Integrating Top-Level Corporate Forecasts with Distribution Planning Forecasts

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ESIG Load Forecasting Conference

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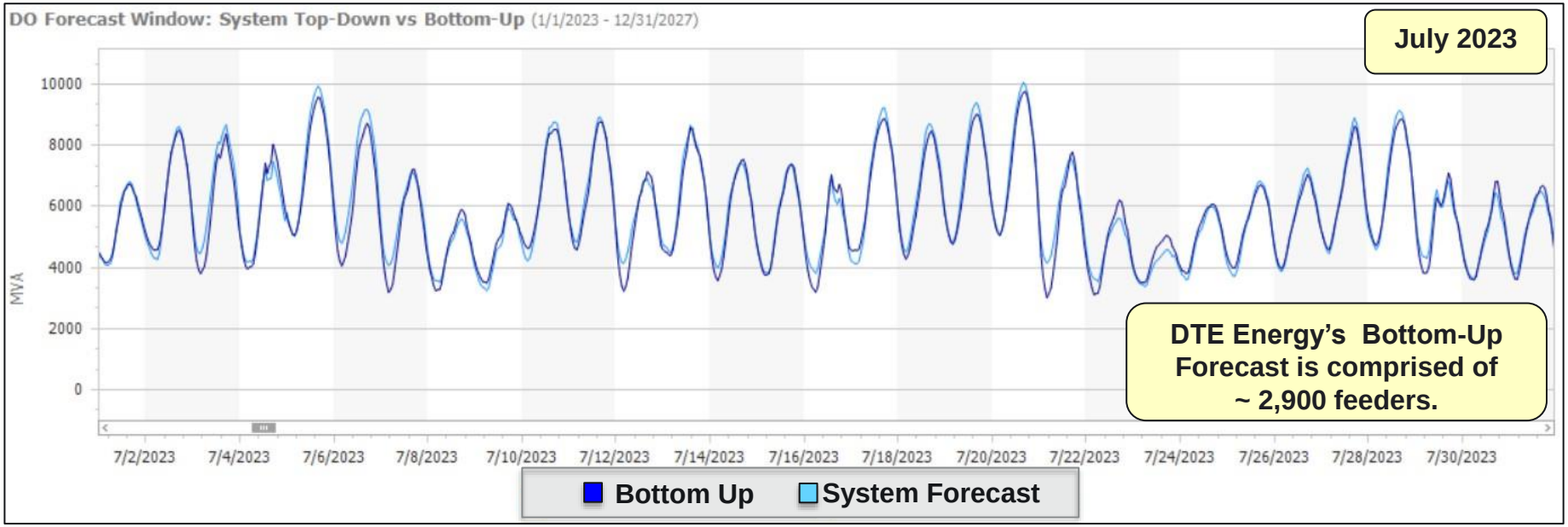
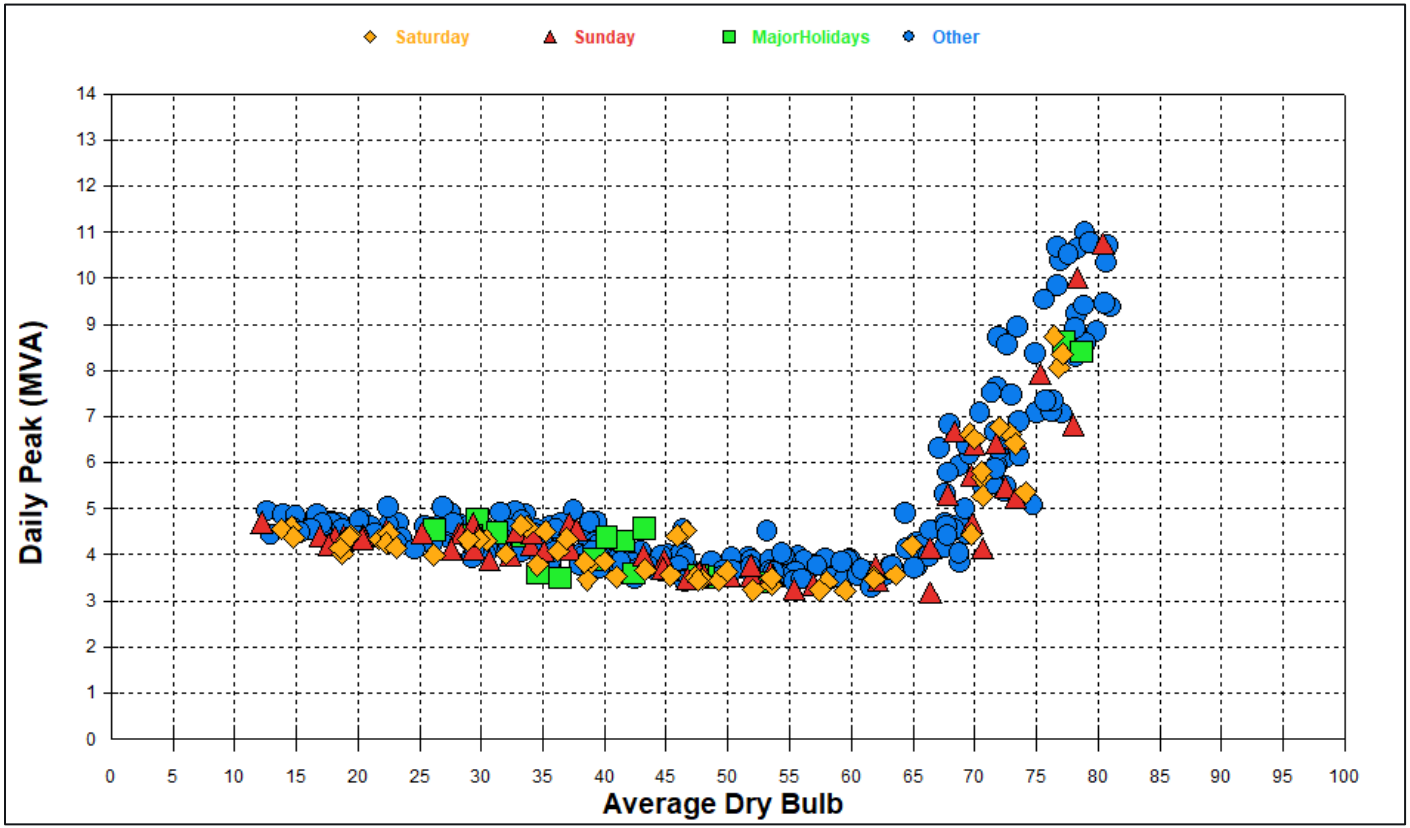
Bottom-Up Feeder Forecast vs System Forecast

» The DTE Distribution Planning Forecasting solution is designed to generate 20-year ahead hourly forecasts by feeder (~2,900), busbar (~1,200), and substation (~550), integrating DERs, new technologies and their appropriate interactions.



Baseline Loads

Feeder Peak Load (MVA) vs Daily Average Dry Bulb



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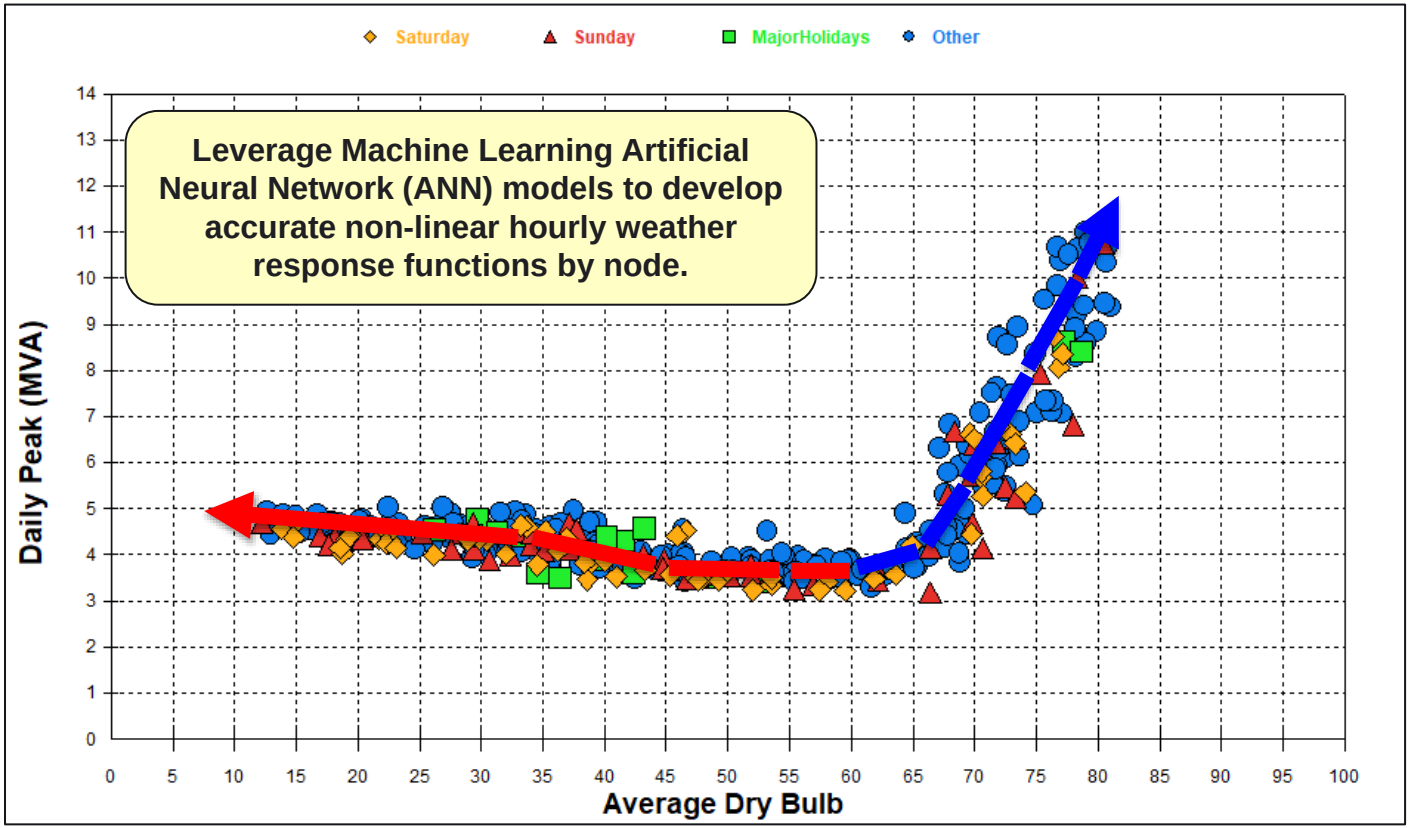
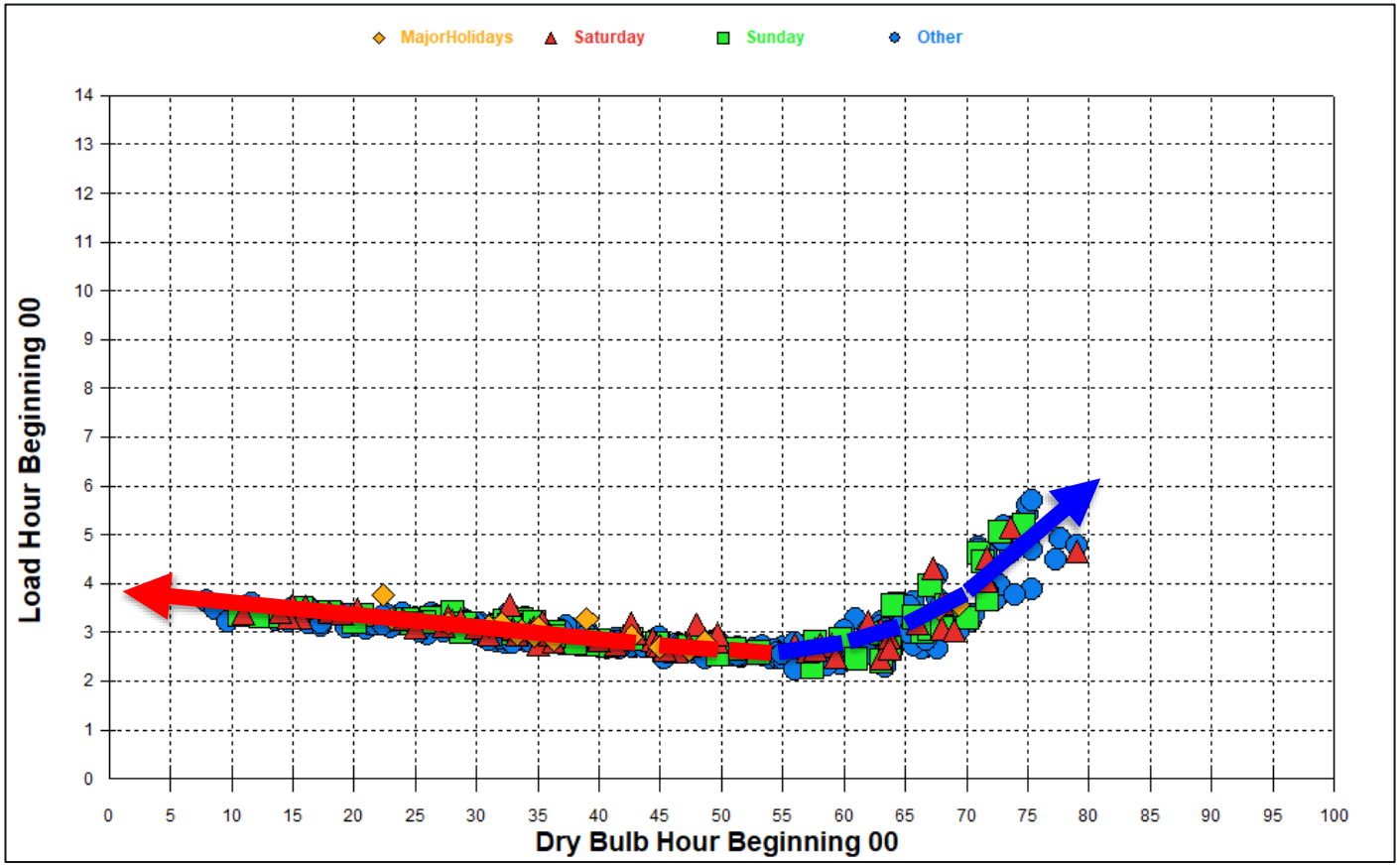
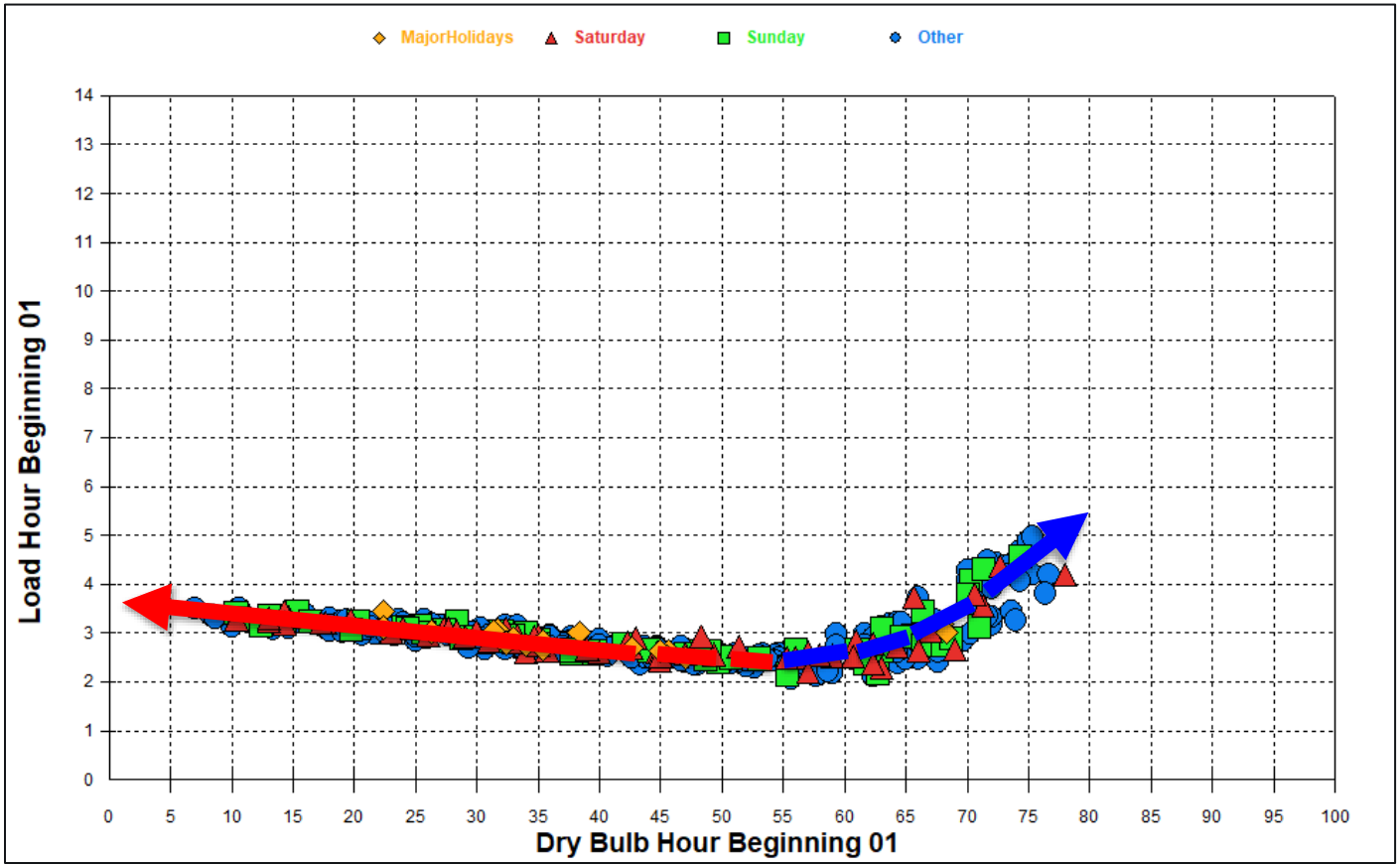


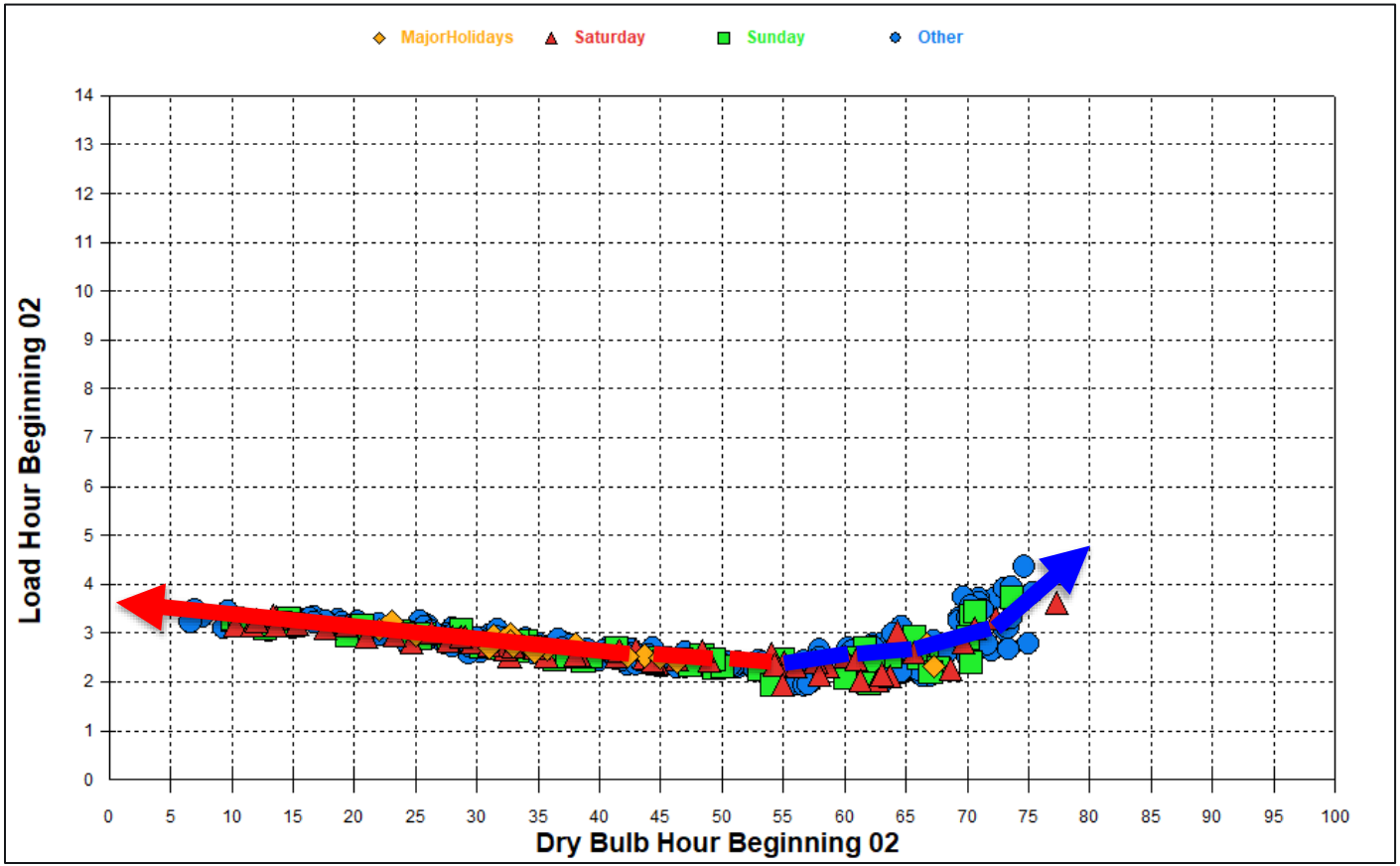
Feeder Hourly Load (MVA) Vs Dry Bulb 12AM



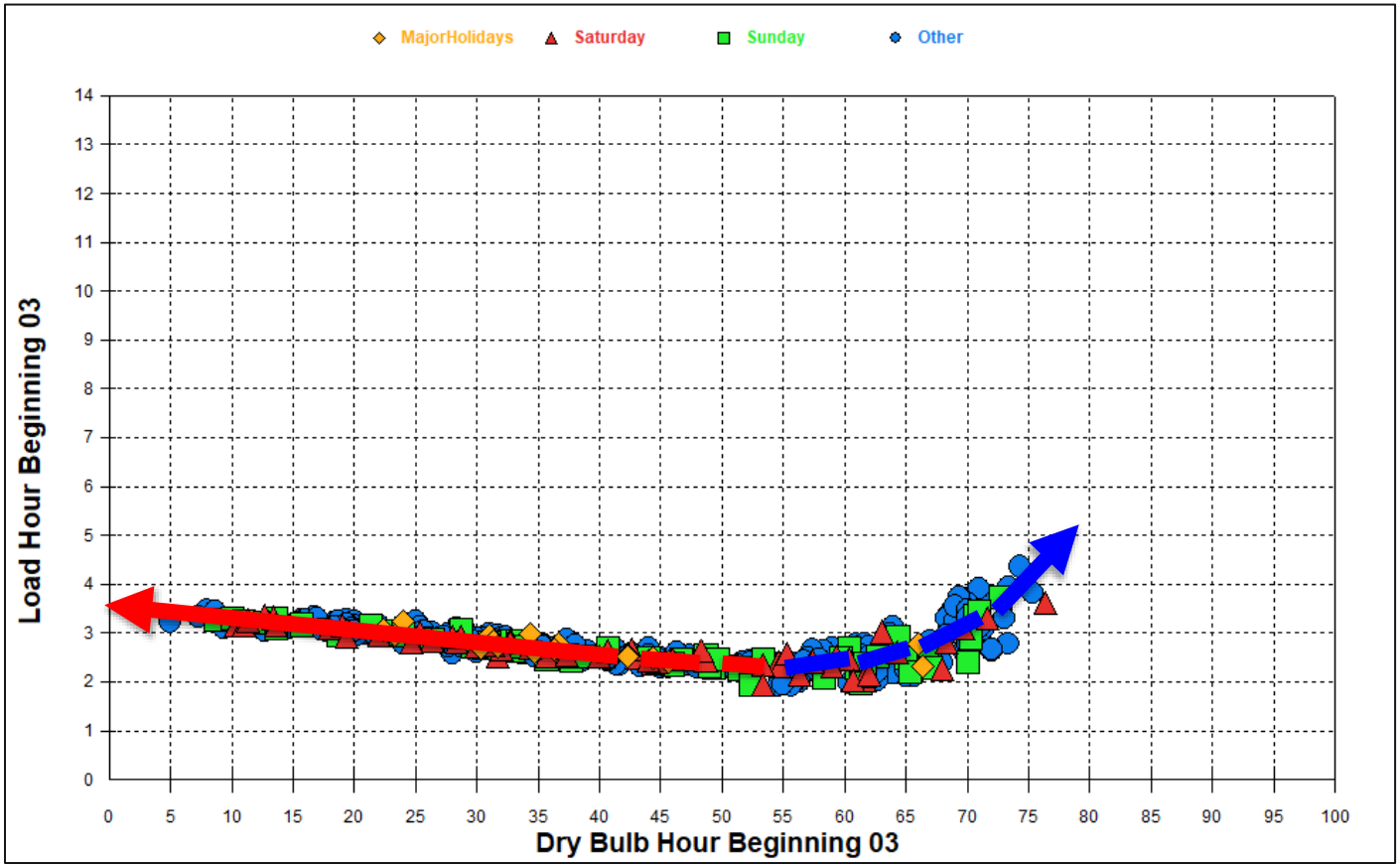
Feeder Hourly Load (MVA) Vs Dry Bulb 1AM



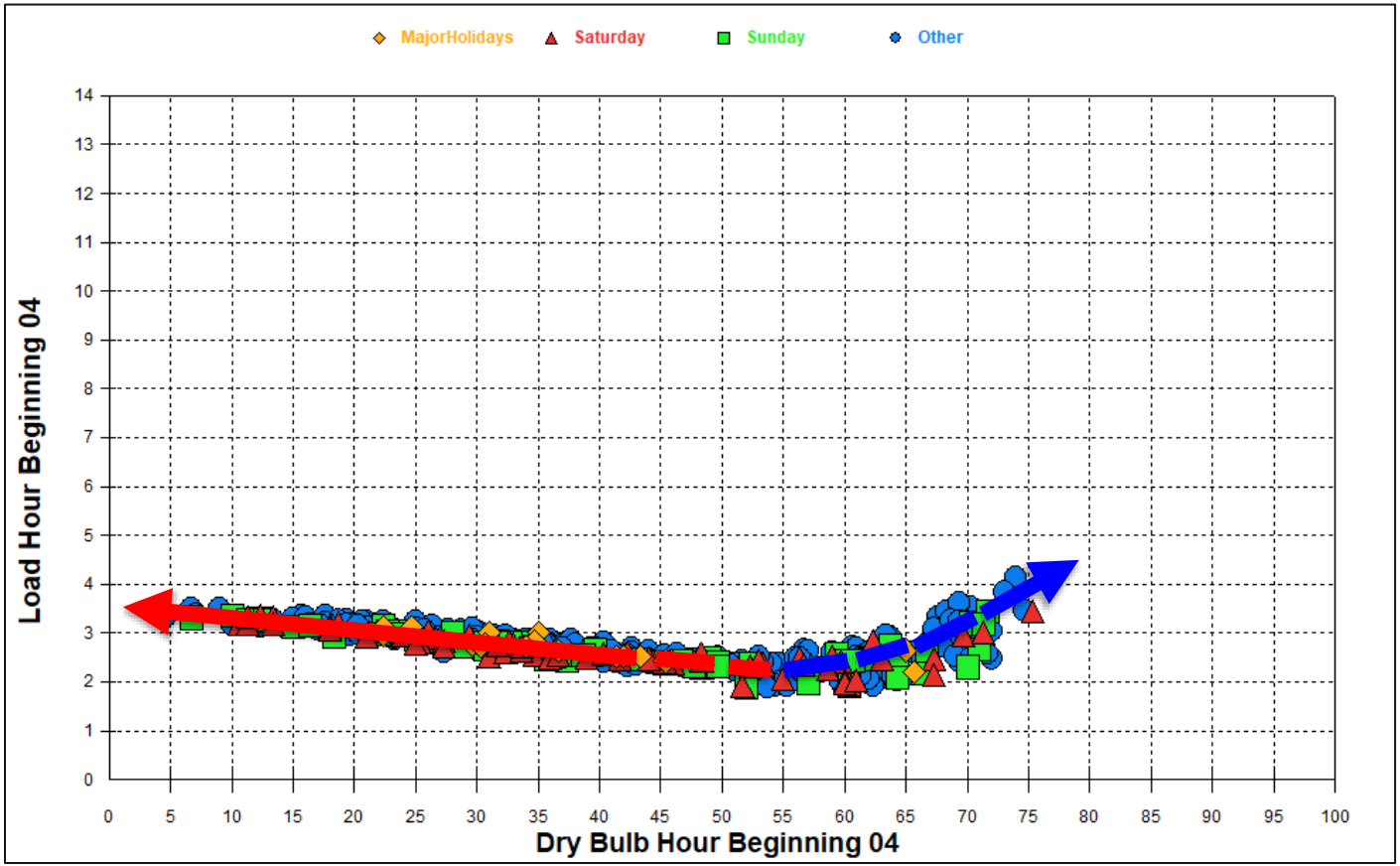
Feeder Hourly Load (MVA) Vs Dry Bulb 2AM



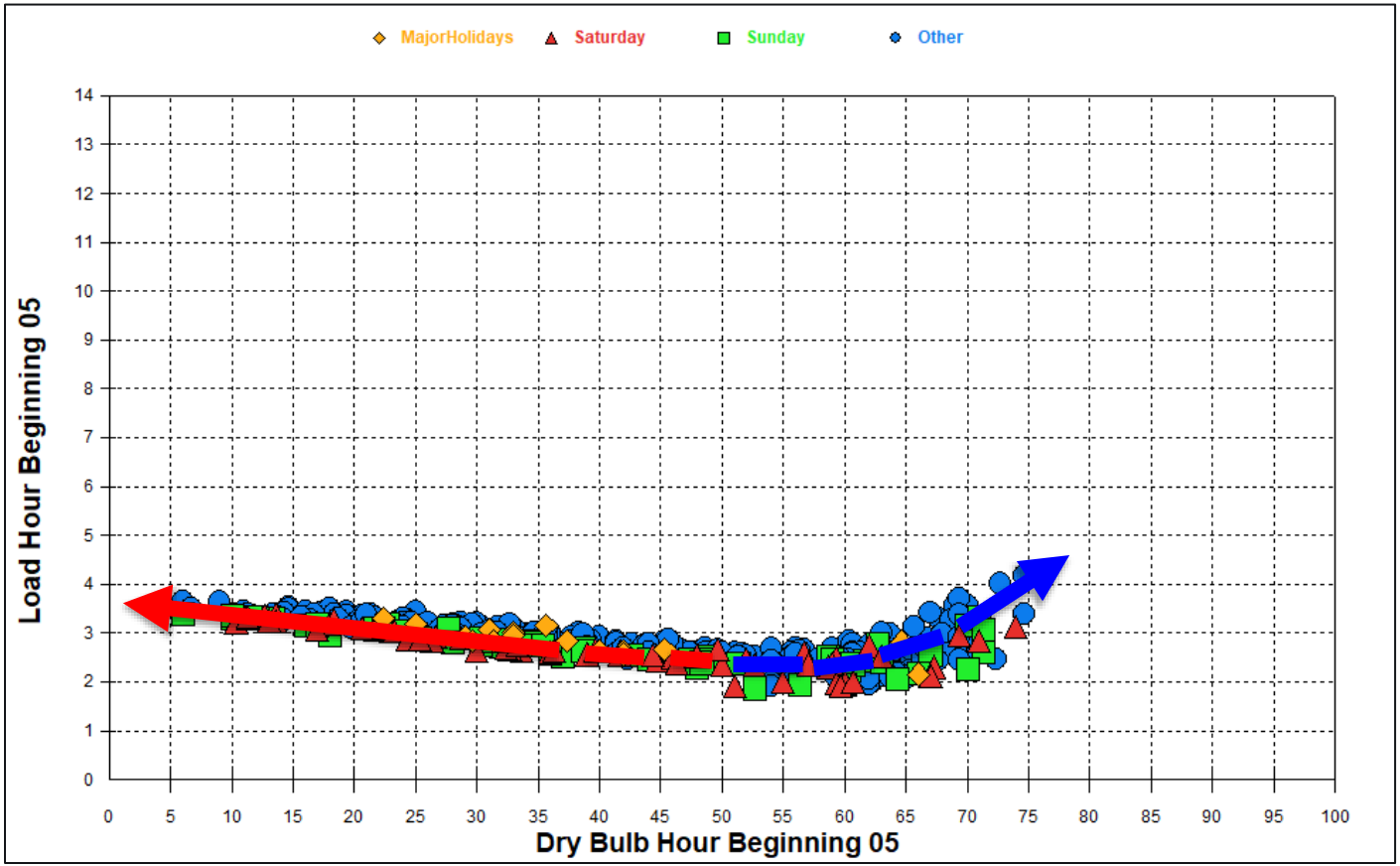
Feeder Hourly Load (MVA) Vs Dry Bulb 3AM



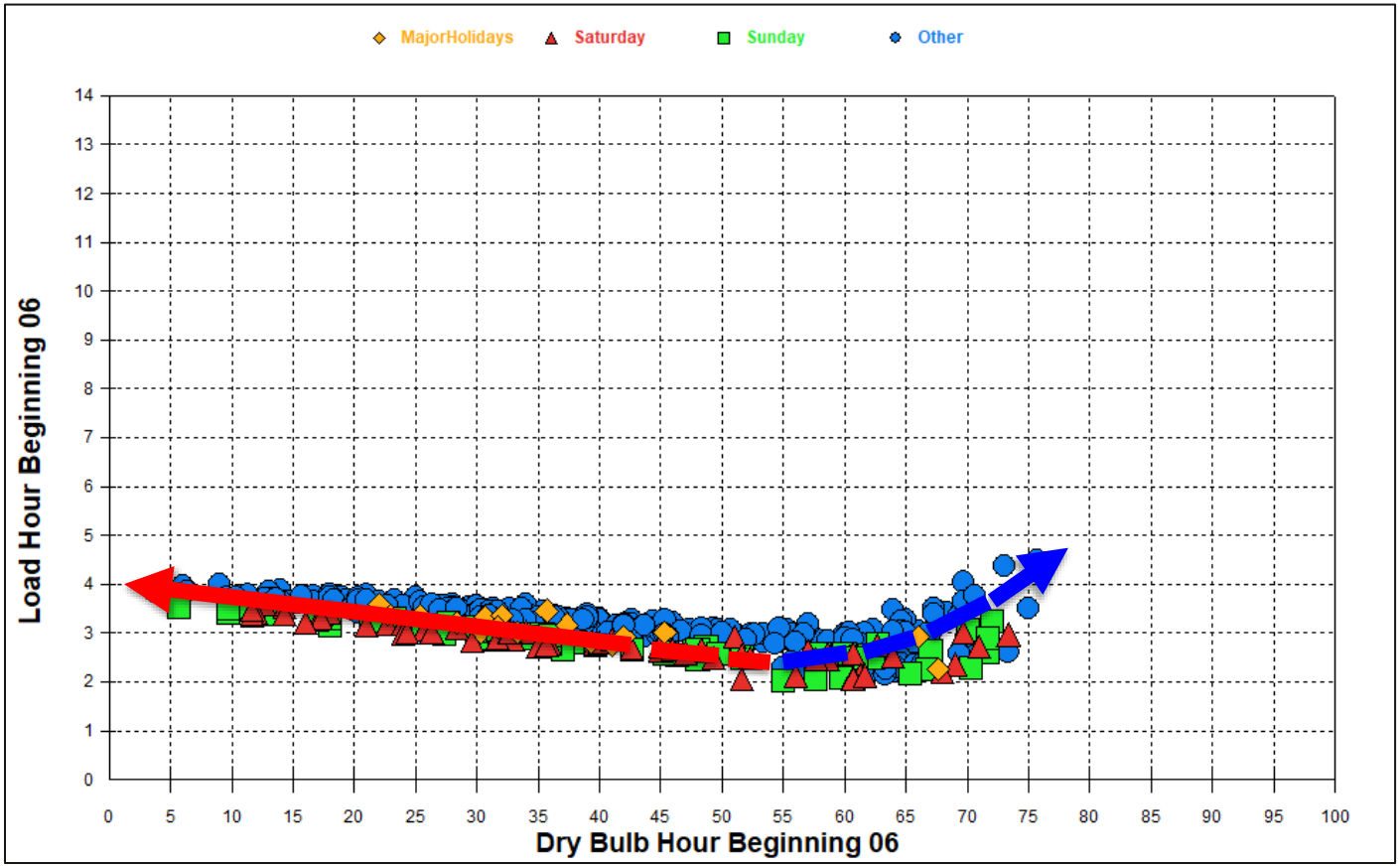
Feeder Hourly Load (MVA) Vs Dry Bulb 4AM



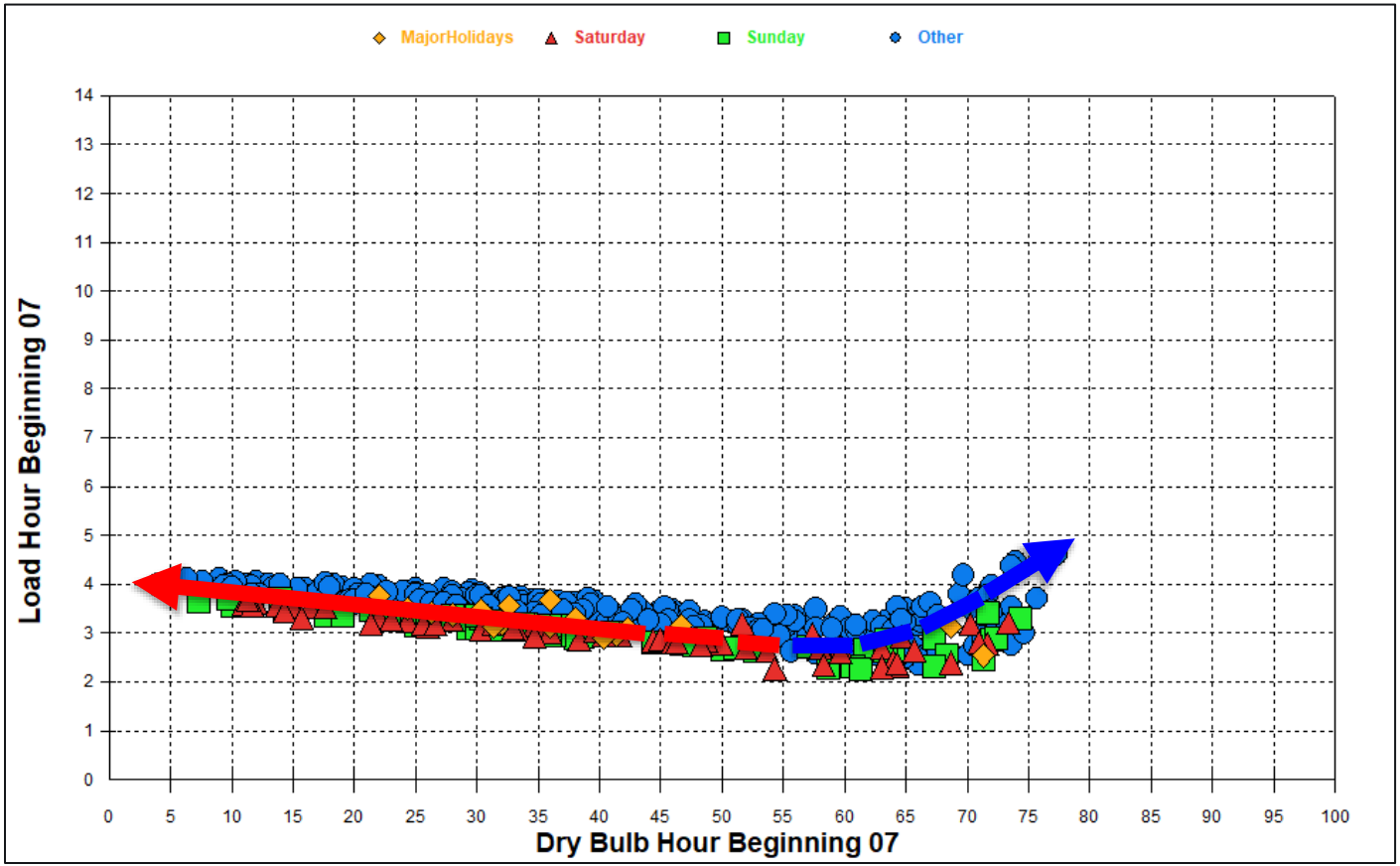
Feeder Hourly Load (MVA) Vs Dry Bulb 5AM



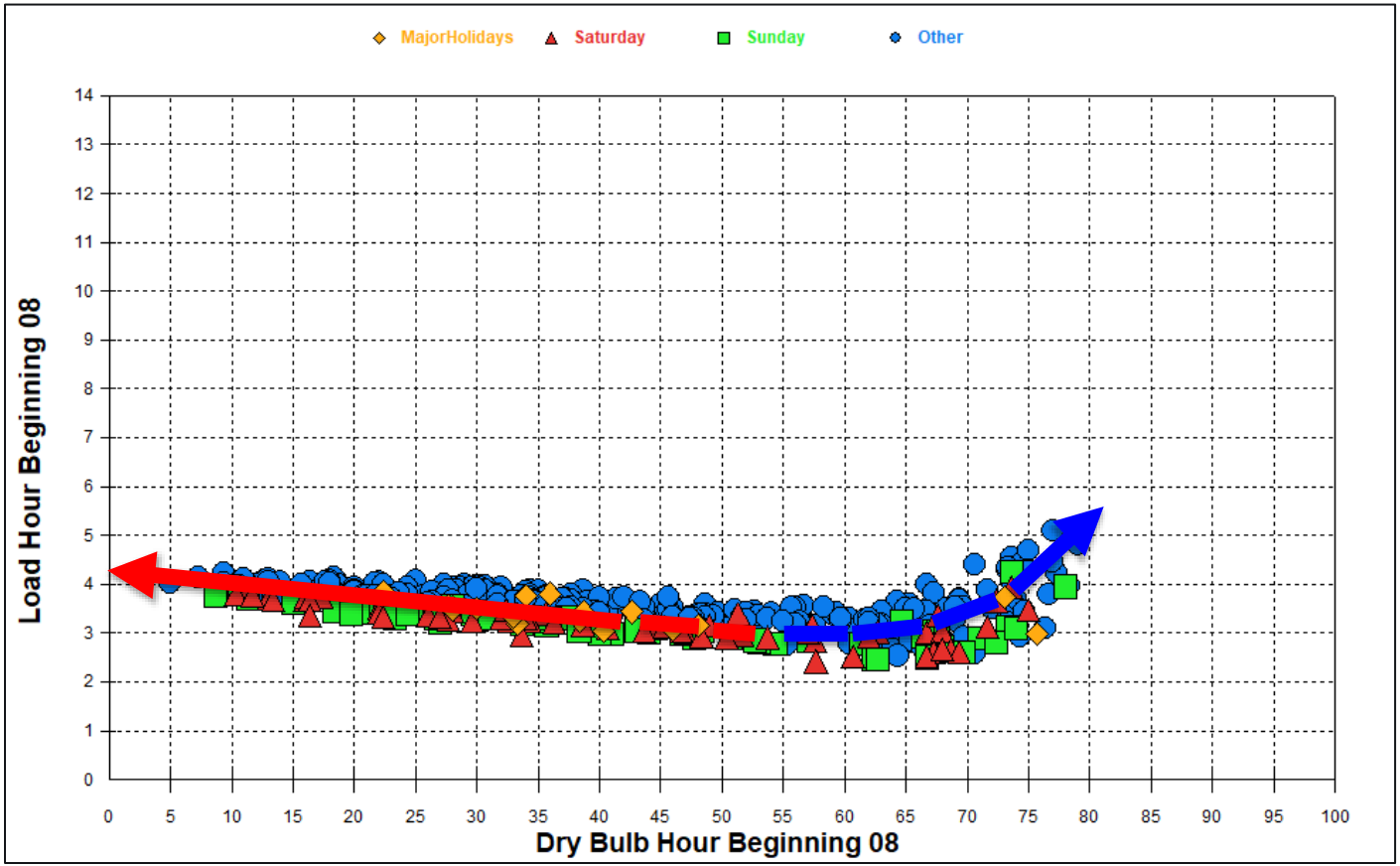
Feeder Hourly Load (MVA) Vs Dry Bulb 6AM



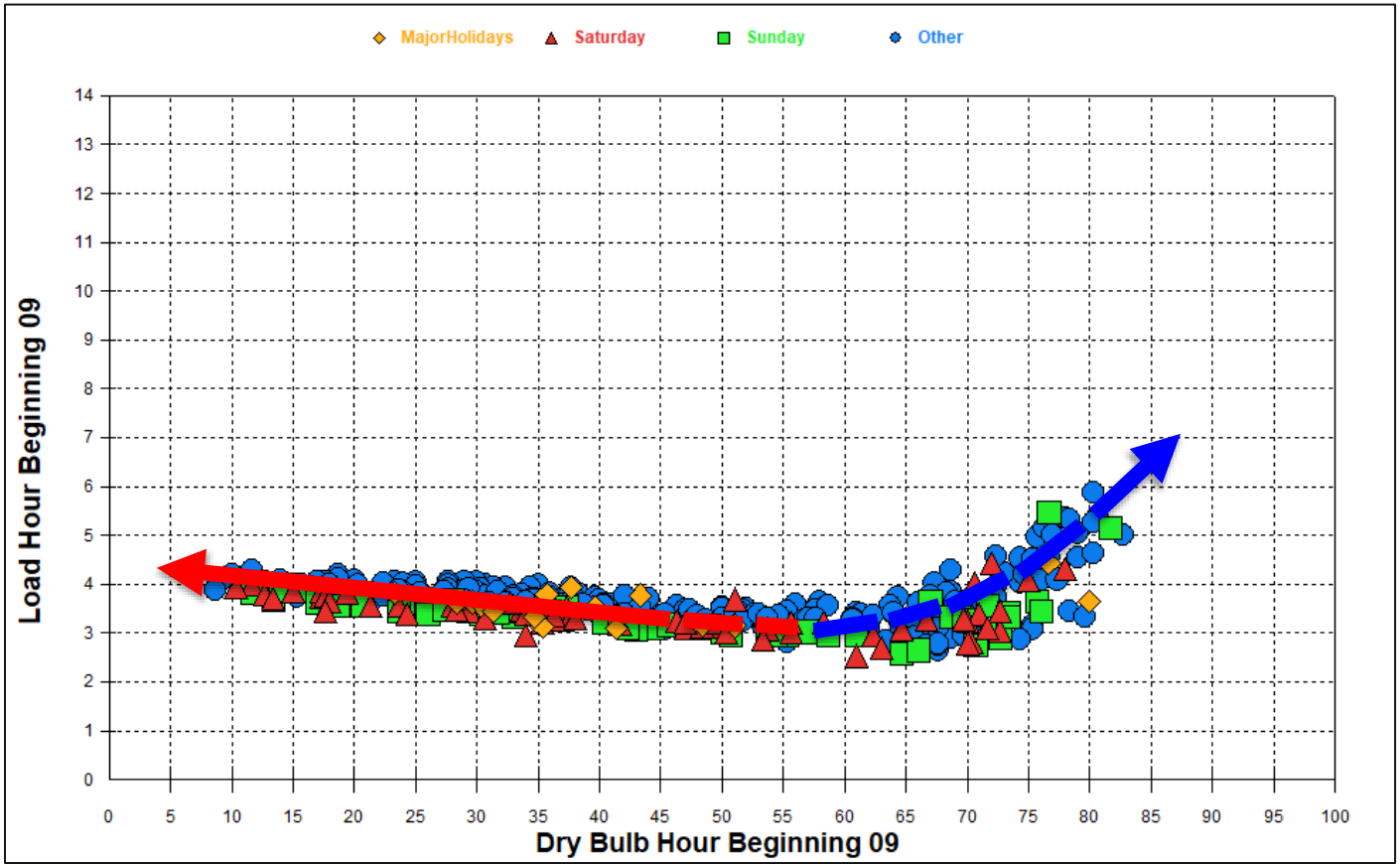
Feeder Hourly Load (MVA) Vs Dry Bulb 7AM



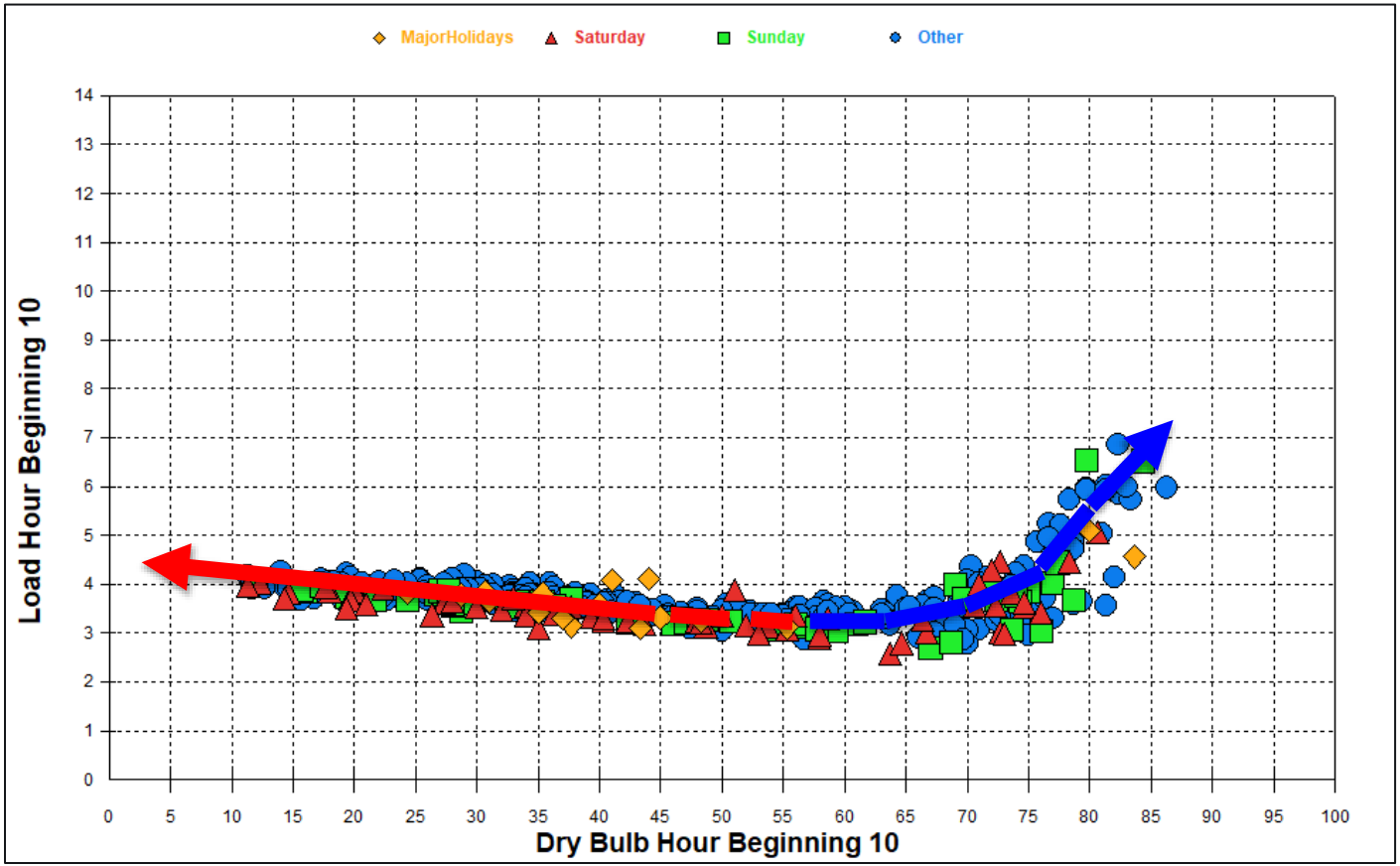
Feeder Hourly Load (MVA) Vs Dry Bulb 8AM



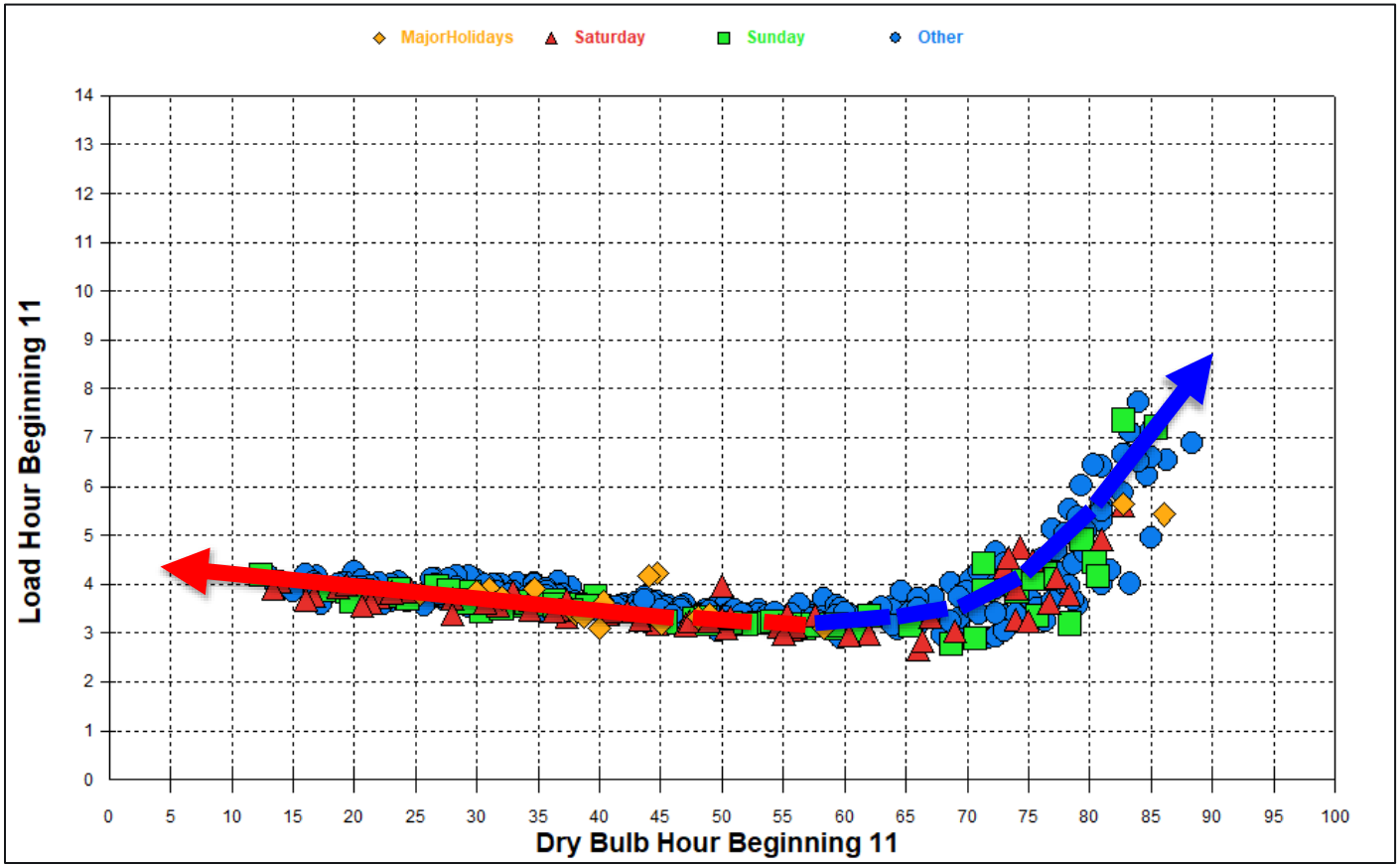
Feeder Hourly Load (MVA) Vs Dry Bulb 9AM



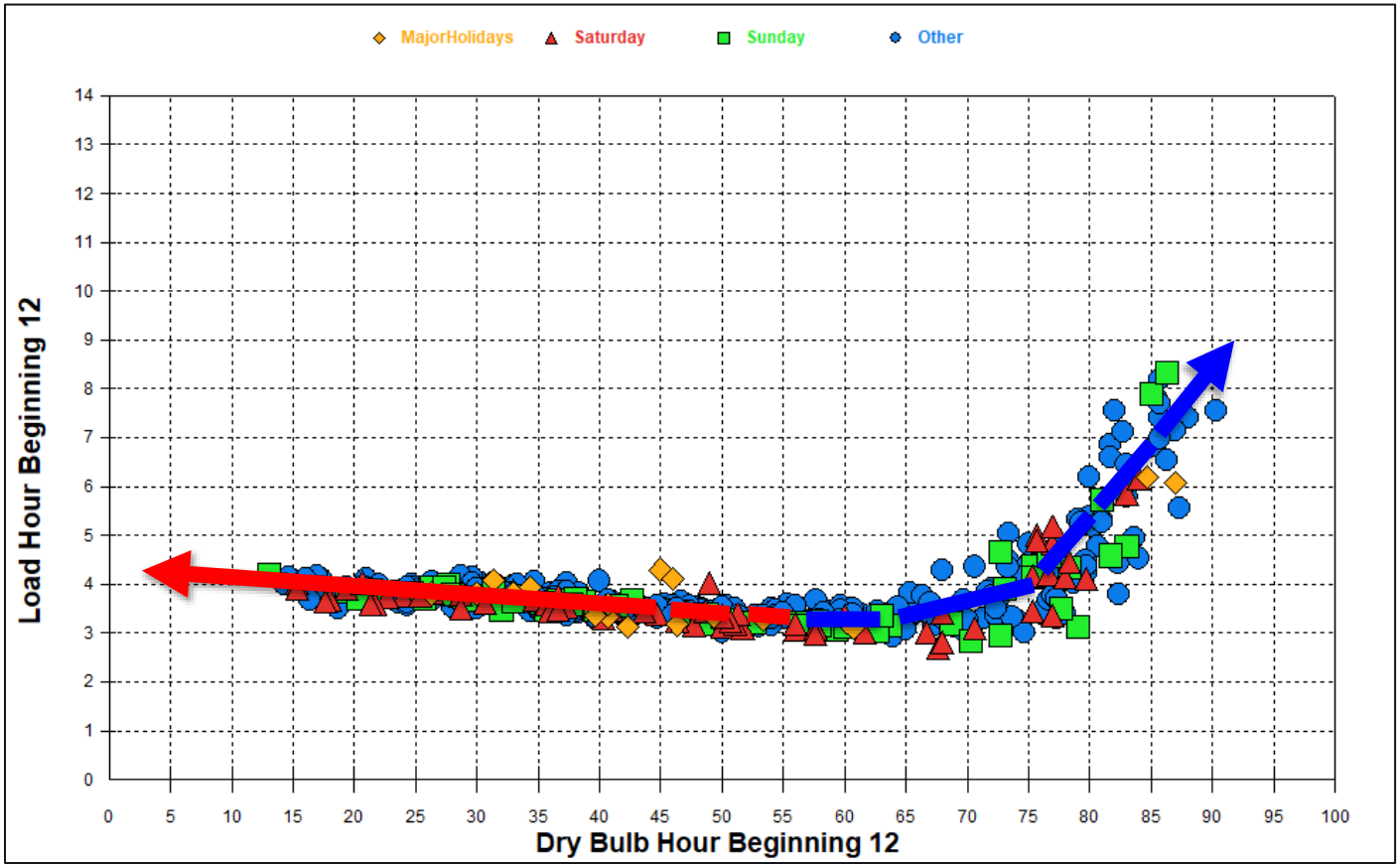
Feeder Hourly Load (MVA) Vs Dry Bulb 10AM



Feeder Hourly Load (MVA) Vs Dry Bulb 11AM



Feeder Hourly Load (MVA) Vs Dry Bulb 12PM



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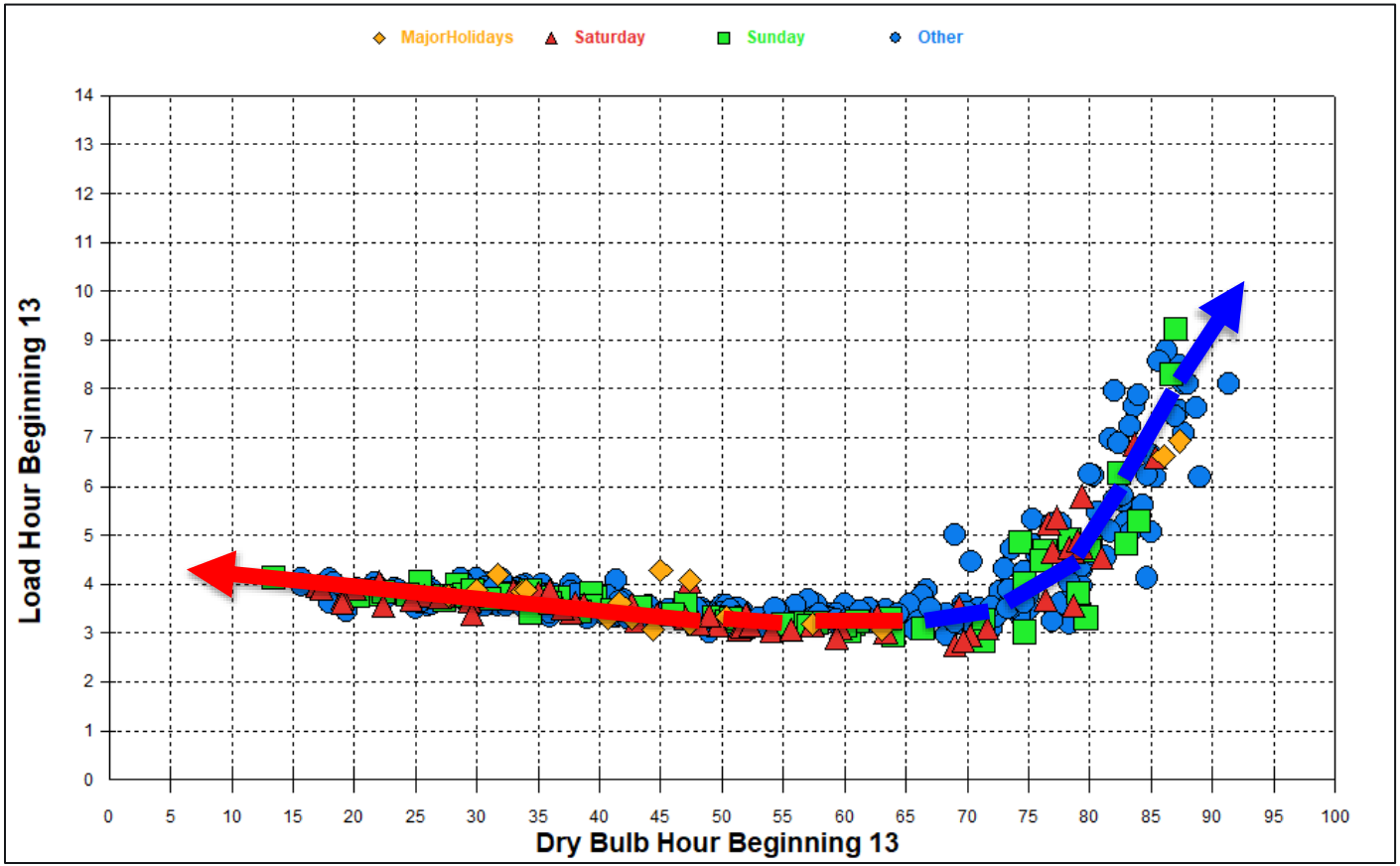

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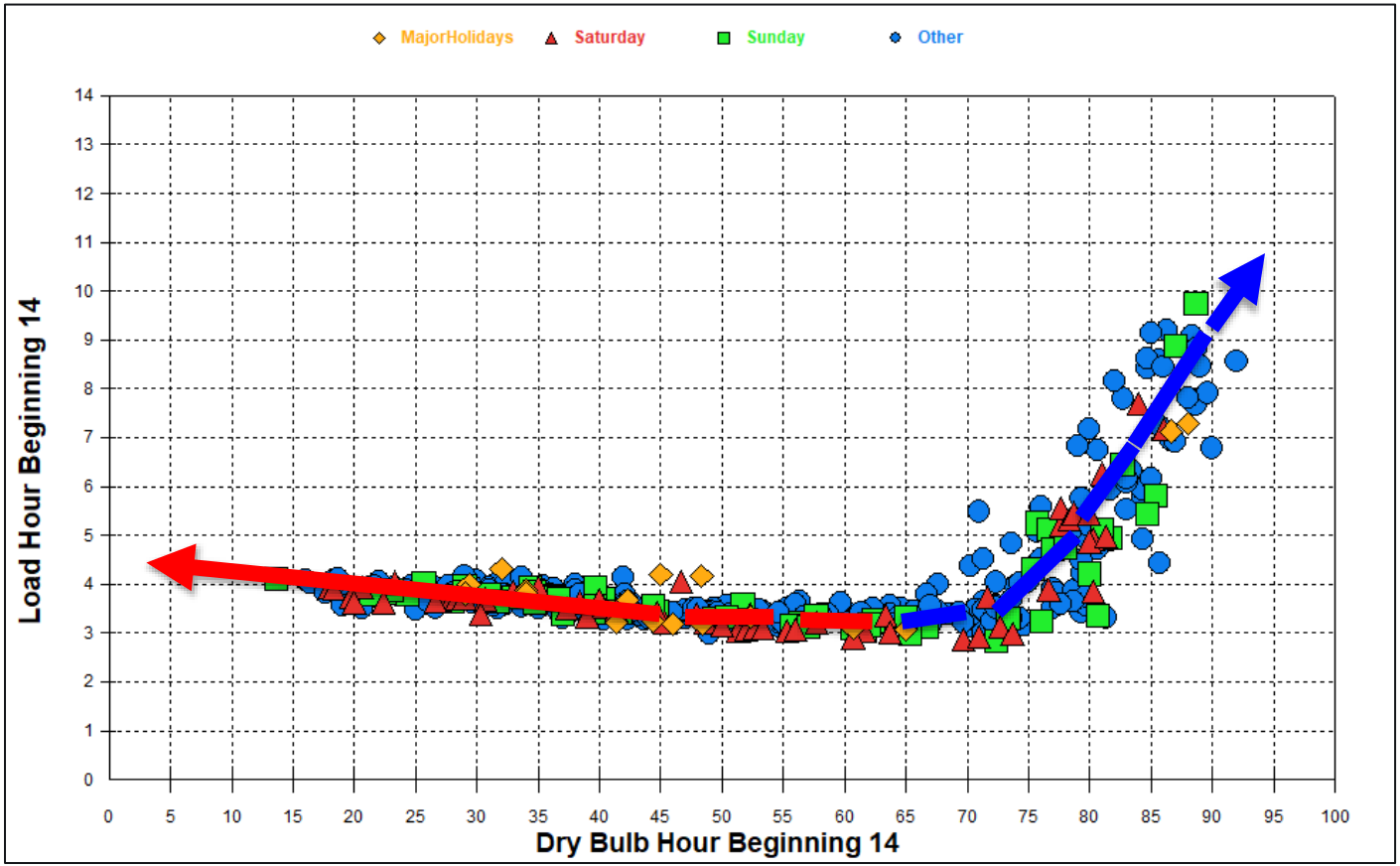
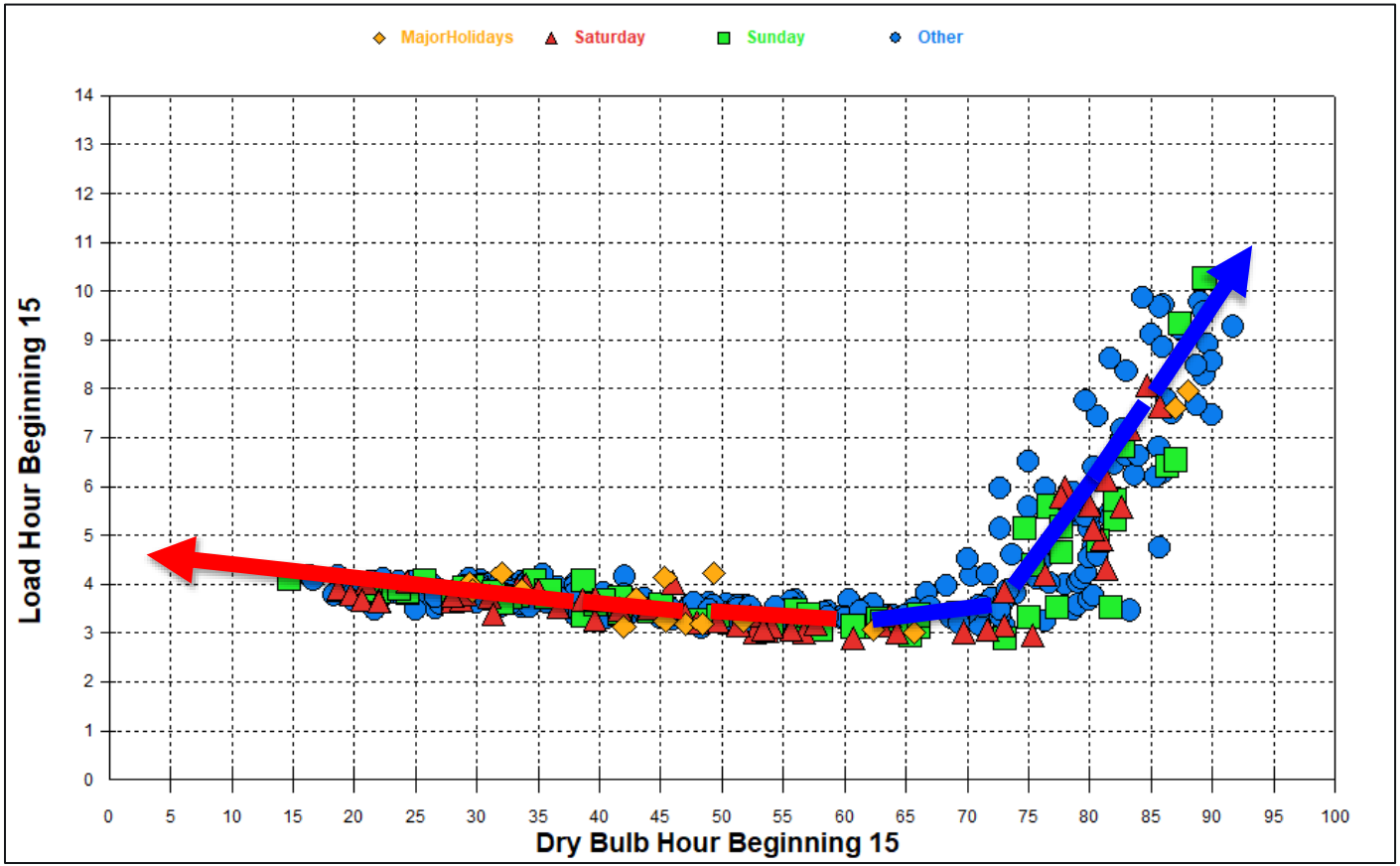


Feeder Hourly Load (MVA) Vs Dry Bulb 3PM



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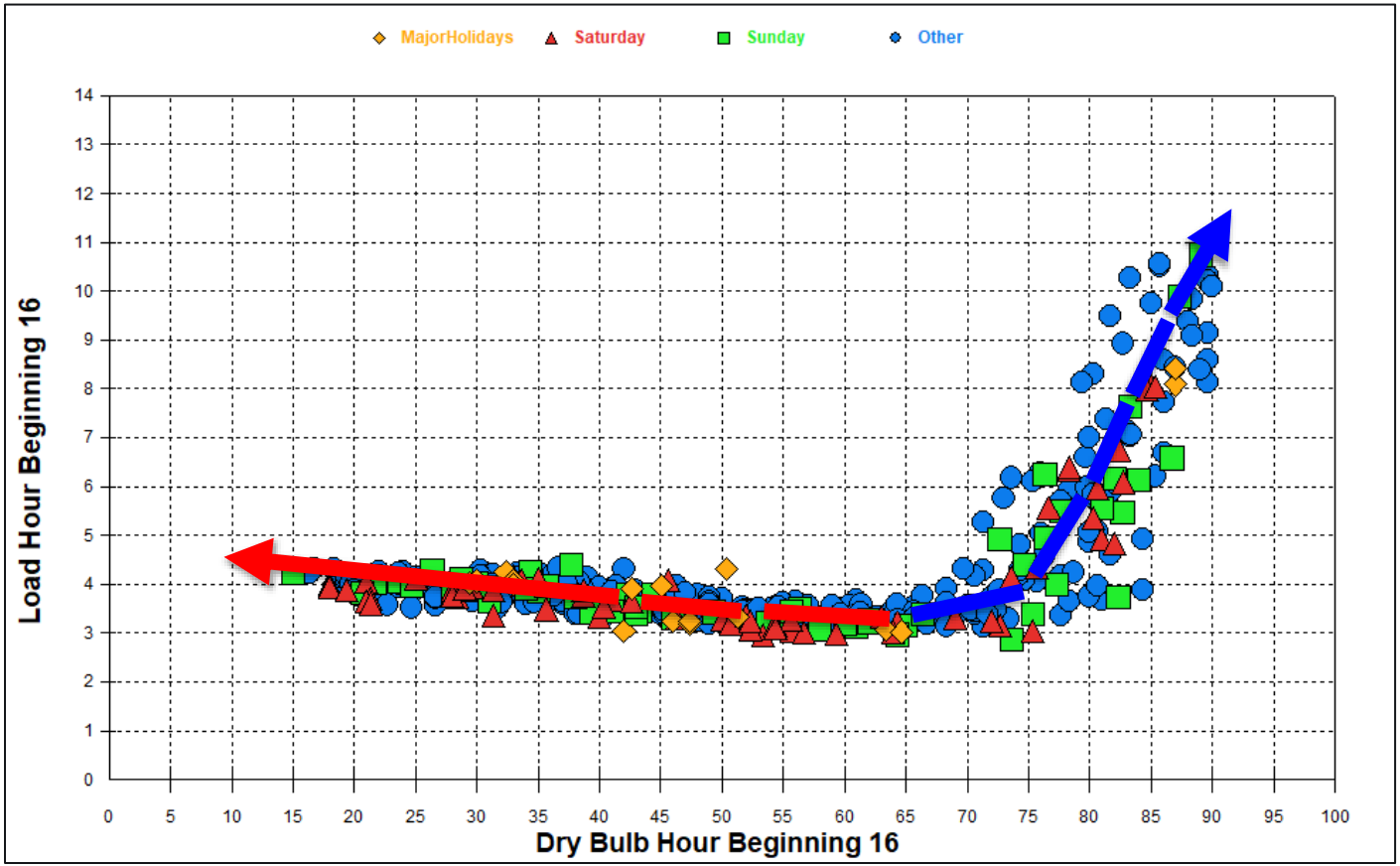
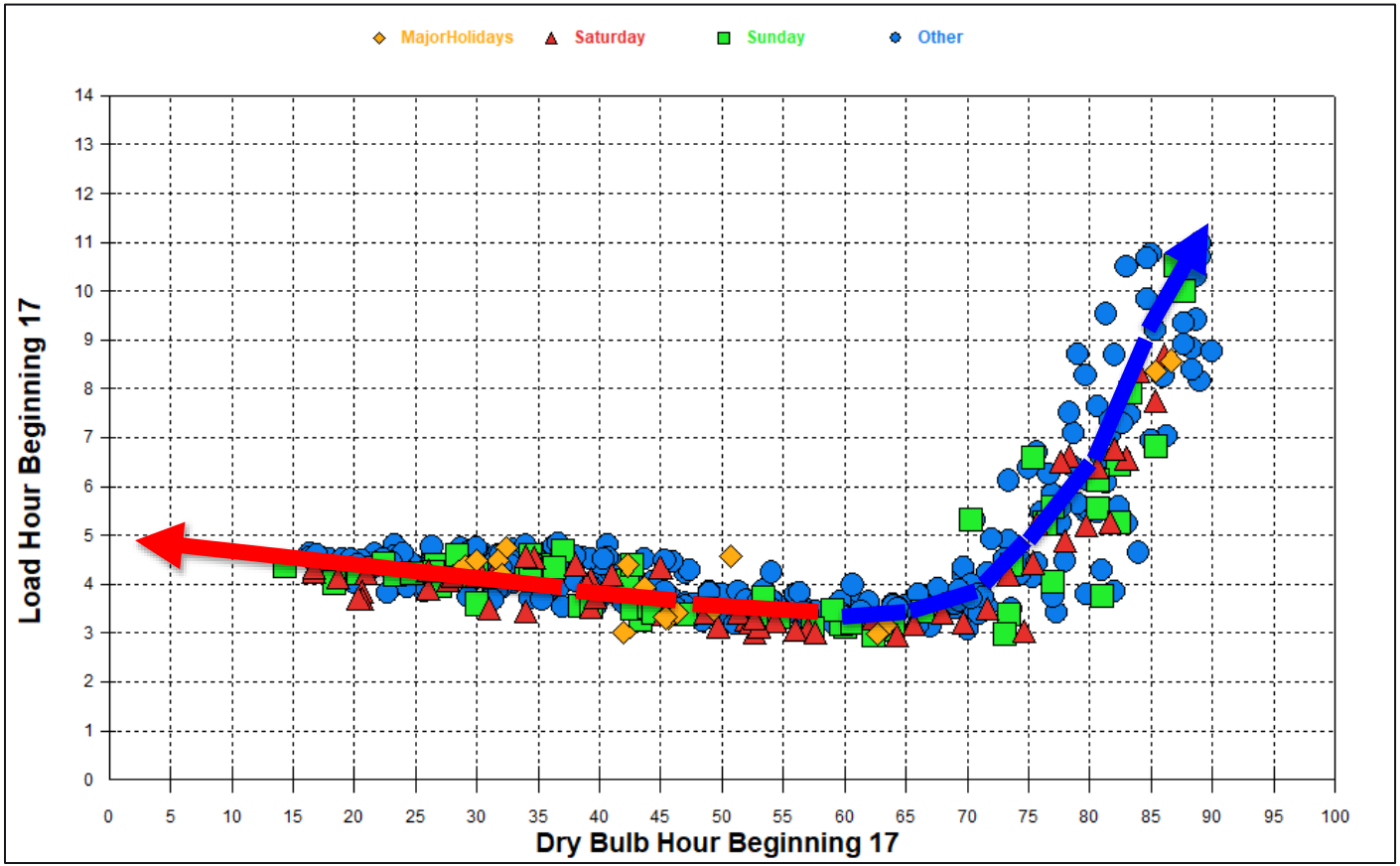


Feeder Hourly Load (MVA) Vs Dry Bulb 5PM



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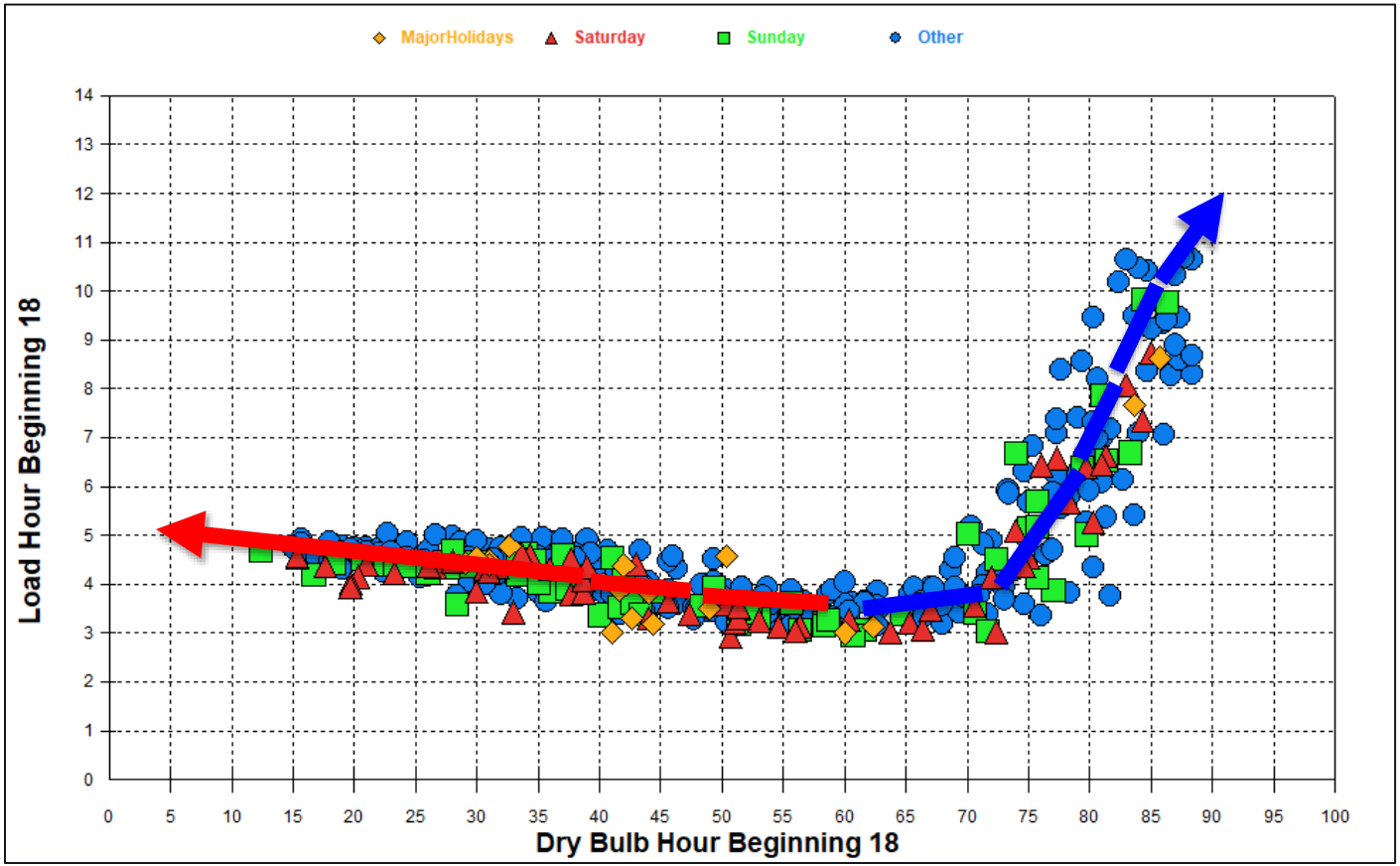

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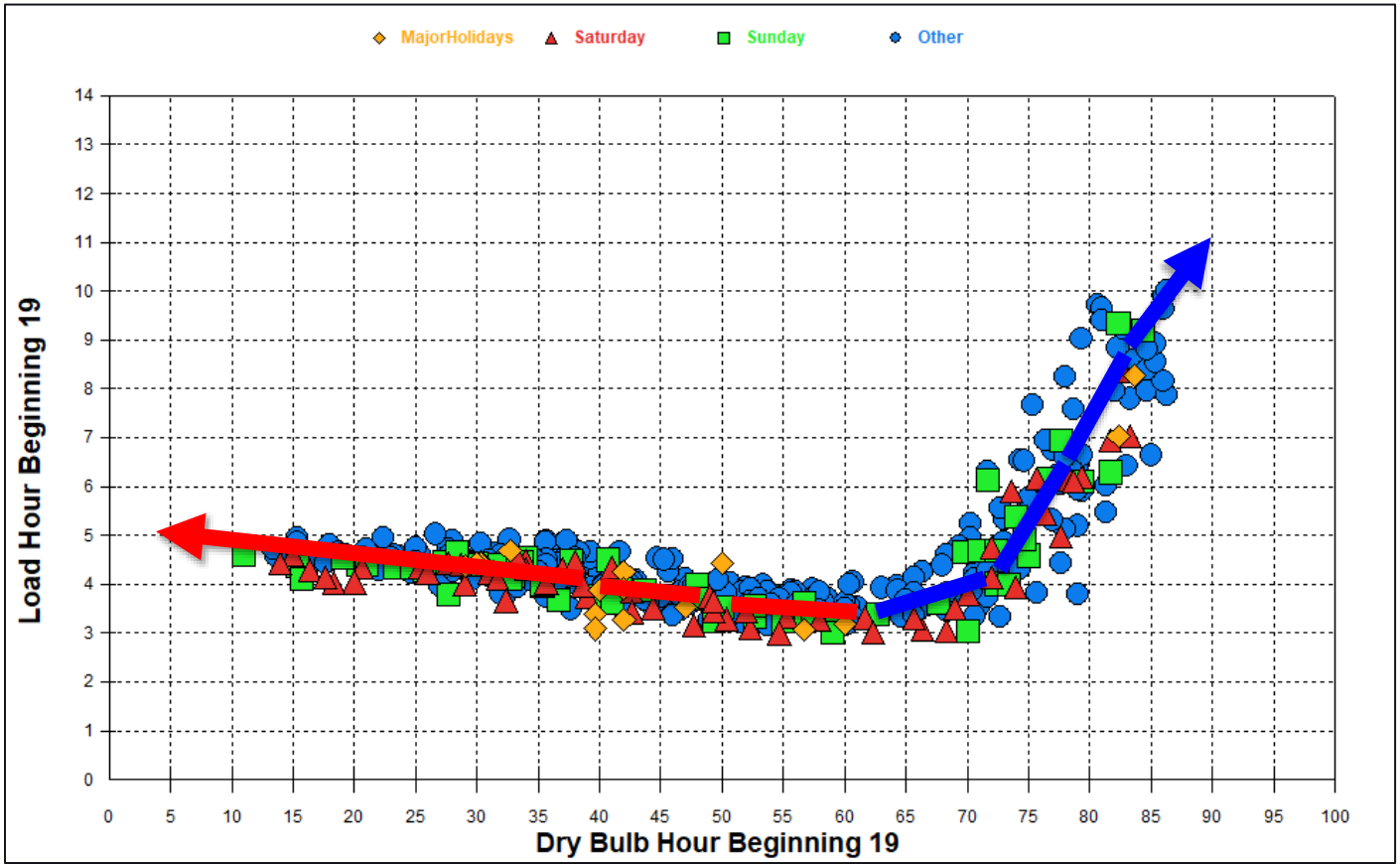

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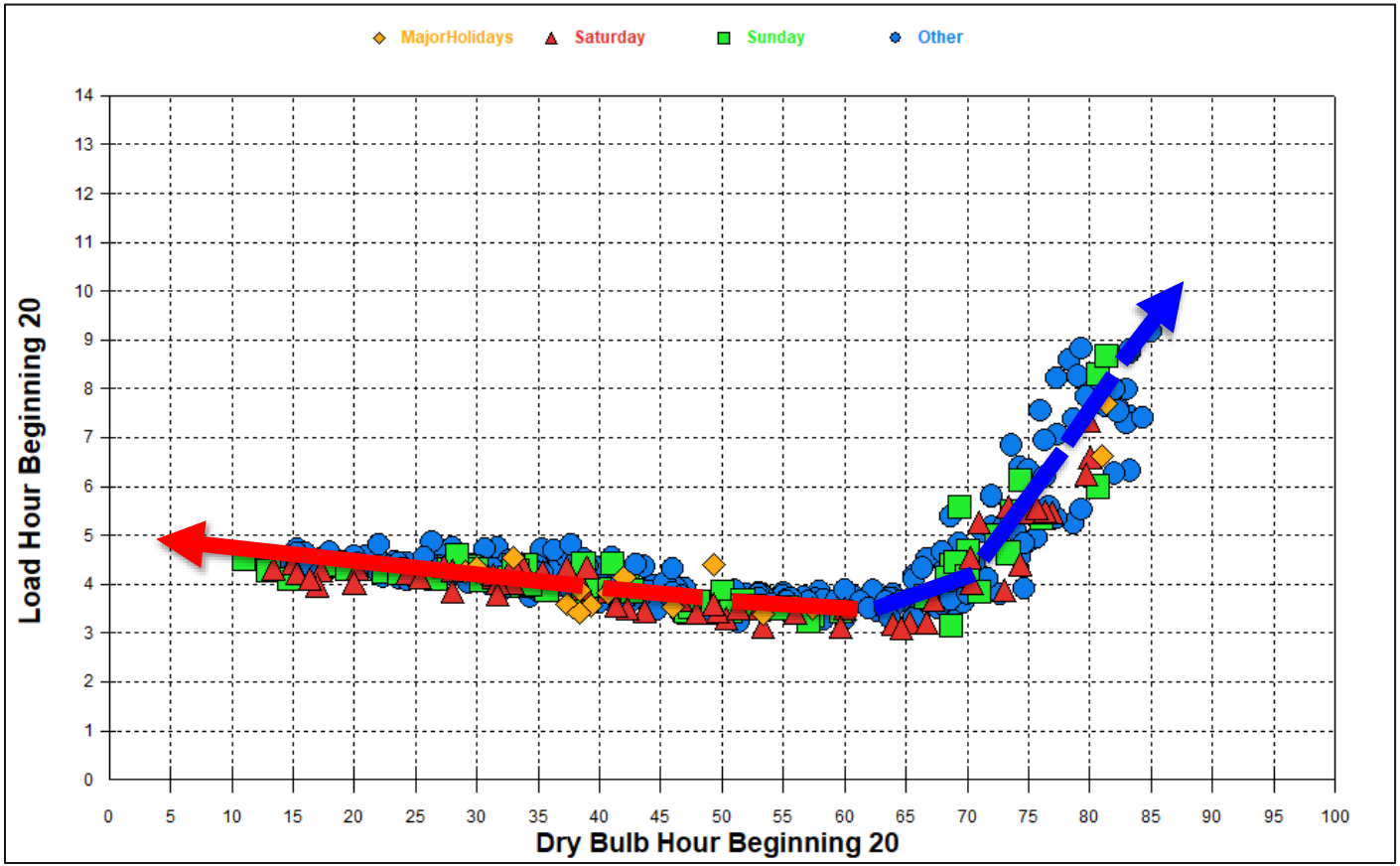

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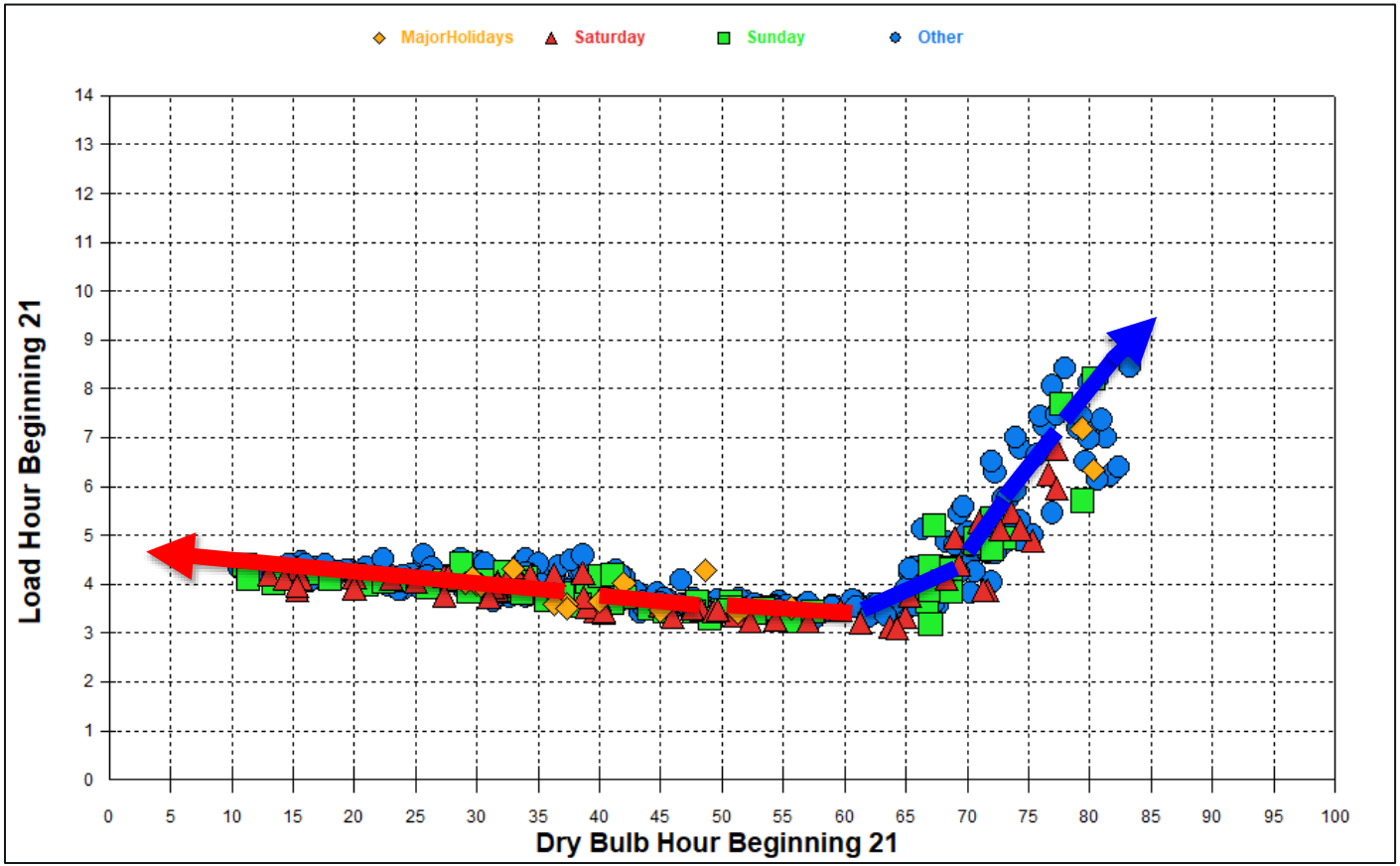
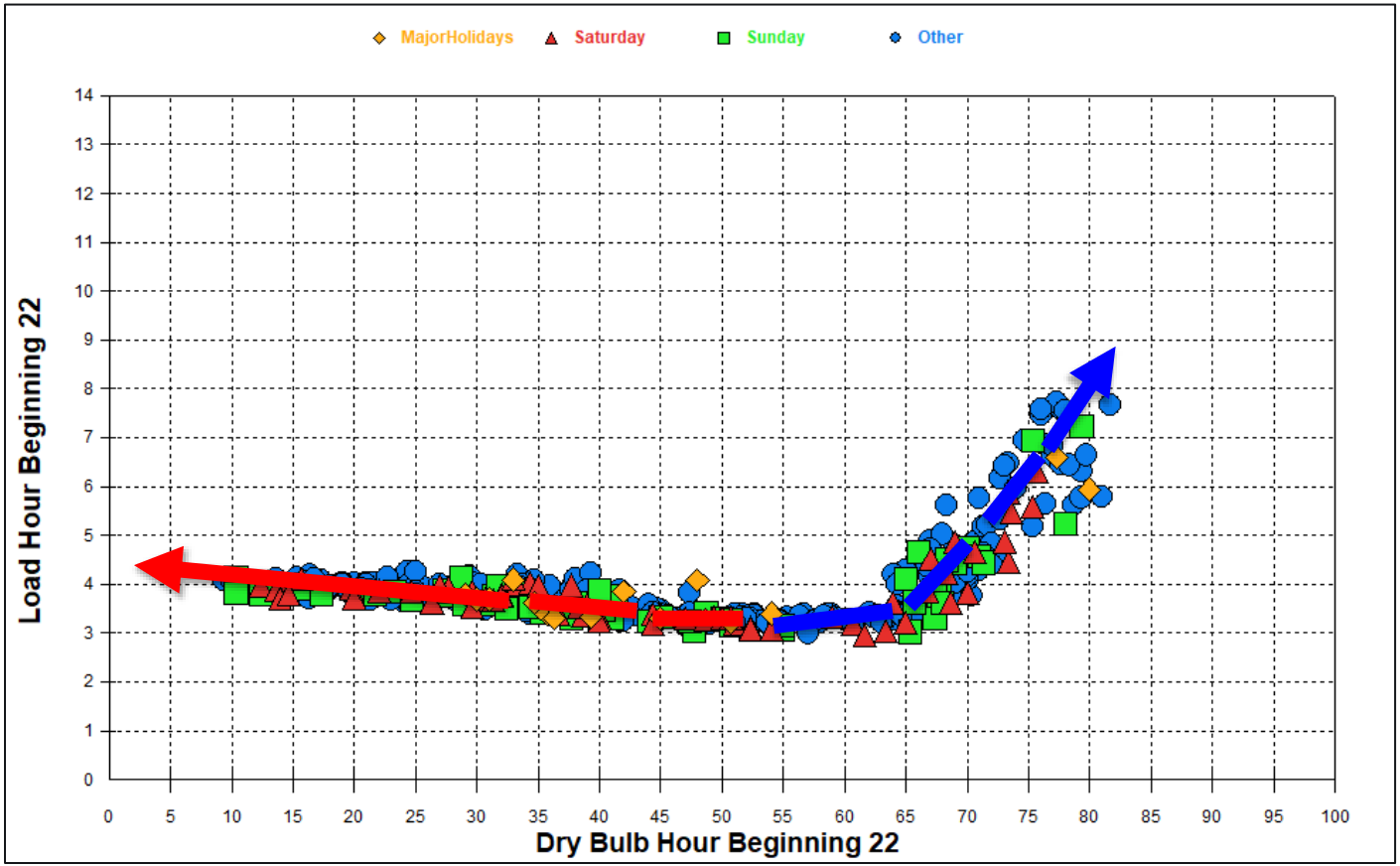
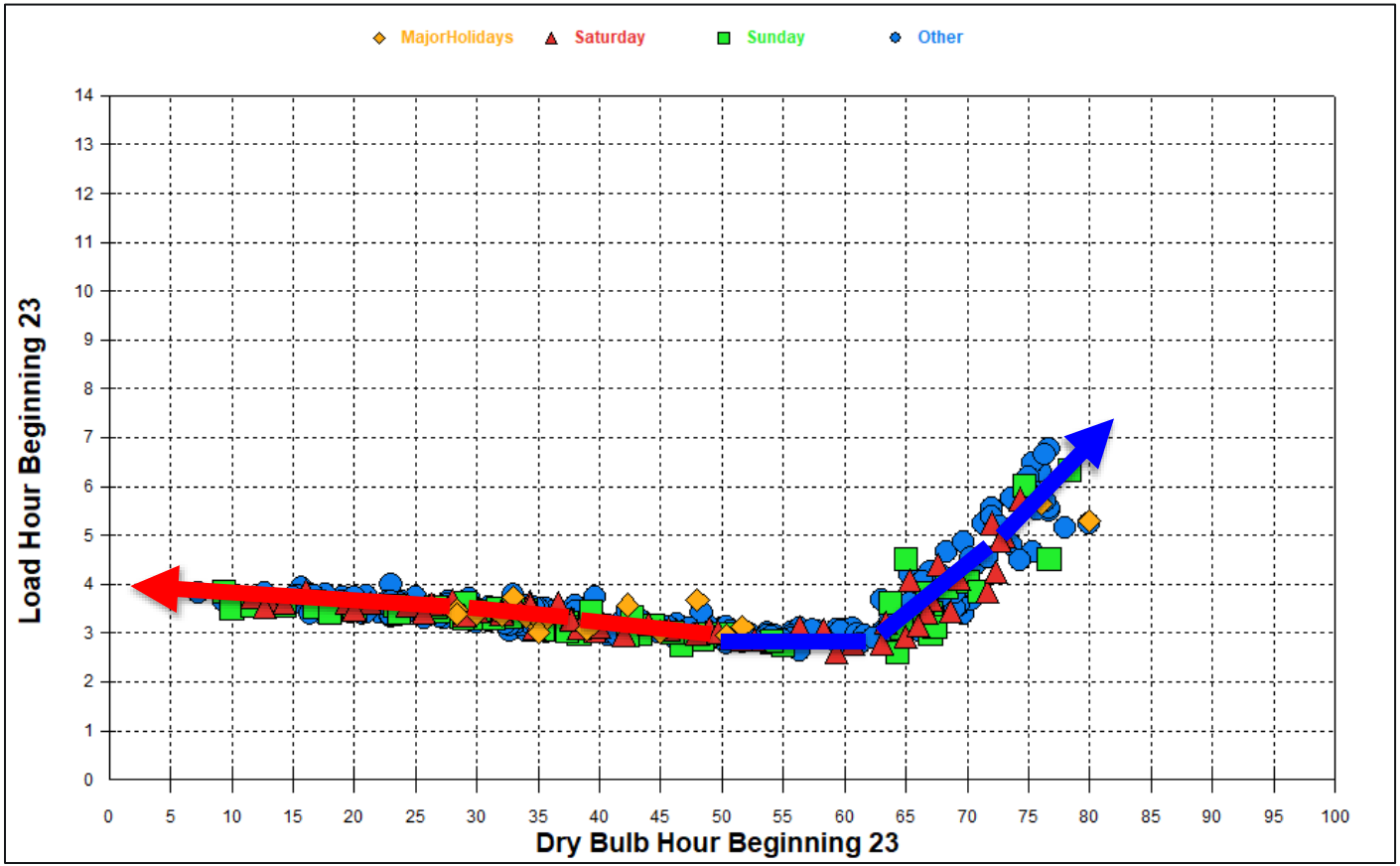


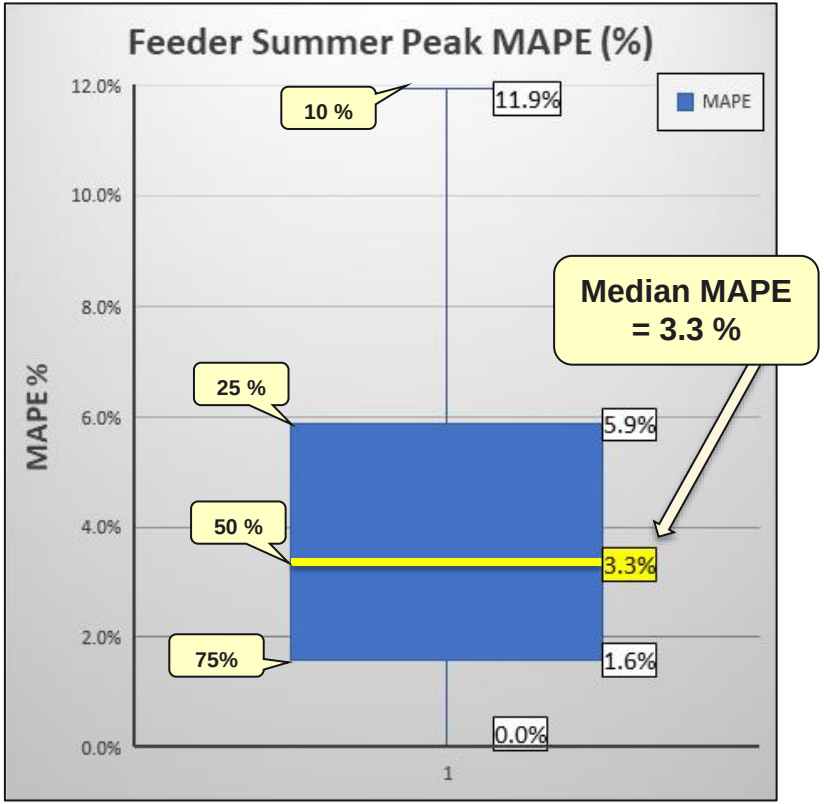
Feeder Hourly Load (MVA) Vs Dry Bulb 10PM

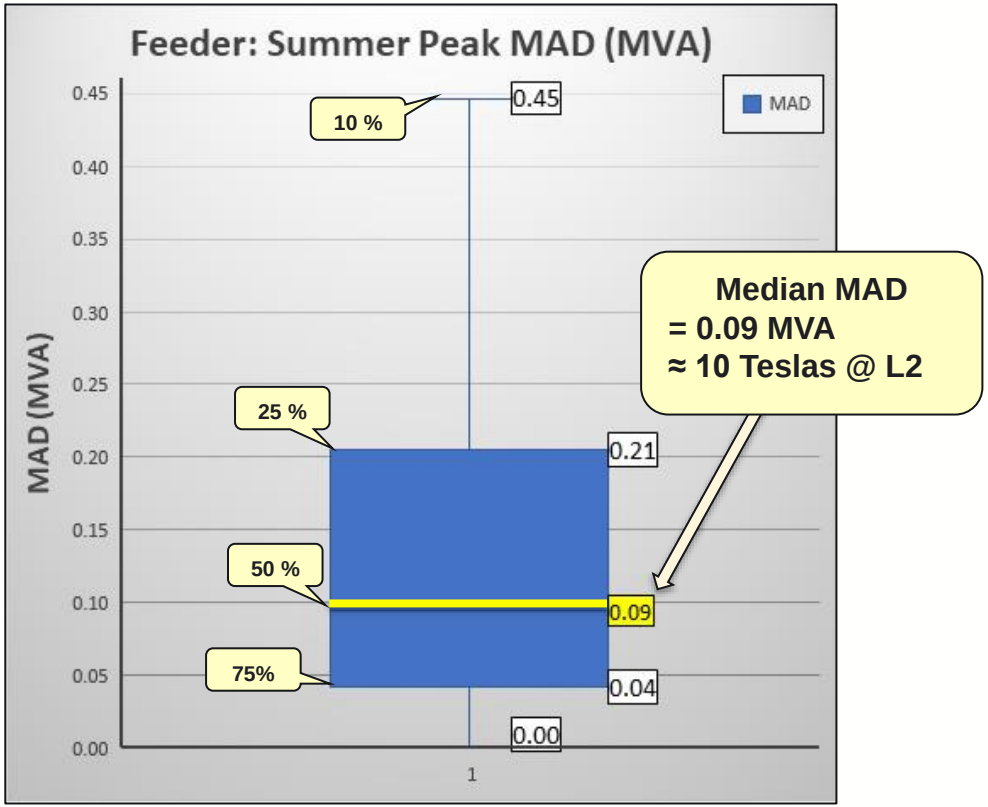


Feeder Hourly Load (MVA) Vs Dry Bulb 11PM

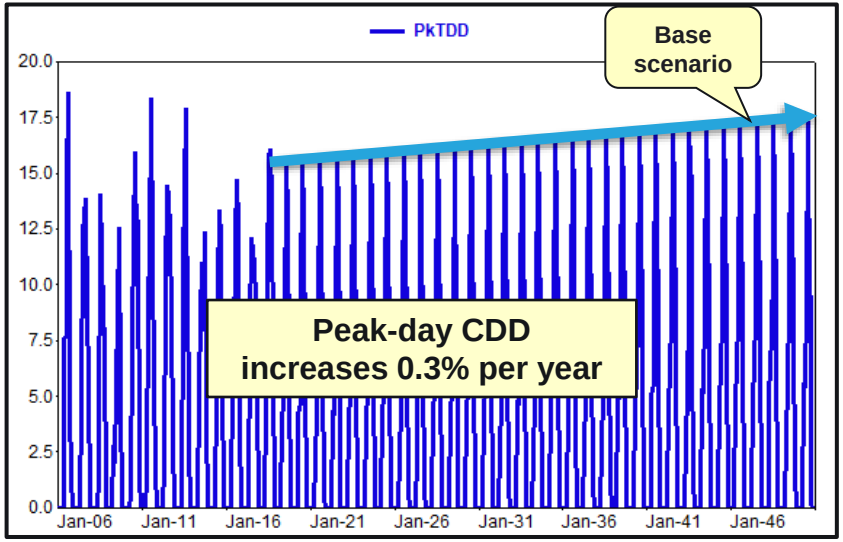


Feeder Summer Peak Accuracy Distribution:



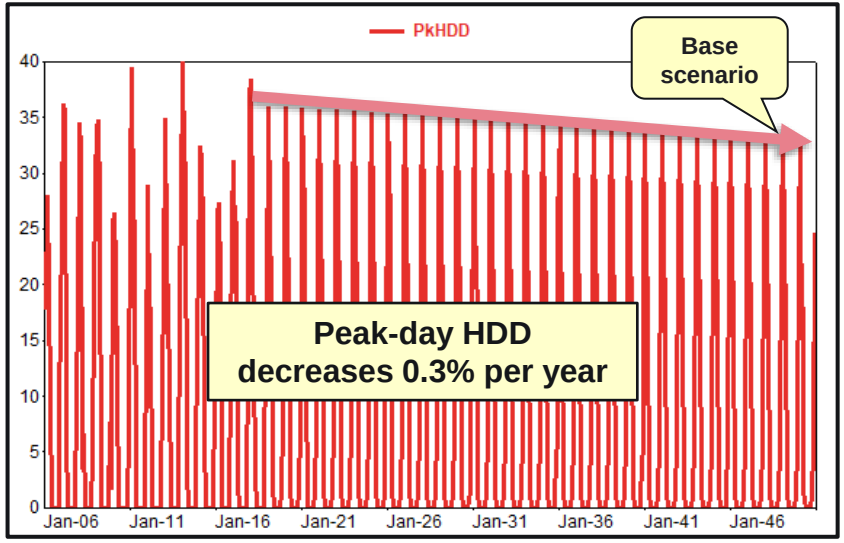


Peak Weather: Climate Change Trends



Extreme Summer Weather

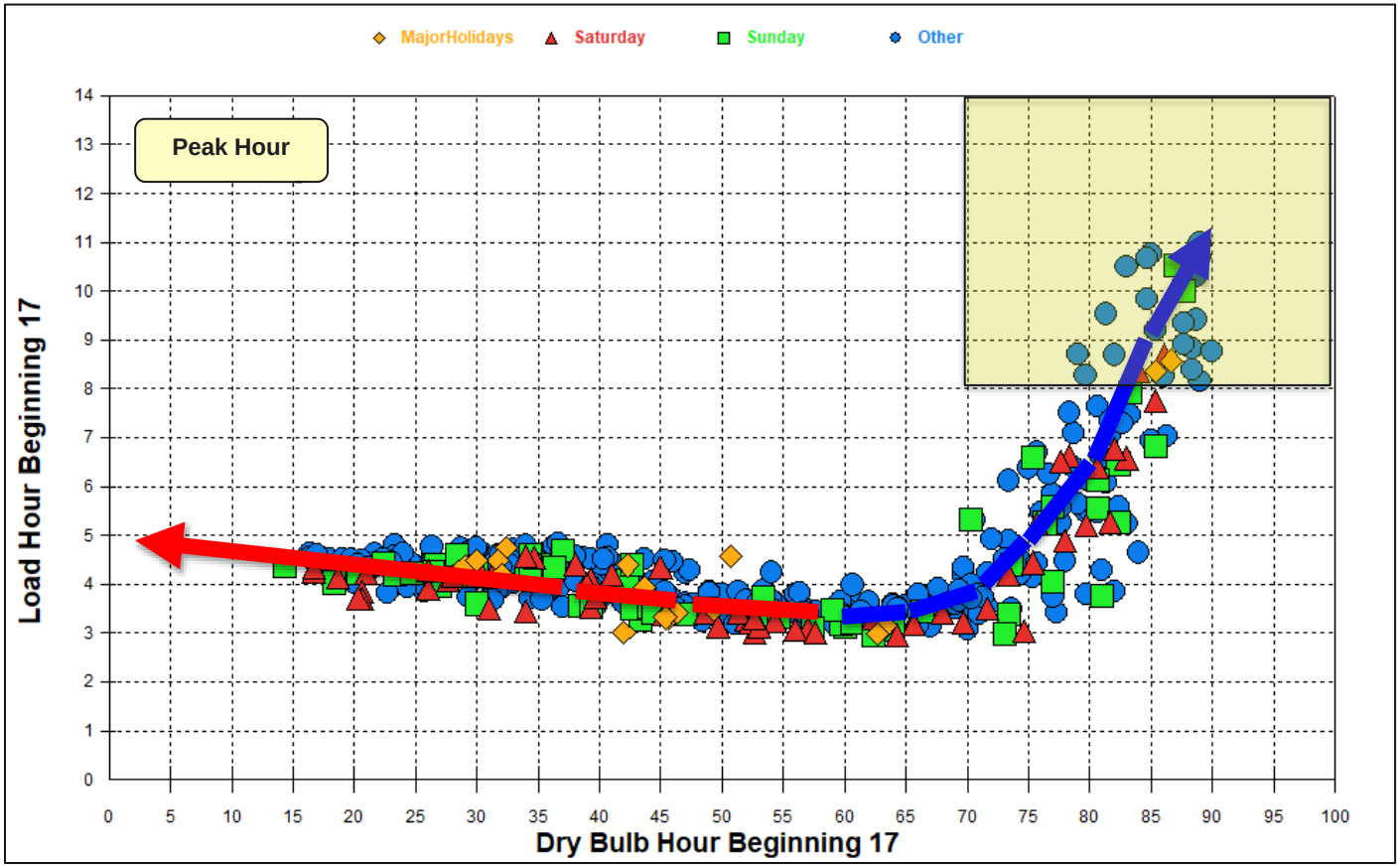
- 1 in 10 Summer Peak DB = 2.3 deg > Base
- 1 in 20 Summer Peak DB = 5.6 deg > Base



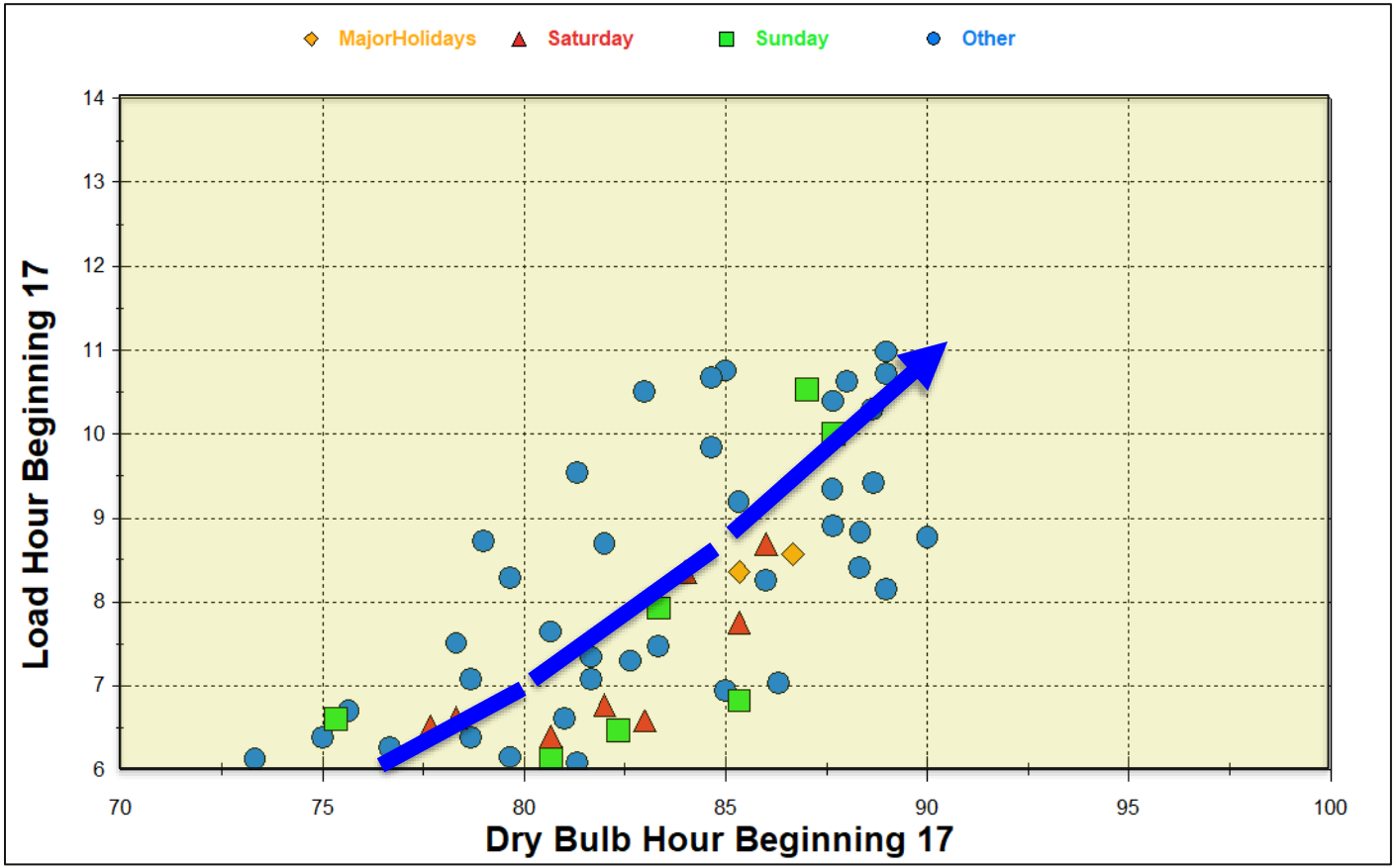
Extreme Winter Weather

- 1 in 10 Winter Peak DB = 6.8 deg < Base
- 1 in 20 Winter Peak DB = 18.1 deg < Base

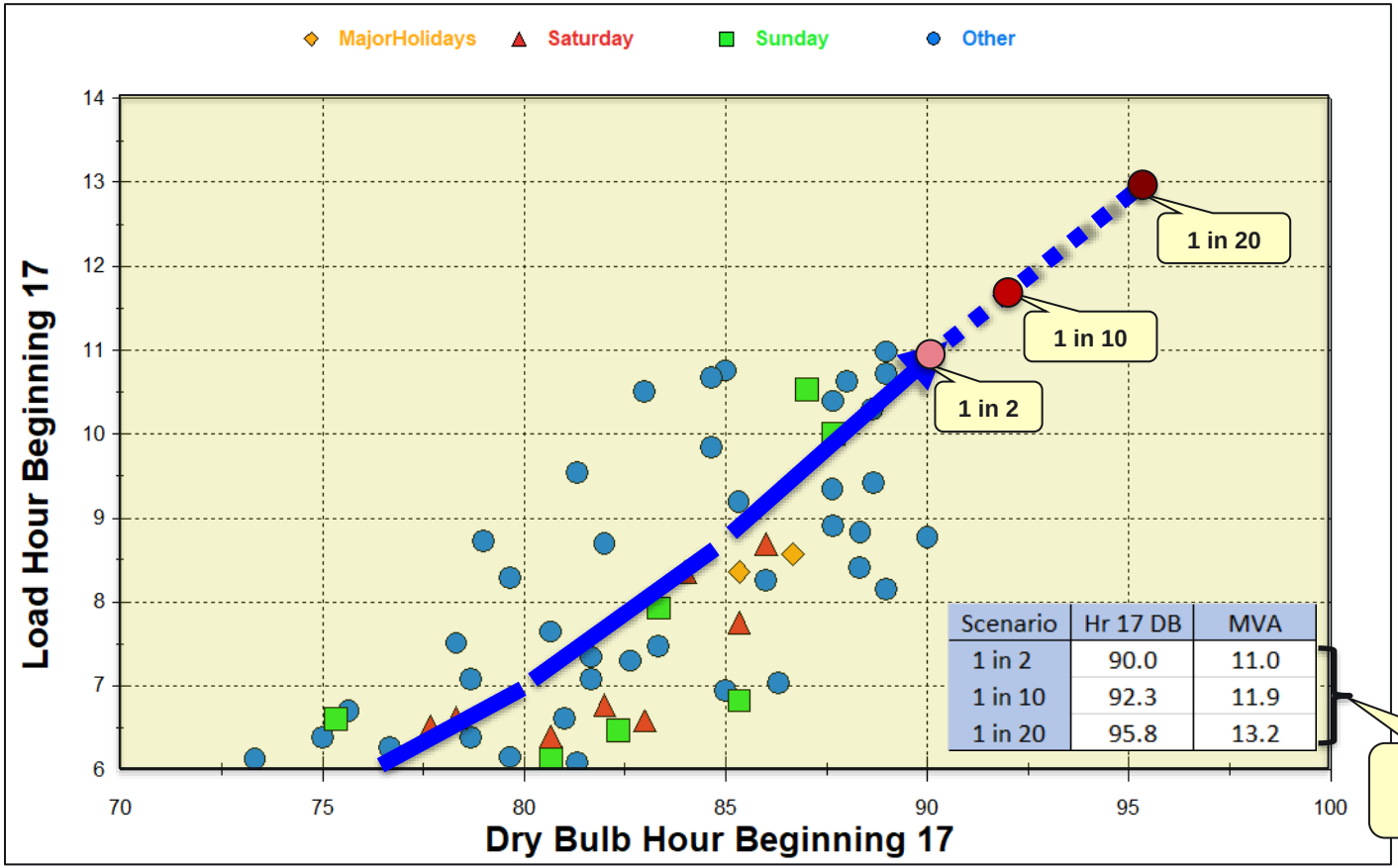
Feeder Hourly Load (MVA) 5PM



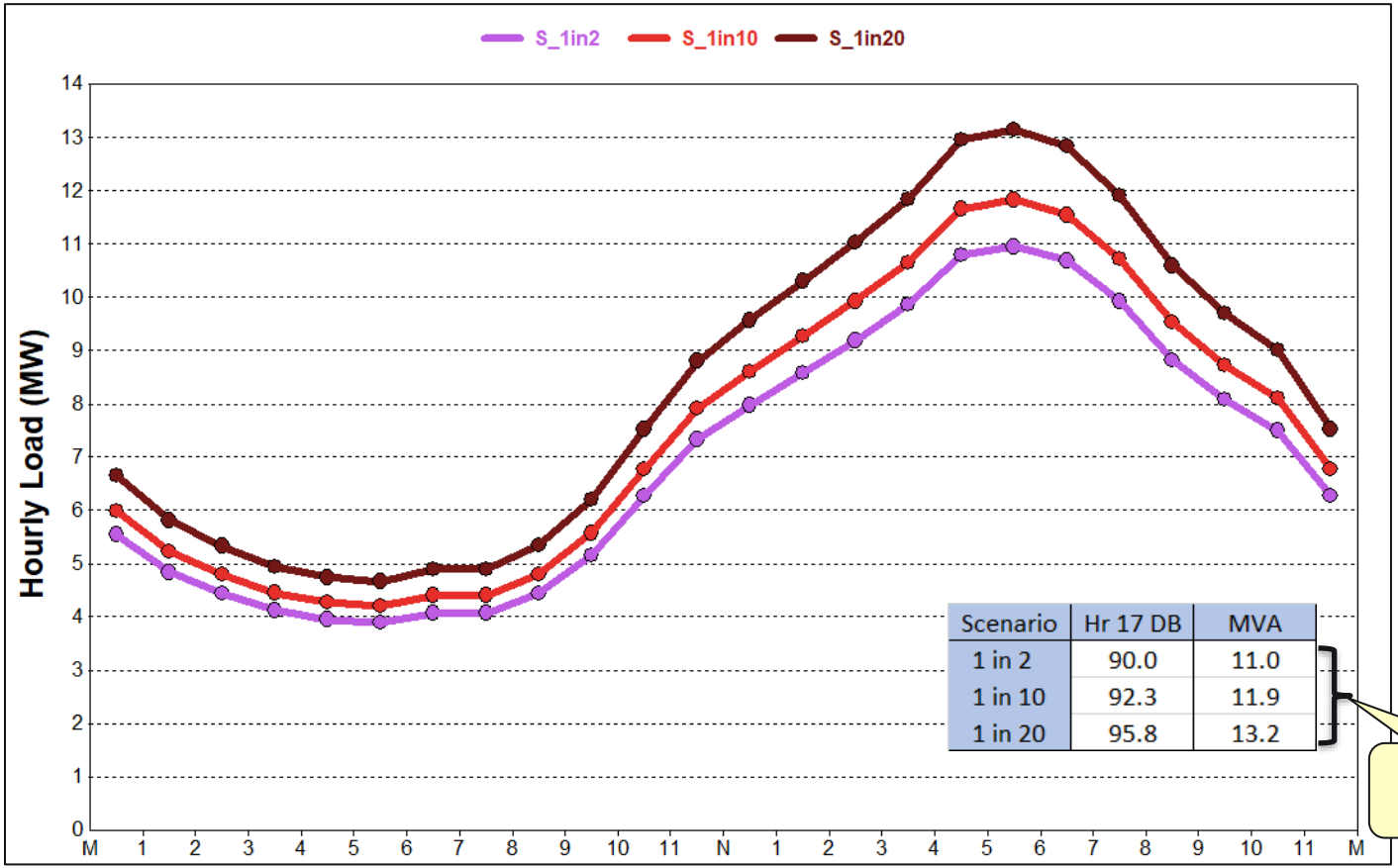
Feeder Hourly Load Vs Dry Bulb 5PM: Peak Zoom



Load Vs Dry Bulb 5PM: Scenario Forecasts



Feeder Baseline Peak Day Load Shape

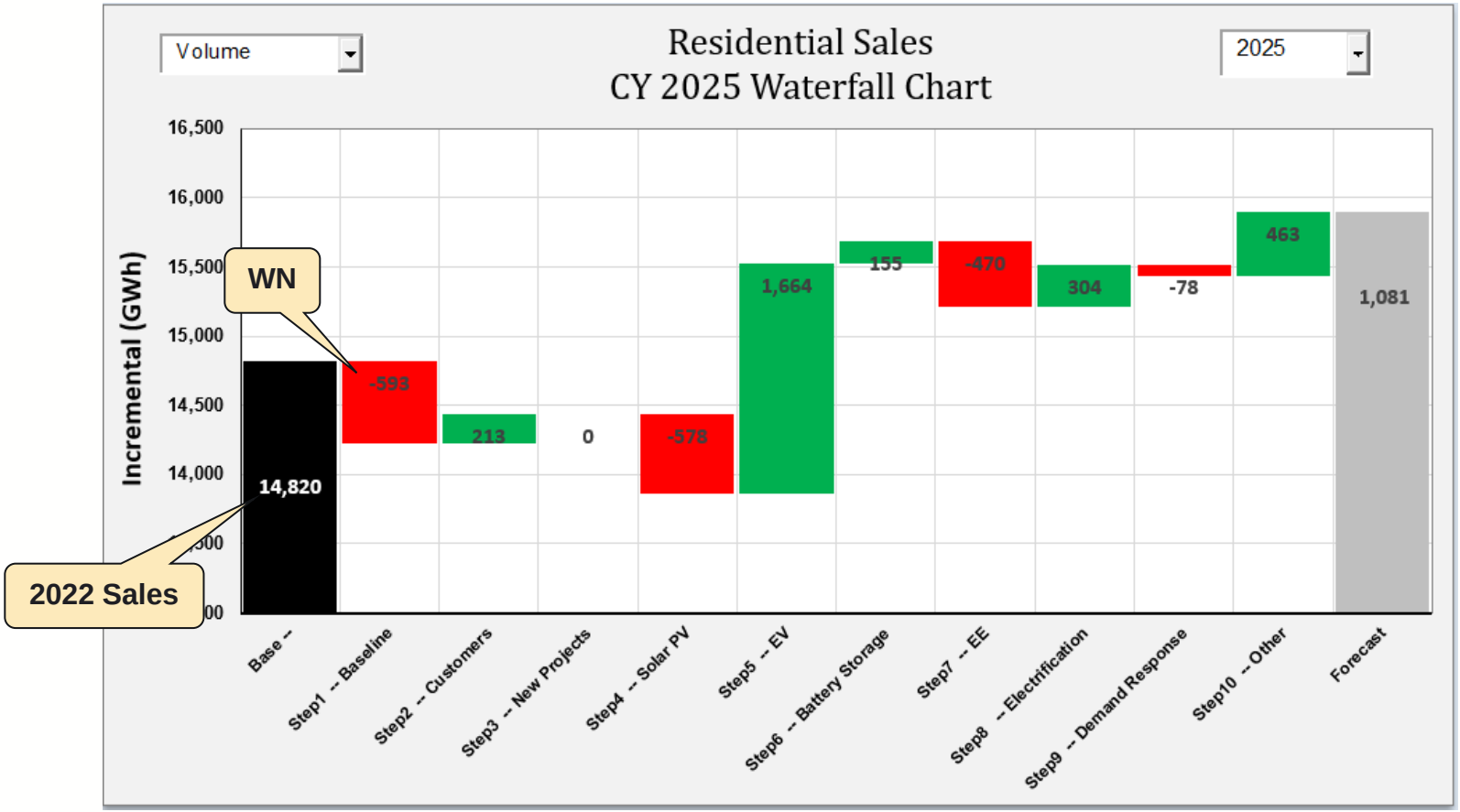


Scenario	Hr 17 DB	MVA
1 in 2	90.0	11.0
1 in 10	92.3	11.9
1 in 20	95.8	13.2

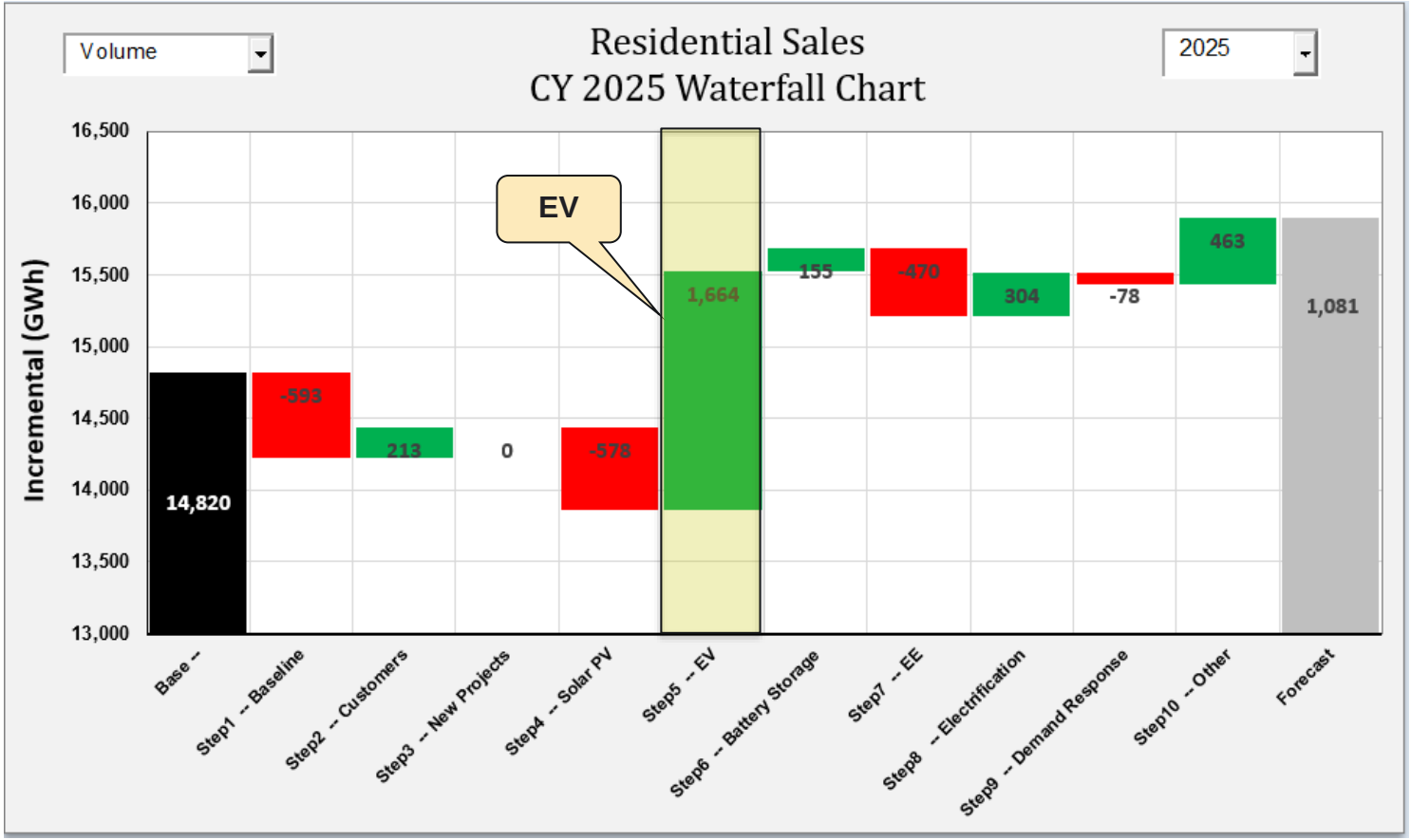
≈ 240 Teslas @ L2

Components of Change

Forecast Waterfall Example



Forecast Waterfall Example



Electric Vehicle subcomponents

Fleet Vehicle Charging	
Charging Type	Stock Units
Light-Duty Sedan	Vehicle Miles Traveled
Medium-Duty Truck	Vehicle Miles Traveled
Agriculture Truck	Vehicle Miles Traveled
Construction Truck	Vehicle Miles Traveled
Utility Truck	Vehicle Miles Traveled
Tractor-Trailer	Vehicle Miles Traveled
Drayage Truck	Vehicle Miles Traveled
Refuse Truck	Vehicle Miles Traveled
Bus	Vehicle Miles Traveled

Each fleet vehicle charging category requires forecasts of the following:

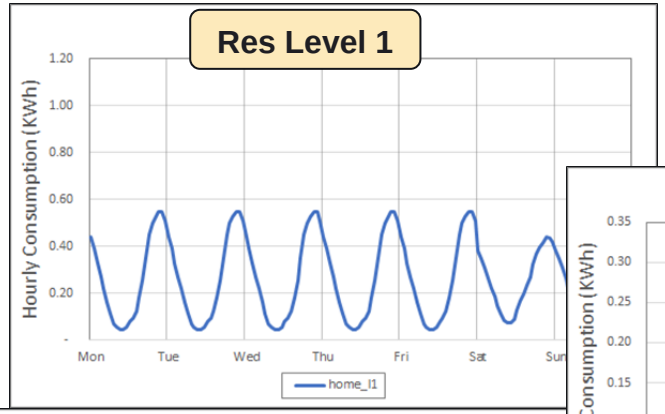
- # of Vehicles
- Vehicles Miles Traveled
- KWh / Mile
- Hourly Load Shape

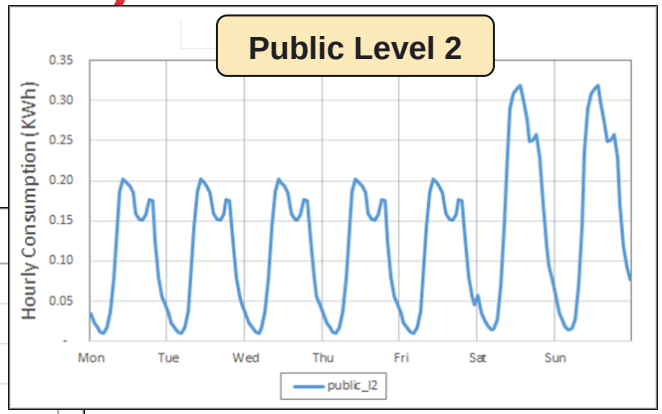
Passenger Vehicle Charging	
Charging Type	Stock Units
Res Level 1	# of Ports
Res Level 2	# of Ports
Workplace Level 2	# of Ports
Public Charging Level 2	# of Ports
Public Charging DCFC	MW or MVA

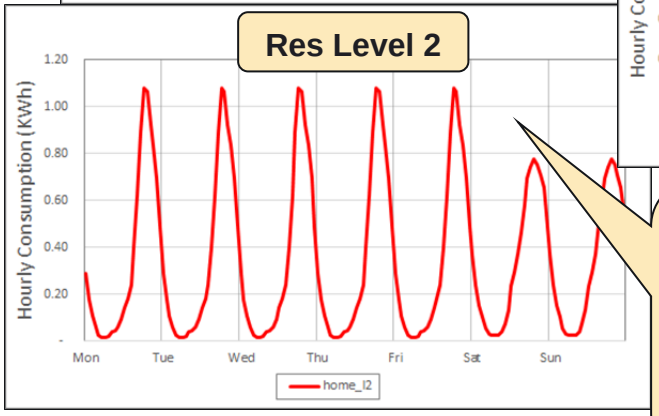
Each passenger vehicle charging category requires forecasts of the following:

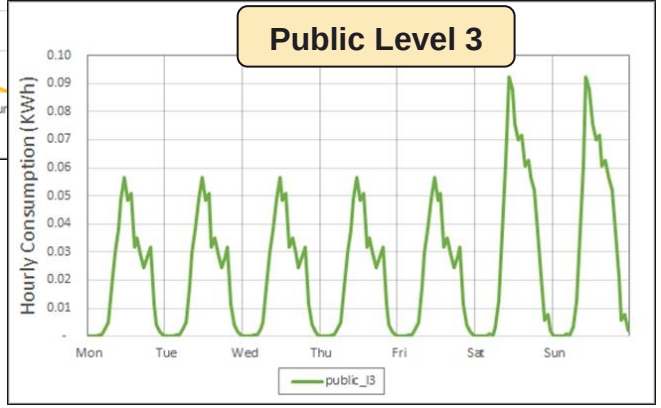
- # of Ports
- Annual KWh / Port
- Hourly Load Shape

Passenger EV Load Shapes (EVI-Pro Lite)









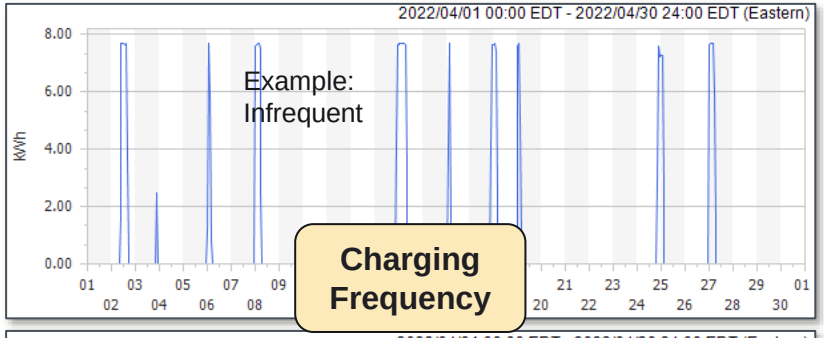
Charging Strategies

1. Plug in after work
2. Plug in at 11 PM
3. Charge By Morning
4. Slow Charge
5. Random

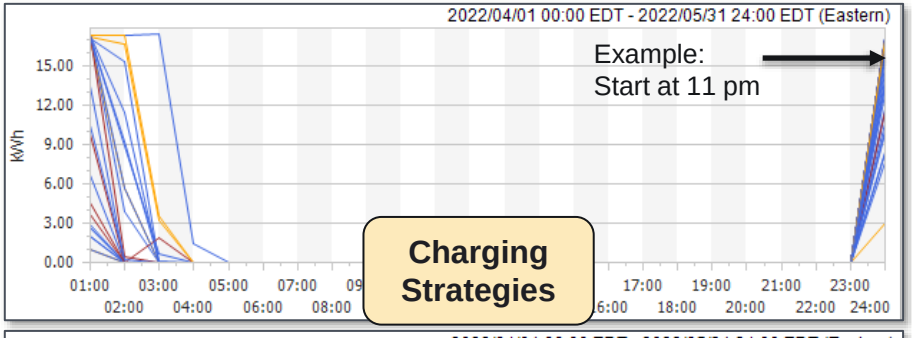
Residential Level 2 Charging – EV Submeter Data

- Utility sample of 1,200 customers on their EV Rate
  - Dedicated submeter for EV charging
  - 11 pm - 9 am is off peak
  - On/Off price ratio: ~ 2 to 1

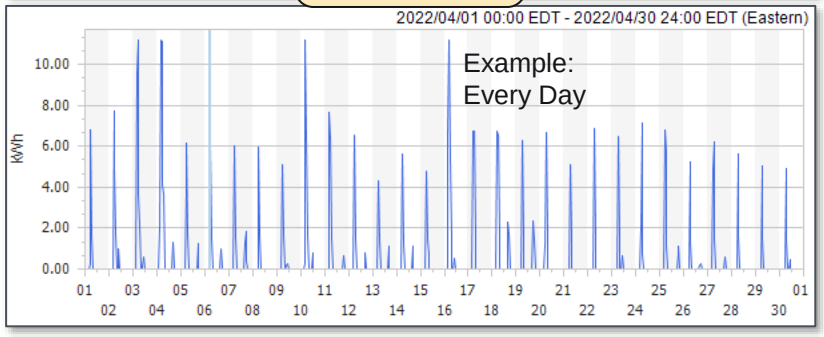
Individual EV Submeter Data

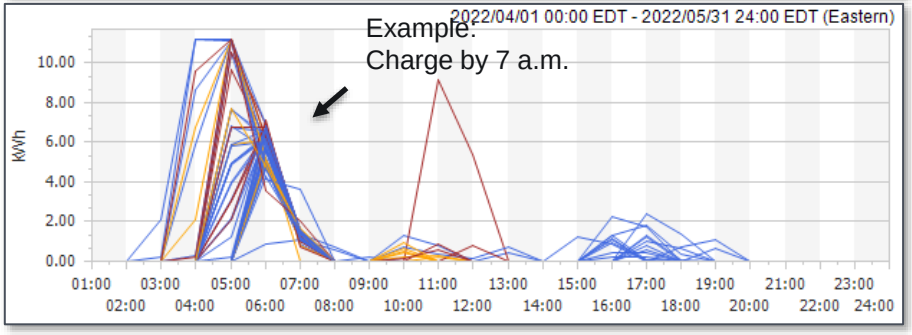


Charging Frequency



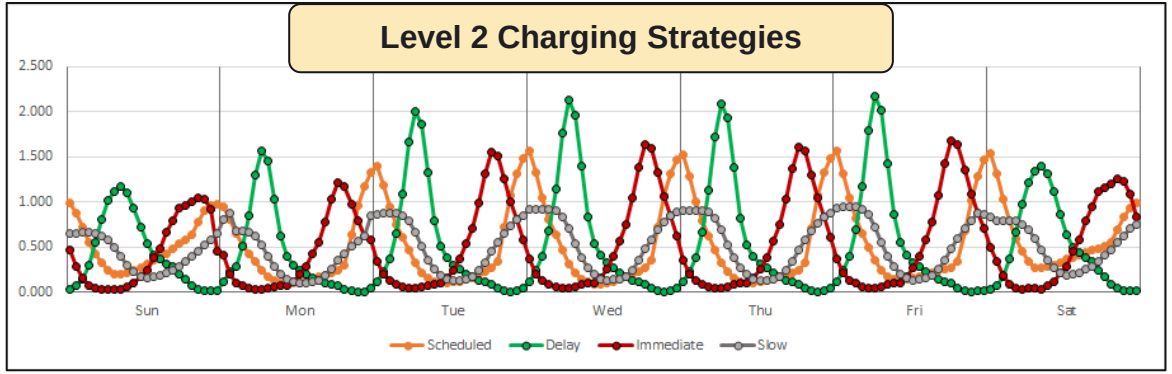
Charging Strategies



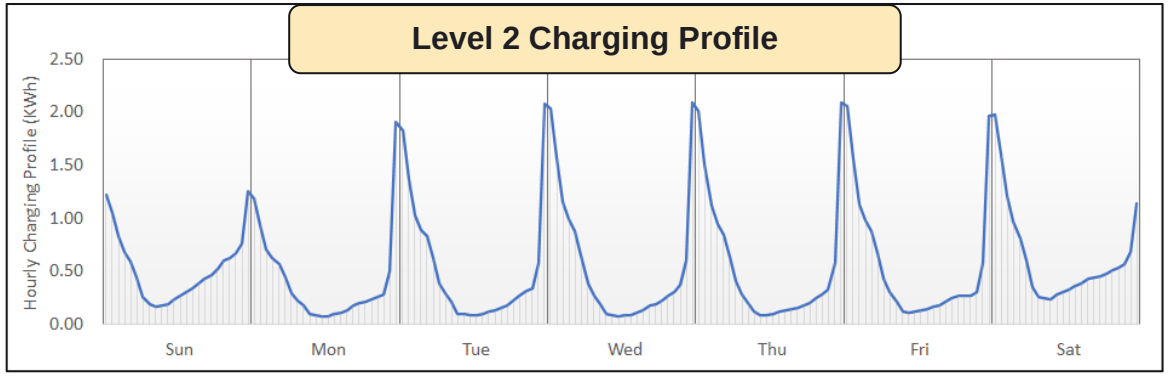


Residential Level 2: Weighting Charging Strategies

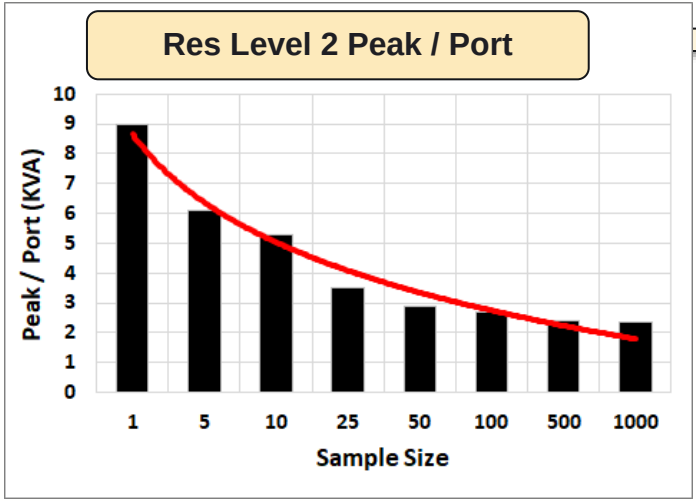
- Charging Strategies
  - Scheduled: charge at 11PM
  - Delay: – charge by 05,06,07,08
  - Immediate: – charge after work
  - Slow: – flatter version of immediate

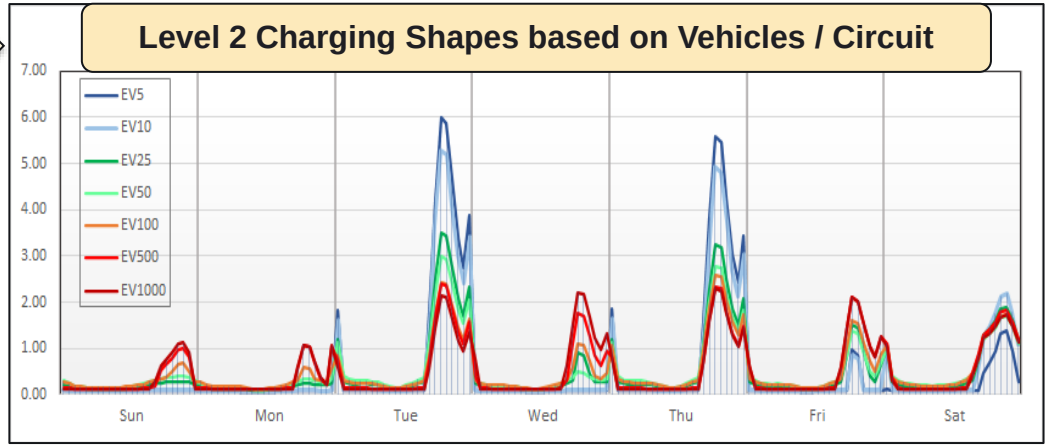


- Final Level 2 profile is a weighted average of the strategy profiles, where the weights vary over time.



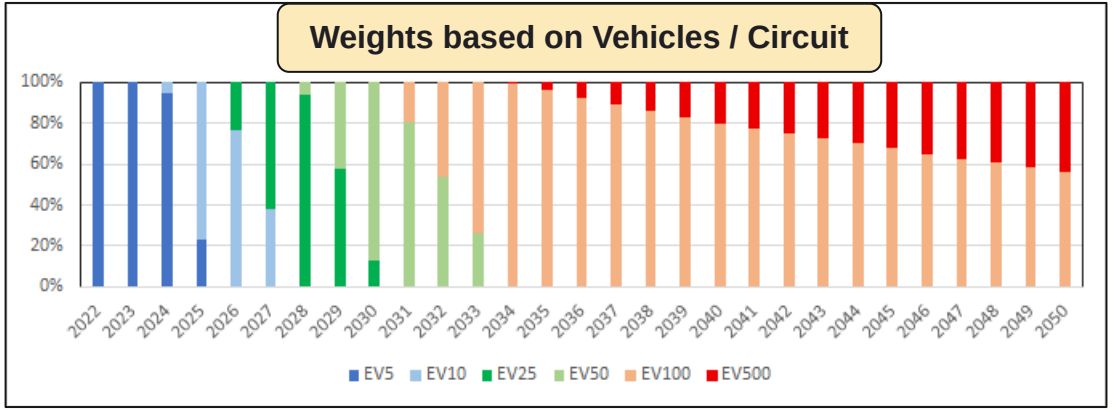
EV Diversity by Sample Size





Diversity Analysis

- Based on # of Res L2 Ports
- Max KVA / Port falls as number of ports grows
- Weight shapes over time based on vehicles per feeder



Presenting the Forecast

Distribution Planning Dashboard:

Node:	AKRON
Type:	Substation
WS:	1 in 10

Import Data

Restore Defaults

Toggles

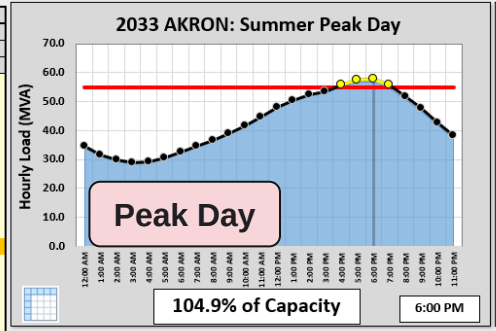
2033 | Summer | 1 in 2 | Calibrate

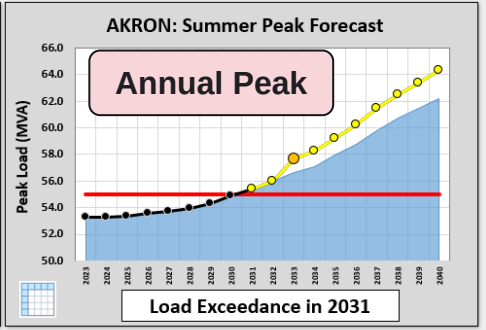
Thursday, July 21, 2033

Planner Inputs

Forecast Inputs

	X01 Existing		X02	X03	X04	X05a	X05b	X05c	X05d	X05e	X05f	X06	X07	X08	X09
Year	Summer	Winter	Cust	Projects	Solar PV	ResEV L1	Res EV L2	Work EV	PC EV L2	PC EV FC	Fleet EV	Storage	Elec	EWR	DR
Units	MVA	MVA	#	MVA	MVA	Ports	Ports	Ports	Ports	MVA	#	MVA	%	%	MVA
2023	53.4	31.3	41	0.0	0.0	25	69	0	5	0.0	1	0.0	100%	100%	0.0
2024	53.4	31.4	82	0.0	0.1	58	172	0	14	0.0	1	0.0	100%	100%	0.0
2025	53.4	31.4	123	0.0	0.1	100	317	0	25	0.0	3	0.0	100%	100%	0.0
2026	53.4	31.4	164	0.0	0.2	151	510	0	39	0.0	6	0.0	100%	100%	0.0
2027	53.4	31.4	205	0.0	0.3	211	754	0	58	0.0	10	0.0	100%	100%	0.0
2028	53.4	31.4	246	0.0	0.4	281	1,064	0	82	0.0	16	0.0	100%	100%	0.0
2029	53.4	31.4	287	0.0	0.5	366	1,459	0	113	0.0	23	0.0	100%	100%	0.0
2030	53.4	31.4	328	0.0	0.5	468	1,952	0	152	0.0	34	0.0	100%	100%	0.0
2031	53.4	31.4	320	0.0	0.5	578	2,520	0	198	0.0	46	0.0	100%	100%	0.0
2032	53.5	31.3	350	0.0	0.6	688	3,125	0	246	0.0	61	0.0	100%	100%	0.0
2033	53.4	31.3	376	0.0	0.7	795	4,507	0	298	0.0	77	0.0	100%	100%	0.0
2034	53.4	31.3	402	0.0	0.7	897	5,289	0	351	0.0	95	0.0	100%	100%	0.0
2035	53.4	31.1	428	0.0	0.8	993	6,085	0	406	0.0	114	0.0	100%	100%	0.0
2036	53.4	31.2	451	0.0	0.9	1,081	6,886	0	462	0.0	133	0.0	100%	100%	0.0
2037	53.4	31.2	471	0.0	1.0	1,158	7,690	0	519	0.0	152	0.0	100%	100%	0.0
2038	53.4	31.2	488	0.0	1.1	1,224	8,480	0	575	0.0	172	0.0	100%	100%	0.0
2039	53.4	31.3	503	0.0	1.1	1,274	9,228	0	629	0.0	190	0.0	100%	100%	0.0
2040	53.4	31.1	516	0.0	1.2	1,309	9,923	0	679	0.0	207	0.0	100%	100%	0.0



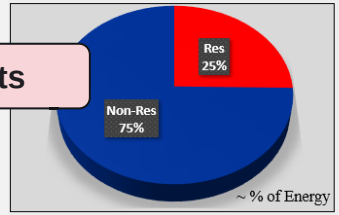


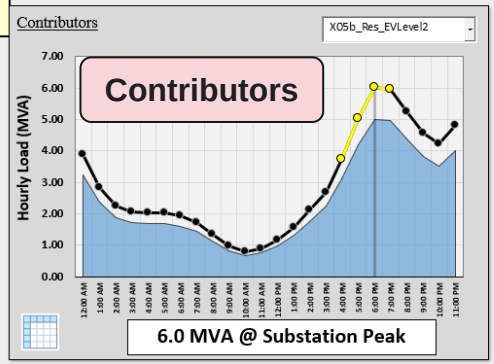
2033 AKRON: Summer Peak Day			
Results	Base	Scenario	Δ
Capacity (MVA)	55.00		
Peak (MVA)	56.68	57.69	1.0
Exceedance (MVA)	1.68	2.69	1.0
*Peak Time	6:00 PM	6:00 PM	0
Residential Cust	6,945	6,945	
Com Sec Cust	1,037	1,037	
Com Pri Cust	931	931	
Ind Cust	0	0	0
Total Cust	8,914	8,914	0
Peak / Cust (KVA)	6.4	6.5	0.1

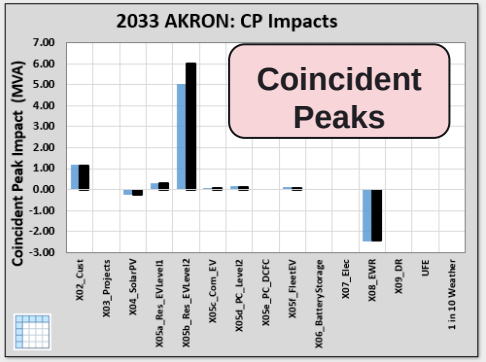
*Eastern Prevailing Time (Hour Beginning)

Results

2033 Scenario Peak Forecast Δ		
6:00 PM	1.0 MVA	1.8%







Base — Capacity — Scenario — Load Exceedance

CONTACT US

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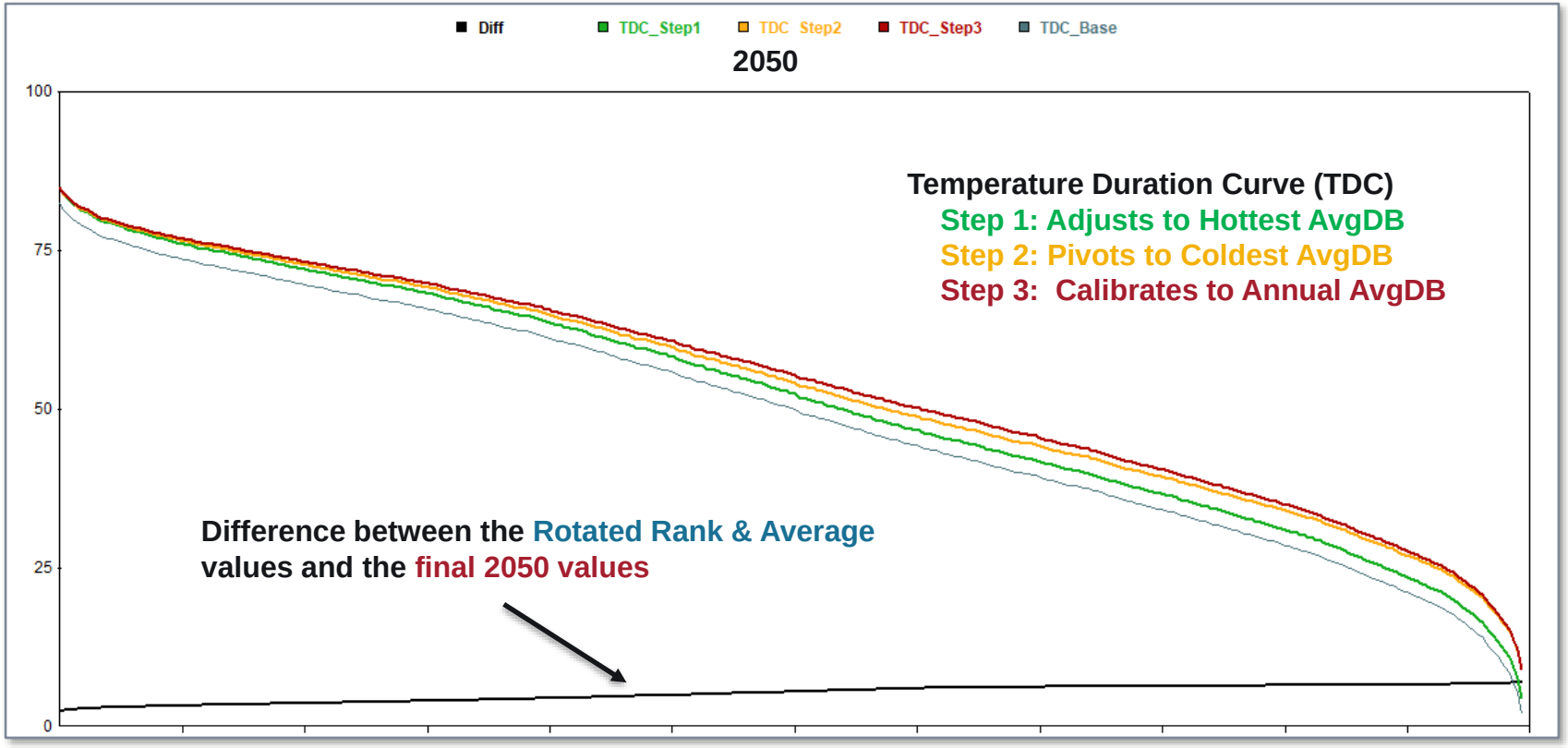
BONUS SLIDES

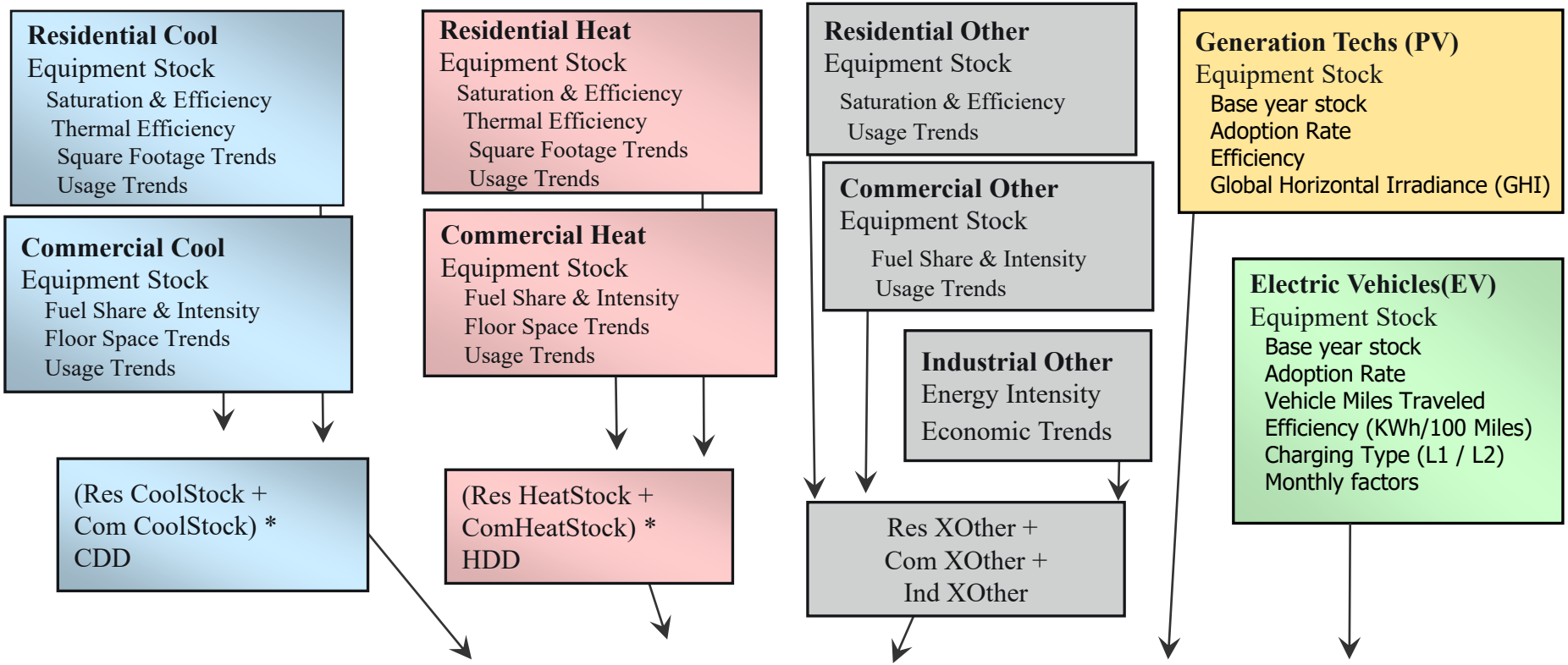
Summary of Modeling Methods

	Error Minimization	Penalty Function	Hyper Params	Train MAPE	Test MAPE	MAPE Delta
OLS	Sum of Squared Errors (SSE)			1.43	1.51	0.08
Ridge	Sum of Squared Errors (SSE)	L2	λ1	1.43	1.51	0.08
Lasso	Sum of Squared Errors (SSE)	L1	λ2	1.43	1.51	0.08
Elastic Net	Sum of Squared Errors (SSE)	L1, L2	λ1, λ2	1.43	1.51	0.08
Least Absolute	Sum of Absolute Errors (SSD)			1.44	1.55	0.11
Quantile	Sum of Max(q×e, (q-1)×e), LAD if q = .5			1.39	1.52	0.13
Support Vector	Sum of Absoulte (e - eps)	L1	C, eps	1.44	1.54	0.10
Decision Tree	Wide Tree	Depth, Split Limits,#Factors, ...		1.47	2.98	1.51
Random Forest	Many Wide Trees	#Trees, Depth, Split Limits, ...		1.07	2.48	1.41
Gradient Boosting	Tall stack of weak learners	# Levels, Depth, Learning Rate, ...		0.95	1.62	0.67
OLS with Boosting	Regression with GBR model of errors	Settings for Boosting		0.90	1.36	0.46
OLS with AR1	Regression with AR1 model of errors	Order for AR process		1.25	1.35	0.10

Climate Change Adjustment Process – Trend through 2050

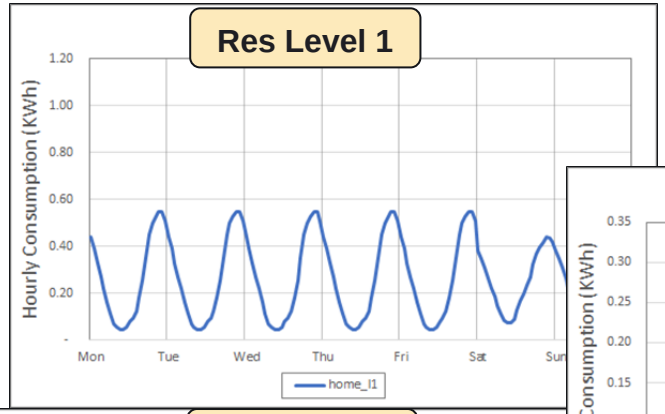


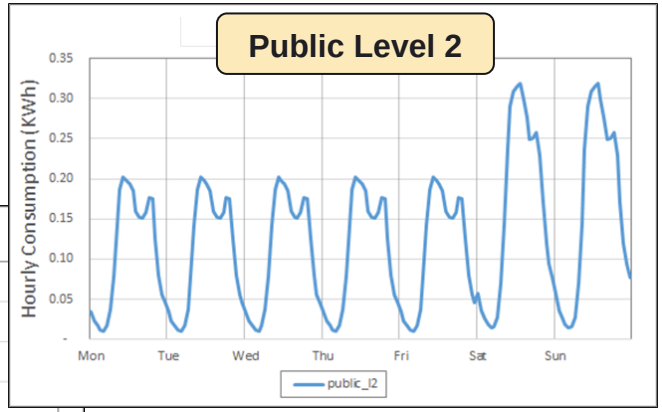
SAE Modeling Framework

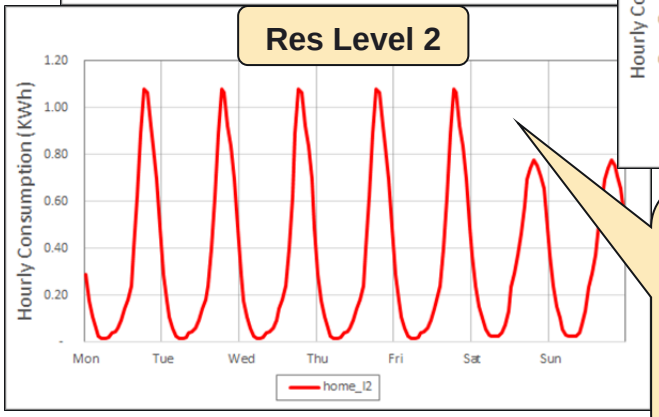


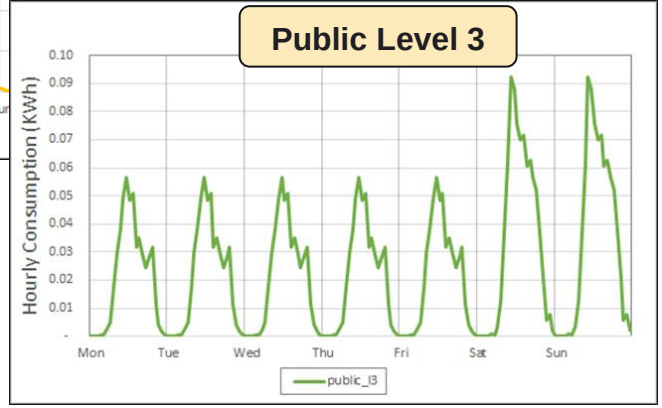
$$Energy_m = a + b_c \times XCool_m + b_h \times XHeat_m + b_o \times XOther_m - b_g \times GenTech_m + b_e \times EV_m + e_m$$

EV Load Shapes (EVI-Pro Lite)







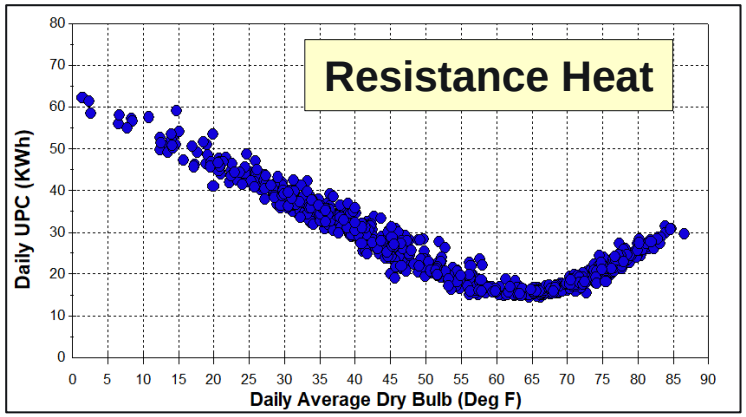


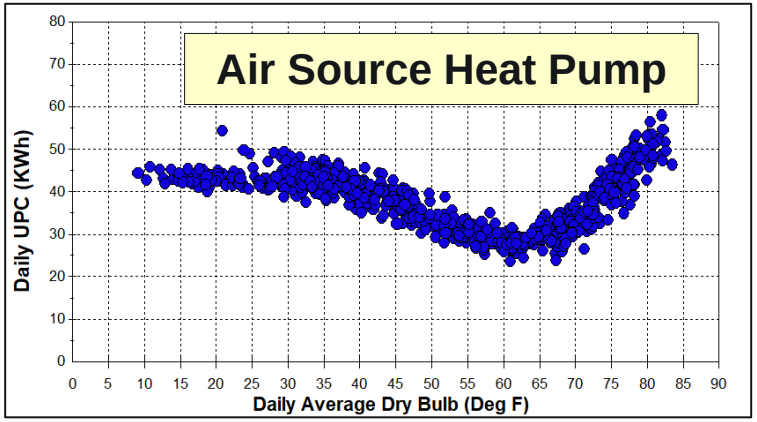
Charging Strategies

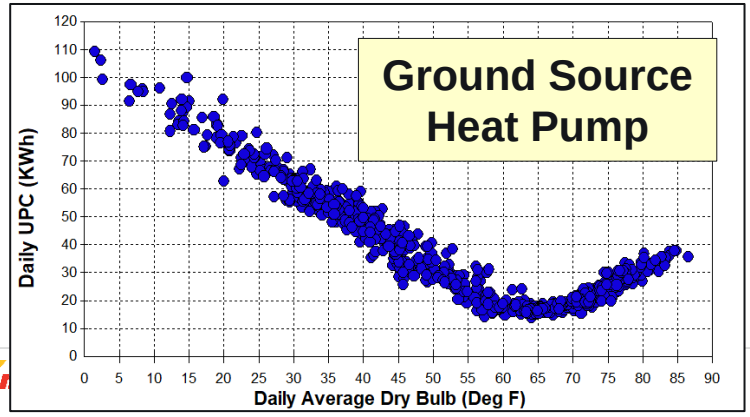
1. Plug in after work
2. Plug in at 11 PM
3. Charge By Morning
4. Slow Charge
5. Random

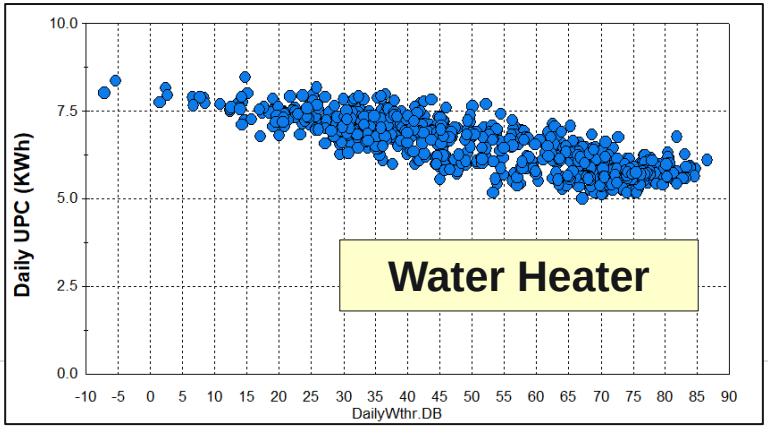
Residential Heating Equipment Impacts

Use / Customer vs Temperature









Res Stock End Use Saving Shapes (EUSS)

- Basic enclosure
- Enhanced enclosure
- Heat pumps, min-efficiency, electric backup
- Heat pumps, high-efficiency, electric backup
- Heat pumps, min-efficiency, existing heating as backup
- Heat pump water heaters
- Whole-home electrification, min-efficiency
- Whole-home electrification, high efficiency
- Whole-home electrification, high efficiency + basic enclosure package
- Whole-home electrification, high efficiency + enhanced enclosure package