Energy Modeling Optimization

The Process of Using Telemetry to Its Fullest Potential

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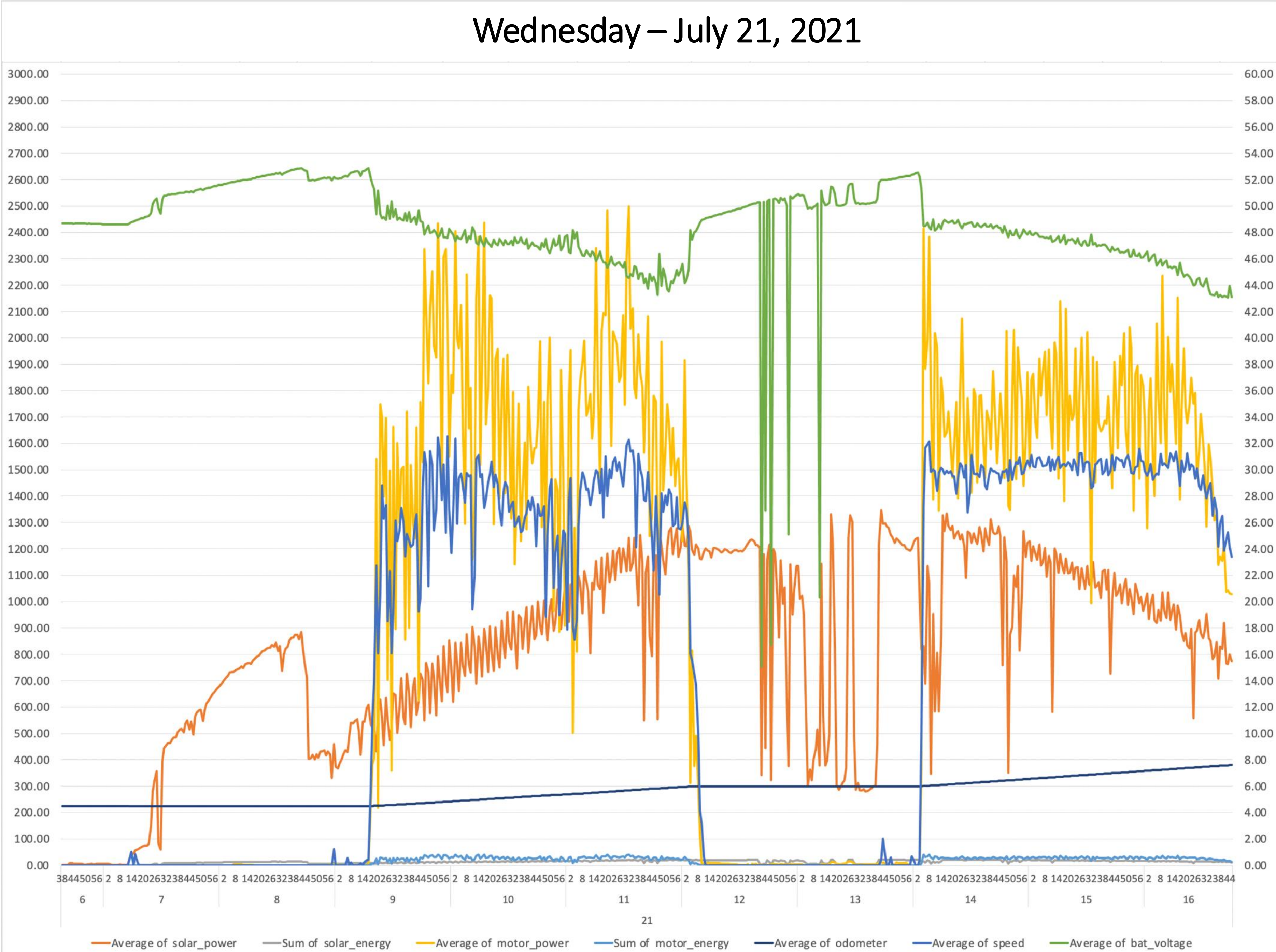
1/17/26

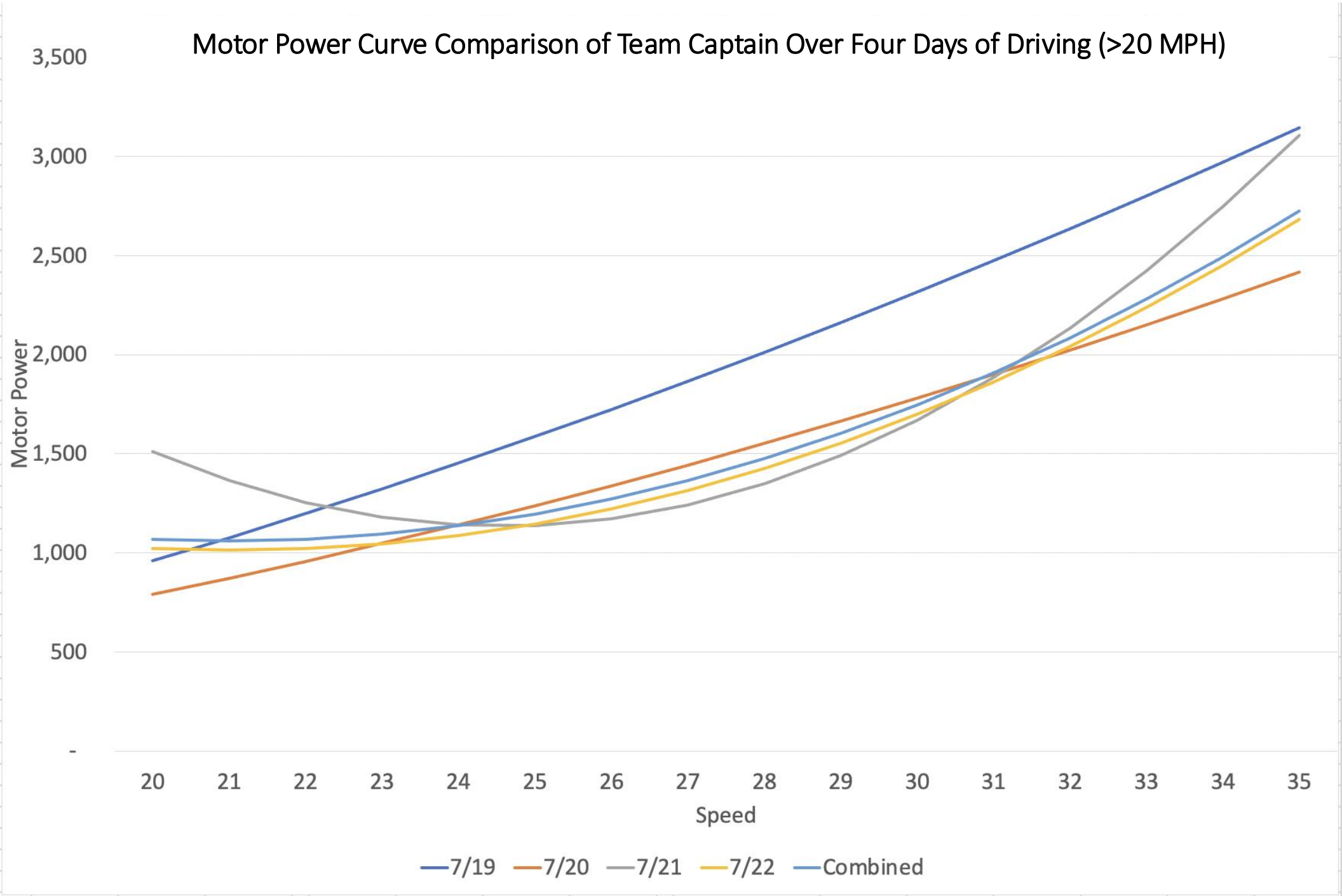
The Path From Telemetry To Full Energy Modeling Optimization

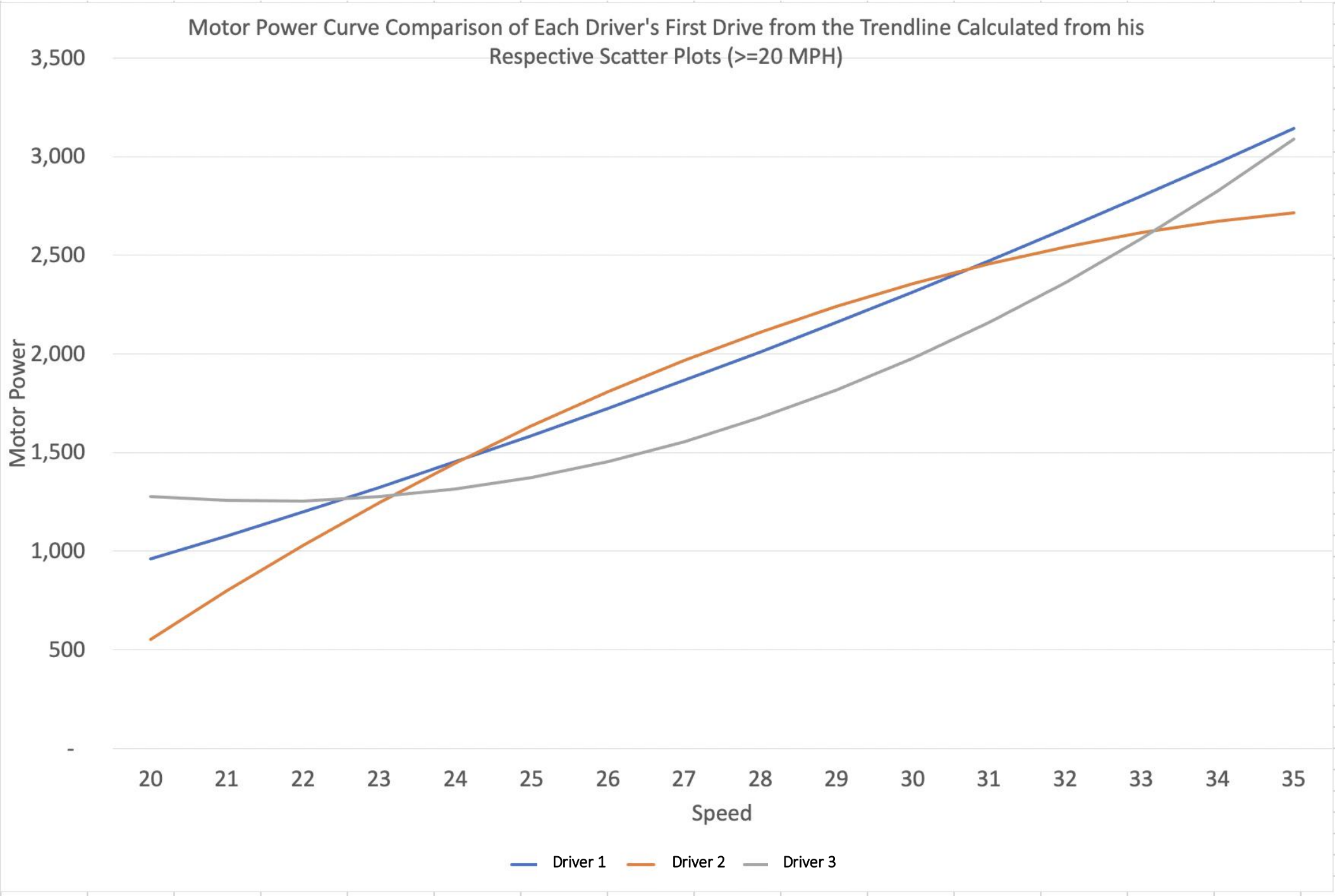
- The 2023 workshop had an excellent telemetry presentation by the former Okemos Solar Car Team
  - It covered what telemetry is, why it is important, collecting data, etc.
  - I encourage you to check it out
- Each solar car's telemetry hardware specifics will likely be unique
  - This is due to the fact that there is a wide team to team variation on which charge controller, motor controller, and battery is being used
  - The process we have used and is being described today was successfully applied to both an Outback Power Systems (U.S.) and iPanda Galaxy (China)
  - In both cases, these systems gather much of the needed data
- Which data is needed and for what purpose
  - Power Consumption → key inputs of power consumed vs speed
  - Solar Production → key inputs of solar energy production vs GHI
  - Battery Energy → how much energy is currently in the battery
- Optimization
  - With the above information, full parameterization of the car is possible
  - Applying solar irradiance forecasting allows optimal speed determination

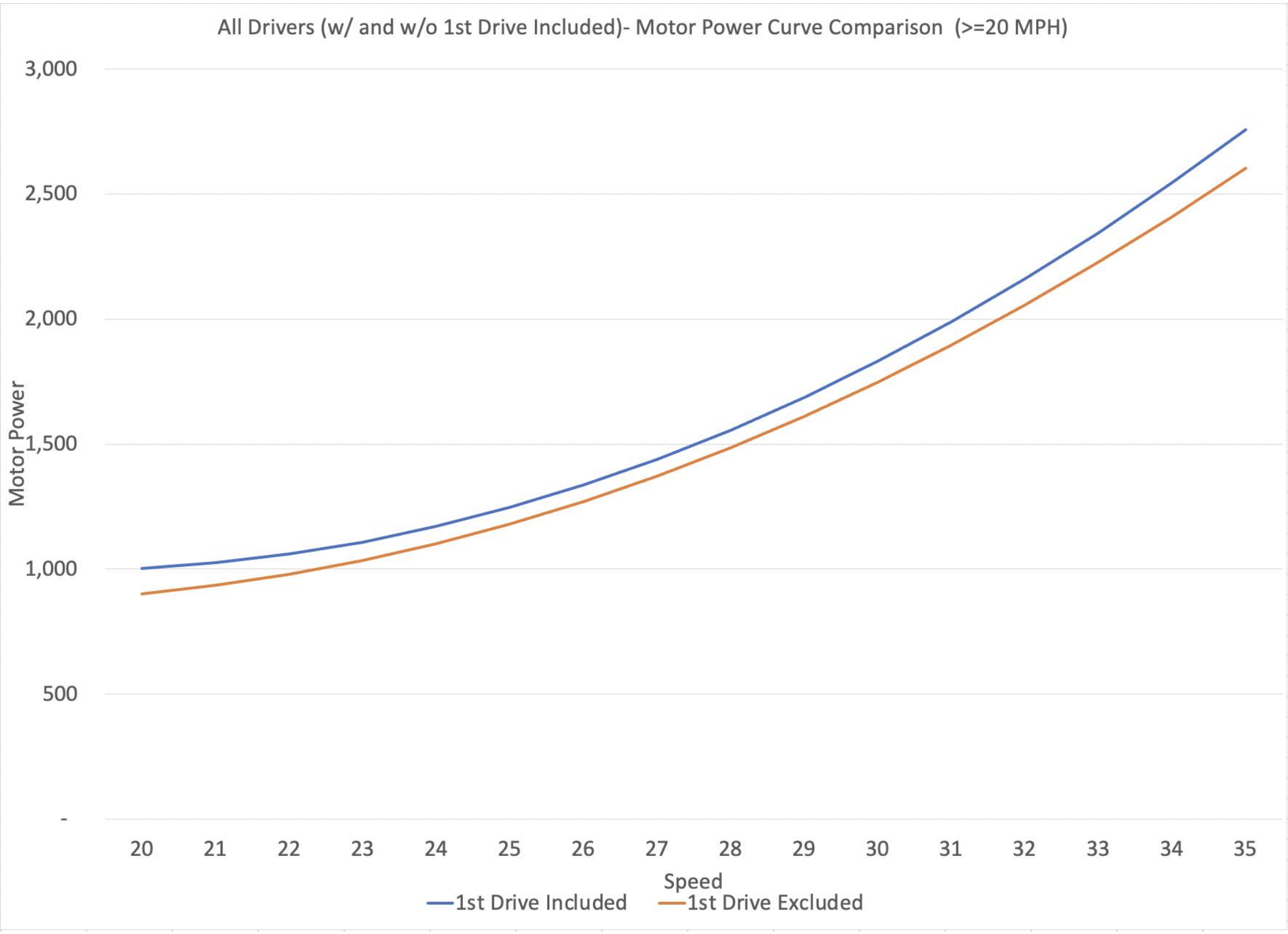
Data Gathered From 2021 Solar Car Challenge & The Insights Gained

Data Gathered From 2021 Solar Car Challenge




Motor Power Curve Comparison of Team Captain Over Four Days of Driving (>20 MPH)
3,500
3,000
2,500
2,000
1,500
1,000
500
-
Motor Power
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
Speed
7/19
7/20
7/21
7/22
Combined


Motor Power Curve Comparison of Each Driver's First Drive from the Trendline Calculated from his Respective Scatter Plots (>=20 MPH)
3,500
3,000
2,500
2,000
1,500
1,000
500
-
Motor Power
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
Speed
Driver 1
Driver 2
Driver 3


All Drivers (w/ and w/o 1st Drive Included)- Motor Power Curve Comparison (>=20 MPH)
3,000
2,500
2,000
1,500
1,000
500
-
Motor Power
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
Speed
1st Drive Included
1st Drive Excluded

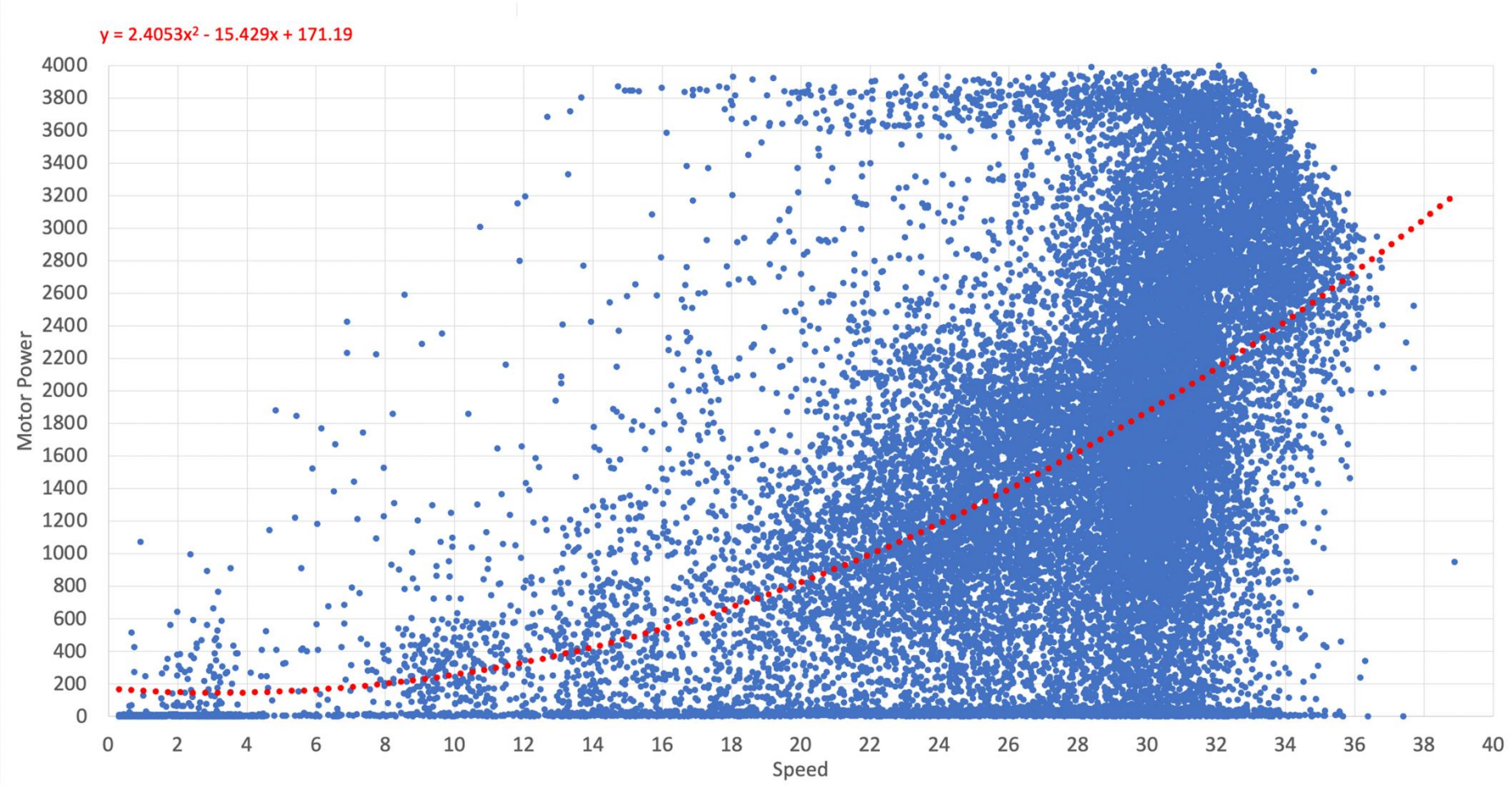
Complete 2021 Race Stats and Summary of Optimization Opportunity

Race Total (Act)	Motor Energy (W)	Miles Driven	Avg Wh/Mile	Track Minutes	Avg Speed	Avg W/Min
AM	13,864	237.13	58.47	549	25.92	1515.22
PM	17,281	283.68	60.92	589	28.90	1760.36
Total	31,141	520.81	59.79	1138	27.46	1641.85

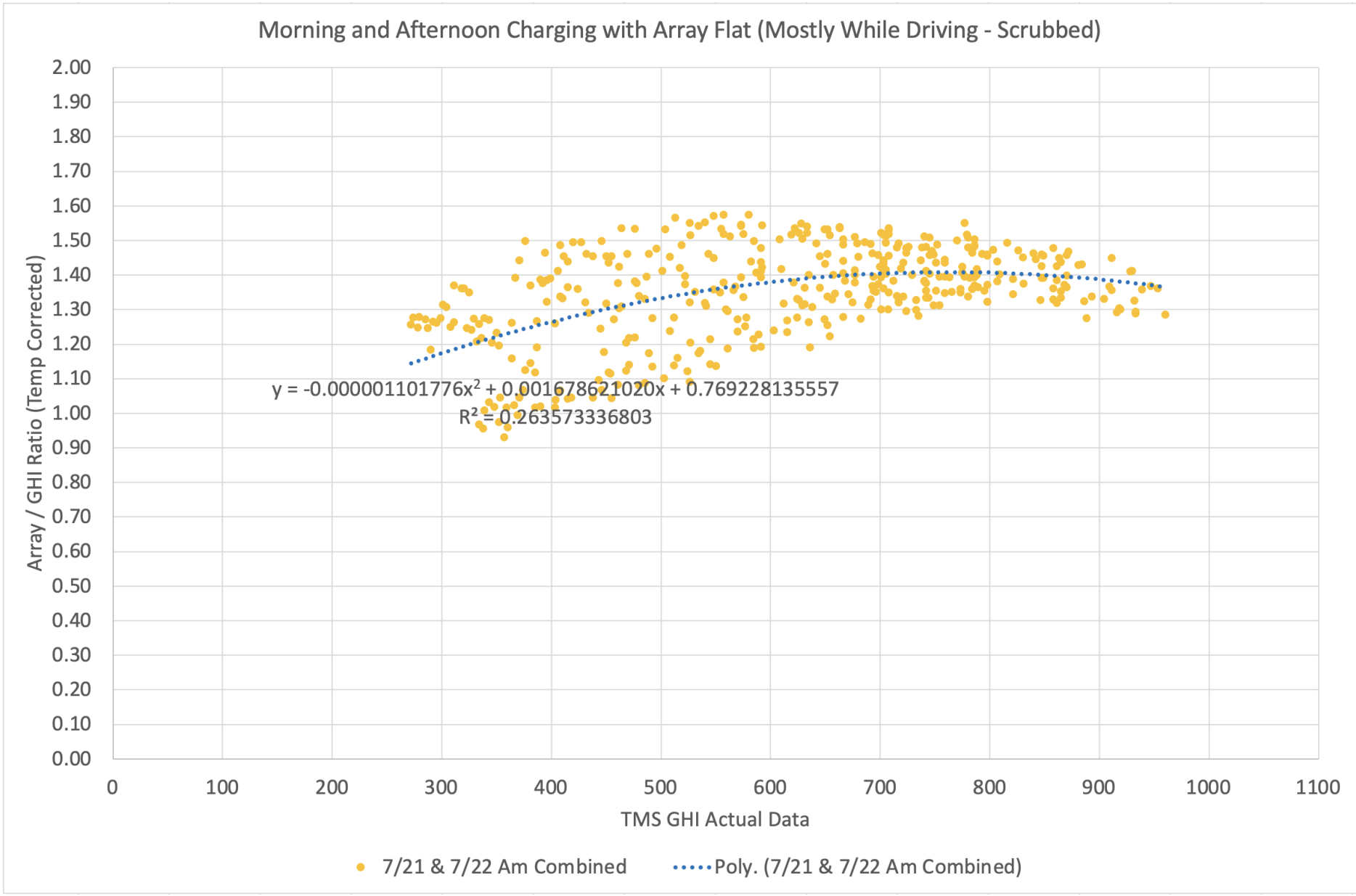
Overall Race Optimization Opportunity		Miles	% Improvement Opportunity	
	Actual Miles Driven	520.81		
	Opt Opp Using Same Day Driver Regressions	6.47	1.24%	
	Opt Opp Using 2nd+ Day Driver Regressions	24.81	4.76%	<--- The lowest hanging fruit, is driver training
	Full Day Opt Opp Using 2nd+ Day Driver Regressions	1.90	0.37%	
	Total Optimization Opportunity	33.18	6.37%	
	Full Optimized Mileage Potential	553.99		

Parameterization of Your Solar Car and the Optimization Possibilities

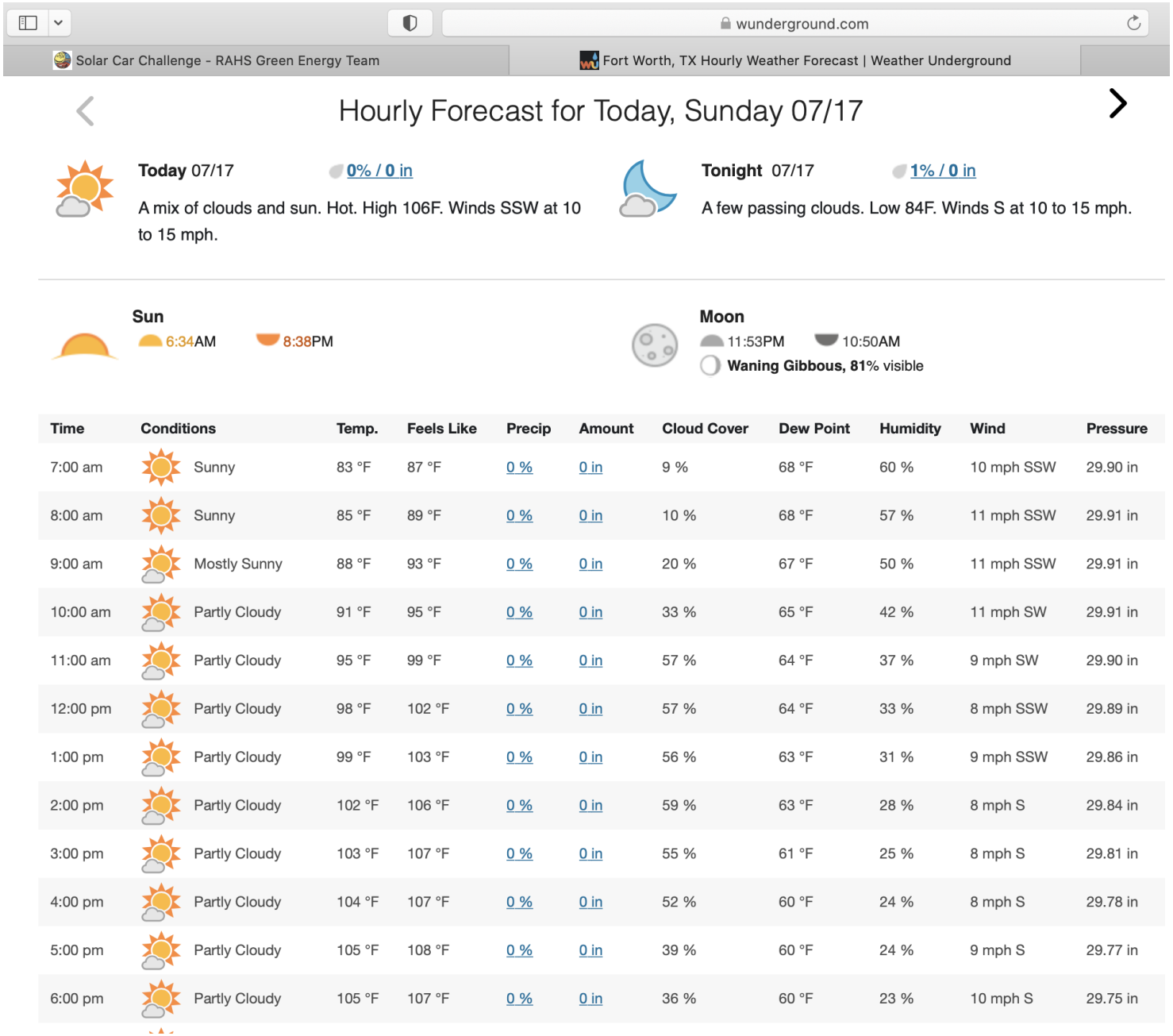
Power Consumption



Solar Production During The Race (Array In Flat Orientation)



Typically Available Weather Forecasting



Hourly Forecast for Today, Sunday 07/17

Today 07/17 — 0% / 0 in

A mix of clouds and sun. Hot. High 106F. Winds SSW at 10 to 15 mph.

Tonight 07/17 — 1% / 0 in

A few passing clouds. Low 84F. Winds S at 10 to 15 mph.

Sun

6:34AM 8:38PM

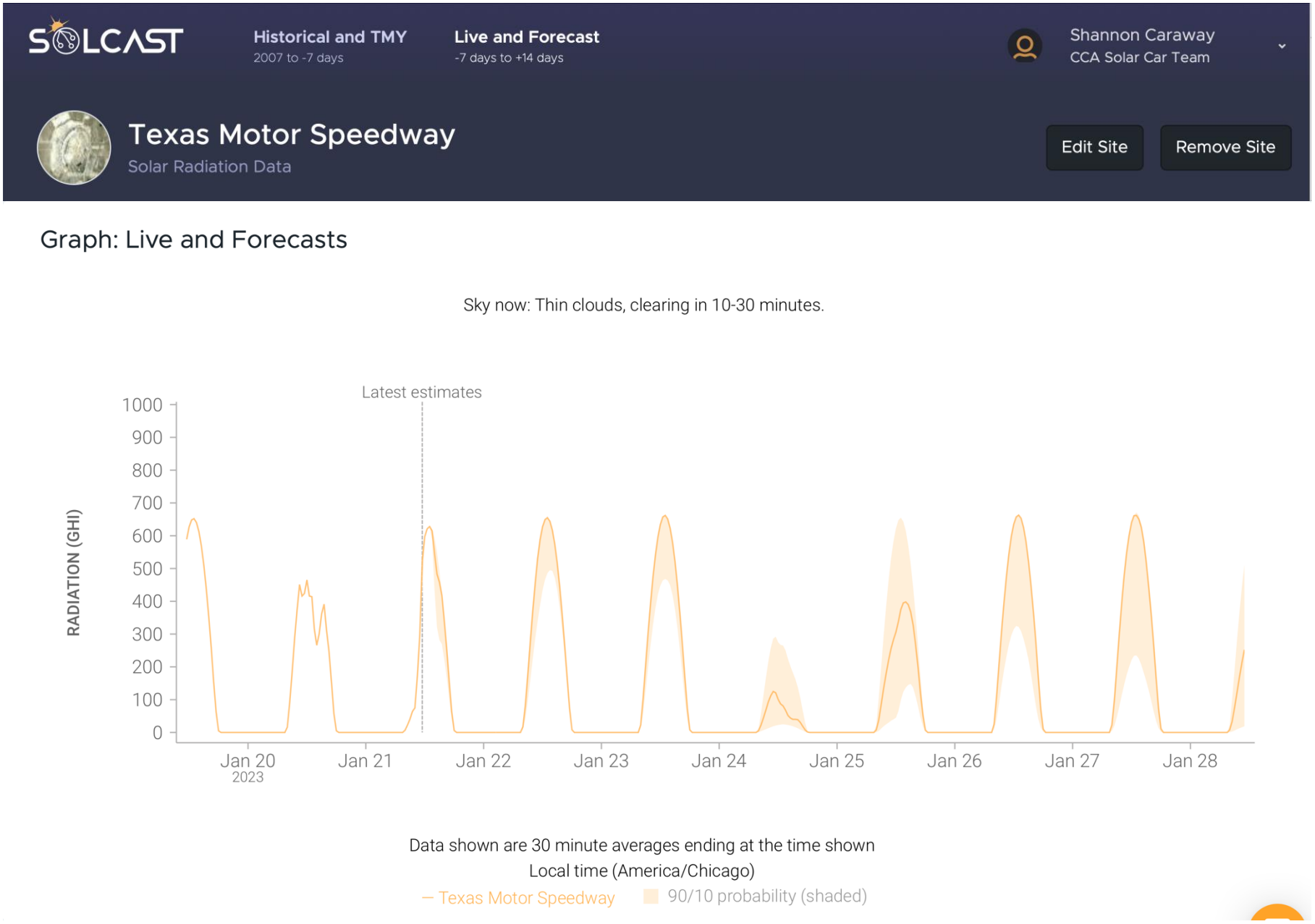
Moon

11:53PM 10:50AM

Waning Gibbous, 81% visible

Time	Conditions	Temp.	Feels Like	Precip	Amount	Cloud Cover	Dew Point	Humidity	Wind	Pressure
7:00 am	Sunny	83 °F	87 °F	0 %	0 in	9 %	68 °F	60 %	10 mph SSW	29.90 in
8:00 am	Sunny	85 °F	89 °F	0 %	0 in	10 %	68 °F	57 %	11 mph SSW	29.91 in
9:00 am	Mostly Sunny	88 °F	93 °F	0 %	0 in	20 %	67 °F	50 %	11 mph SSW	29.91 in
10:00 am	Partly Cloudy	91 °F	95 °F	0 %	0 in	33 %	65 °F	42 %	11 mph SW	29.91 in
11:00 am	Partly Cloudy	95 °F	99 °F	0 %	0 in	57 %	64 °F	37 %	9 mph SW	29.90 in
12:00 pm	Partly Cloudy	98 °F	102 °F	0 %	0 in	57 %	64 °F	33 %	8 mph SSW	29.89 in
1:00 pm	Partly Cloudy	99 °F	103 °F	0 %	0 in	56 %	63 °F	31 %	9 mph SSW	29.86 in
2:00 pm	Partly Cloudy	102 °F	106 °F	0 %	0 in	59 %	63 °F	28 %	8 mph S	29.84 in
3:00 pm	Partly Cloudy	103 °F	107 °F	0 %	0 in	55 %	61 °F	25 %	8 mph S	29.81 in
4:00 pm	Partly Cloudy	104 °F	107 °F	0 %	0 in	52 %	60 °F	24 %	8 mph S	29.78 in
5:00 pm	Partly Cloudy	105 °F	108 °F	0 %	0 in	39 %	60 °F	24 %	9 mph S	29.77 in
6:00 pm	Partly Cloudy	105 °F	107 °F	0 %	0 in	36 %	60 °F	23 %	10 mph S	29.75 in

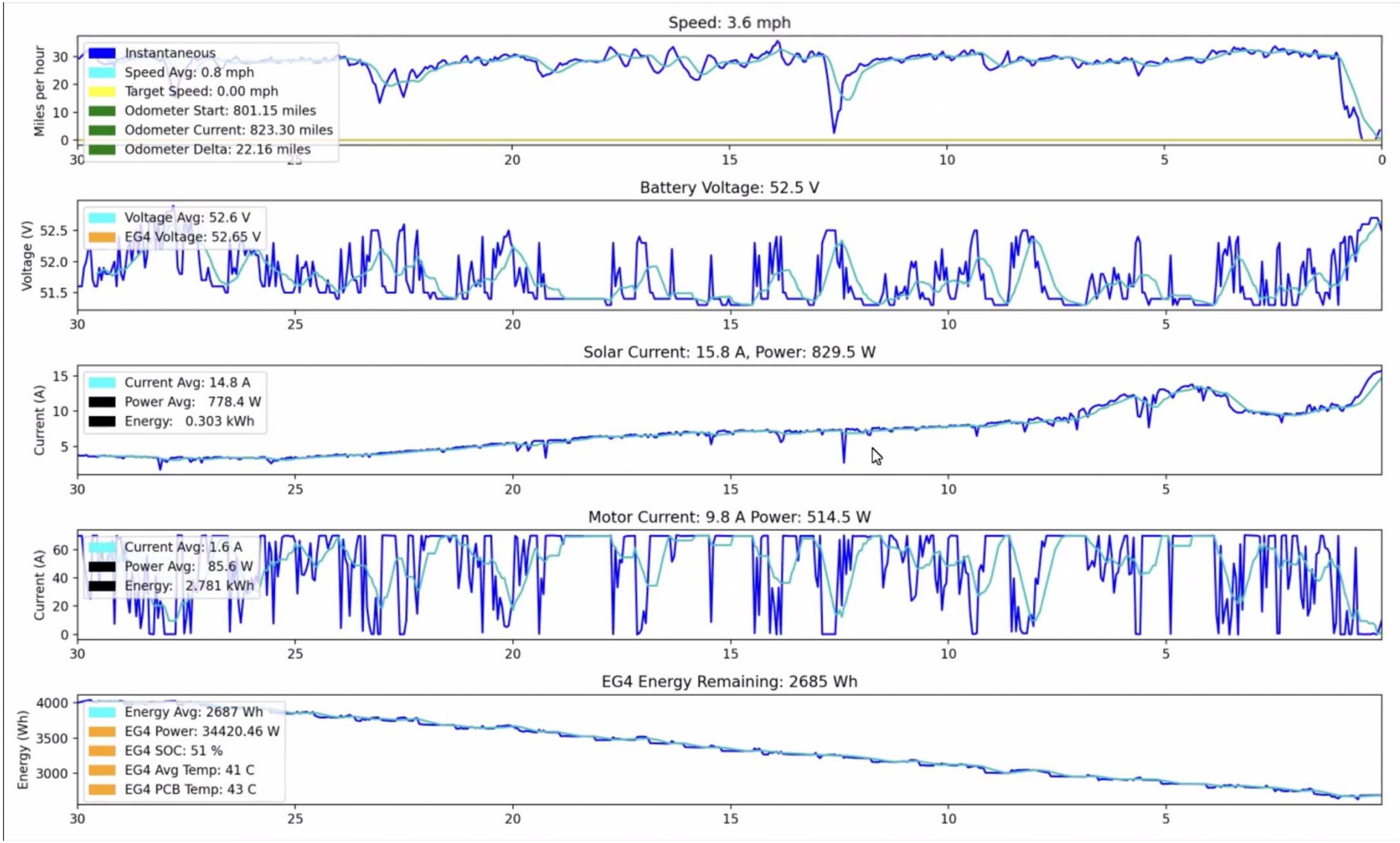
The Type of Weather Forecasting Needed for Optimization



Bringing It All Together for the 2022 Solar Car Challenge

Speed	Power Draw		Power Draw	Speed		**Night Before Plan**	
20.0	1004		1000	19.72		Stored Battery Energy (est.)	3300
20.5	1012		1050	21.75		Solcast Forecast	2954
21.0	1025		1100	22.84			6254
21.5	1041		1150	23.69			
22.0	1060		1200	24.41			**1563**
22.5	1082		1250	25.04			
23.0	1108		1300	25.61			
23.5	1138		1350	26.14		**5:30 AM Monday Morning Plan**	
24.0	1171		1400	26.63		Stored Battery Energy (est.)	3500
24.5	1207		1450	27.09		Solcast Forecast	3164
25.0	1247		1500	27.53			6664
25.5	1290		1550	27.95			
26.0	1336		1600	28.35			**1666**
26.5	1386		1650	28.73			
27.0	1439		1700	29.10			
27.5	1496		1750	29.45		**9:30 AM Monday Morning Plan**	
28.0	1556		1800	29.79		Stored Battery Energy (est.)	3500
28.5	1620		1850	30.13		Solcast Forecast	2791
29.0	1687		1900	30.45			6291
29.5	1757		1950	30.76			
30.0	1831		2000	31.07			**1573**
30.5	1908						
31.0	1989						
28.2	1583	<--- Optimal Target Speed for Morning Driving Period					

Importance Of Real Time Visualization Tool (Your Dashboard)



Application During 2023 Solar Car Challenge Cross Country Race

The Pinnacle of the CCA Solar Car Team Energy Optimization Snyder, TX to Carlsbad, NM (Screen Shot at 4:02 PM on July 17, 2023)

For the first time in our team's history, we finally had all the pieces in place to develop a daily energy optimization strategy, confidently use every last kWh from the battery, and make SCC history for the most miles driven on this leg of the race.

The Pinnacle of the CCA Solar Car Team Energy Optimization Snyder, TX to Carlsbad, NM – Record Breaking Distance Achieved!

Day 2: Snyder, TX to Carlsbad. NM
(204.7 driving miles available)

Day Rank	Overall Rank	Team	Miles Driven	Penalty Miles	Day Miles	Total Miles
Classic						
1	2	Falcon EV	82.5	0.0	82.5	123.1
2	1	Okemos Solar Racing Club	74.5	1.0	73.5	145.0
3	3	Poly Solar Car Team	53.1	1.0	52.1	119.1
4	4	The Stripes	5.7	5.7	0.0	23.1
Advanced Classic						
1	1	Covenant Christian Academy	196.2	3.0	193.2	354.4
2	2	Wylie East Solar Car	147.8	1.0	146.8	327.3
3	3	Prosper Engineering Team	122.9	0.0	122.9	271.0
4	4	Solar Falcons	25.3	0.0	25.3	82.9
5	5	Presidio Solar	20.1	20.1	0.0	19.0
Advanced						
1	2	Oregon Solar Car Team	156.5	3.0	153.5	250.3
2	1	Iron Lions	126.7	0.0	126.7	329.3
3	3	Burning Daylight	50.0	0.0	50.0	162.4
4	4	Ballard Bombers	18.8	0.0	18.8	66.5
Electric-Solar Powered						
1	1	Heroes' Alliance Vehicle Technology Team	67.3	0.0	67.3	150.4
2	2	Blazin' Bulldogs	6.7	6.7	0.0	61.9

The prior distance record for the Snyder, TX to Carlsbad, NM leg of the Solar Car Challenge was 169.6 miles, set by the Houston Solar Race Team in 2018 and that was a solar car racing in the Advanced Division, rather than Advanced Classic Division.

Energy Modeling Optimization Allows The Maximum Performance To Be Extracted From A Given Solar Car Design

If you have questions about Energy Modeling Optimization for your solar car, please feel free to contact me:
email - swcaraway68@gmail.com, phone - 214-478-6009