	December	2018 TOTAL
BMW i3	382	623	992	503	424	580	464	1,013	461	424	490	356	**6,712**
Chevy Bolt (est.)	1,177	1,424	1,774	1,275	1,125	1,083	1,100	1,400	1,449	1,775	2,071	2,366	**18,019**
Ford Focus Electric	73	70	137	83	88	50	46	7	4		1		**559**
Honda Clarity EV	203	104	48	7	37	126	112	29	59	68	69	86	**948**
Jaguar I-PACE										5	165	223	**393**
Nissan LEAF	150	895	1,500	1,171	1,576	1,367	1,149	1,315	1,563	1,234	1,128	1,667	**14,715**
Tesla Model 3 (est.)	2,400	3,030	2,750	4,777	7,600	4,063	13,500	17,000	24,040	17,000	18,000	25,570	**139,730**
Tesla Model S (est.)	2,300	2,000	2,430	2,200	2,500	2,530	2,100	2,500	3,400	2,100	2,500	3,100	**29,660**
Tesla Model X (est.)	2,200	1,930	2,040	2,200	2,300	2,570	2,300	2,400	2,300	2,200	2,550	3,300	**28,290**
Volkswagen e-Golf	178	198	164	128	76	32	18	32	14	62	230	222	**1,354**
100% Electric Total	**9,063**	**10,274**	**11,835**	**12,344**	**15,726**	**12,401**	**20,789**	**25,696**	**33,290**	**24,868**	**27,204**	**36,890**	**240,380**

- Tesla Model 3 alone was selling every month as much or more as all of BMW passenger (3/5/7 more) cars in North America since August 2018

All Battery Electric Vehicles for 2018

EV Model	Q4 2018	Q4 2017	% Change	YTD 2018	YTD 2017	% Change
BMW i3	1,270	1,641	-22.6%	6,712	6,458	3.9%
Chevy Bolt	6,212	8,995	-30.9%	18,019	23,971	-24.8%
Ford Focus Electric	1	349	-99.7%	559	1,796	-68.9%
Honda Clarity EV	223			948		
Jaguar I-PACE	393			393		
Nissan LEAF	4,029	490	722.2%	14,715	10,289	43.0%
Tesla Model 3	60,570	1,550	3807.7%	139,730	1,872	7364.2%
Tesla Model S	7,700	7,600	1.3%	29,660	31,942	-7.1%
Tesla Model X	8,050	7,200	11.8%	28,290	24,576	15.1%
Volkswagen e-Golf	514	835	-38.4%	1,354	3,420	-60.4%
100% Electric Total	**88,962**	**28,660**	**210.4%**	**240,380**	**104,324**	**130.4%**

Chevy Volt Discontinued Mar 2019
Chevy Bolt lives on



Energy Refresher

Newton : N

Joule : $N \cdot m$

Watt : $\frac{N \cdot m}{s}$

KWatt Hour : $1000 \cdot \frac{N \cdot m}{s} \cdot 3600$ (3600 seconds in hour)

or 3.6 MJ (Mega Joule)

Lifting a 2-liter of pop (2 kg) 1 m is 20 Joules

E

Practical Example

- A Tesla Model S 100D contains a 100 kWh Battery
- This is equivalent to

$$100 \cdot 3.6\ MJ = 360\ MJ$$

E

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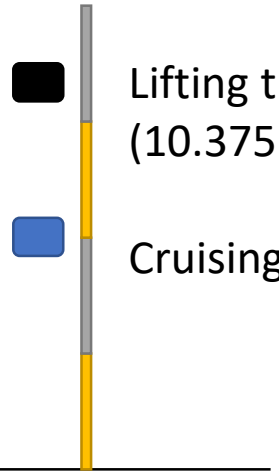
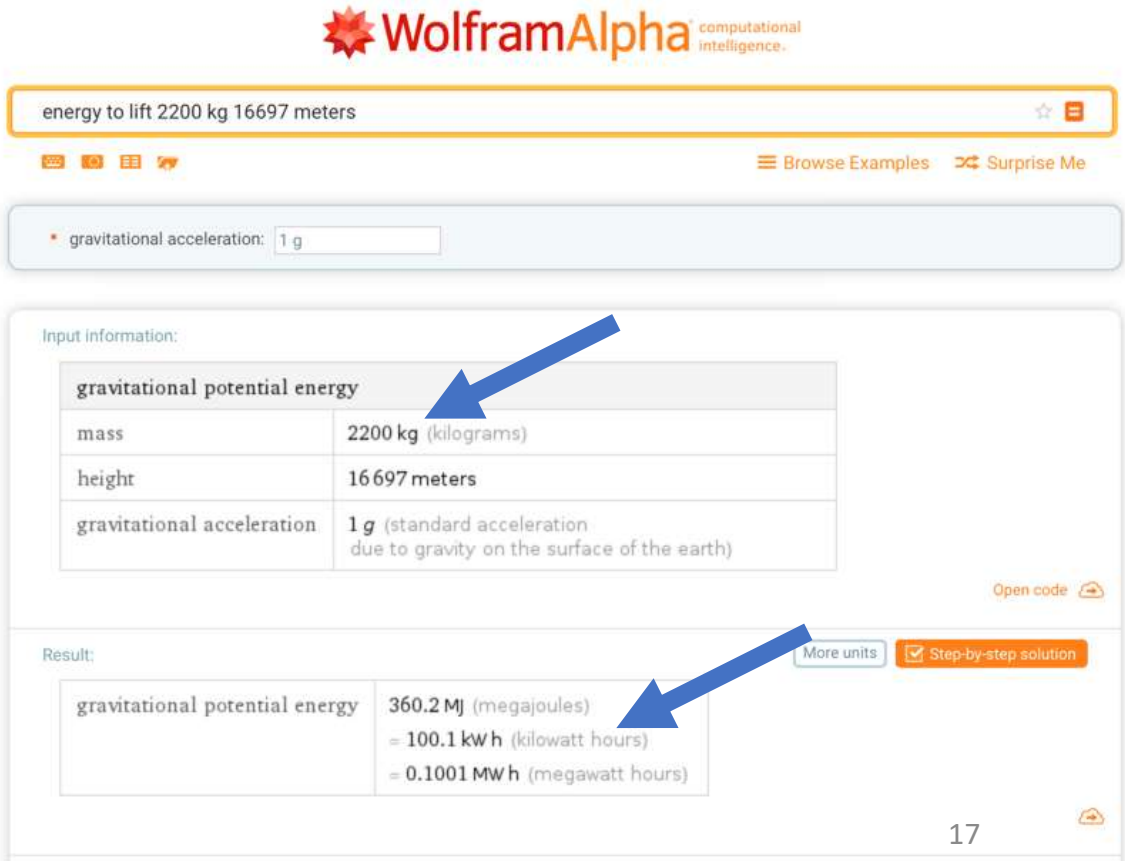


Lifting the Tesla Model S 100D 54780 Feet!
(10.375 miles)

Cruising Altitude of Planes 35000 Feet

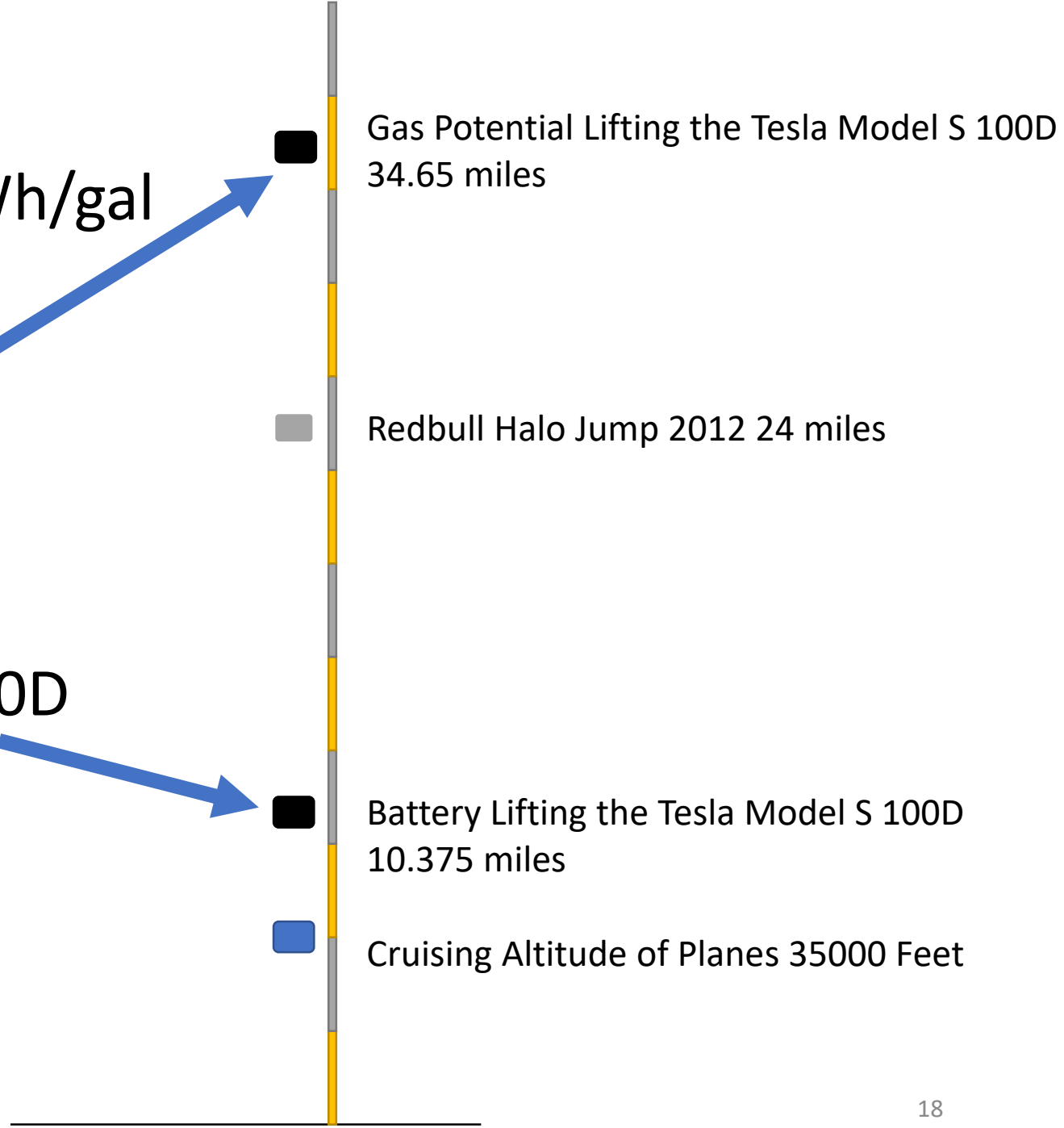


Gallon of Gasoline has 33.4 kWh/gal

334 kWh in 10 gallons of gas

Versus

100 kWh in a Tesla Model S 100D



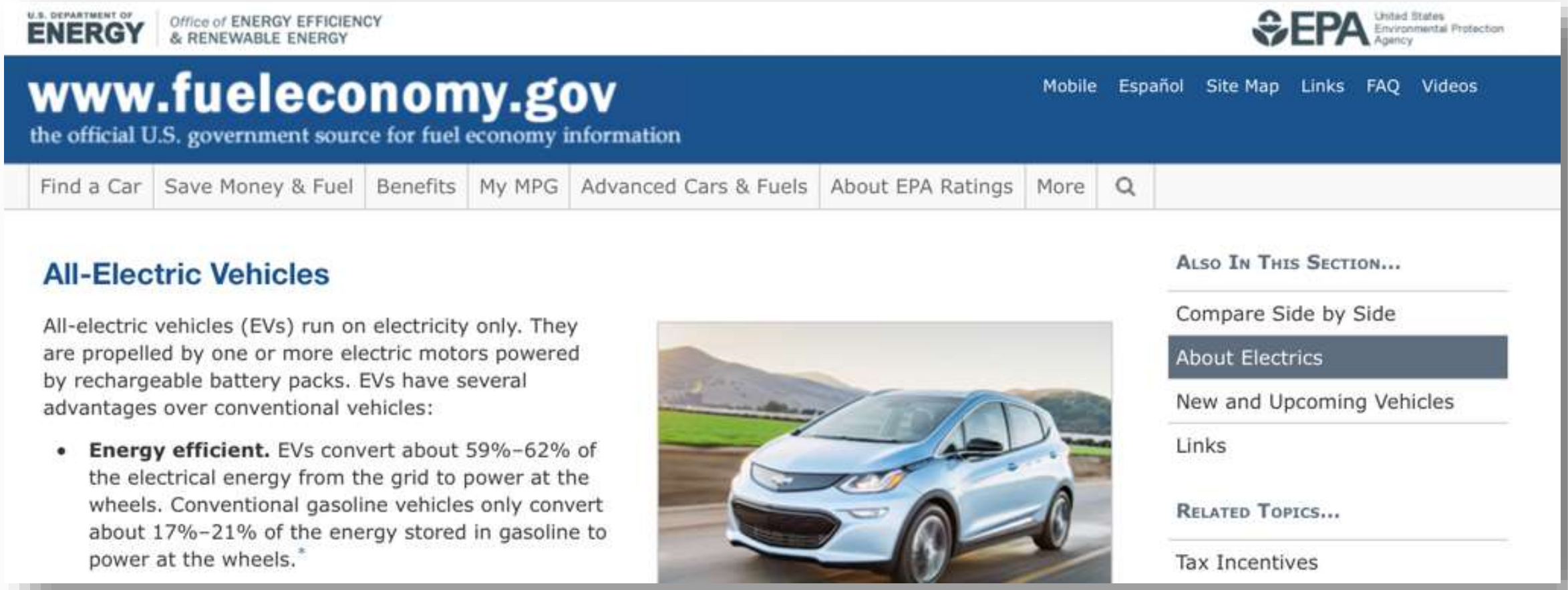
What is your Home Energy Usage

- How much electricity does an American home use?

- In 2016, the average annual electricity consumption for a U.S. residential utility customer was 10,766 kilowatthours (kWh), an average of 897 kWh per month. Louisiana had the highest annual electricity consumption at 14,881 kWh per residential customer and Hawaii had the lowest at 6,061 kWh per residential customer.

About 7 full charges of a Tesla Model S 100D a month

H



59% efficiency from grid to wheels for EV -> 79% efficiency from battery to wheels
17% efficiency from gas to wheels for gasoline

79% versus 17% is 4.6x more efficient motor and drivetrain

334 kWh in 10 gallons of gas -> 260 miles of range in Toyota Avalon
1280 Wh/mi *(using rated 26 MPG)*

Versus

100 kWh in a Tesla Model S 100D -> 335 miles of range
299 Wh/mi

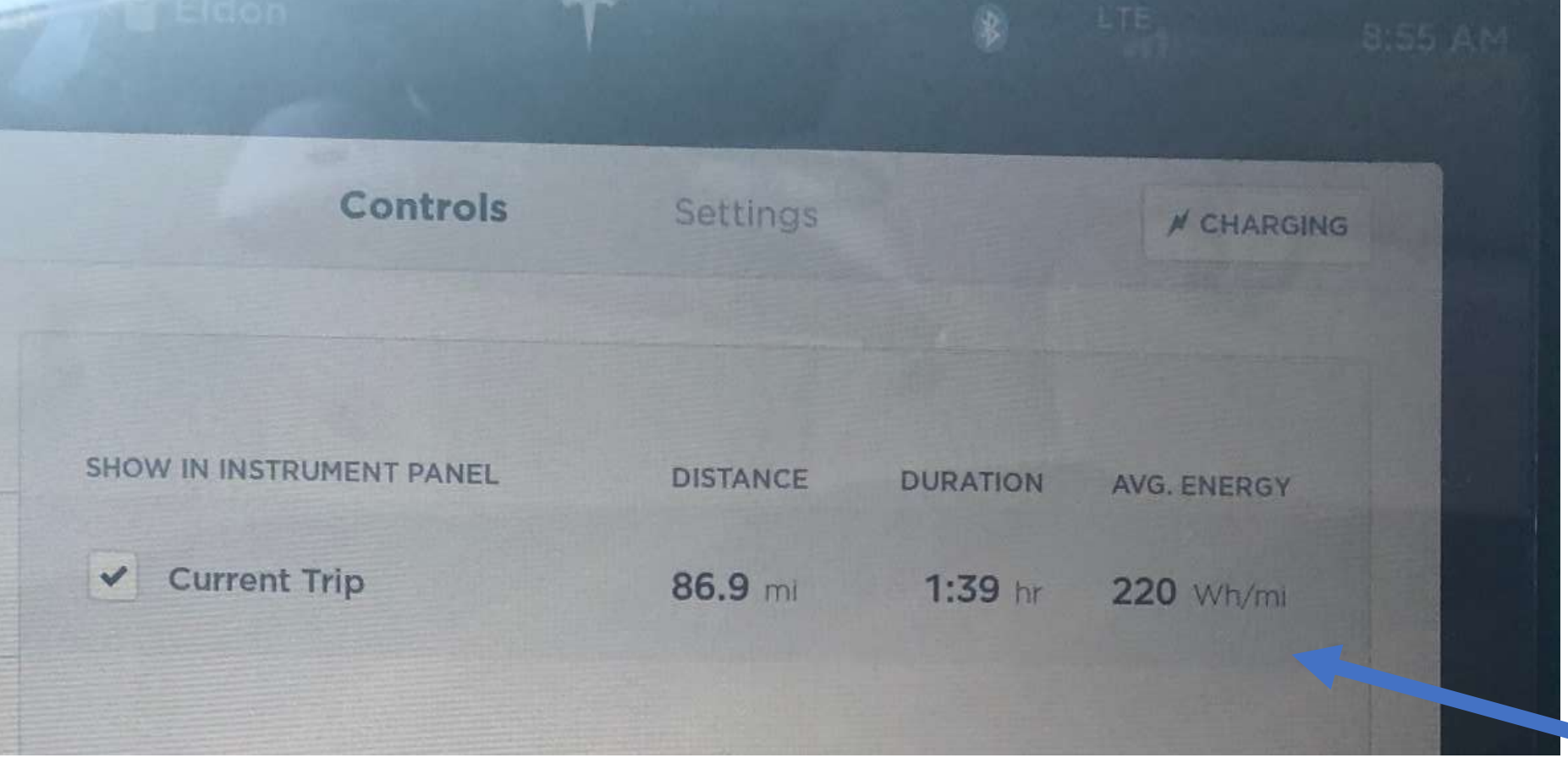
4.3x energy efficiency difference


Eldon
7:55 P
Controls
Settings
CHARGING
SHOW IN INSTRUMENT PANEL
DISTANCE
DURATION
AVG. ENERGY
Current Trip
6.0 mi
11 min
368 Wh/mi
SHOW IN INSTRUMENT PANEL
DISTANCE
TOTAL ENERGY
AVG. ENERGY
Since Last Charge
233.8 mi
62.5 kWh
268 Wh/mi
Trip A
1,519.8 mi
421.7 kWh
277 Wh/mi
Trip B
5,631.9 mi
1,519.1 kWh
270 Wh/mi
Odometer
7,569.1 mi
Reset Current Trip
Reset Trip A
Reset Trip B
LIGHTS
FRONT TRUNK
DOME
AMBIENT

I travelled 233.8 Miles
and used 62.5 kWh
which results in an efficiency
of 268 Wh/mi

I've averaged 270 Wh/mi for over the last 5600 miles

(equivalent to getting 370 mile range)



It is possible to get better highway energy use by driving a bit slower (65 mph vs 73) and drafting semis – Rochester to Edina – *454 mile rang if you drove like that*

F

Model year	Model	EPA highway dyno score at 48.3 mph	Advertised EPA rated range	At 55 mph	At 60 mph	At 65 mph	At 70 mph	At 75 mph	At 80 mph
2018	Model S 100D 19"	455.4 mi	335 mi	396	365	336	308	284	259
2018	Model 3 LR, 18" -aero	454.7 mi	310 mi	395	365	336	307	283	259
2018	Model 3 LR, 18" +aero	474.7 mi	310 mi	413	381	350	321	296	270

Power to overcoming aerodynamic drag goes by the **cube** of speed

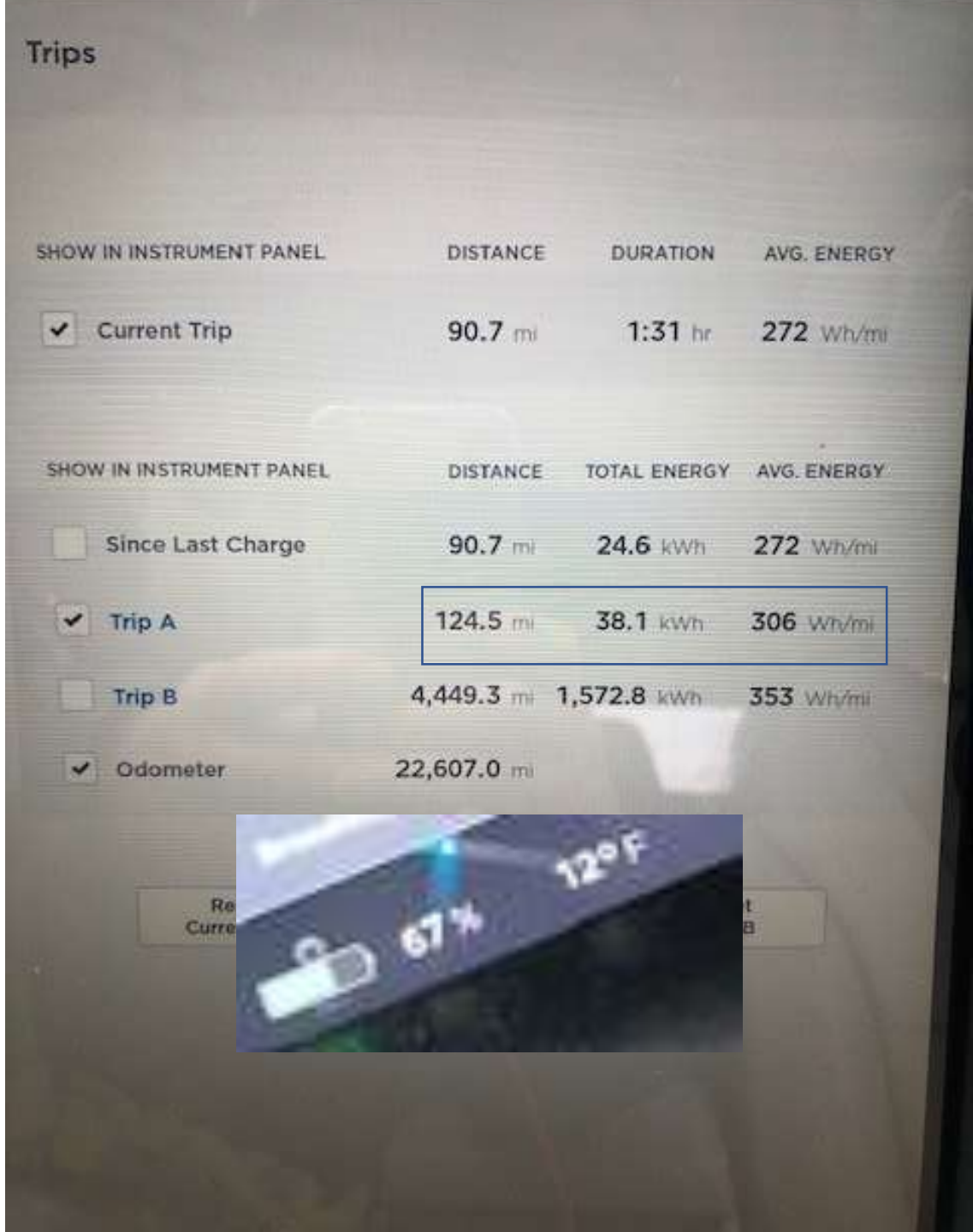
2.5x drag at 75 mph vs 55mph
40% more range at 55 mph than at 75 mph

Cold Weather 10F

- In 10F weather over 124 mile trip
- **Almost all highway** Roch to Twin Cities
- Still able to get **306** Wh/mi

Car rated for EPA estimates

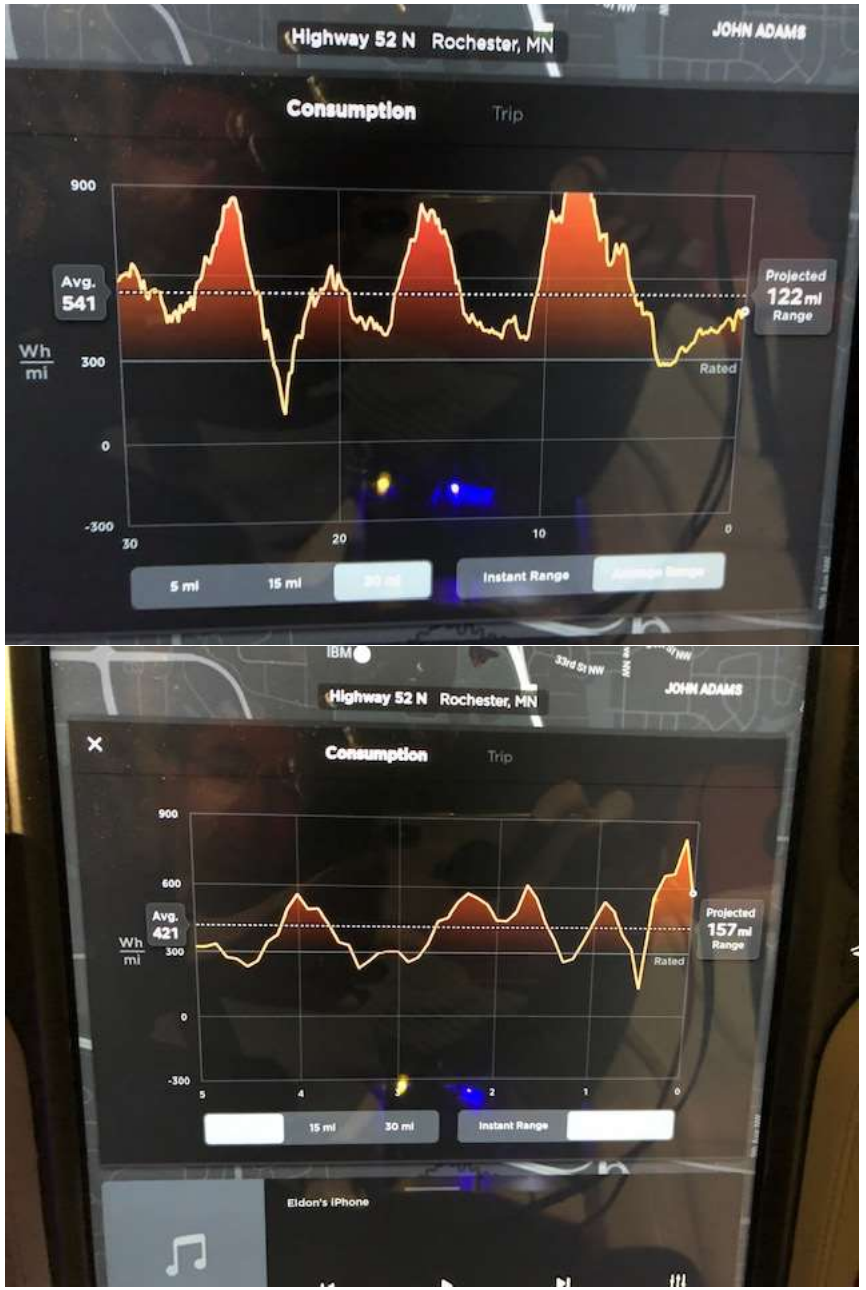
at 300 Wh/mi



Even Colder Jan 19 (0 F)

- In 0 F for driving a **city miles** with constant heater
- All within Rochester
- 541 Wh/mi over 30 mile average
- 421 Wh/mi over 05 mile average

- Worst case, you would get **184 miles** (541 Wh/mi) on a Tesla Model S **versus 335 EPA**



Owning an Electric Vehicle in Minnesota

- Use heated seats! Much more efficient and some other benefits
- Preheat the car in the garage – plus bonus
- Keep your charging cable in your car in case you need it or to top off at relatives house
- Want more range just go a little slower
  - *40% more range at 55 mph than at 75 mph*

J

US Mileage by Age and Gender

U.S. Department of Transportation
Federal Highway Administration

FHWA Home | Feedback

OHPI

Office of Highway Policy Information

Average Annual Miles per Driver by Age Group

Age	Male	Female	Total
16-19	8,206	6,873	7,624
20-34	17,976	12,004	15,098
35-54	18,858	11,464	15,291
55-64	15,859	7,780	11,972
65+	10,304	4,785	7,646
Average	16,550	10,142	13,476

Back to ONH page

This page last modified on March 29, 2018

ICE Car Fuel Cost Calculation

Miles Per Year	30000	
Gas Cost Per Gallon	$2.76	Gas Buddy Minnesota 09/08 : $3.23 Premium
Miles Per Gallon	26	Toyota Avalon Combined mpg
Cost Per Year	$3185	

$$\frac{Miles\ Per\ Year}{Miles\ per\ Gallon} \times Cost\ of\ Gas$$

Electric Vehicle Fuel Cost Calculation

Miles per Year	30000	
Cost per kWh	$0.10	Rochester Standard Rate
Charge Efficiency	80%	From Electrical Mains to Battery (1.25)
wh per mile	300	Tesla Model S
KWh Consumed	8640	8.6 Mwh!
Cost per Year	$1125	

$$Kwh\ Consumed = \frac{(Miles\ per\ Year \times wh\ per\ Mile)}{1000 \times Cost\ per\ kWh} \times 1.25$$

$$Cost\ per\ Year = kWh\ Consumed \times Cost\ per\ kWh$$

Fuel Cost Comparison

$3185 ICE vs. $1125 Electric

$2060 a year (2.83x less)

Savings Over 10 Years of Ownership

Toyota Avalon (26 mpg)	$20600
Ford F150 4WD (19 mpg)	$32330
BMW 7 Series (23 mpg) *premium	$30880

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What will gas prices be in 2023 or 2028?

Fuel Cost Comparison

$3185 ICE vs. $1125 Electric

$2060 a year (2.83x less)

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H

Fuel Cost Comparison

$3185 ICE vs. $1125 Electric

$2060 a year (2.83x less)

FYI Xcel in the Twin Cities has off-peak EV charging of 5 cents versus Rochester 10 cents.

Over 10 years that is an extra $5625 saved beyond the below!

Savings Over 10 Years of Ownership

Toyota Avalon (26 mpg)	$20600
Ford F150 4WD (19 mpg)	$32330
BMW 7 Series (23 mpg) *premium	$30880

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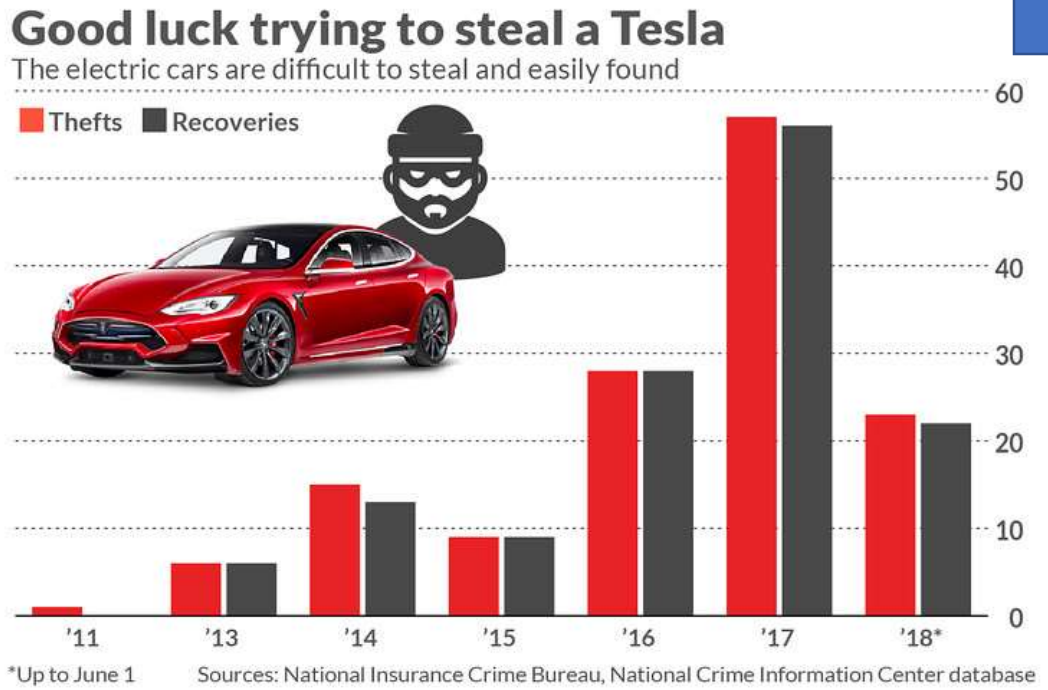
Theft Rate of Tesla

- 2016 Recovery Rate 100% for Teslas
- 2016 Recovery Rate 58.4%
  for all Vehicles



"I'm wondering if the thieves' intellect might have been overwhelmed just sitting in a Tesla, much less figuring out how to operate it for any length of time."

Frank Scafidi
Director of Public Affairs at the
National Insurance Crime Bureau

Home Charging

How Much to Install a Tesla Wall Connector

$50 to $1500

09/2018 $2.75 a gallon

Charging Estimator

MODEL S | MODEL X

05:48
Time

$8.03
Cost

$18.16
Gasoline Savings

Distance Driven

0 150 300

200 miles

Price / kWh: $ 0.12

Price / Gallon: $ 2.75

Type of Travel

Daily | Roadtrip

Charging Option(s)

Wall Connector
11.5 kW

Charge times are approximate. Charge cost assumes national average of $0.12 per kilowatt hour. Gasoline savings assumes 21 mpg.

A 60 amp circuit breaker is recommended for most Wall Connector installations. Learn more about the Wall Connector on our support page.

Charging Estimator

MODEL S | MODEL X

01/2019 $2.05 a gallon

05:48	$8.03	$11.50
Time	Cost	Gasoline Savings

Distance Driven

0 150 300

200 miles

Price / kWh: $ 0.12

Price / Gallon: $ 2.05

Type of Travel

Daily | Roadtrip

Charging Option(s)

Wall Connector
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Charging Estimator

MODEL S | MODEL X

Parity at $0.85 a gallon

05:48	$8.03	$0.07
Time	Cost	Gasoline Savings

Distance Driven

0 150 300

200 miles

Price / kWh: $ 0.12

Price / Gallon: $ 0.85

Type of Travel: **Daily** | Roadtrip

Charging Option(s): **Wall Connector** 11.5 kW

Charge times are approximate. Charge cost assumes national average of $0.12 per kilowatt hour. Gasoline savings assumes 21 mpg.

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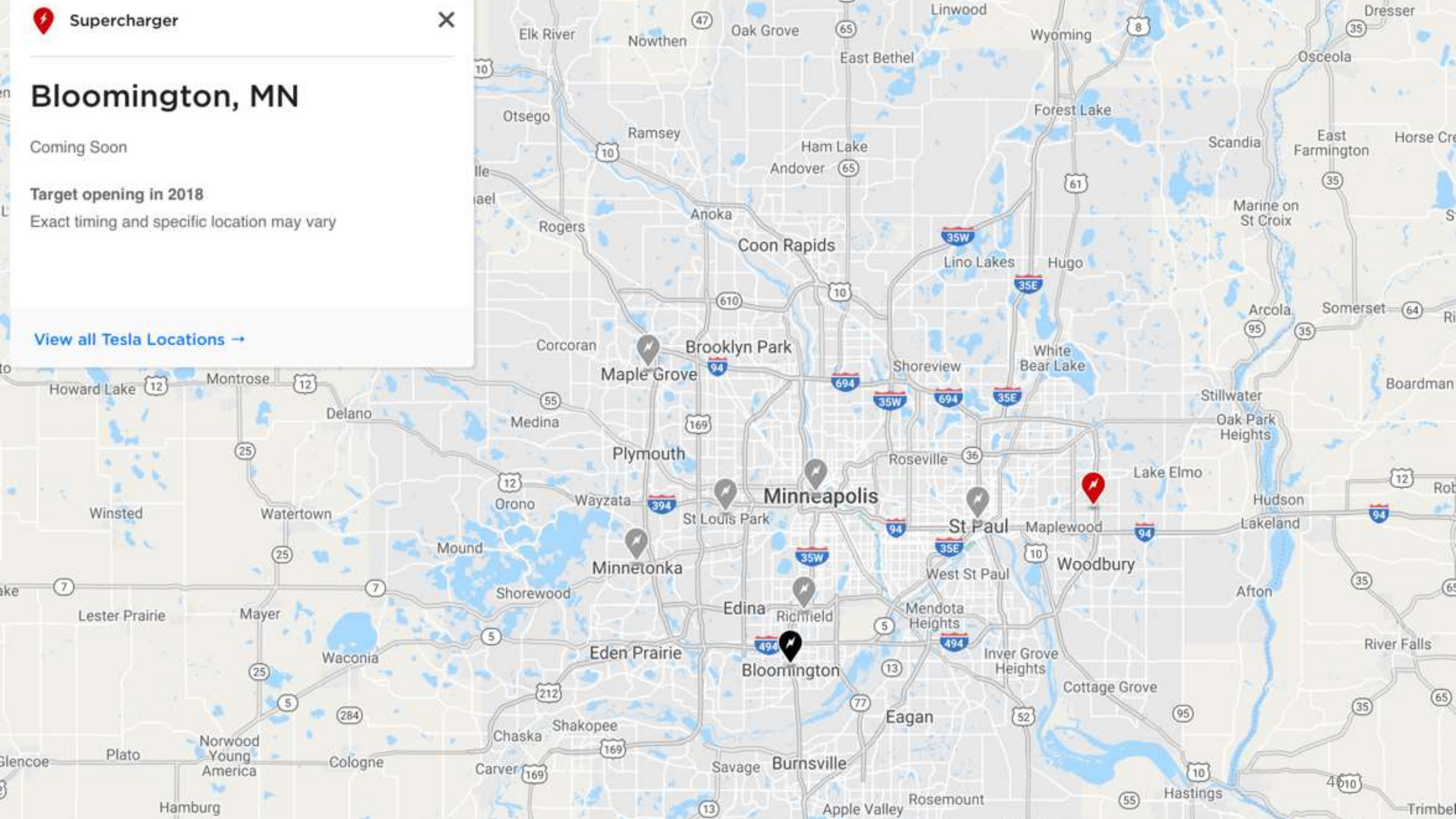
Tesla Supercharger Network


TESLA
VEHICLES


Supercharger
Bloomington, MN
Coming Soon
Target opening in 2018
Exact timing and specific location may vary
View all Tesla Locations →
Elk River
Nowthen
Oak Grove
Linwood
Wyoming
East Bethel
Dresser
Osceola
Otsego
Ramsey
Ham Lake
Andover
Forest Lake
Scandia
East Farmington
Horse Cre
Anoka
Rogers
Coon Rapids
Lino Lakes
Hugo
Marine on St Croix
Arcola
Somerset
Corcoran
Brooklyn Park
Maple Grove
Shoreview
White Bear Lake
Boardman
Howard Lake
Montrose
Delano
Medina
Stillwater
Oak Park Heights
Plymouth
Roseville
Lake Elmo
Minneapolis
Orono
Wayzata
St Louis Park
St Paul
Maplewood
Hudson
Lakeland
Winsted
Watertown
Mound
Minnetonka
West St Paul
Woodbury
Shorewood
Afton
Lester Prairie
Mayer
Edina
Richfield
Mendota Heights
Waconia
Eden Prairie
Bloomington
Inver Grove Heights
River Falls
Cottage Grove
Eagan
Shakopee
Chaska
Norwood Young America
Plato
Cologne
Carver
Savage
Burnsville
Hastings
Glencoe
Hamburg
Apple Valley
Rosemount
Trimbel

Mobile Service is available in this area. Details

Enter location

Destination Charging

TownePlace Suites by Marriott Rochester

2829 43rd St NW
Rochester, Minnesota 55901
Driving Directions

https://www.marriott.com/hotels/travel/rstts-towneplace-suites-rochester/ →

Phone	(507) 281-1200
Roadside Assistance	(877) 798-3752

Charging
4 Tesla Connectors, up to 16kW.
Available for customers. Self park.

View all Tesla Locations →

Genoa
Douglas
Byron
Salem Corners
Roches
12th St SW
N Broadway Ave

Filter By: Stores and Galleries | Service Centers | Superchargers | Destination Charging

1342 Stations
11013 Superchargers


Minneapolis
Chicago
Indianapolis
Nashville
Atlanta
Jacksonville
Orlando
Tampa
Kansas City
Dallas
Austin
Houston
San Antonio
New Orleans
Detroit
Toronto
Ottawa
Montreal
Quebec City
New York
Philadelphia
Washington
Charlotte
Bermuda
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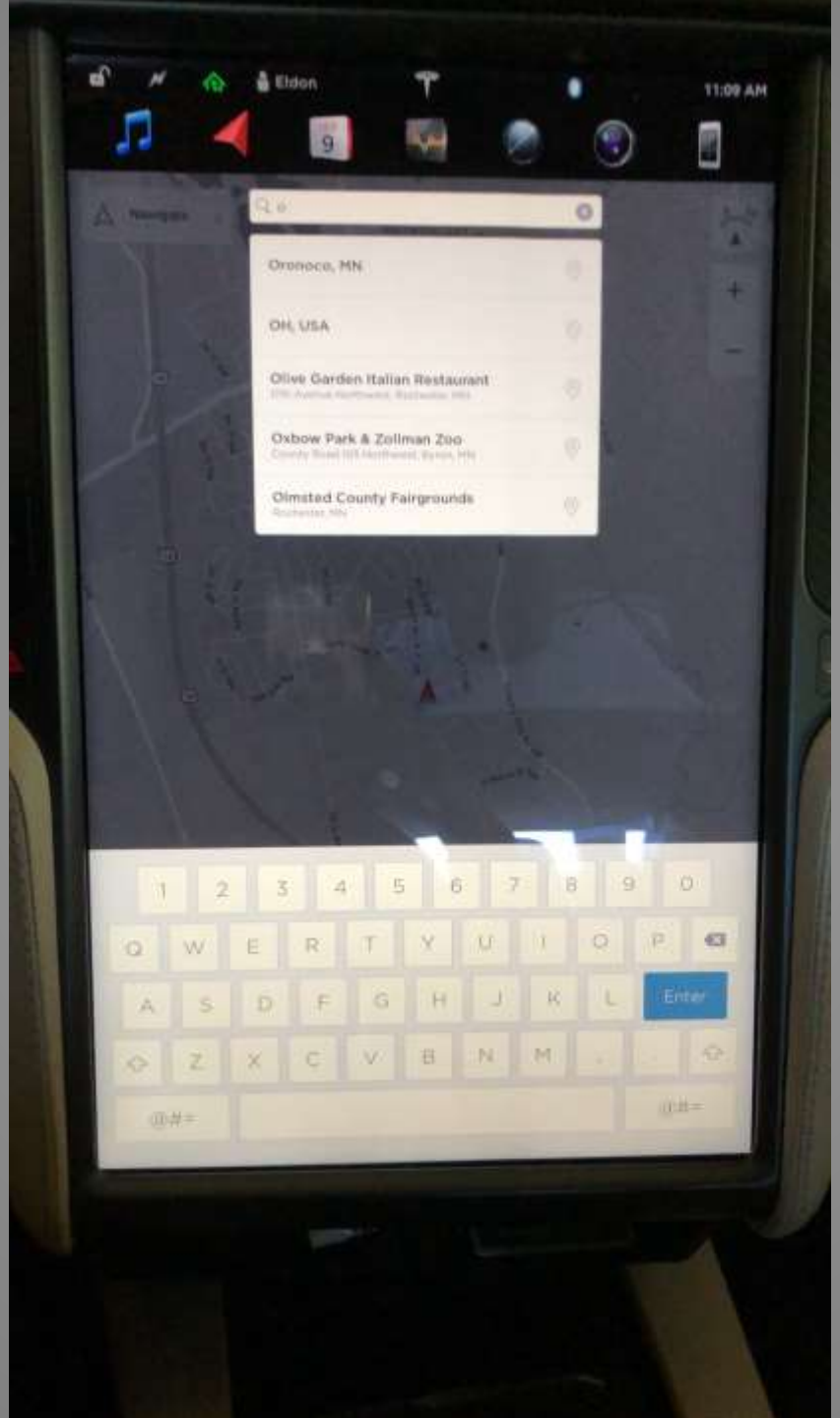
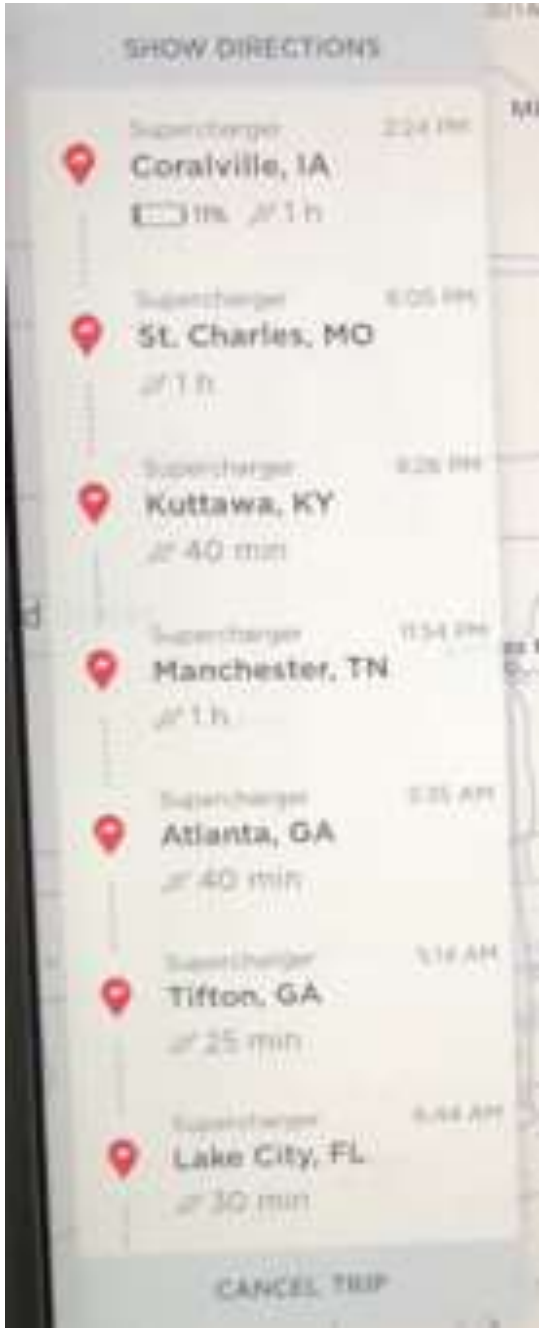
WISCONSIN
MICHIGAN
IOWA
NEBRASKA
ILLINOIS
INDIANA
OHIO
KANSAS
MISSOURI
KENTUCKY
WEST VIRGINIA
VIRGINIA
PENNSYLVANIA
NEW YORK
MARYLAND
NJ
DE
CT
RI
MASSACHUSETTS
VERMONT
NEW HAMPSHIRE
MAINE
NOVA SCOTIA
PRINCE EDWARD ISLAND
NEW BRUNSWICK
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
ARKANSAS
LOUISIANA
TEXAS
OKLAHOMA
NORTH DAKOTA
SOUTH DAKOTA

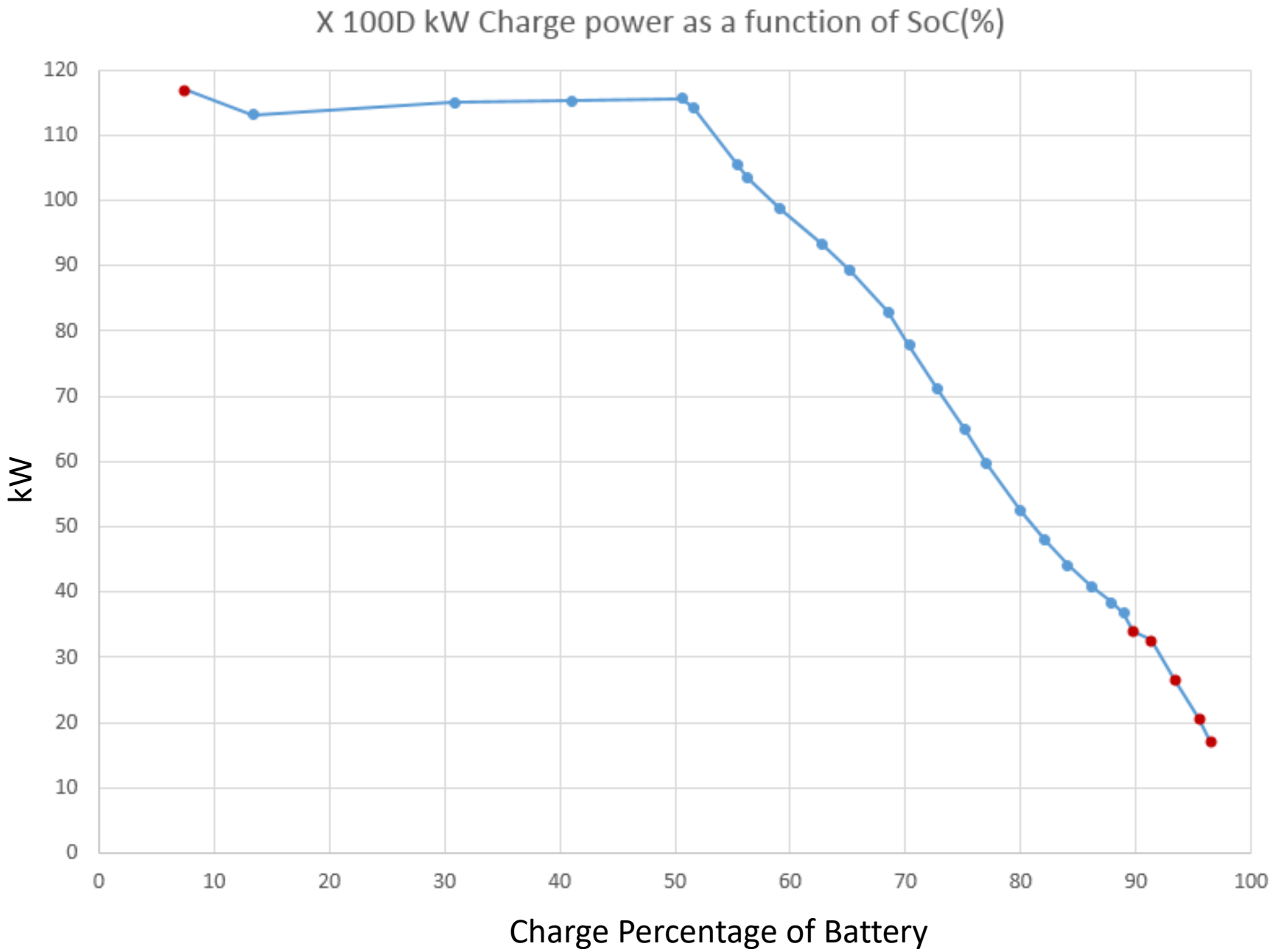

Eldon
11:09 AM
Oronoco, MN
OH, USA
Olive Garden Italian Restaurant
Oxbow Park & Zollman Zoo
Olmsted County Fairgrounds
Enter



City	Drive to Time	Charge Time
Coralville, IA	3h 15m	60 min
St. Charles, MO	2h 41m	60 min
Kuttawa, KY	2h 21m	40 min
Manchester, TN	1h 48m	60 min
Atlanta, GA	2h 10m	40 min
Trifton, GA	2h 9m	25 min
TOTAL	15h 24m	4h 45m

3.25x time spent traveling vs charging

maybe 1h drive time lost in the CST to EST time, but too lazy to figure that out

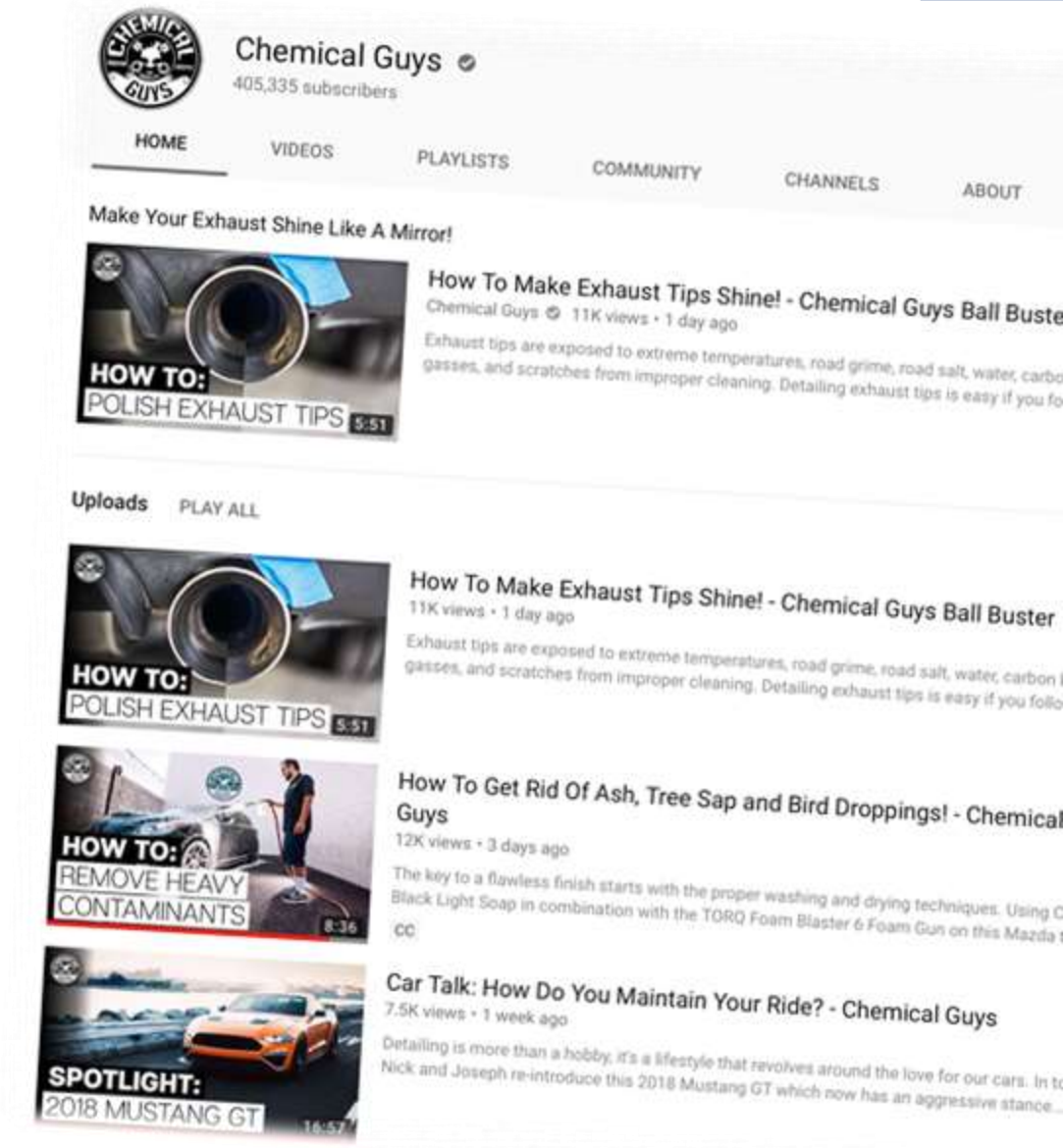


Just like your phone, it charges quickly at low battery and slower at high battery

K

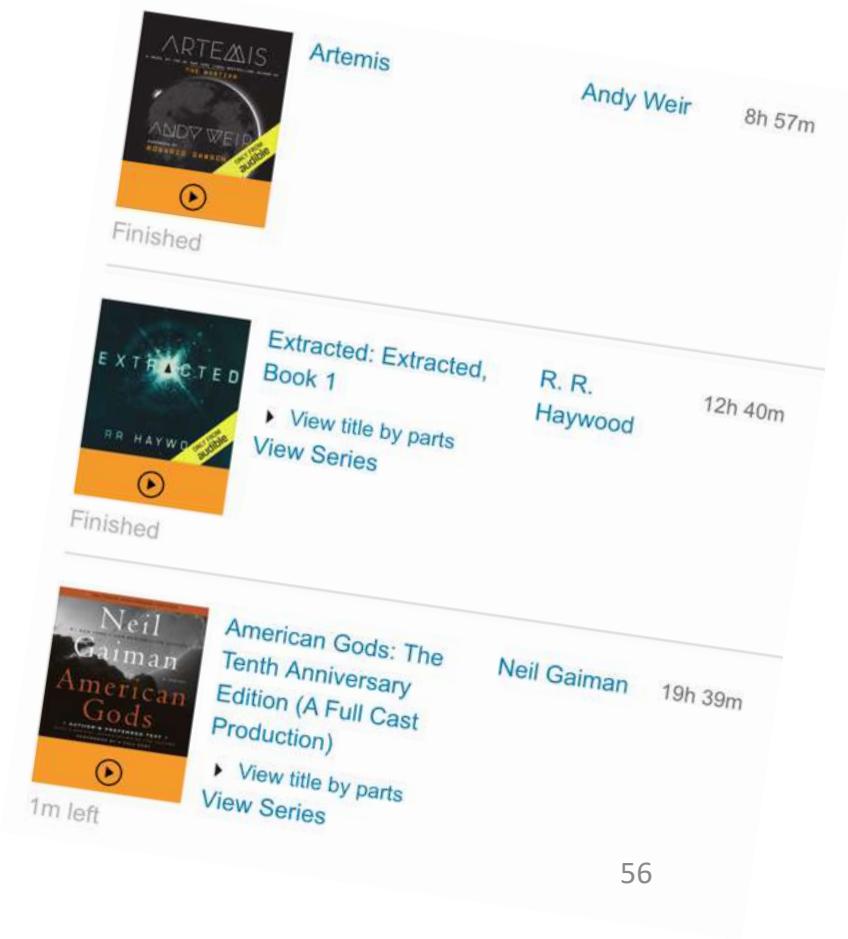
Side Effects 1 of 2

- Appreciation for Car Detailing
- Car Vibration and Car Noise of even the Prius Annoys Me Now
- Don’t Notice or Care About Gas Prices



Side Effects 2 of 2

- Tesla Autopilot Does Reduce Mental Drain of Highway Driving
- Subscription to Audio Book Service Audible.com



Maintenance

	Year 1 12,500 miles	Year 2 25,000 miles	Year 3 37,500 miles	Year 4 50,000 miles
A/C desiccant bag replacement		X		X
Brake fluid replacement		X		X
Cabin air filter replacement		X		X
Key fob battery replacement (set)	X	X	X	X
Multi-point inspection	X	X	X	X
Tire rotation (if needed)	X	X	X	X
Wheel alignment check (and adjustment, if needed)	X	X	X	X
Wiper blade set replacement	X	X	X	X
Battery coolant replacement	Every 8 years or 100,000 miles (160,000 km), whichever comes first			

M

Maintenance (Simplified)

	Year 1 12,500 miles	Year 2 25,000 miles	Year 3 37,500 miles	Year 4 50,000 miles
Brake fluid replacement		X		X
Battery coolant replacement	Every 8 years or 100,000 miles (160,000 km), whichever comes first			

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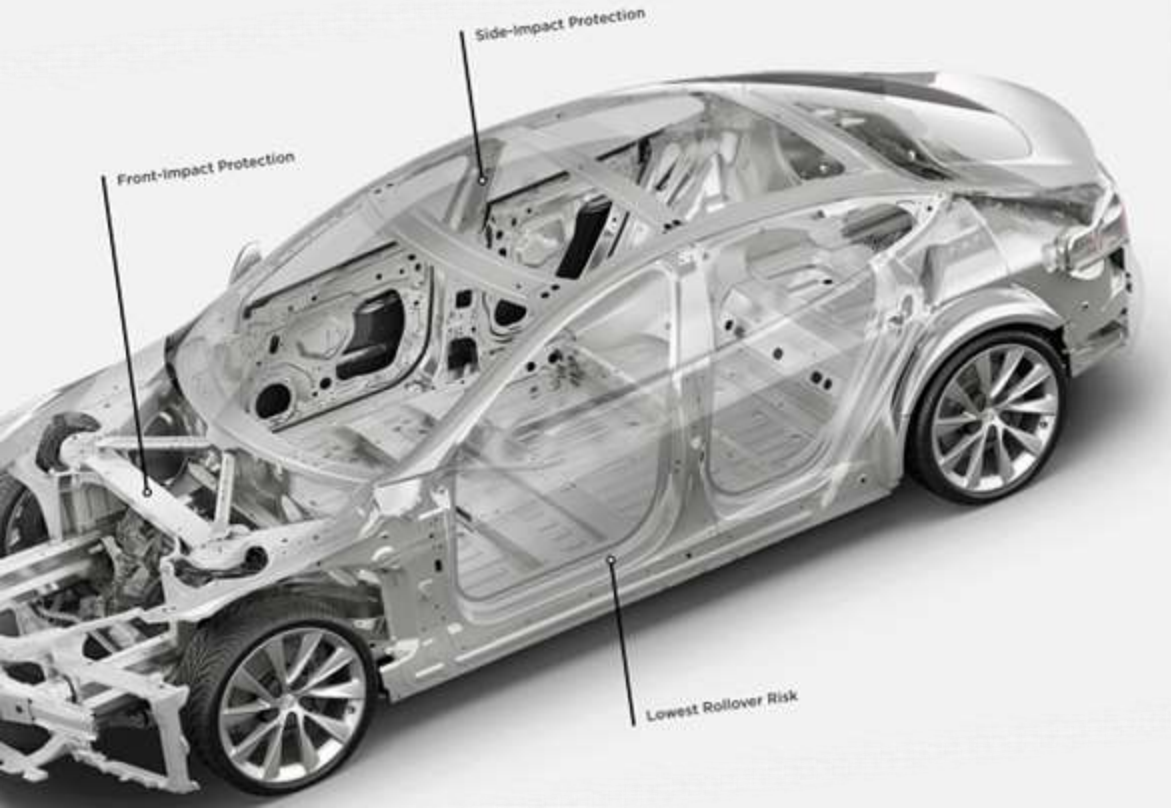
Battery Maintenance



- Keep charge between 90% and 10% for daily use
- Ideally between 80% and 20%
- But, it probably doesn’t matter much

- Charge to 100% sparingly for trips

- Don’t Supercharge Excessively

Thank You and Questions

References Here

https://docs.google.com/document/d/1GJ0LLVTeuh3cJ5s45mfBtR0UAbLffkSctiF1JRz7g-8/edit?usp=sharing