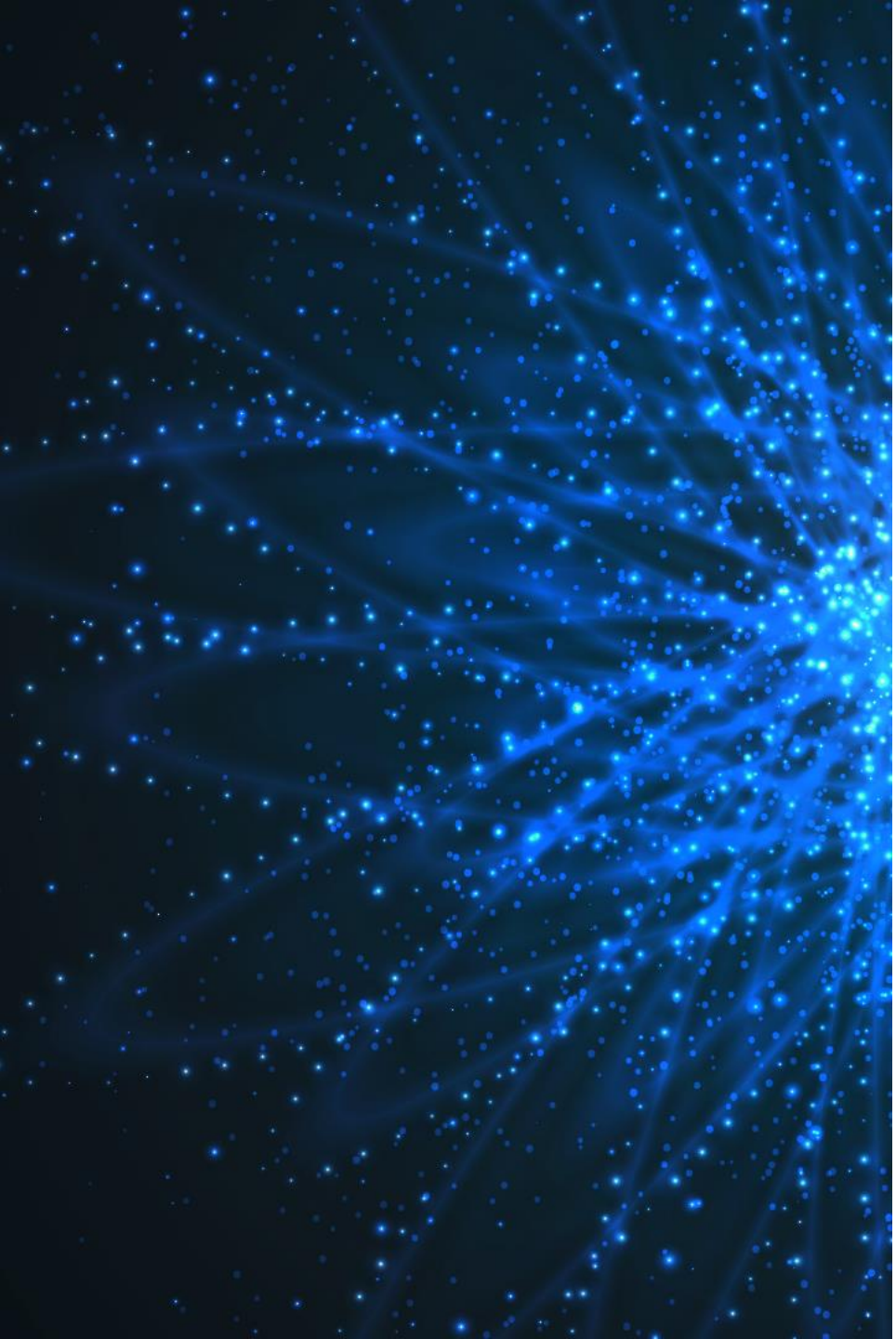
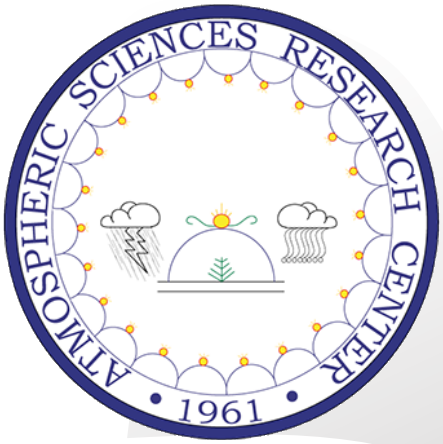


Improving Irradiance Forecast Accuracy

Marc Perez, Ph.D.

ESIG 2019 Meteorology & Market Design for Grid Services Workshop
June 4-6, 2019

Clean Power Research®



EPIC

Clean Power Research®

Itron

Agenda

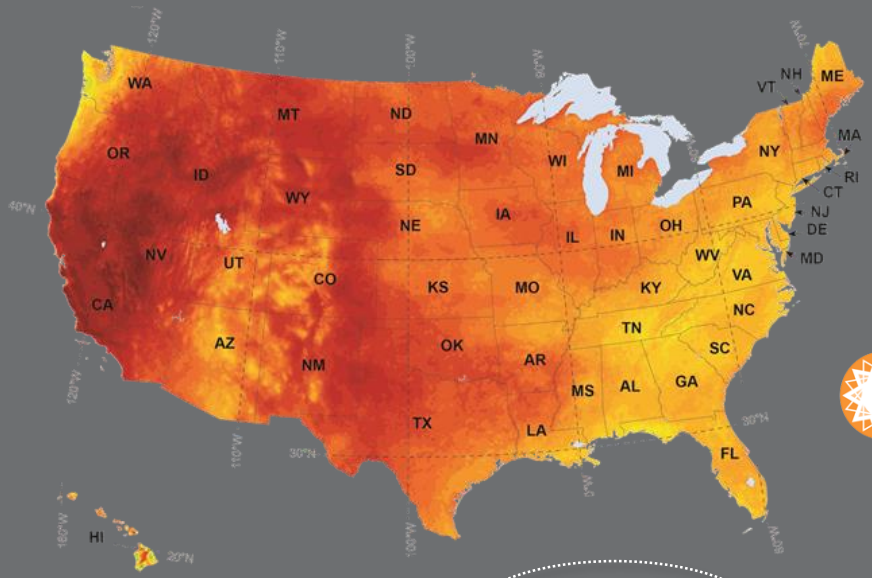
Task II

Improving Irradiance Forecast Accuracy

Task VI

Forecast Error Valuation

The SUNY Solar Forecast Model



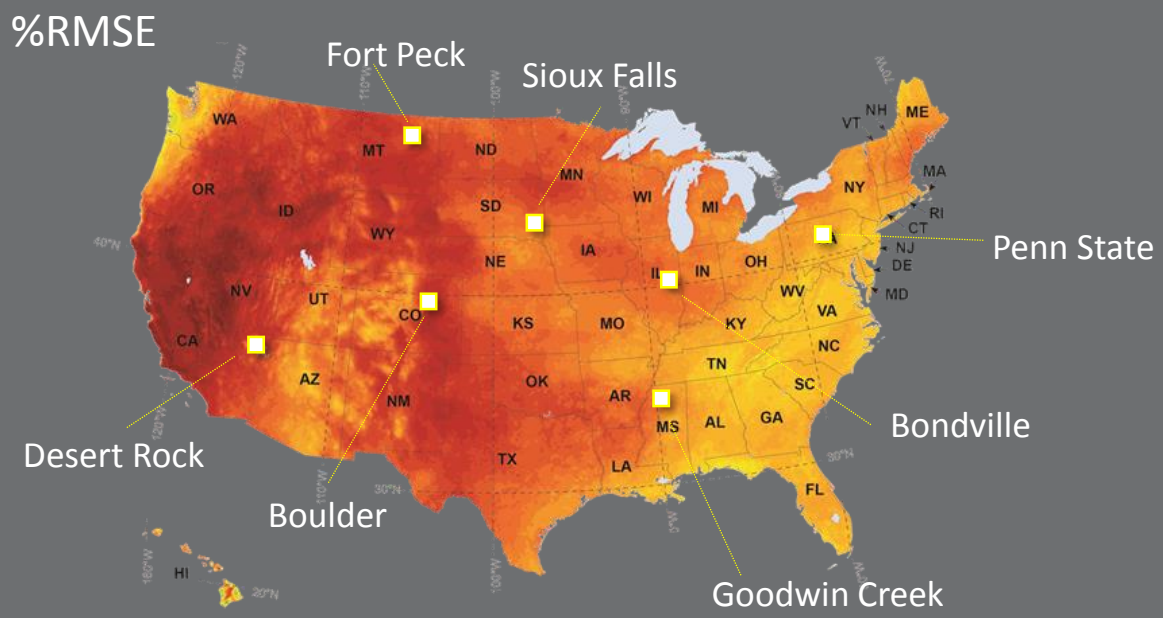
SolarAnywhere®

CLIMATOLOGY NOW FORECAST

Optimum blend:

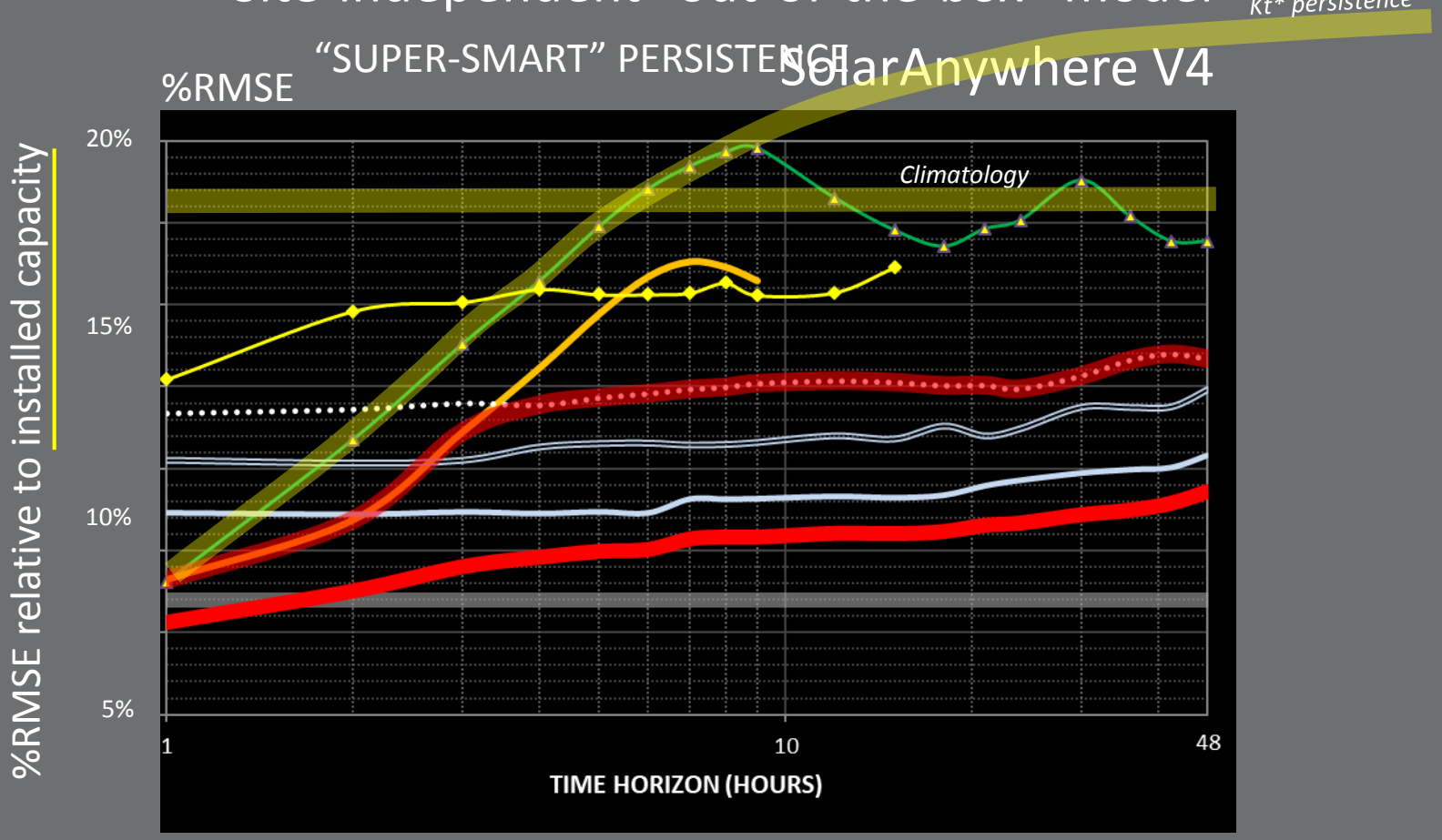
- Satellite-derived cloud motion vector irradiance forecasts
- NWP Forecasts
  - NOAA High Resolution Rapid Refresh cloud cover forecast
  - NCEP GFS irradiance forecasts
  - NCEP NDFD cloud cover forecasts
  - ECMWF irradiance forecasts

Performance Evaluation



7 SURFRAD Network Sites – 10 months of hourly data

Site-independent “out-of-the-box” model



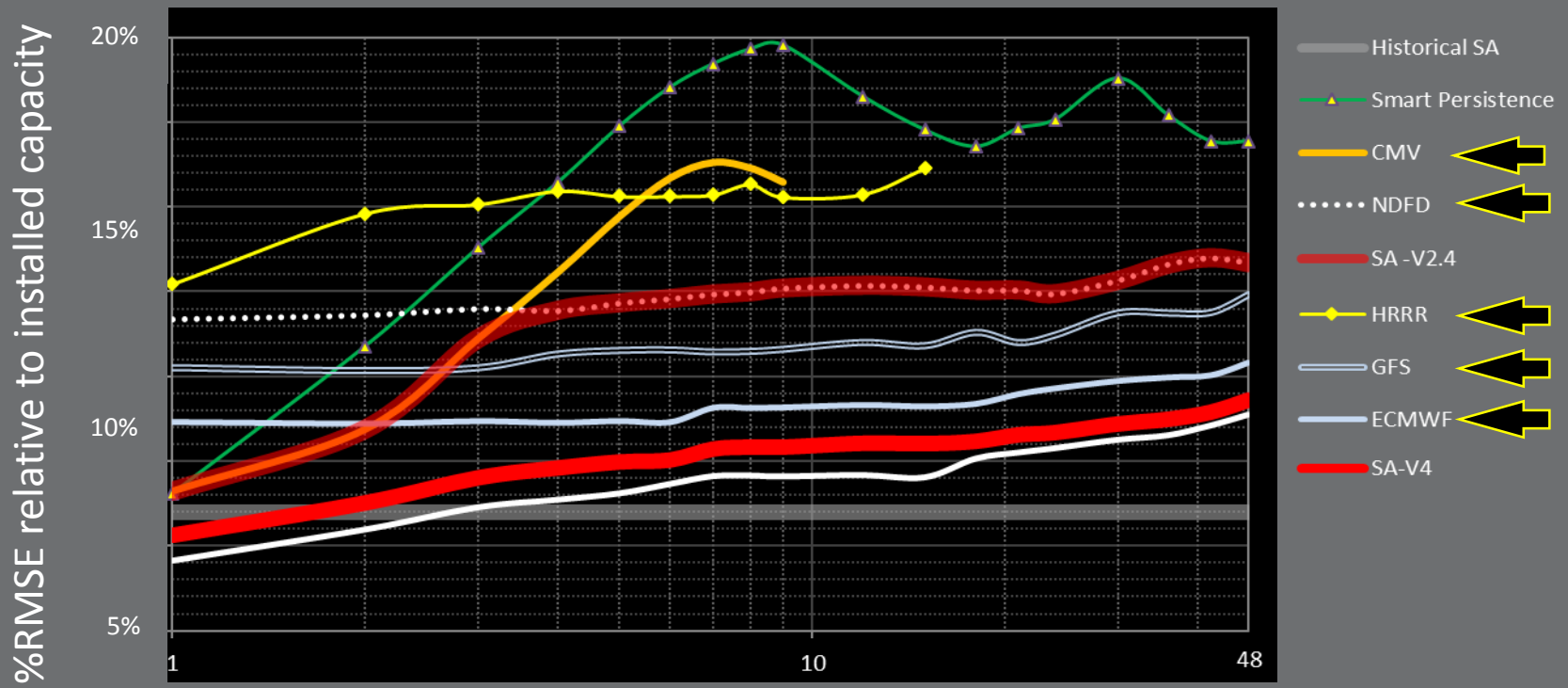
v4 = v3.2

R&D Nomenclature

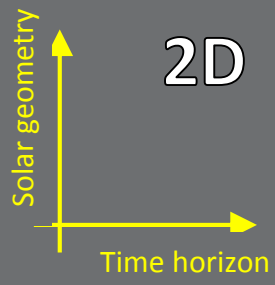
Product Nomenclature

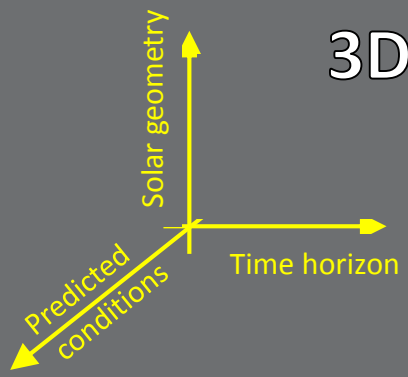
Site-independent “out-of-the-box” model

SolarAnywhere V4 x



MODEL BLEND

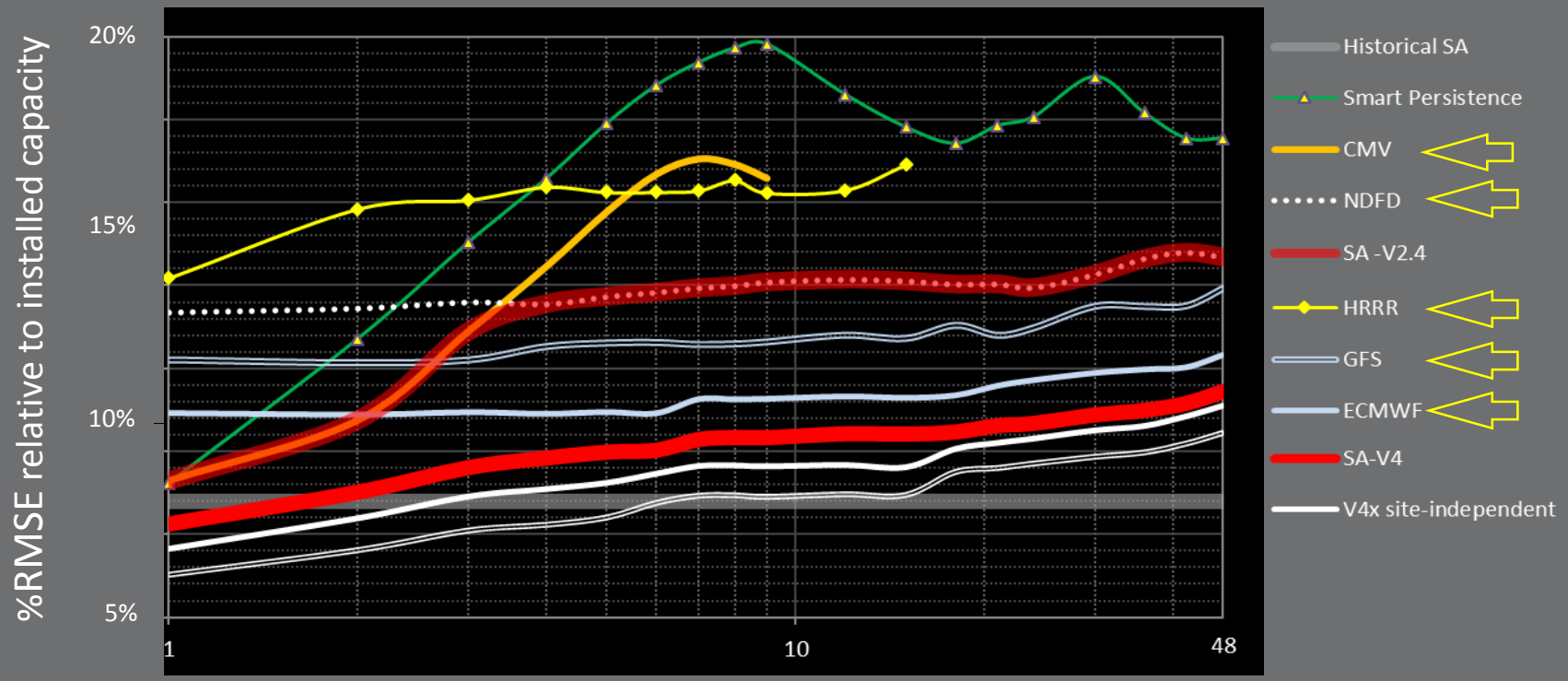




Site-independent "fit-all-in-one-box" model

Site-specific locally-tuned model

SolarAnywhere V4 x



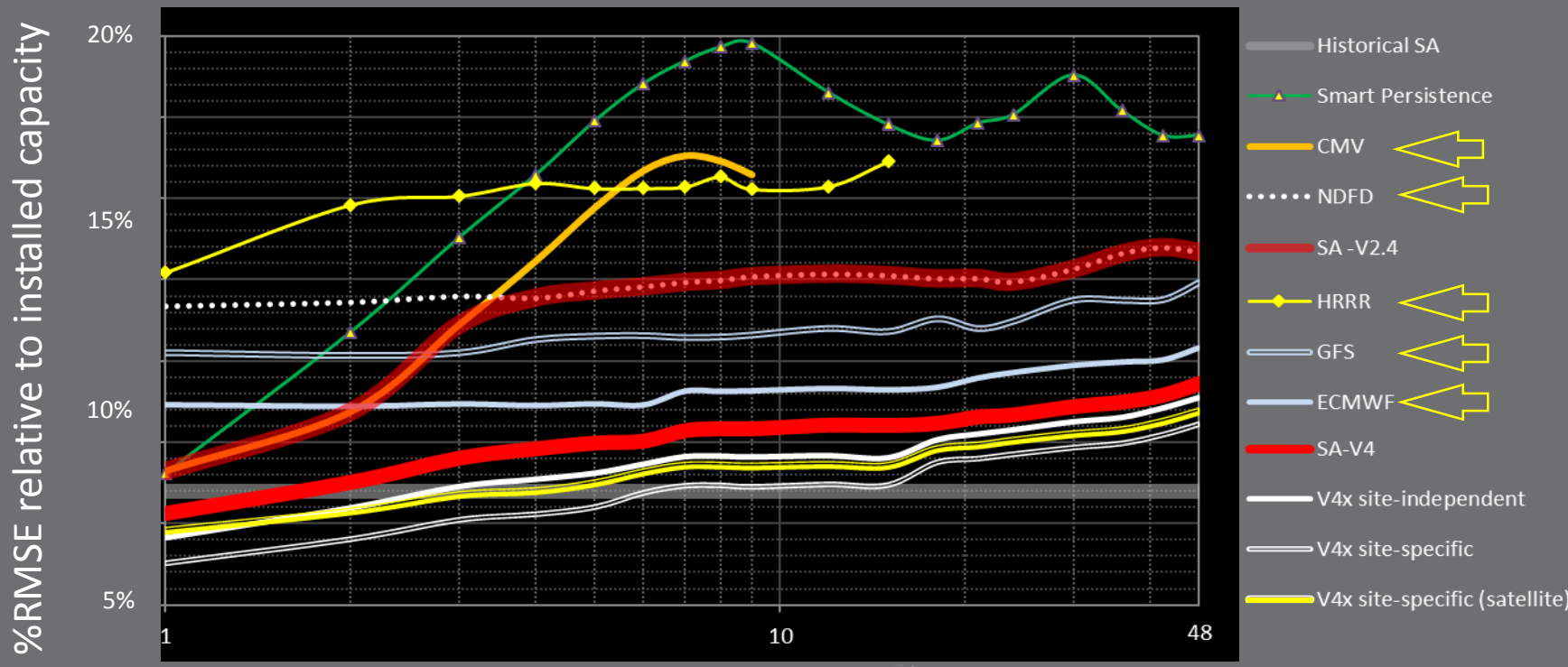
Site-specificity

Tuned with ground measurements

Direct applicability: forecasts for monitored systems

Site-specific tuning locally where model

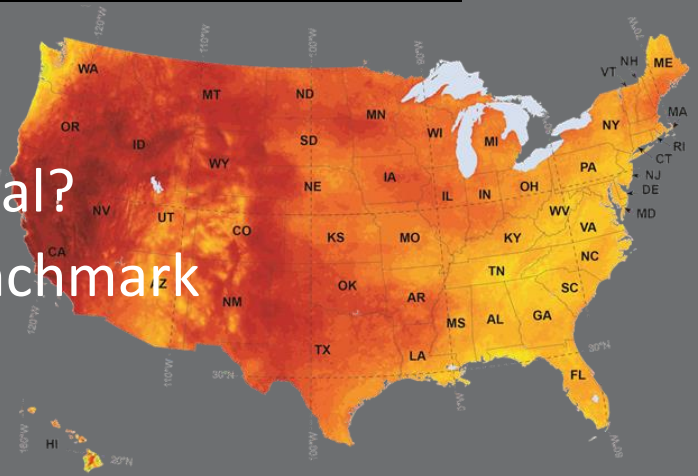
SolarAnywhere V4 x



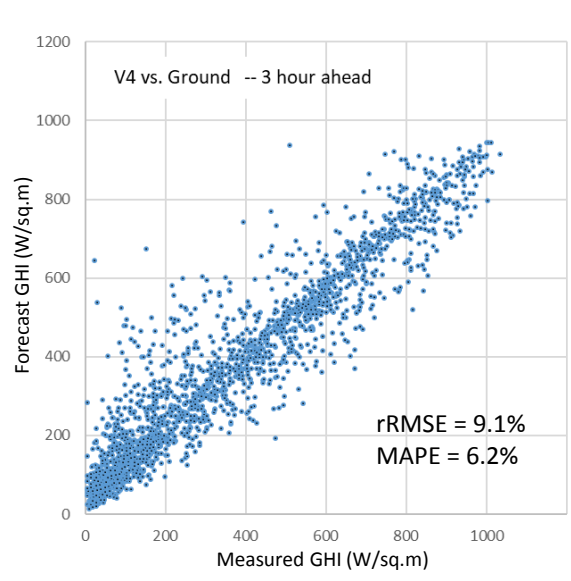
Site-specificity

Tuned with ground measurements?

Effective forecast performance benchmark



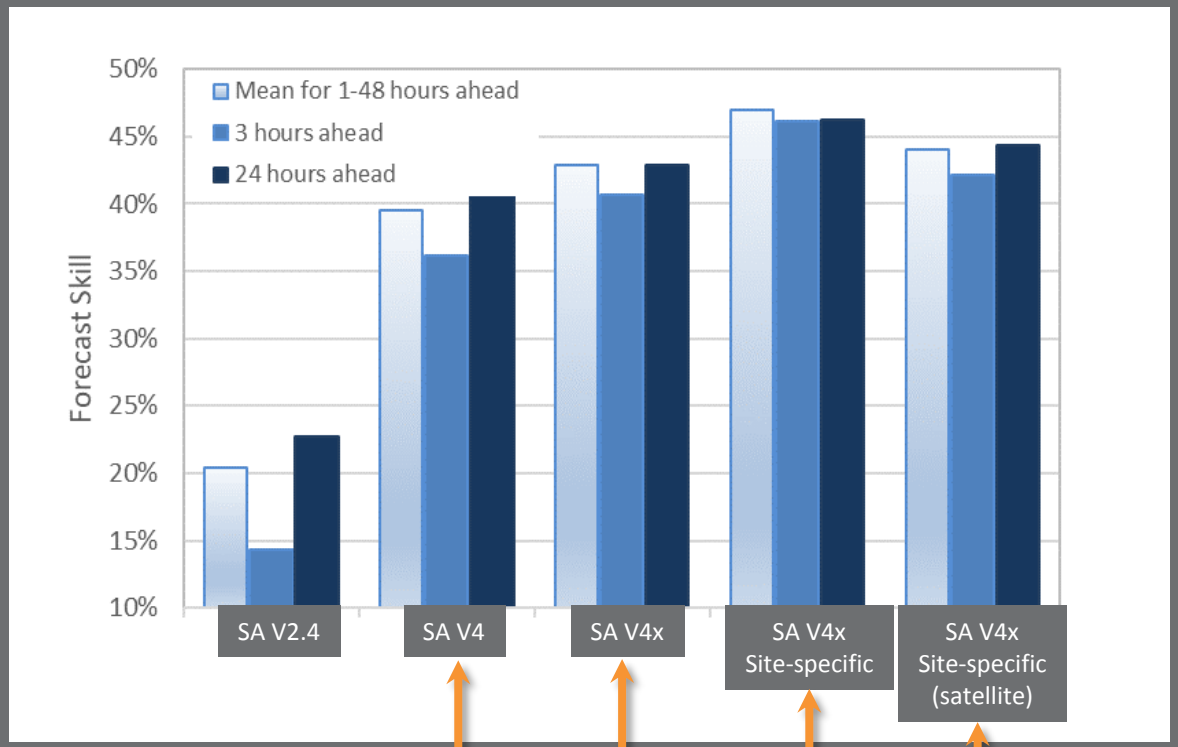
Goodwin Creek: 3 hours ahead



Existing V4

Forecast - Skill

$$1 - \frac{RMSE_{Model}}{RMSE_{Smrt.Persist.}}$$



Existing SolarAnywhere V4

V4x Site-independent

V4x Site-tuned (ground)

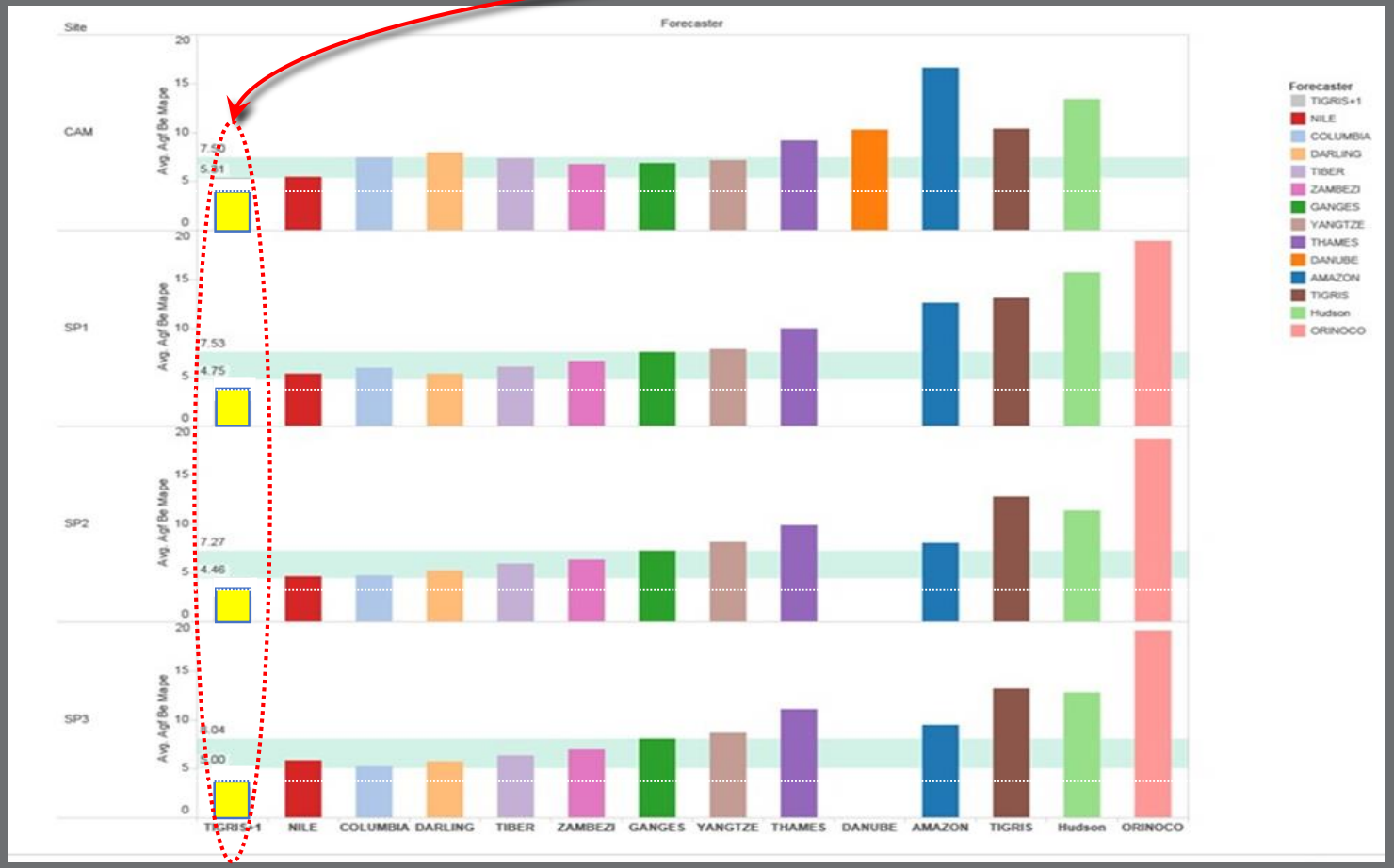
V4x Site-tuned (satellite)

EPRI forecast trial

DAY-AHEAD MAPE

SINGLE POINT – i.e., one single power plant

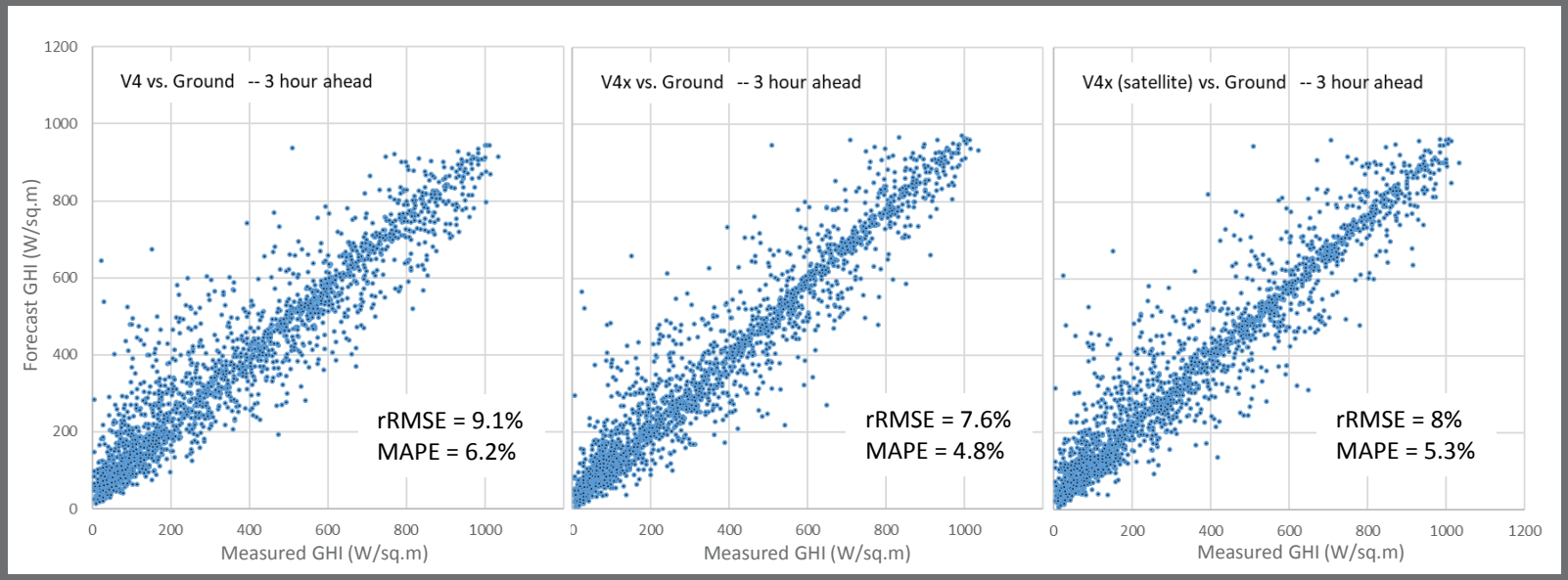
SolarAnywhere V4x



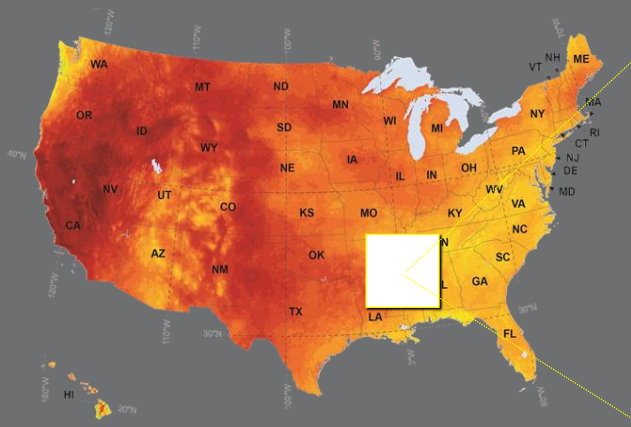
4 Locations

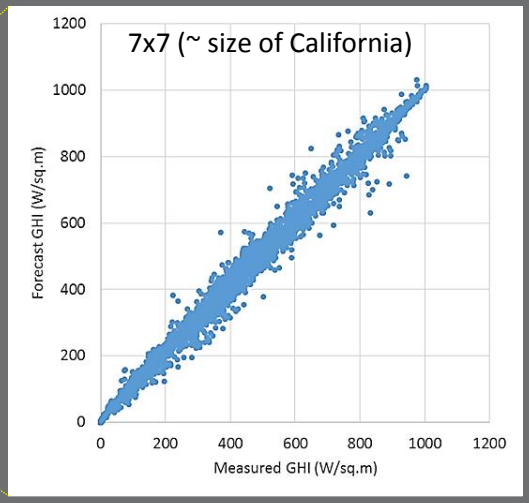
13 Models/vendors

REGIONAL PV FLEET, one single power plant

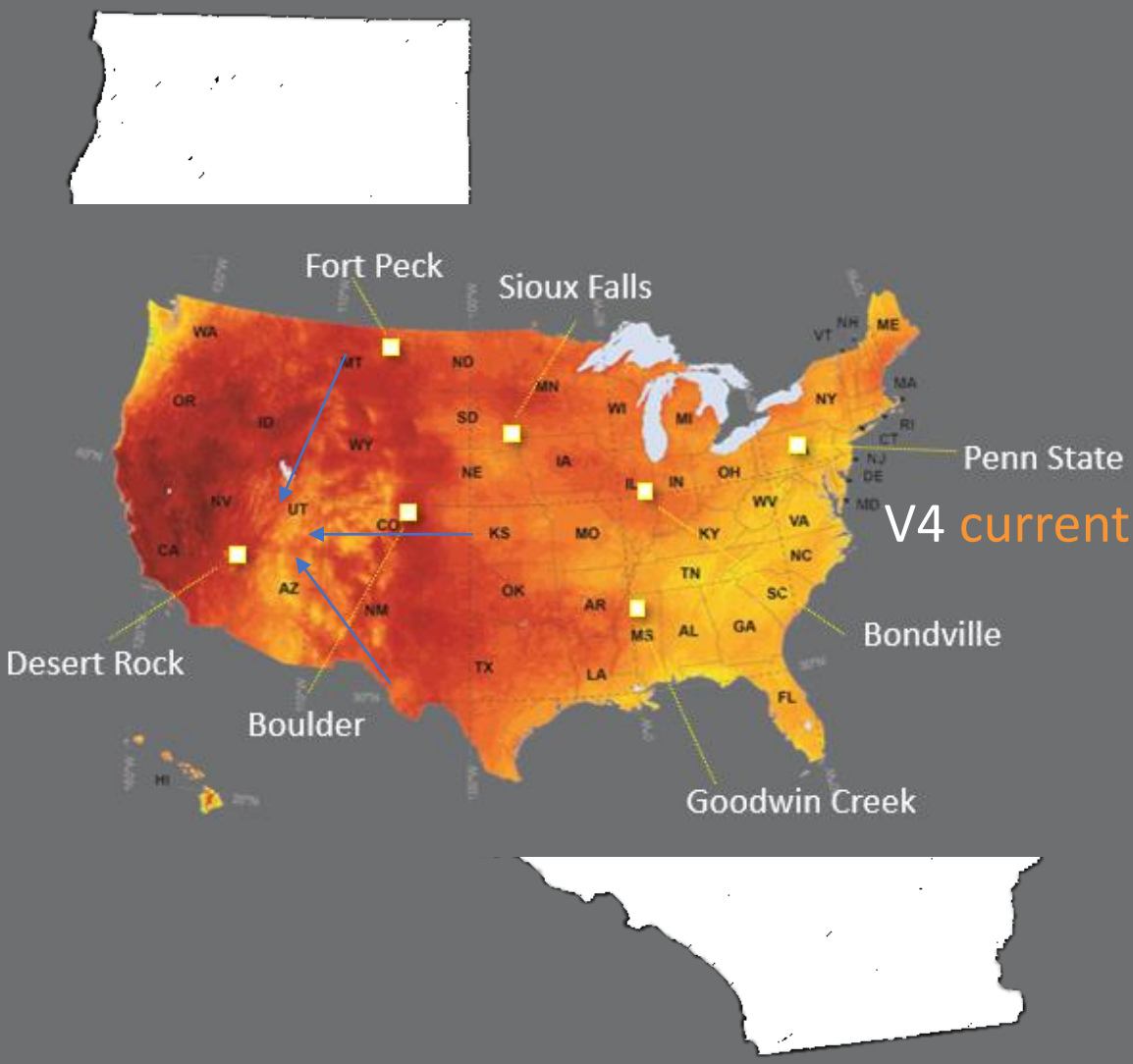


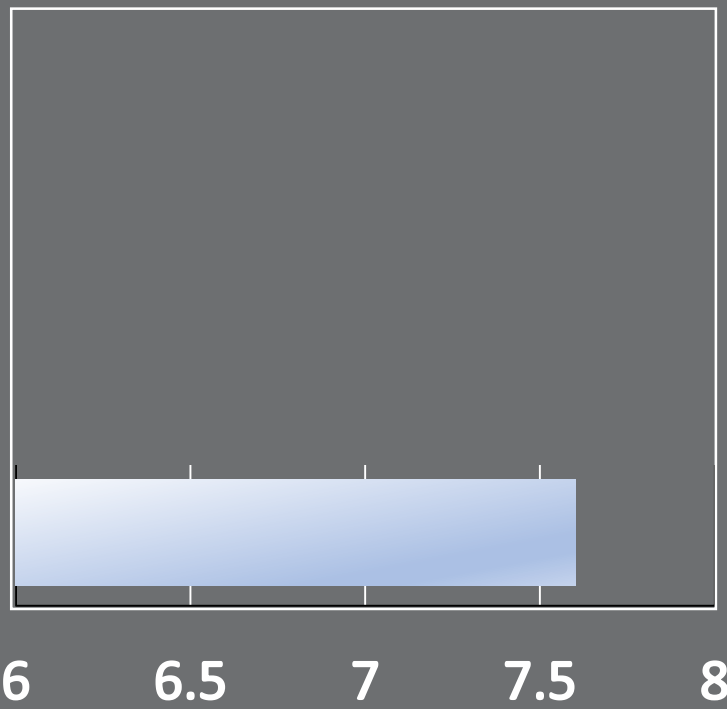
Existing V4 | Site-specific V4x (ground) | Site-specific V4x (Satellite)





Geographic Tuning Specificity





Agenda

Task II

Improving Irradiance Forecast Accuracy

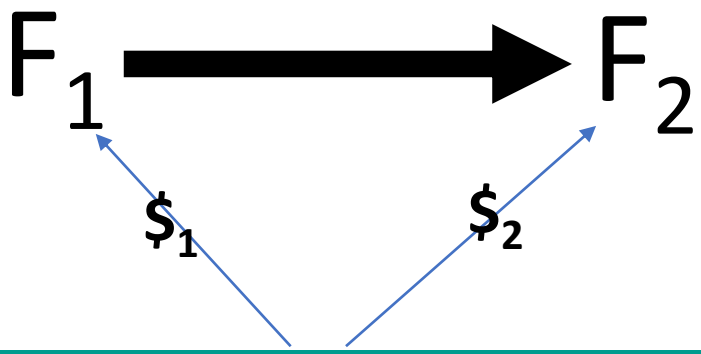
Task VI

Forecast Error Valuation

3 Valuation Methodologies

Methodology	Detail
Resource Adequacy	Cost of capacity linked to standard deviation of forecast errors
Real-Time Market Correction	Implementation of ITRON's existing error valuation method, based largely on: • LMP for day ahead • up/down –reg for day of
Perfect Forecast	Storage quantity (kWh) and cost ($) required to mitigate forecast errors across different timescales both nominal and levelized per kWh delivered

Can we quantify the *value* of such improvements?

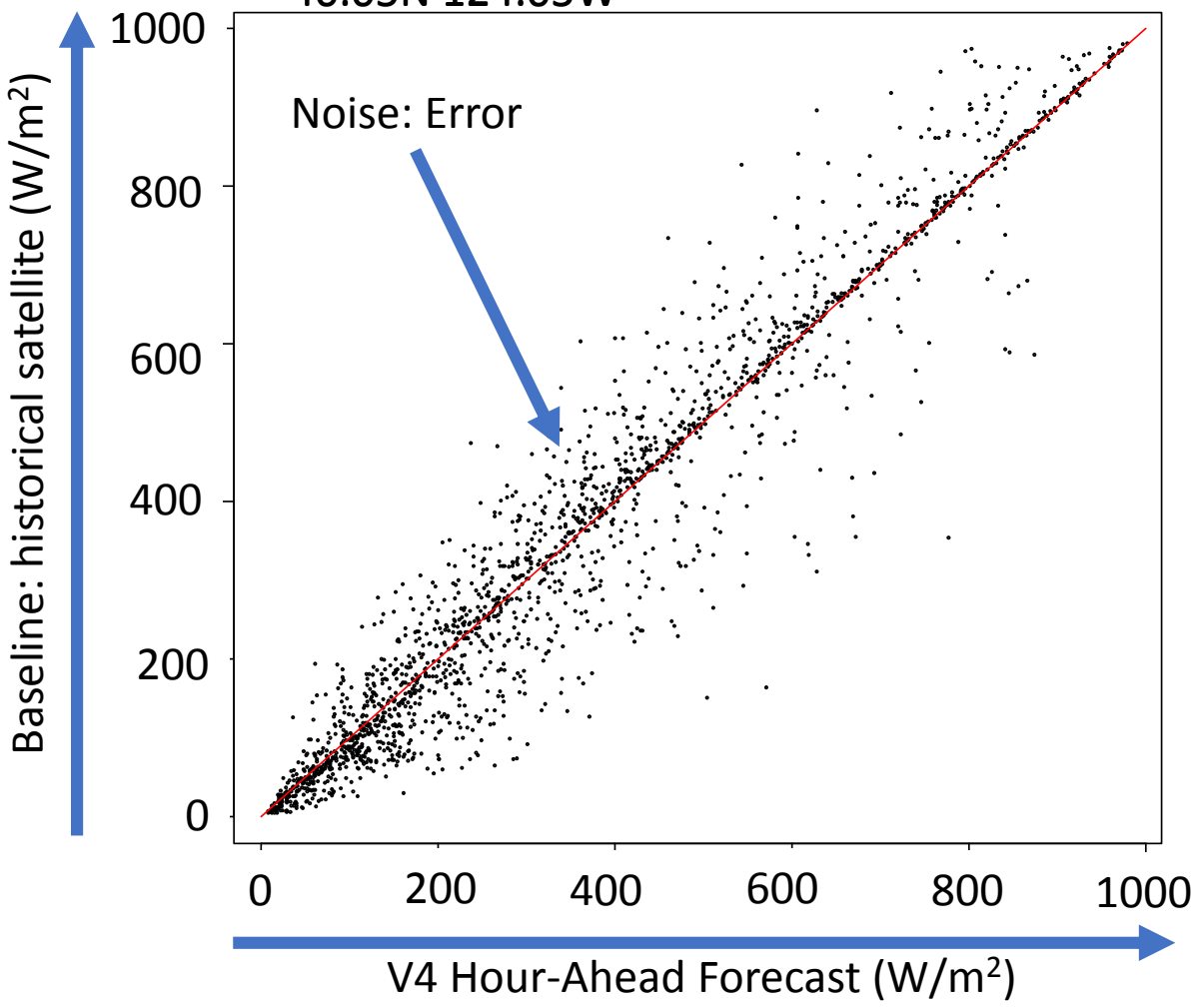


$$\Delta = \$_1 - \$_2$$

- The **Perfect Forecast** methodology calculates the storage required to mitigate overprediction events across a given timescale.
- This storage has a cost **$** which depends on forecast accuracy.
- **Δ$** gives relative value allowing us to assess accuracy improvement in $ terms.

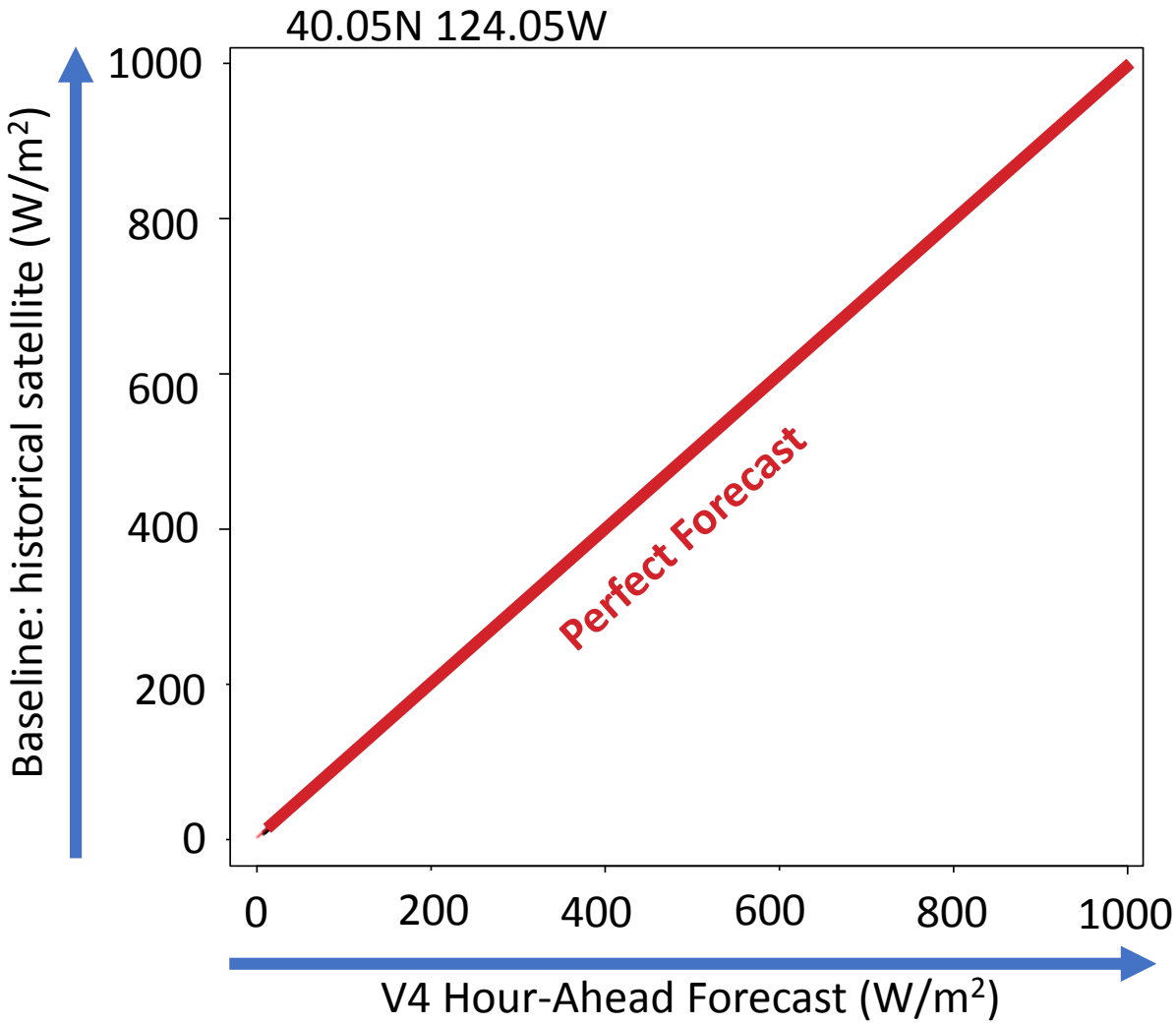
How does the Perfect Forecast Work?

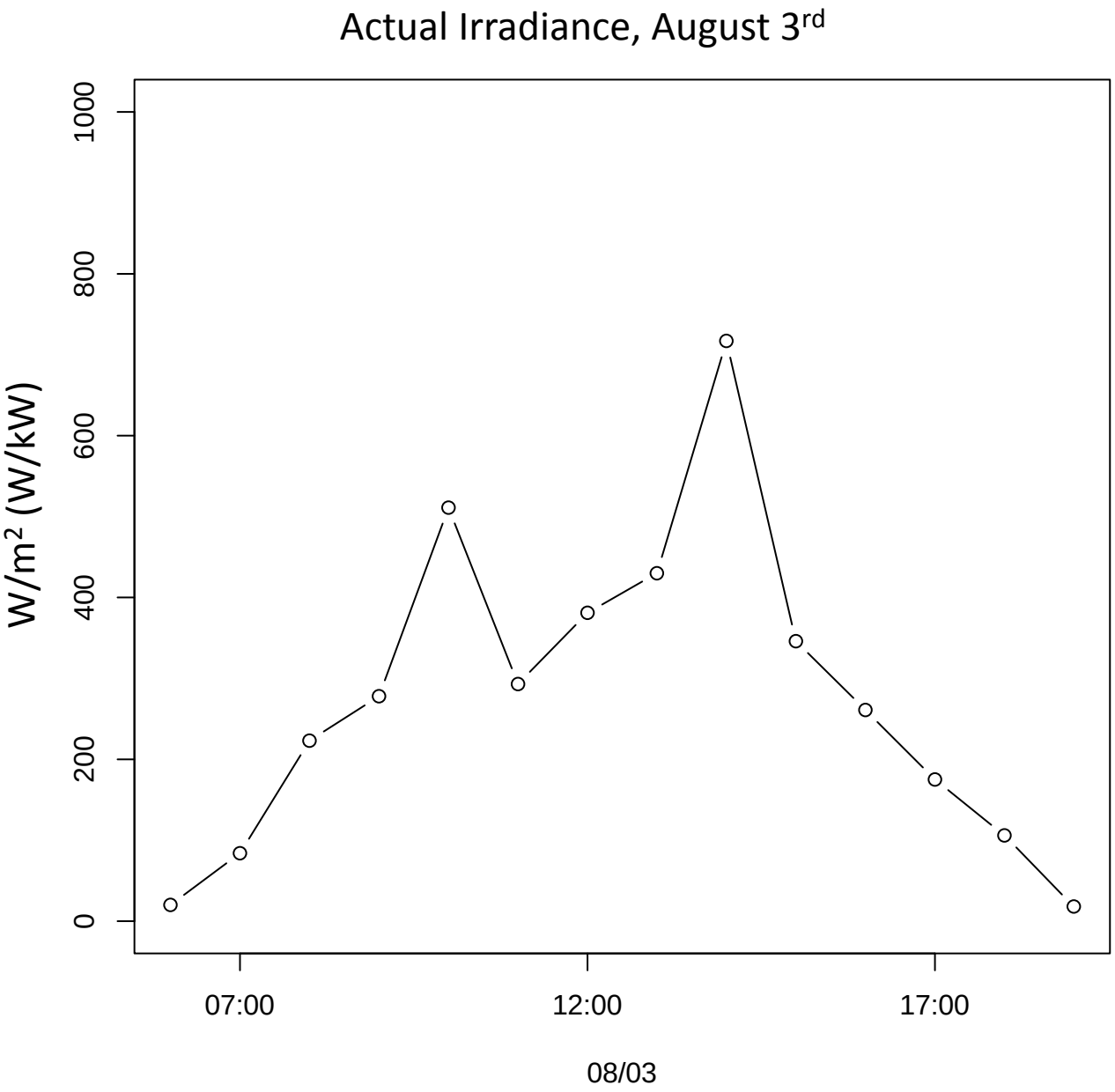
Let's test in one of CA's climatic regions



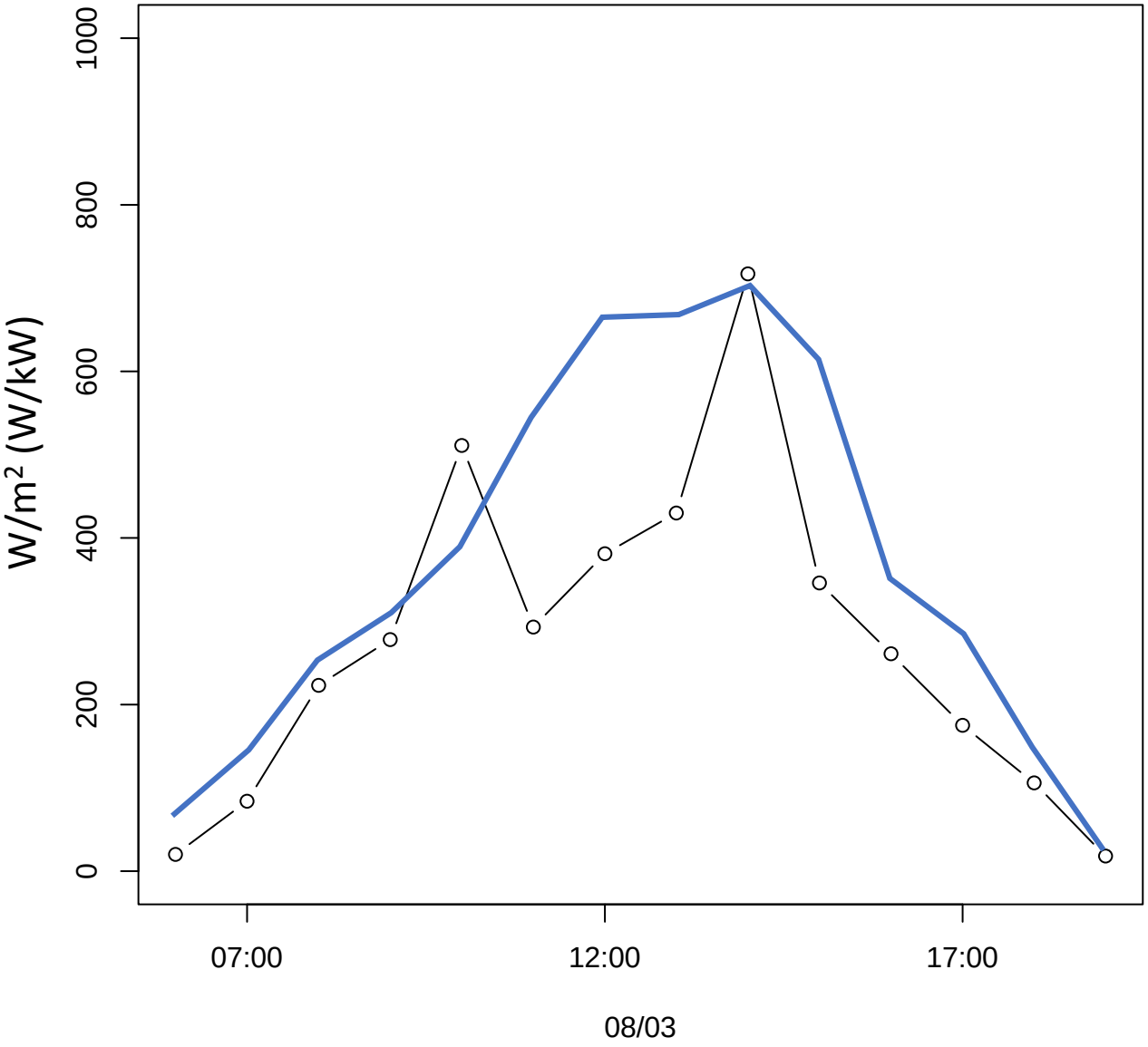
How does the Perfect Forecast Work?

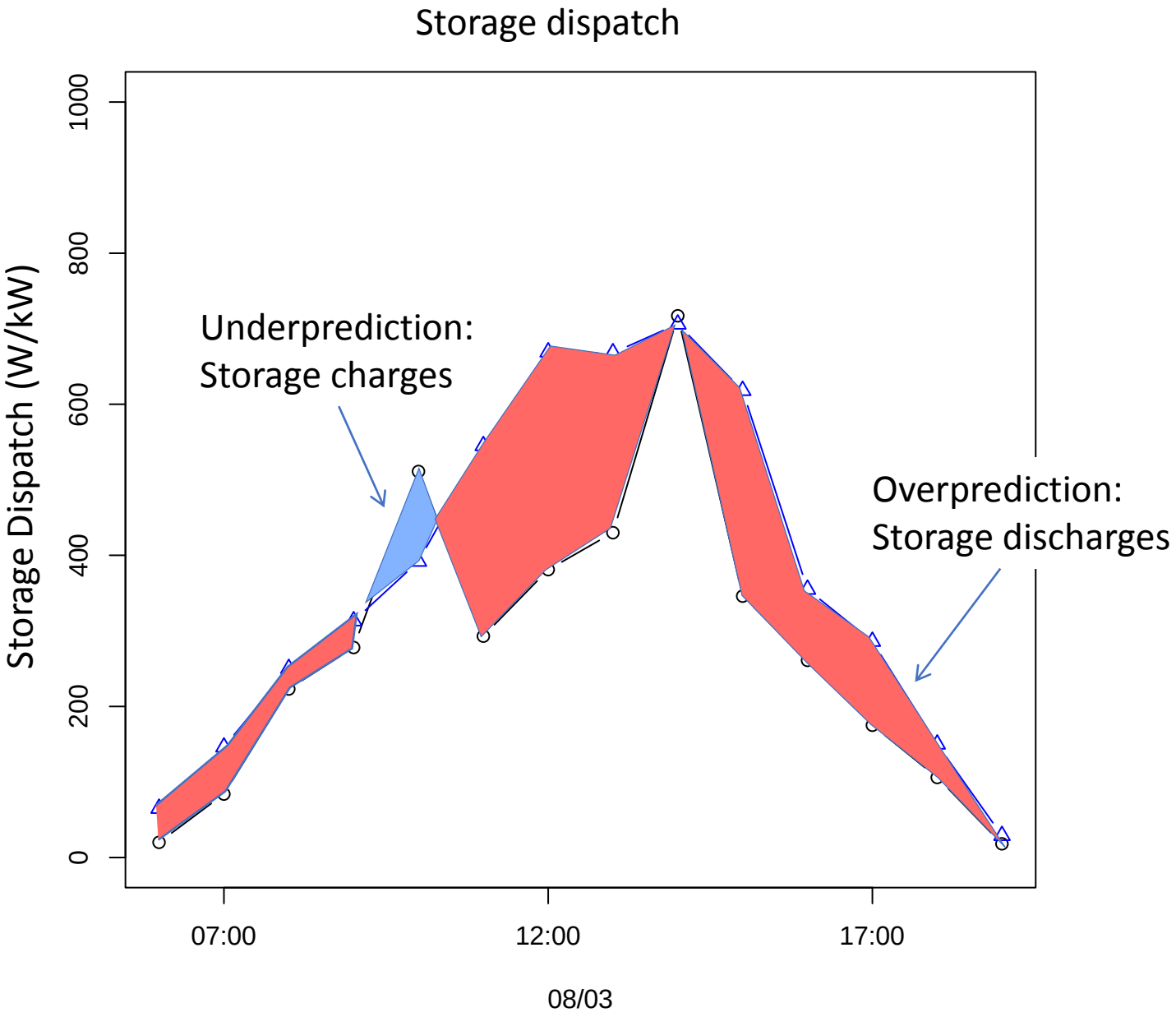
Let's test in one of CA's climatic regions

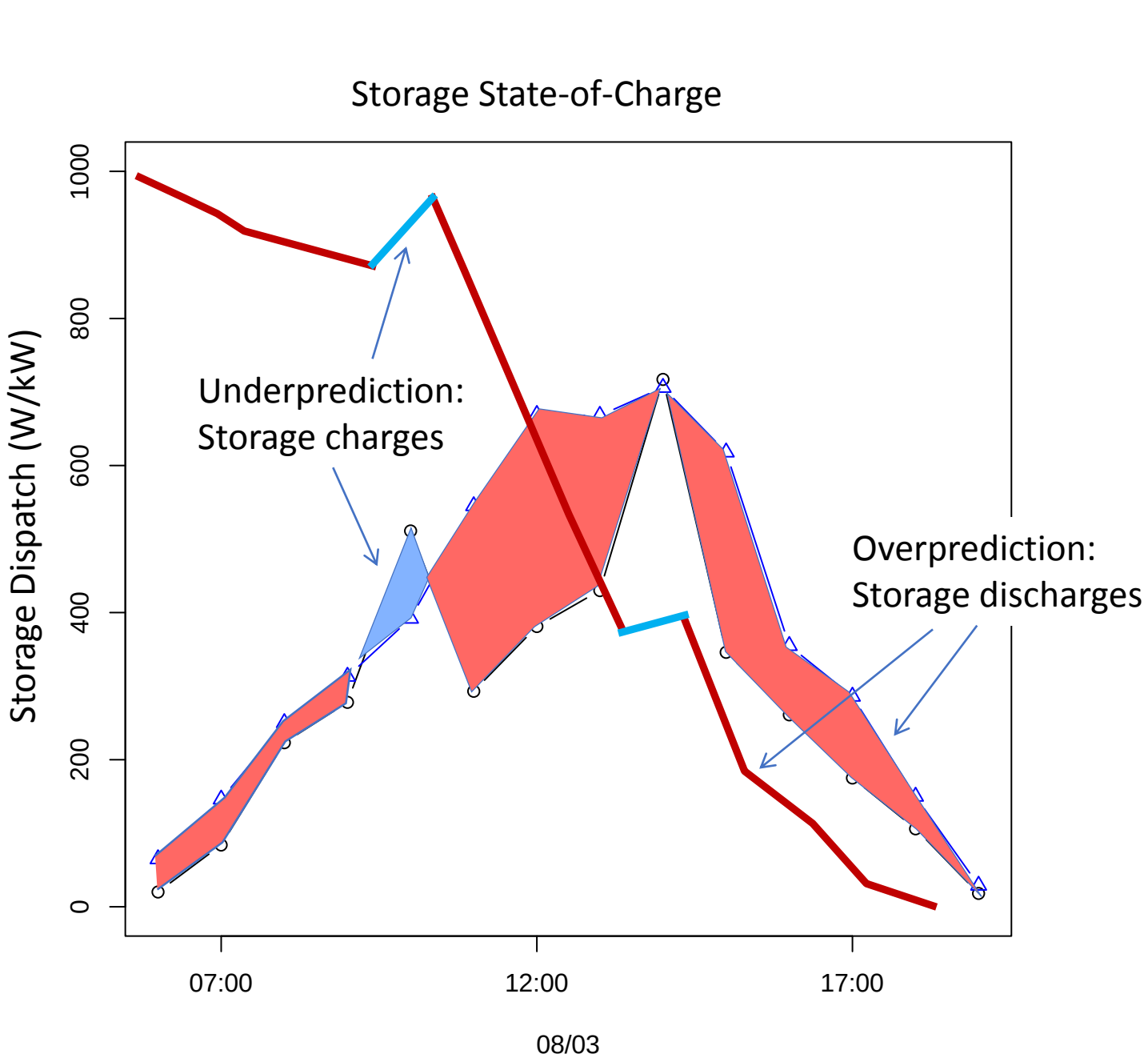


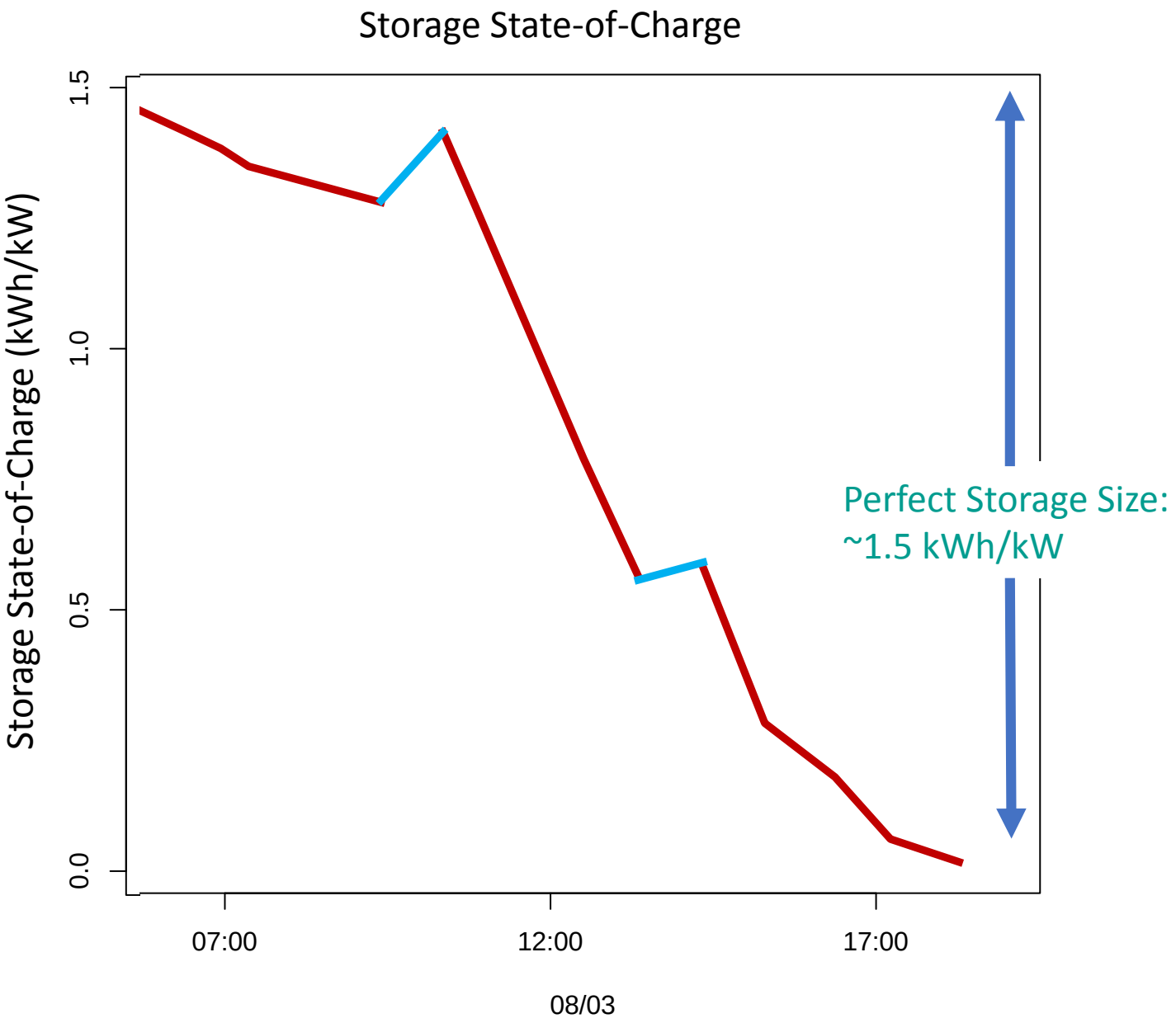

Actual Irradiance, August 3rd
W/m² (W/kW)
0
200
400
600
800
1000
07:00
12:00
17:00
08/03

V4 Hour Ahead Forecast

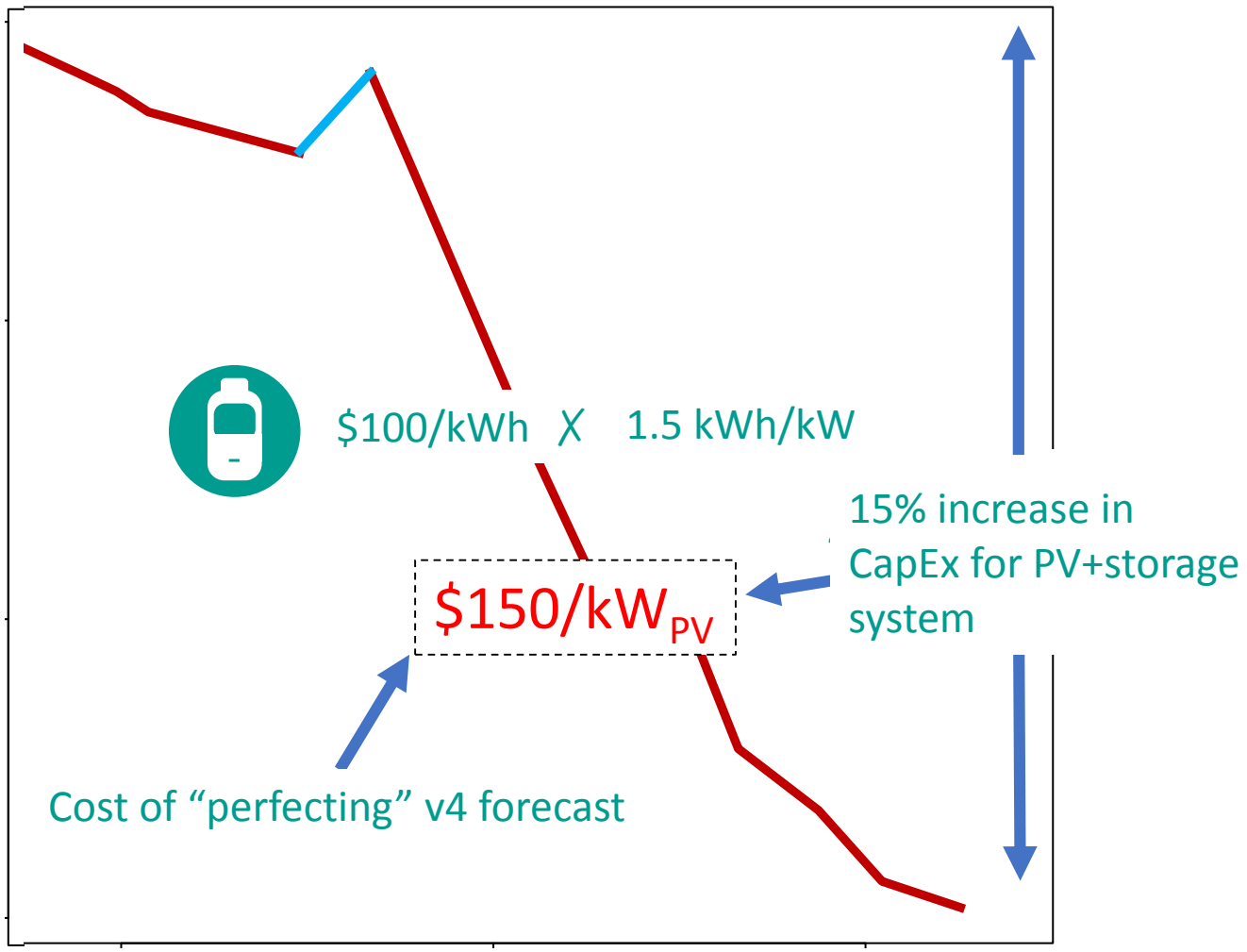


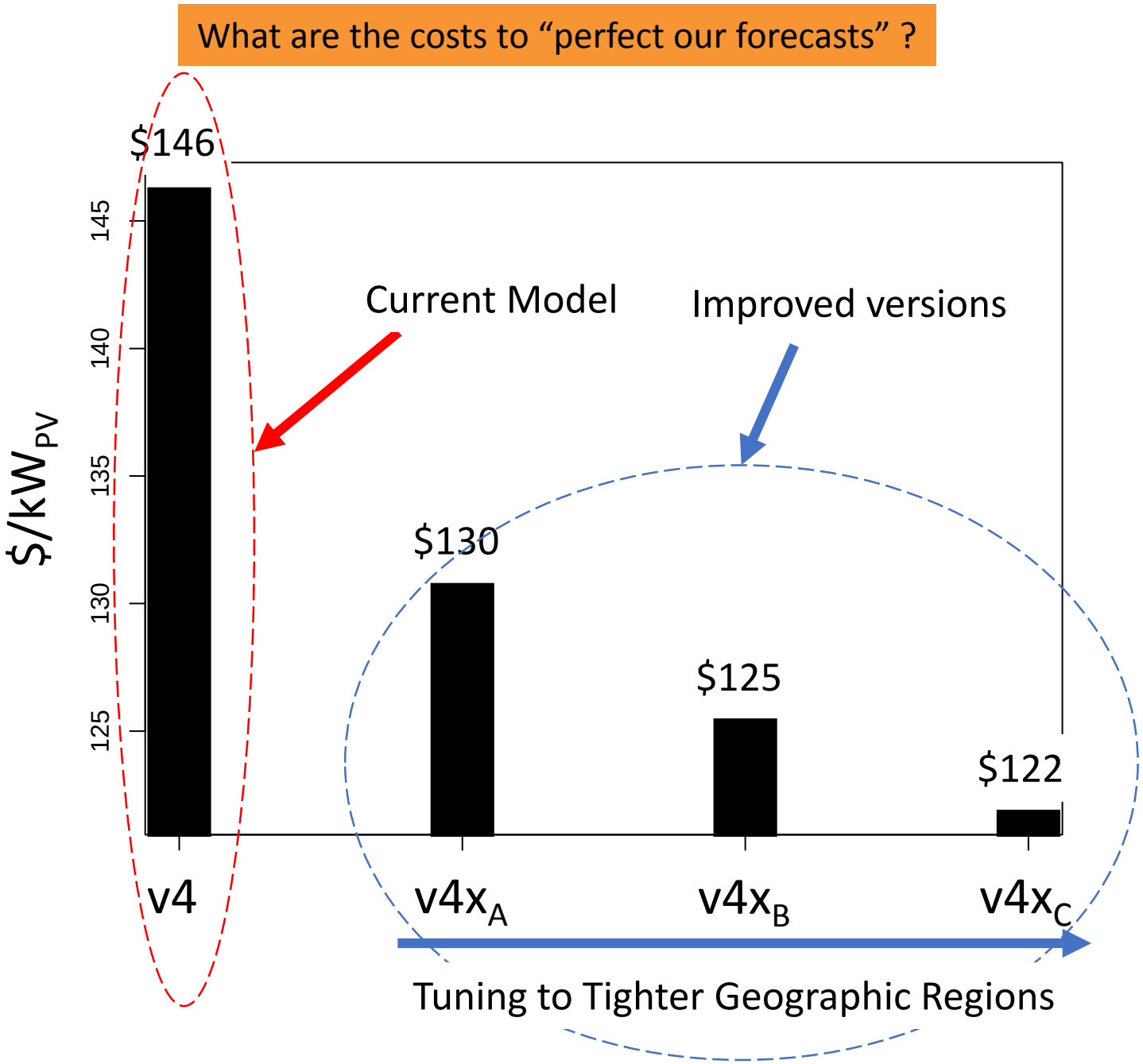

Storage dispatch
Storage Dispatch (W/kW)
0
200
400
600
800
1000
07:00
12:00
17:00
08/03
Underprediction:
Storage charges
Overprediction:
Storage discharges


Storage State-of-Charge
Storage Dispatch (W/kW)
0
200
400
600
800
1000
07:00
12:00
17:00
08/03
Underprediction:
Storage charges
Overprediction:
Storage discharges

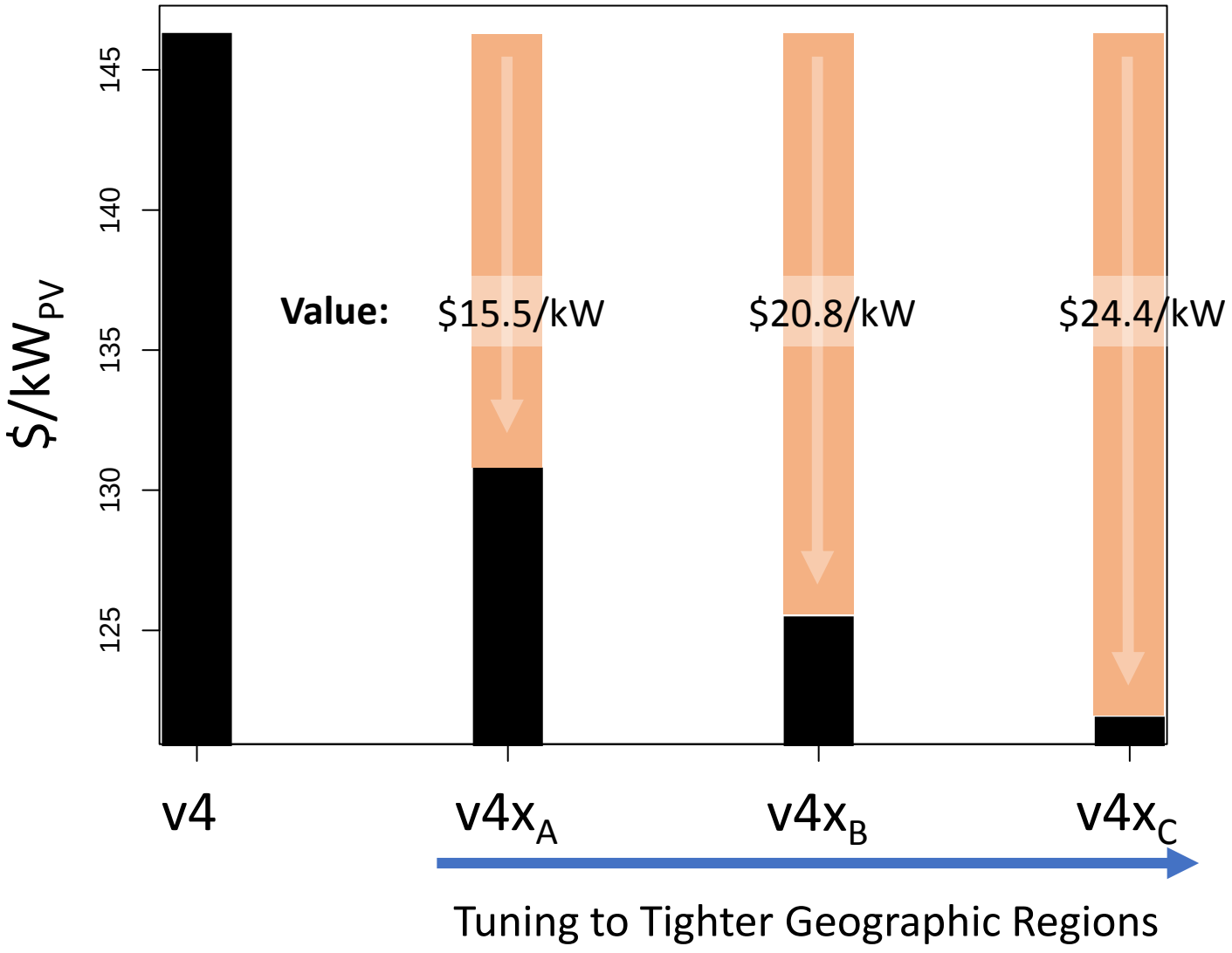

Storage State-of-Charge
Storage State-of-Charge (kWh/kW)
0.0
0.5
1.0
1.5
07:00
12:00
17:00
08/03
Perfect Storage Size:
~1.5 kWh/kW

How do we transform kWh into $?

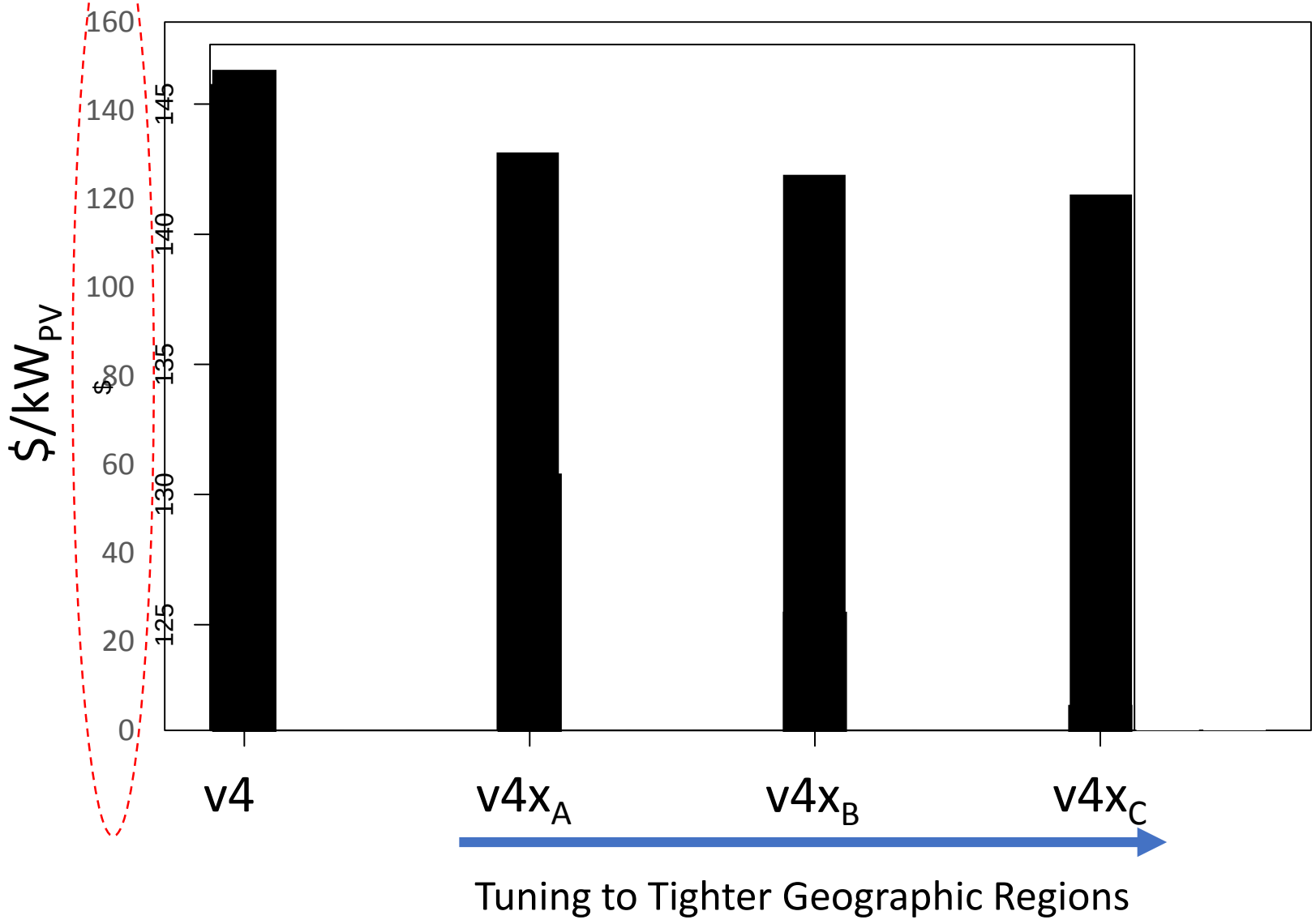



What are the costs to “perfect our forecasts” ?
$146
$130
$125
$122
Current Model
Improved versions
$/kW$_{PV}$
145
140
135
130
125
v4
v4x$_A$
v4x$_B$
v4x$_C$
Tuning to Tighter Geographic Regions

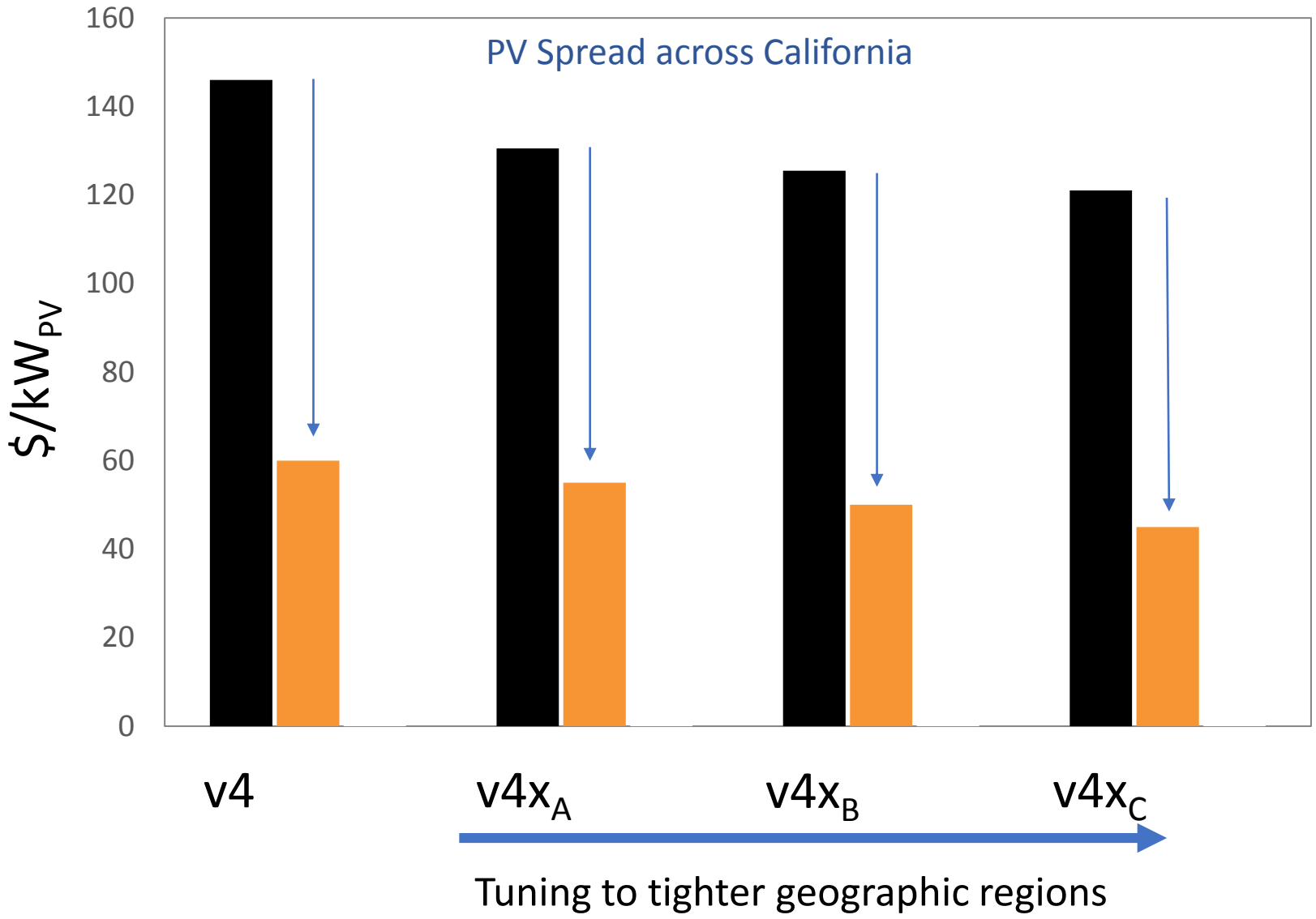
What is the value of improving our forecast?



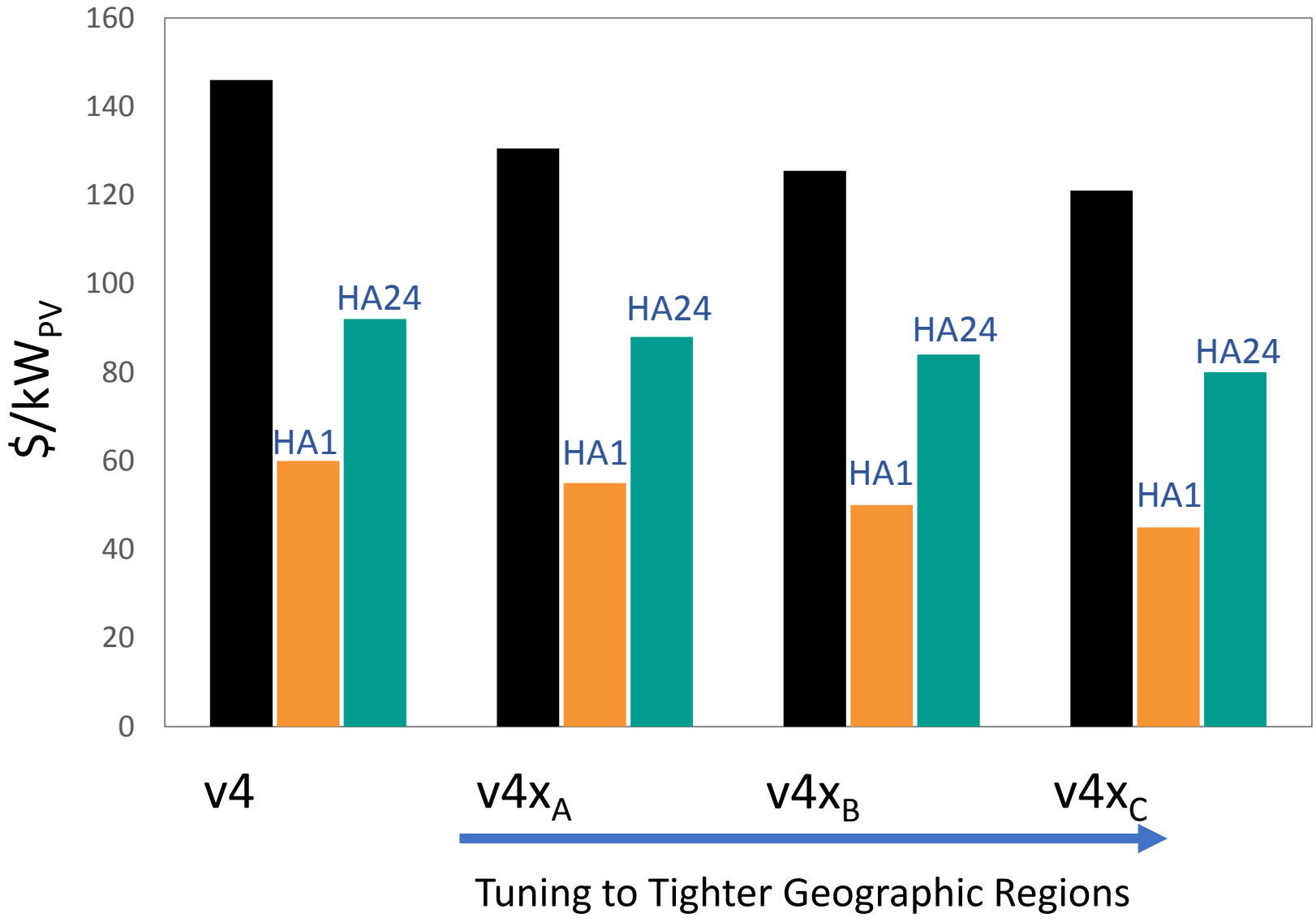
How does the forecast error change with Geographic extent?



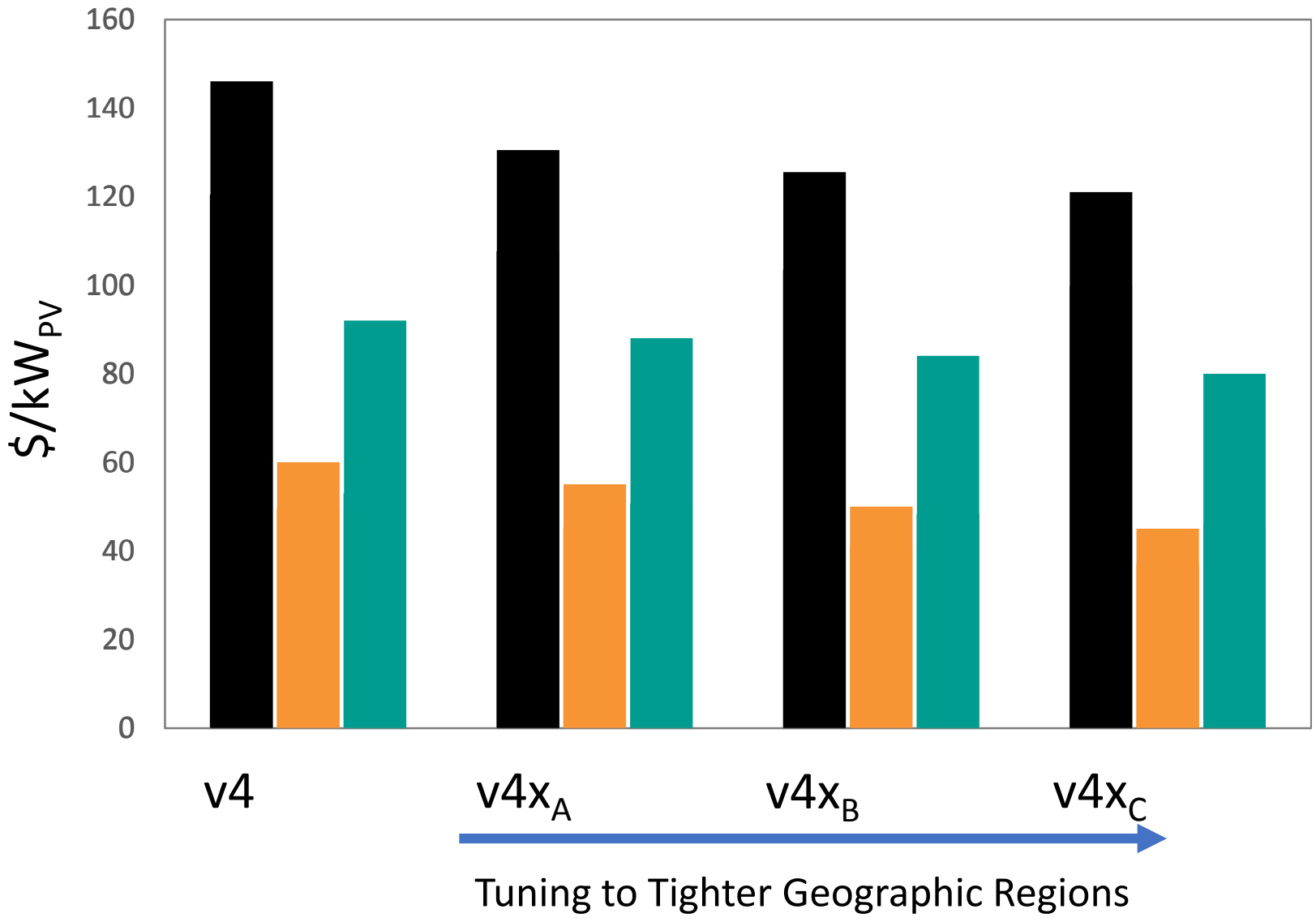
How does the forecast error change with geographic extent?



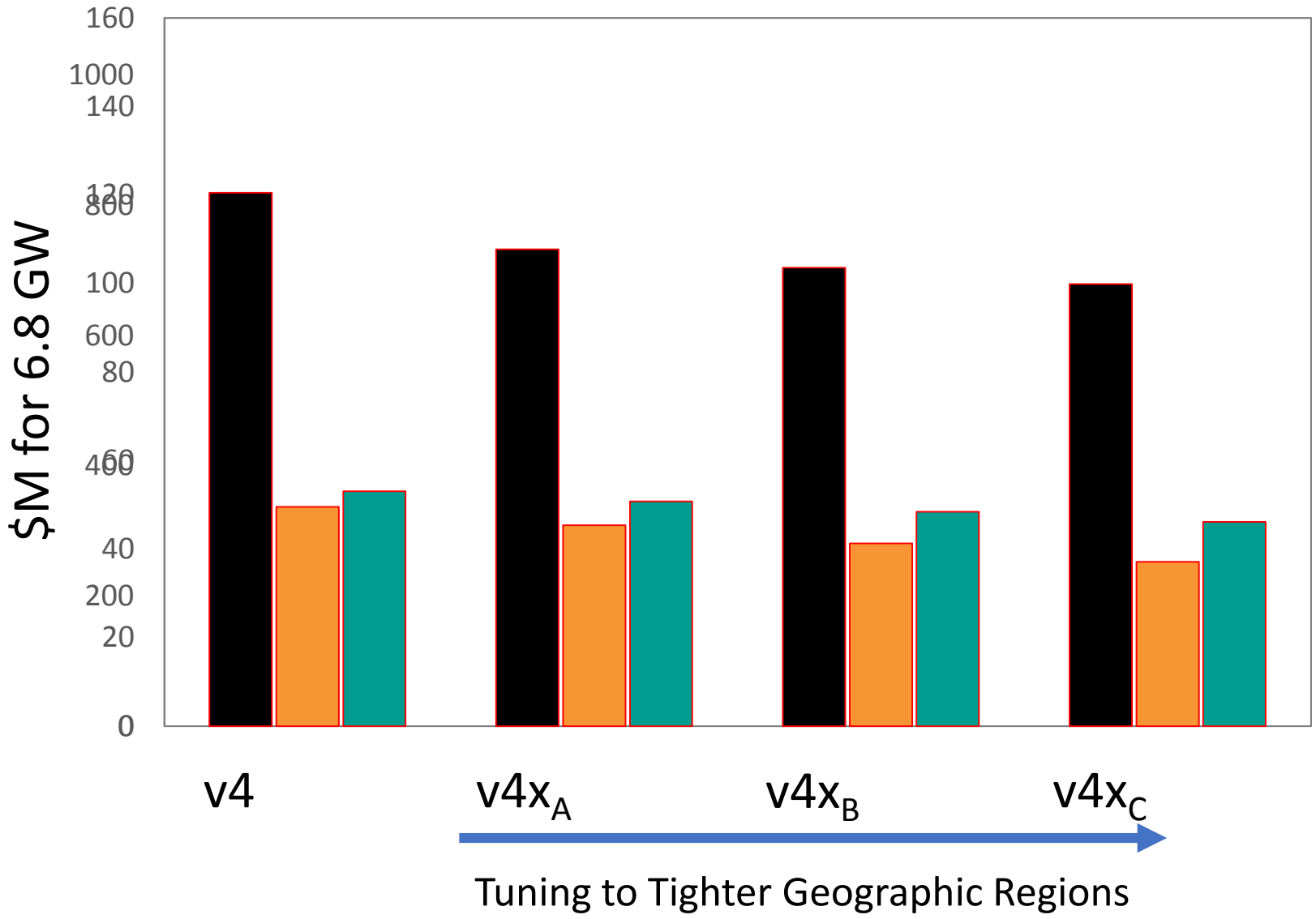
What about with Time Horizon?



What about with oversizing + curtailment?



What about aggregate value for all BTM PV across CA?



Concluding Remarks

- Presented an improved site-independent “out-of-the-box” forecast model operational anywhere in North-America.
- Presented evidence of substantial further performance improvement achievable with localized model tuning from measured operational data.
- Showed that a sizeable fraction of this additional site-tuned performance improvement could be incorporated in the “out-of-the-box” model by mining historical SolarAnywhere irradiances.
- Showed three examples of improved site tuning using more or less aggregated data
- Demonstrated the novel “Perfect Forecast” valuation methodology
- Applied this valuation methodology to each of the new forecasts investigated.
- Showed how value changes based on forecast horizon and with the use of oversizing + curtailment.

Thank you

Clean Power Research®