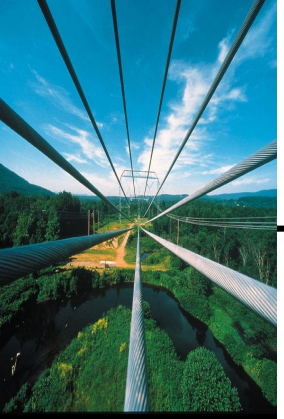
CALIFORNIA ISO
California Independent System Operator

Using PI-ACE to Calculate Regulation Performance Metrics

Prepared by

Craig Taylor and Don DeBerry

Presentation to
2003 OSIsoft T&D Users Conference



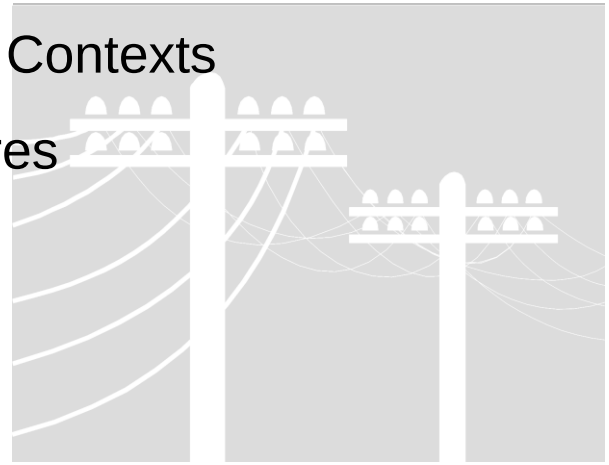
Agenda

Don Covering

- Description of Regulation
- Regulation Performance Metrics
- ProcessBook Display Examples

Craig Covering

- California ISO Server Structure
- PI-ACE Tip: Adding Multiple Similar Contexts
- Our last year: Successes and Failures
- Future PI-ACE Plans



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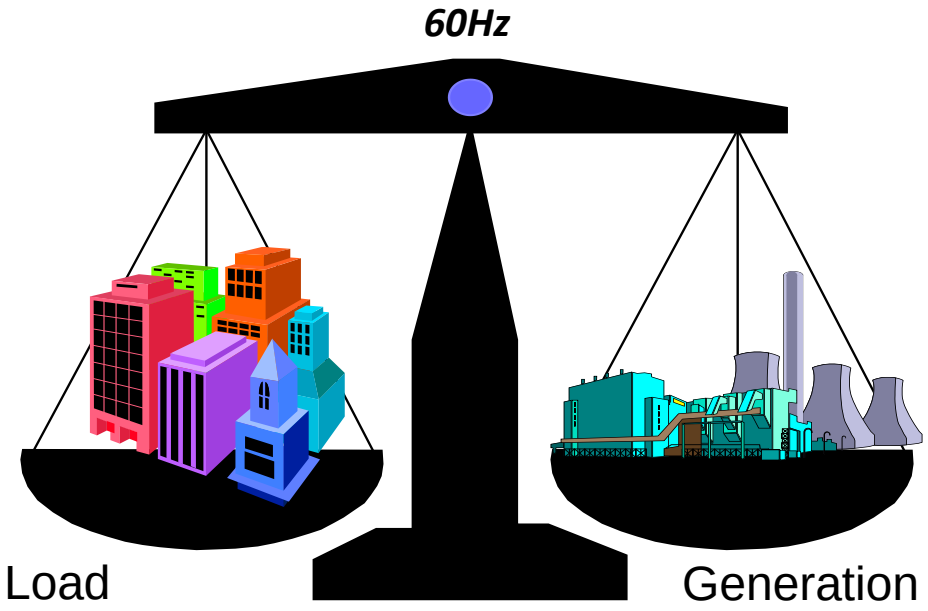
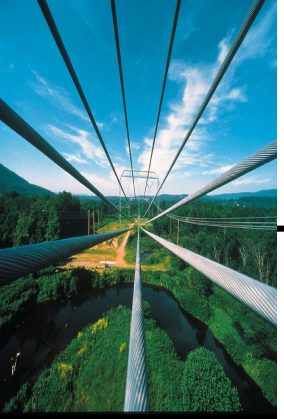
What is Regulation?

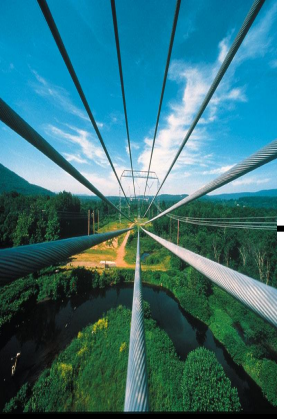
Regulation – Generators equipped with Automatic Generation Control (AGC) that can change output quickly to accommodate the fluctuations in system supply and demand.





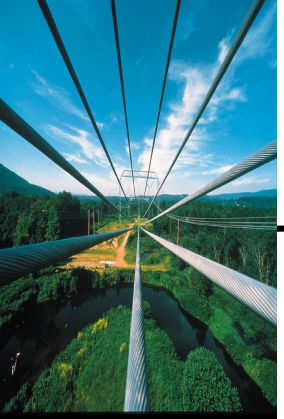
What is Regulation?

- Ancillary Service – Expensive
- Reserved Capacity
- Generators Controlled by CAISO EMS
- Telemetry Requirements
  - Two Way Communication
  - Verify AGC Status
- Generators Require Certification
- Approximately 100 Units Certified
- Typically 5-20 Units (CAISO system)



Why are Performance Metrics Needed?

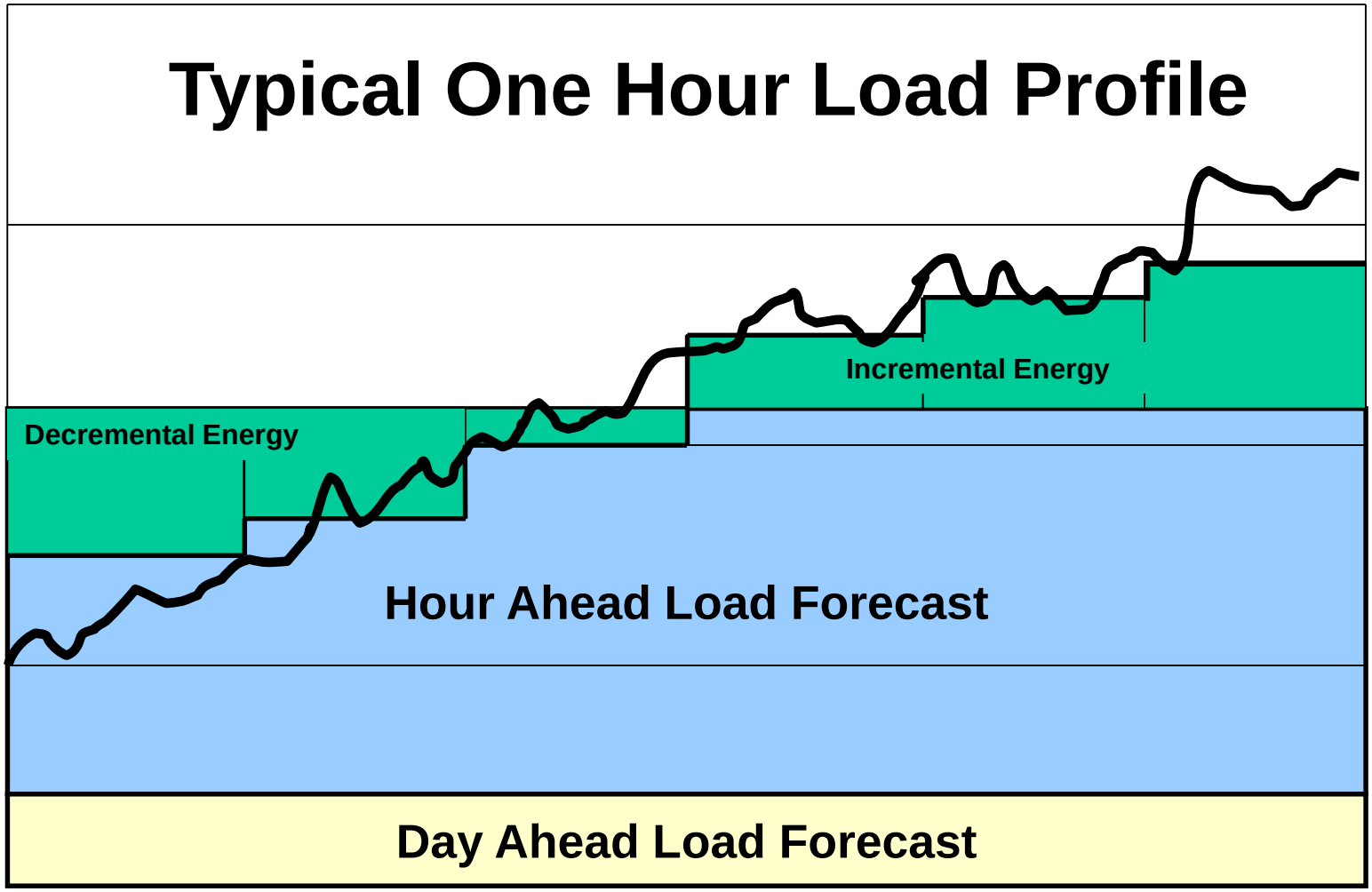
- **Improve the Quality of Regulation Service**
  - Rank Regulation Performance
  - Share information with Generator Owners
  - May Eventually Penalize Poor Performers
- **Improve Reliability**
  - Better Response to System Emergencies
  - NERC Control Performance Standards
- **Reduce Costs**
  - Improve Efficiency of Regulation Service



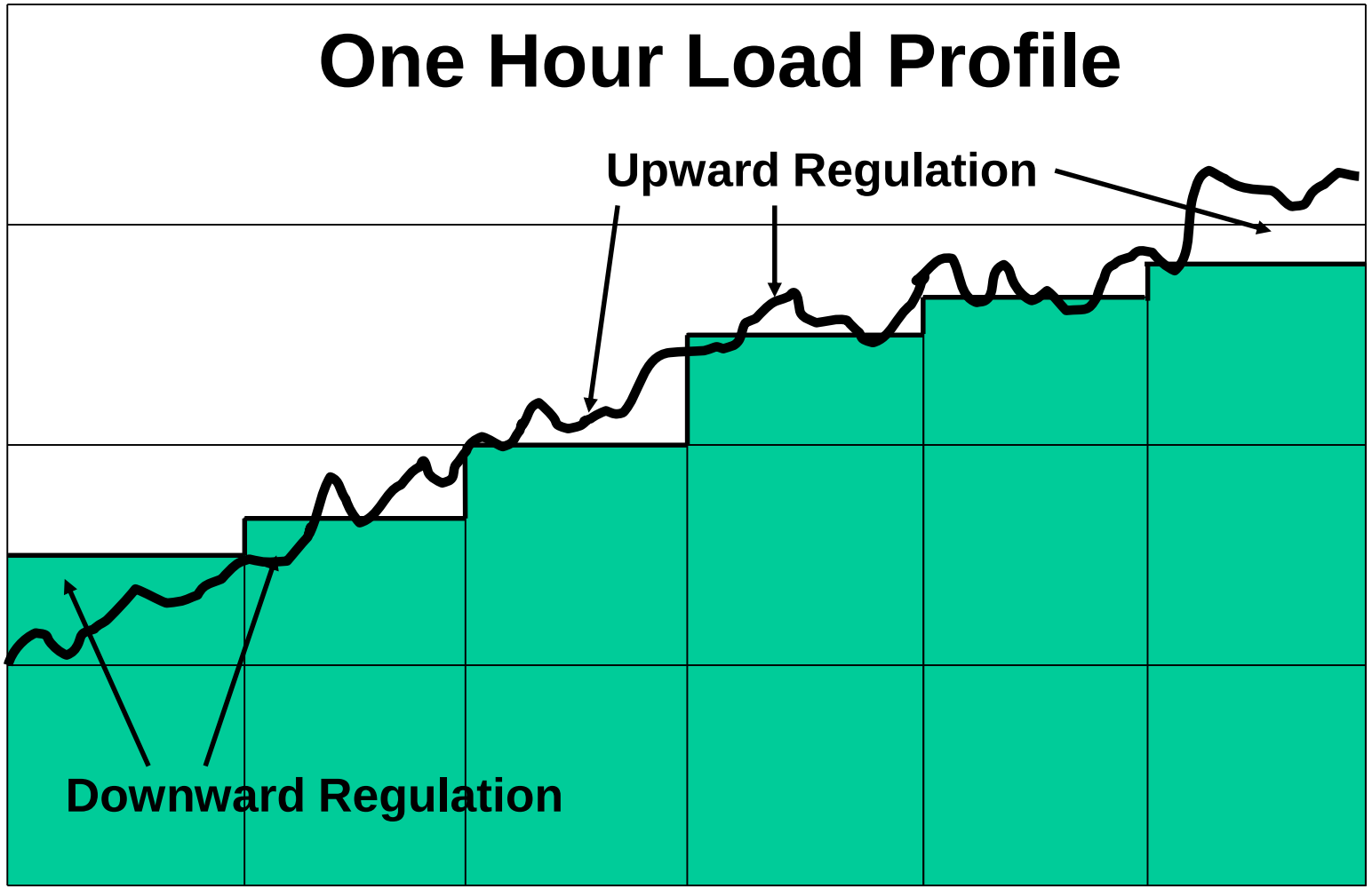
Performance Metric Requirements

- **Operations Requirements**
  - Performance During 10 Minute Intervals
  - Indicate a Variety of Regulation Performance Problems
  - System Performance and Individual Unit Performance
  - Alignment with Certification Tests
- **Compliance Requirements**
  - Performance During 1 Hour Intervals
  - Provides a Link to Billable Market Quantities
  - Historic Information
  - Alignment with Certification Tests
- **EMS Requirements (All of Above Plus…)**
  - Performance Analysis Capabilities
  - Ability to Send Trends to Generator Operators

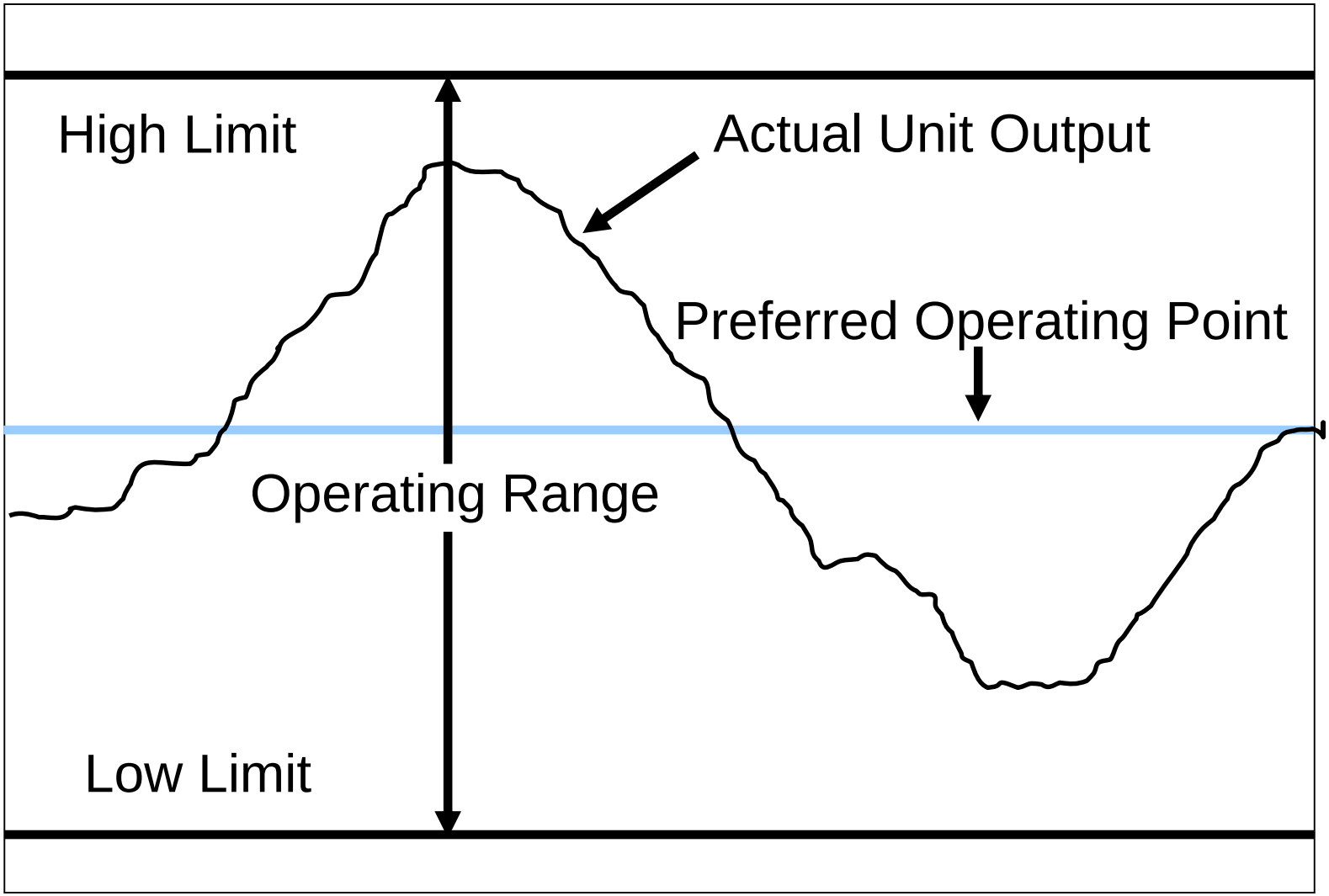
Regulation – System Perspective



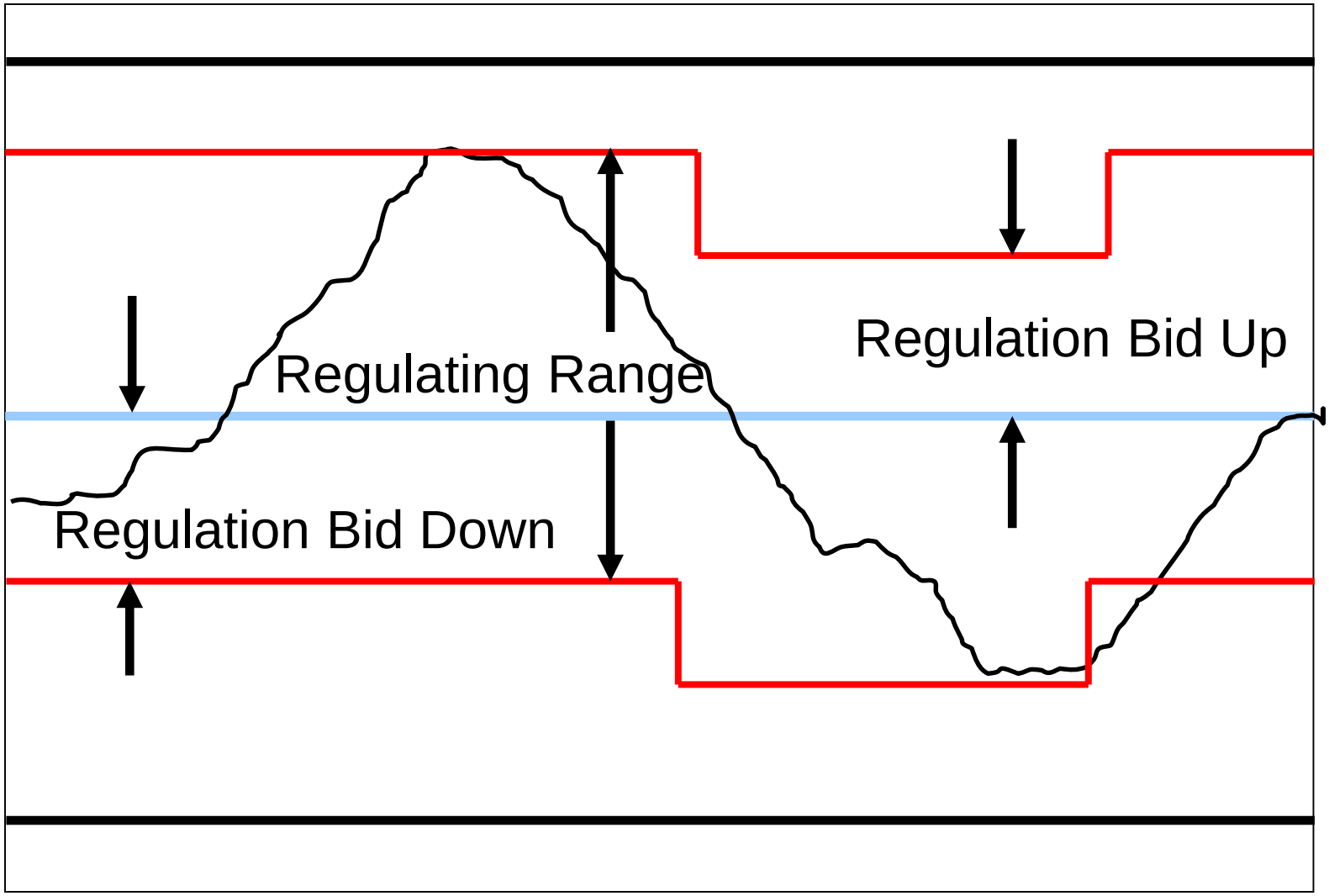
Regulation – System Perspective



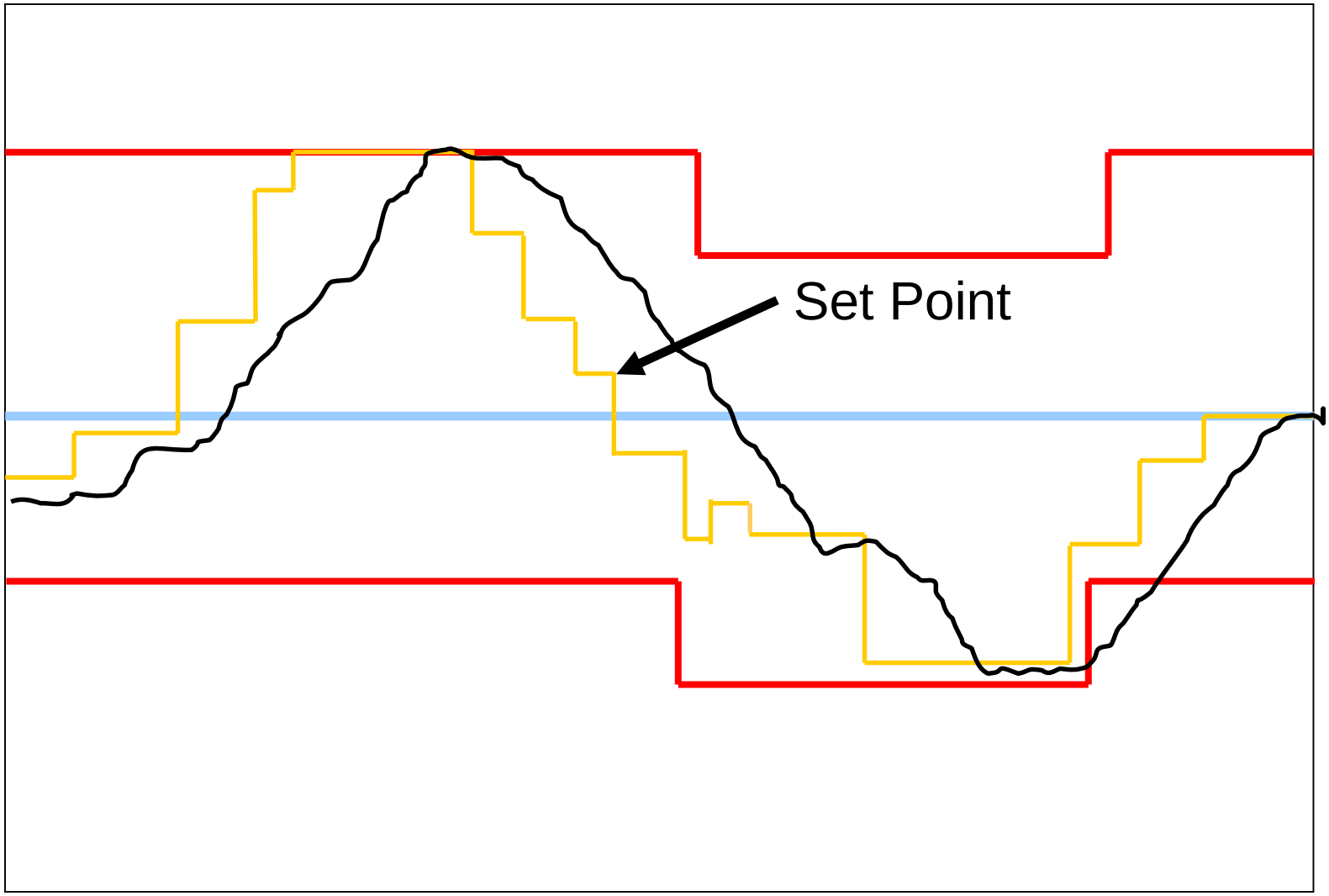
Regulation – Generator Parameters



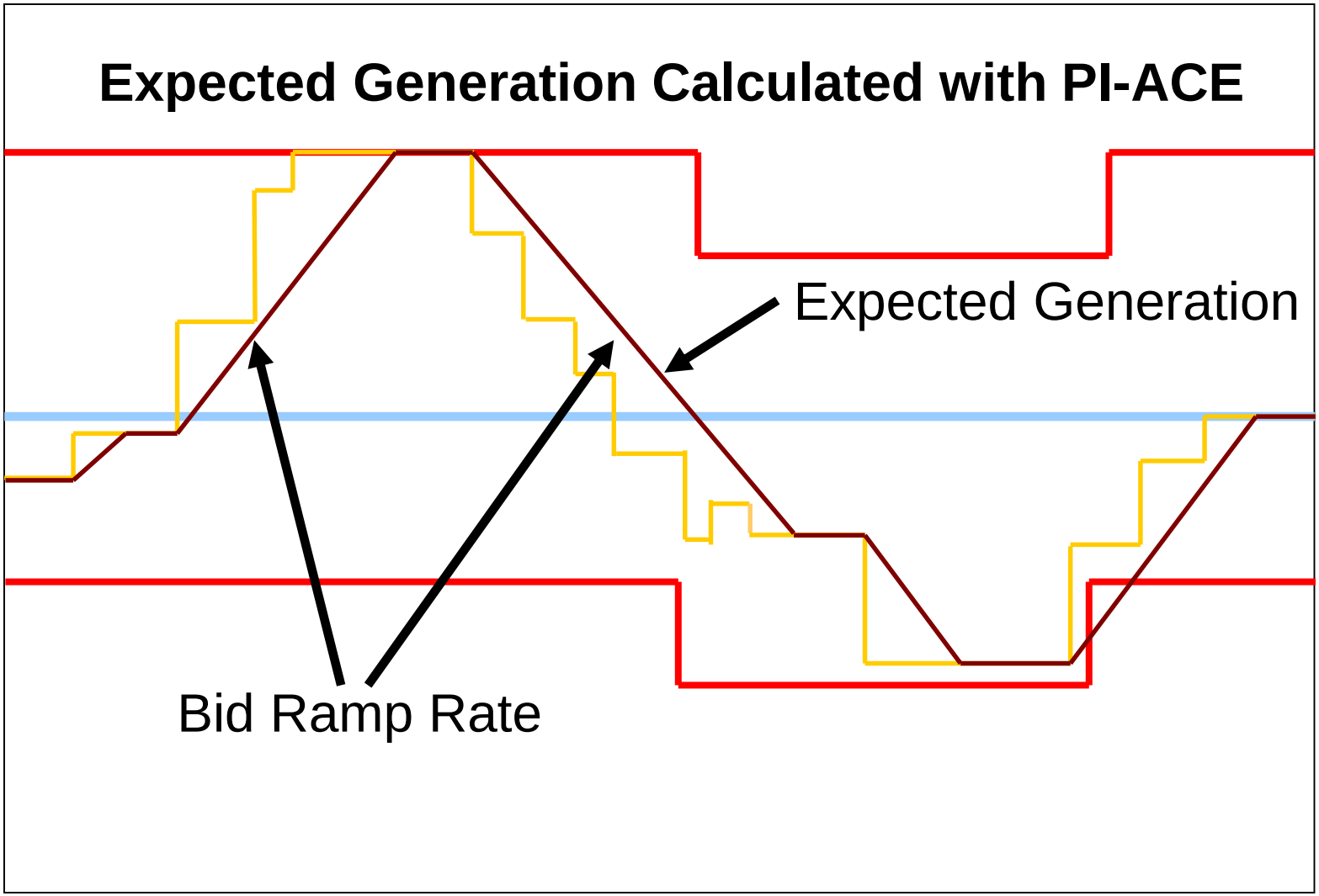
Regulation – Generator Parameters



Regulation – Unit Control

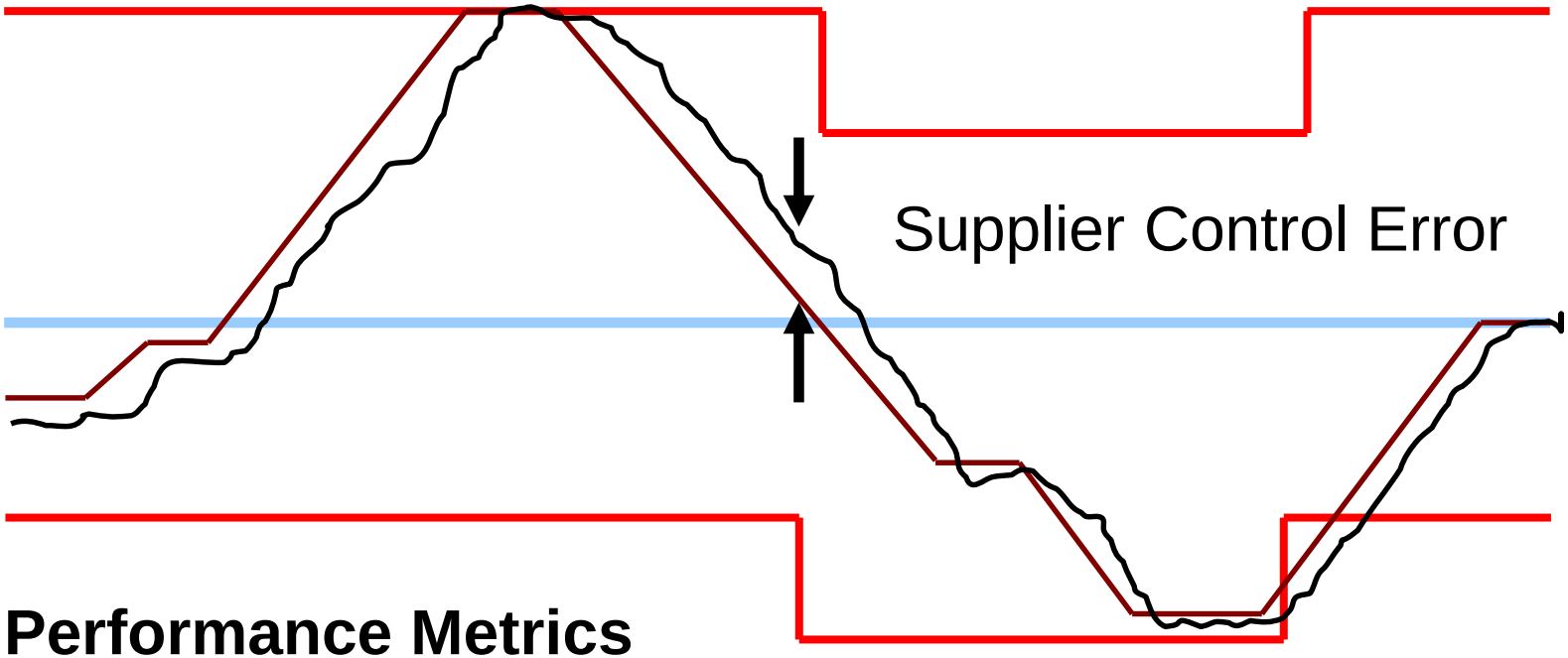


Expected Generation Calculation



Performance Metric Calculation

Calculated with PI-ACE

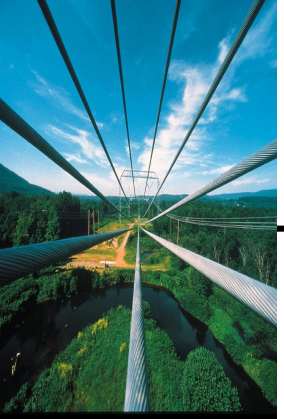


Performance Metrics

1) Energy Calculations
2) Line Statistic Calculations

Calculation Period

- Instantaneous Value
- 10 Min Summation
- 1 Hr Summation



Performance Metric Formulas

Supplier Control Error Energy

$$SCE = \sum_{j=1}^{N} ABS\ (Actual_j - Expected_j)$$

$$SCEPerf = \left(1 - \frac{SCE - bias}{Error}\right) * 100$$

Where:

Bias = 1 mwh

Error = 10 mwh (10*bias)

If SCE > 11*bias, SCEPerf = 0%

Performance Metric Formulas

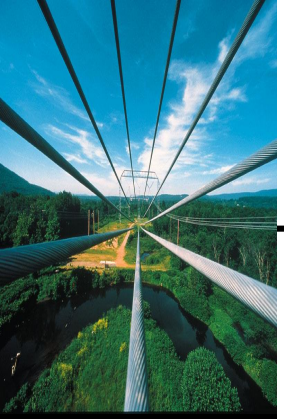
Line Statistics

$$StdDevRatio = \sigma_{Actual} / \sigma_{Expected}$$

$$Correlation = \frac{\sum_{j=1}^{N} (Expected_j - \mu_{Expected})(Actual_j - \mu_{Actual})}{(\sigma_{Actual} * \sigma_{Expected})}$$

$$\boxed{StatPerf = StdDevRatio * Correlation}$$

Where StatPerf = 1 if $\sigma_{Expected} = 0$ or $\frac{\sigma_{Actual}}{\sigma_{Expected}} > 2$



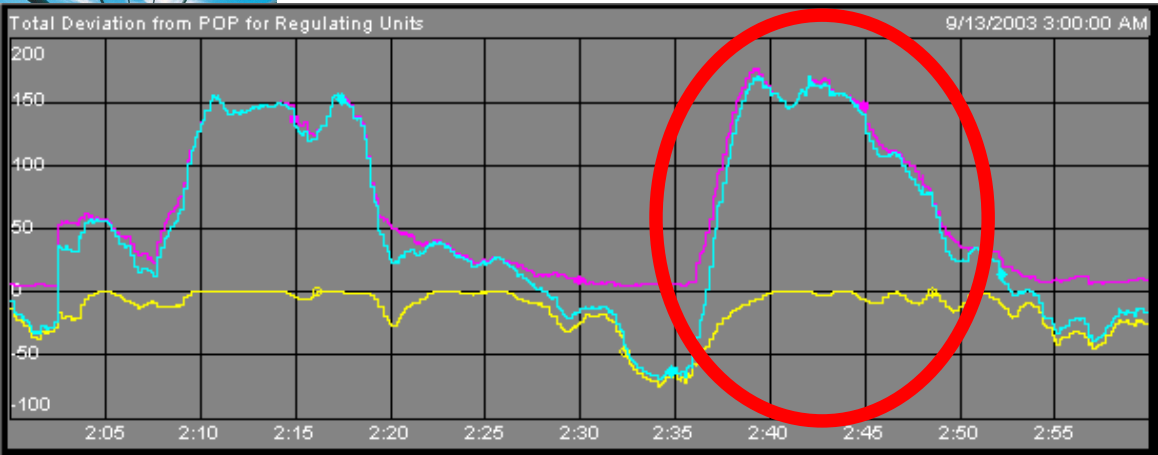
Performance Metric Formulas

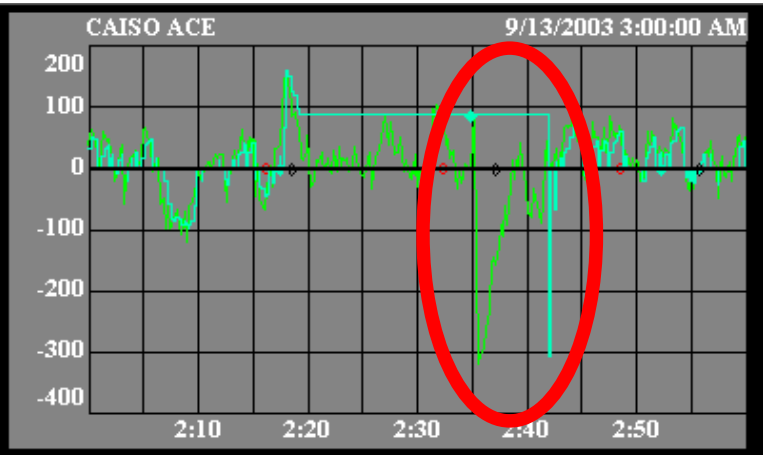
Performance Metric

$$PerfMetric = \frac{(SCEPerf + StatPerf)}{N} * 100$$

Where:
N=1 if StdDevRatio or Correlation fail (StatPerf = 1)
N=2 if StdDevRatio and Correlation are good

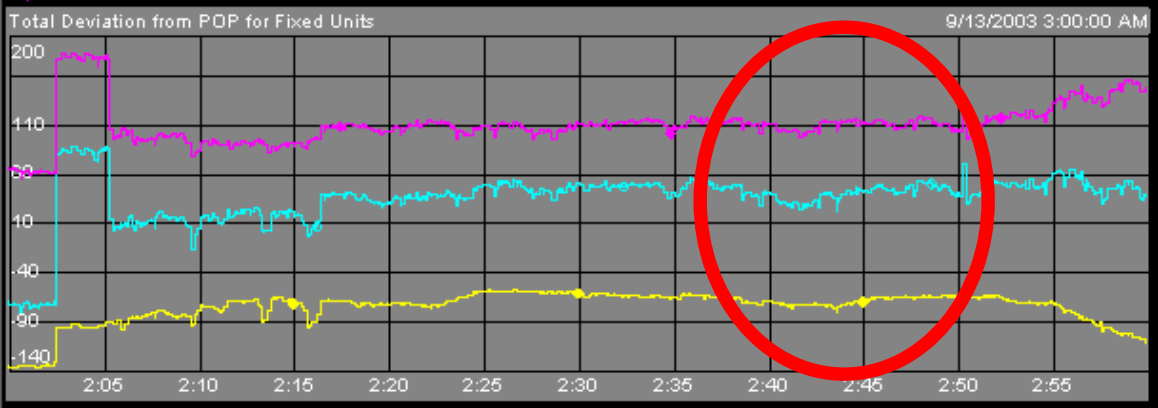
Regulation – System Perspective

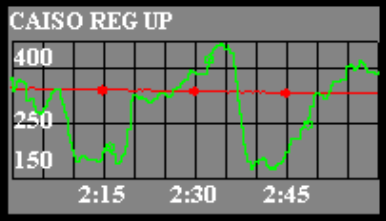


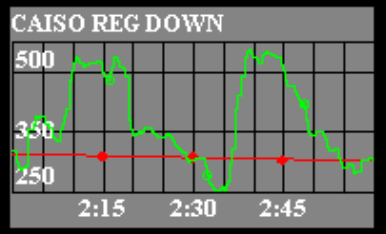


Total Deviation from POP for Fixed Units

Upward 147.70 Downward -111.00 Total 36.69







UPPER REGULATION

REQUIRED	ACTUAL	POP DEV.
302	339	8

LOWER REGULATION

REQUIRED	ACTUAL	POP DEV.
302	304	-26

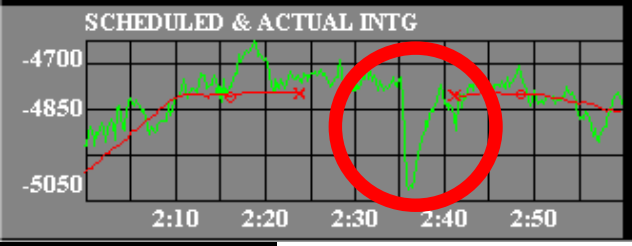
FIXED POP DEV.	TOTAL	REG POP DEV.
37		-17

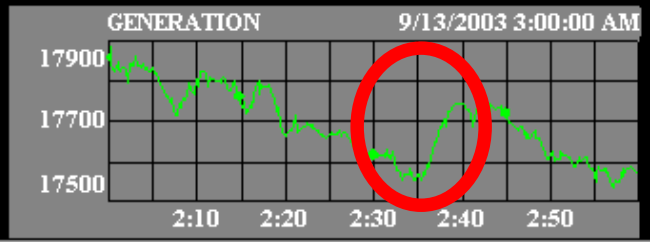
SPINNING RESERVE

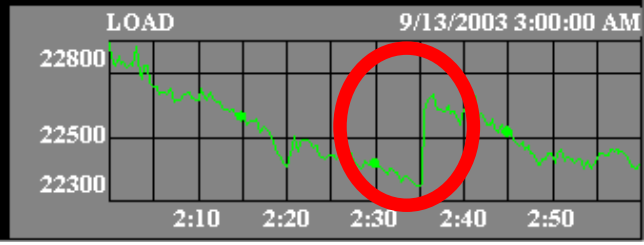
REQUIRED	ACTUAL	
640	1035	5.4 %

OPERATING RESERVE

REQUIRED	ACTUAL	
1280	1696	8.2 %







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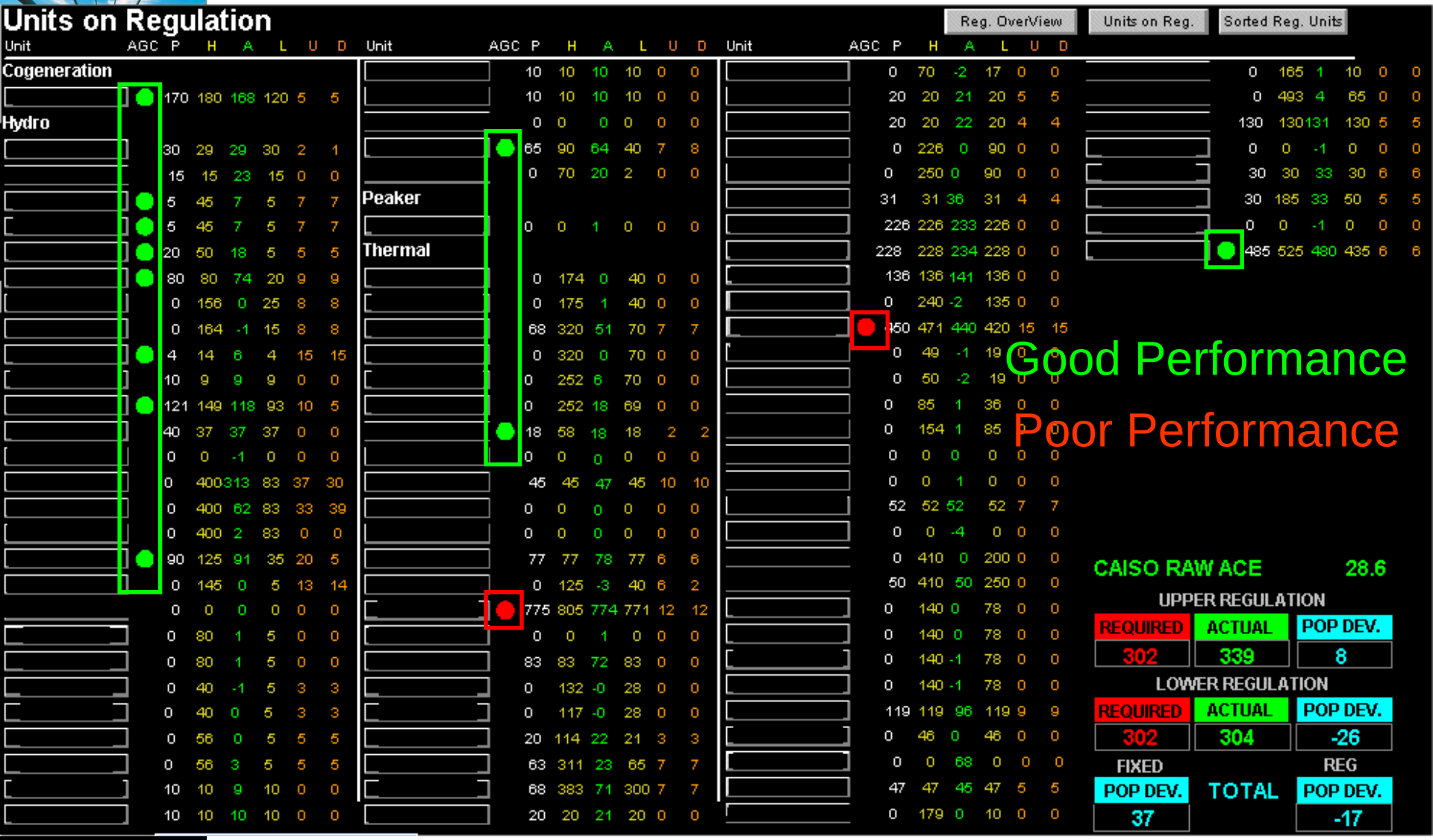
Regulation – System Perspective



Unit Names were Removed

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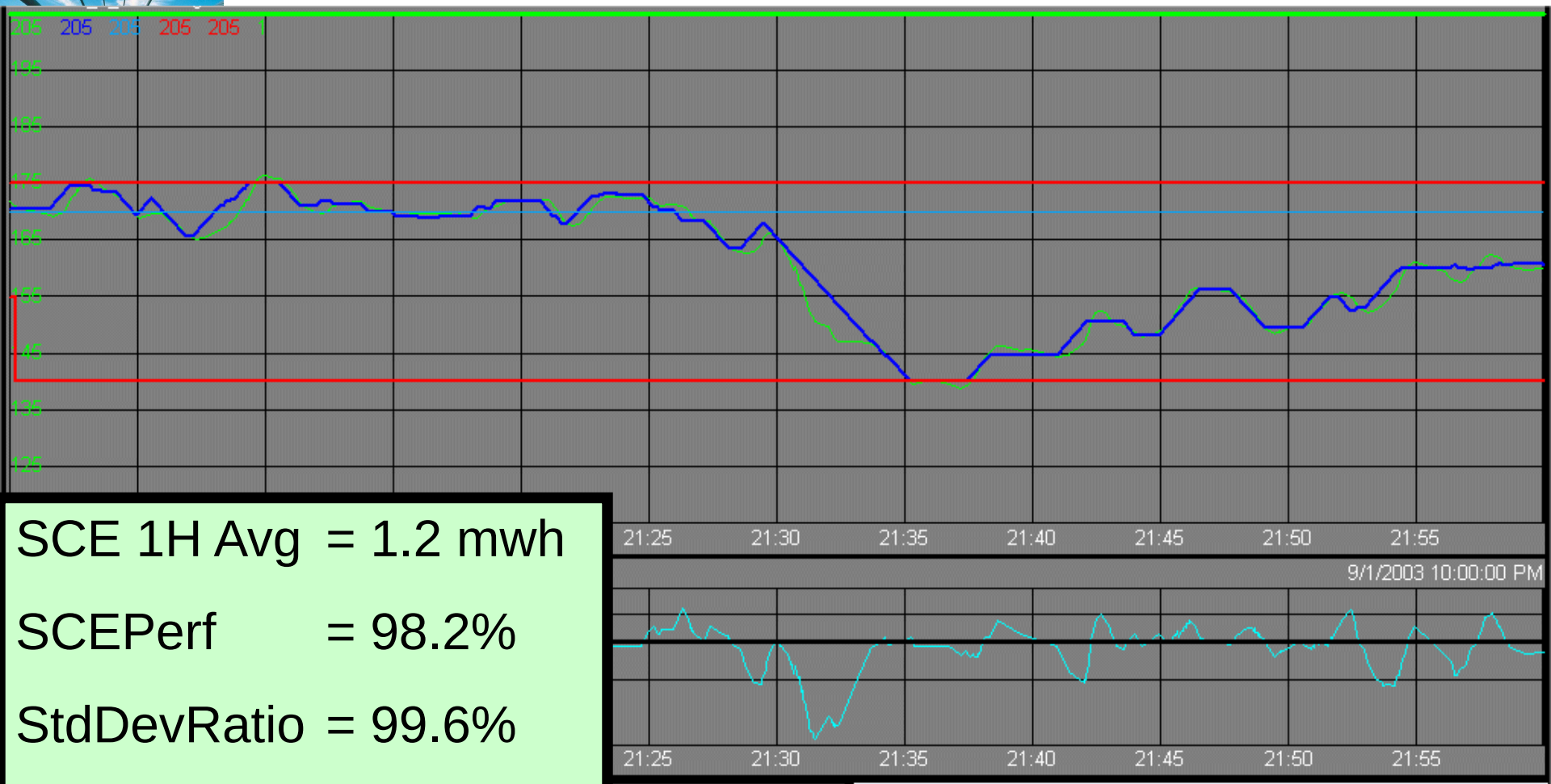
Example - Good Performance



SCE 1H Avg = 1.2 mwh

SCEPerf = 98.2%

StdDevRatio = 99.6%

Correlation = 91.4%

Overall Performance

PerfMetric = 94.6%

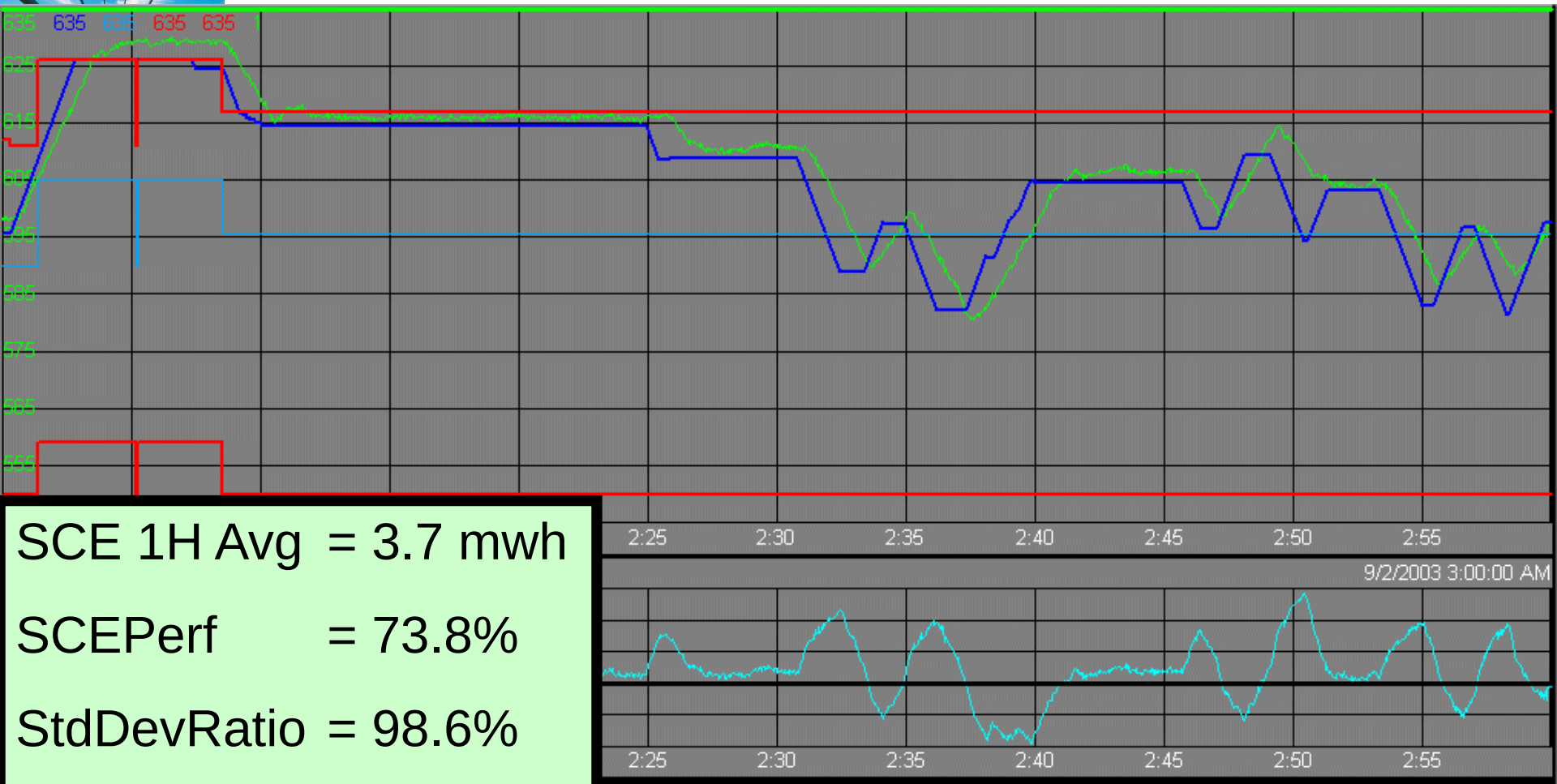
oplier Control Error

E	-0.82
E 10m Avg	0.20
E 1hr Avg	1.18

Control Area AGC Data

CAISO RAW ACE	65.1	Total Upward Deviation from POP	0.5
CAISO Filtered ACE	44.0	Total Downward Deviation from POP	-308.6
CAISO Load	30136.6	Total Deviation from POP	-308.1
CAISO Generation	23900.5		
CAISO Interchange	-6234.2		

Example – Border Line Performance



SCE 1H Avg = 3.7 mwh

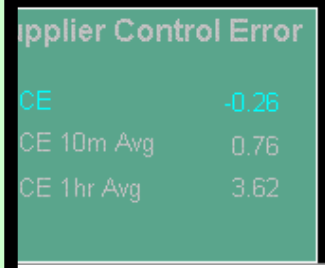
SCEPerf = 73.8%

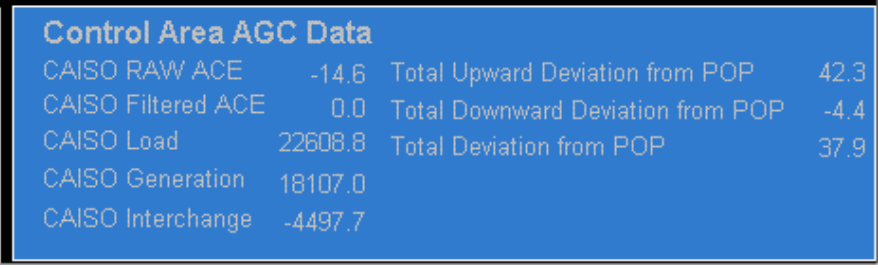
StdDevRatio = 98.6%

Correlation = 66.1%

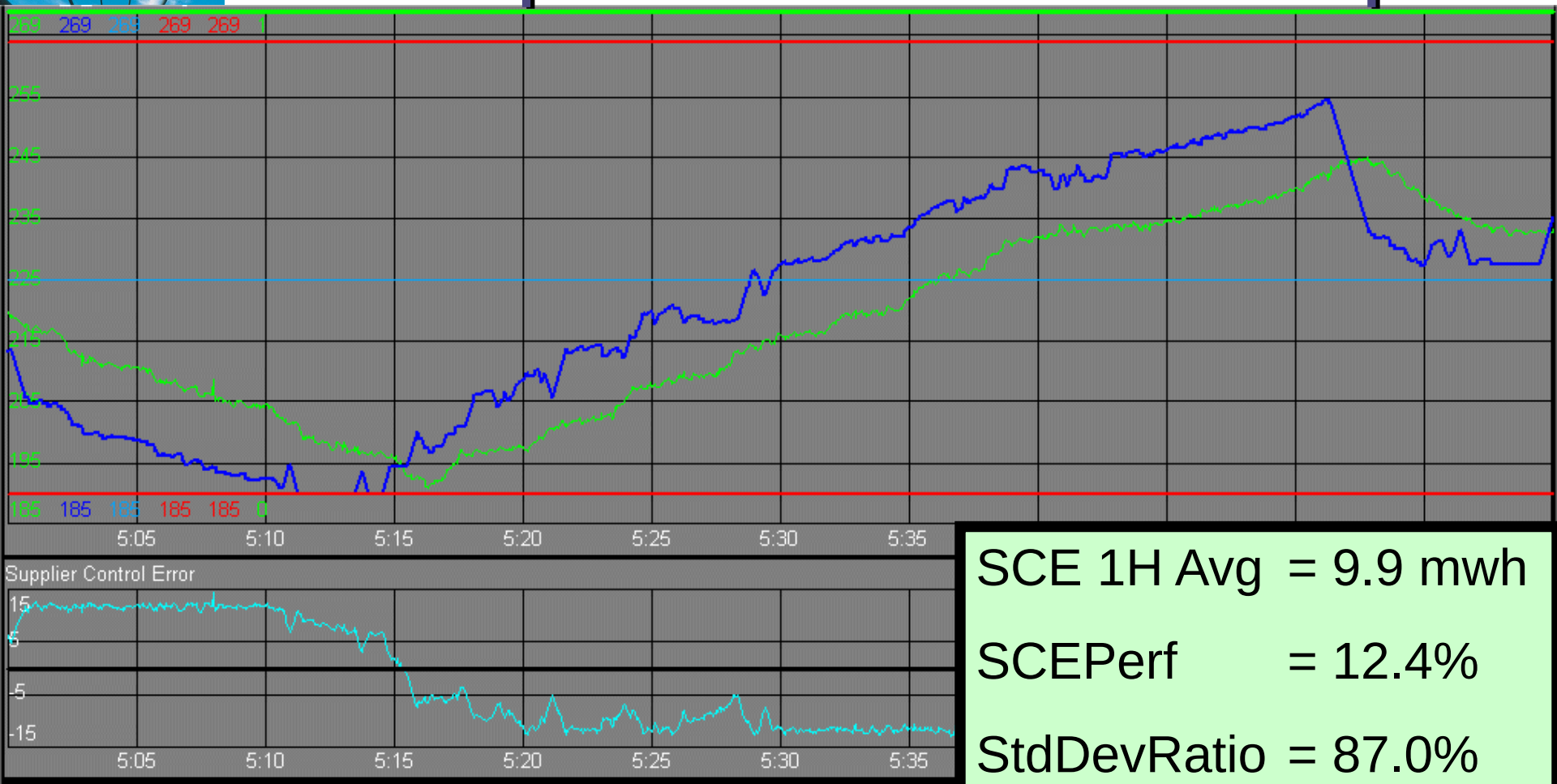
Overall Performance

PerfMetric = 69.5%





Example - Poor Performance – Response



Individual Unit Data			
AGC Status	Closed	AGC Set Point	244.7
Actual Ouput	233.0	Bid Up Regulation	39.0
Expected Gen.	235.1	Bid Down Regulation	-35.0
Eff. POP	225.0	Bid Up Ramp Rate	14.5
High Reg Limit	264.0	Bid Down Ramp Rate	14.5
Low Reg Limit	190.0		

Supplier Control Error	
SCE	-2.26
SCE 10m Avg	1.29
SCE 1hr Avg	9.88

Contro
CAISO
CAISO
CAISO
CAISO
CAISO

SCE 1H Avg = 9.9 mwh

SCEPerf = 12.4%

StdDevRatio = 87.0%

Correlation = 73.5%

Overall Performance

PerfMetric = 38.1%

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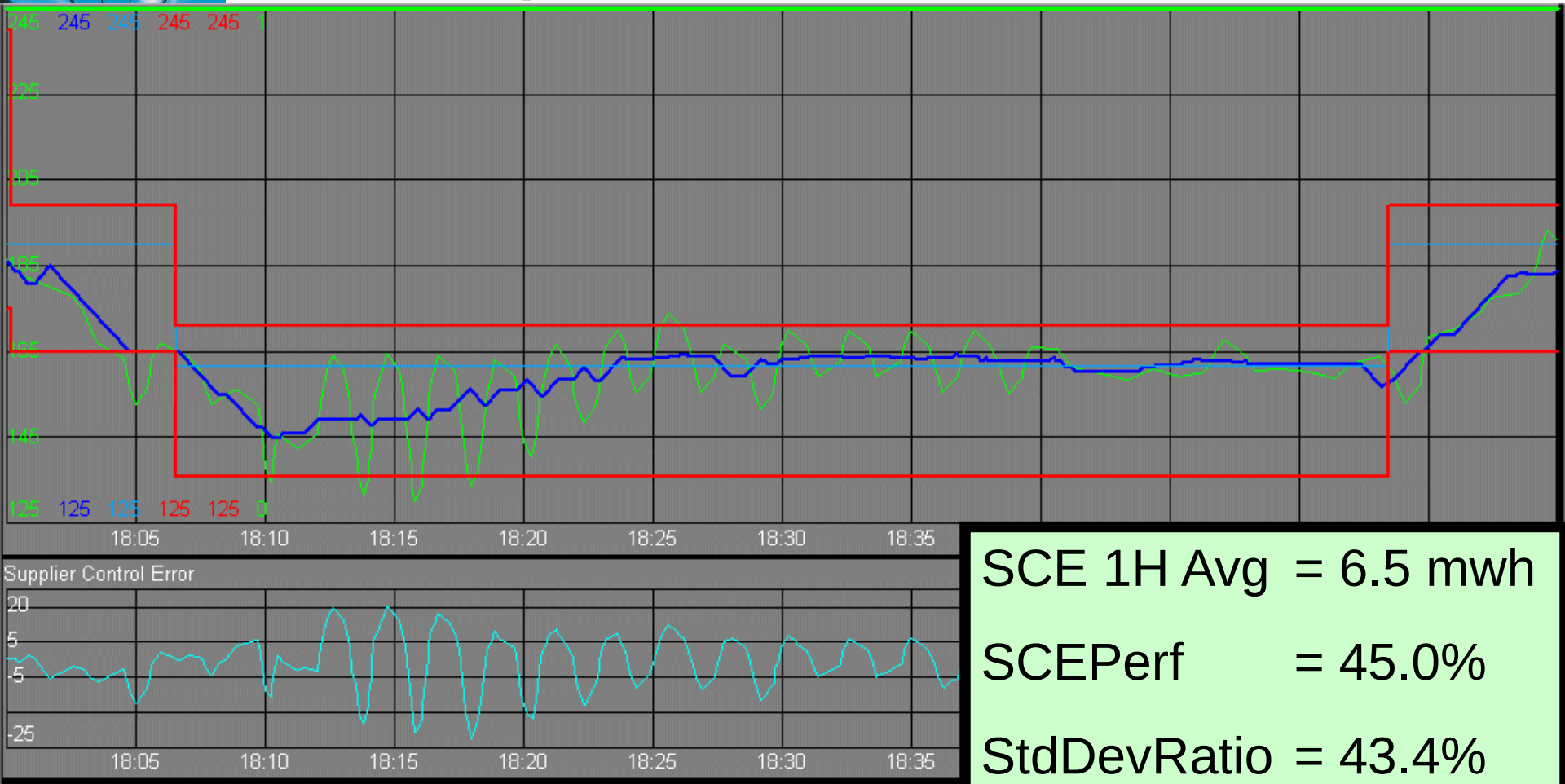
Example - Poor Performance - Oscillation



Individual Unit Data

AGC Status	Closed	AGC Set Point	183.6
Actual Ouput	191.0	Bid Up Regulation	10.0
Expected Gen.	183.6	Bid Down Regulation	-25.1
Eff. POP	190.0	Bid Up Ramp Rate	6.6
High Reg Limit	199.0	Bid Down Ramp Rate	6.6
Low Reg Limit	165.0		

Supplier Control Error

SCE	7.45
SCE 10m Avg	75.49
SCE 1hr Avg	74.86

Contro

CAISO P
CAISO P
CAISO L
CAISO G
CAISO I

SCE 1H Avg = 6.5 mwh

SCEPerf = 45.0%

StdDevRatio = 43.4%

Correlation = 51.0%

Overall Performance

PerfMetric = 33.6%

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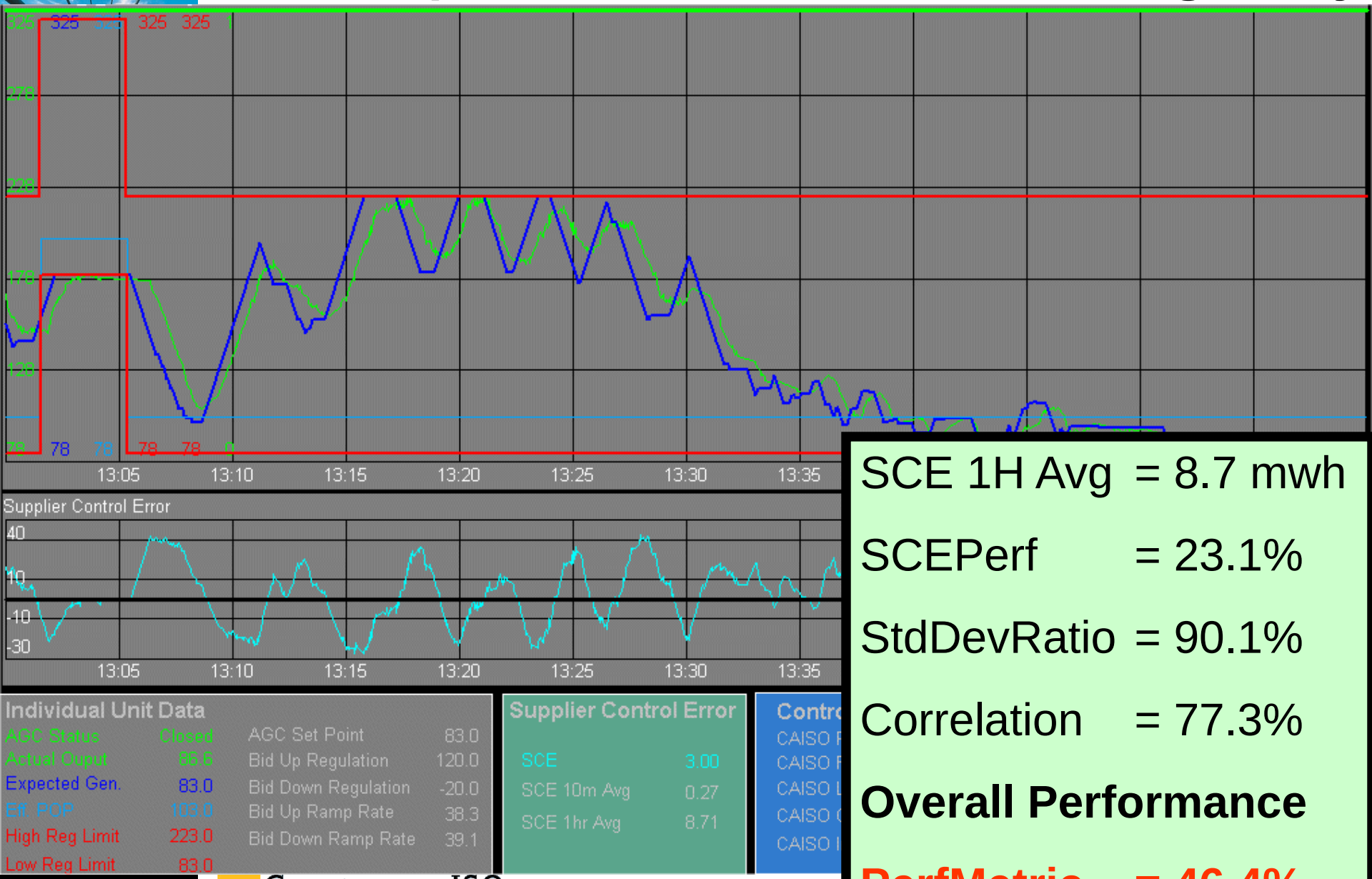
Example - Poor Performance – Long Delay



SCE 1H Avg = 8.7 mwh

SCEPerf = 23.1%

StdDevRatio = 90.1%

Correlation = 77.3%

Overall Performance

PerfMetric = 46.4%

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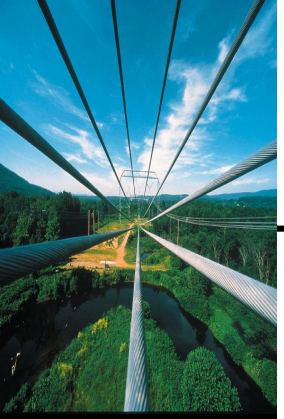
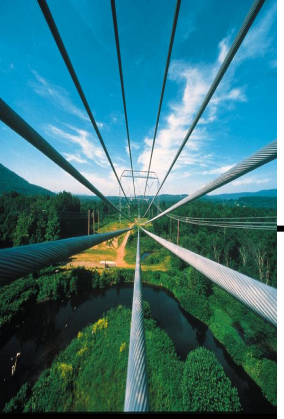


Performance Metric Implementation

- Test Performance Metrics
- Develop Performance Criteria
- Incorporate Performance into Regulation Certification Tests
- Evaluate and Rank the Performance of Regulating Units
- Share Performance Metrics with Regulation Providers
- May Eventually Penalize Poor Regulation Providers

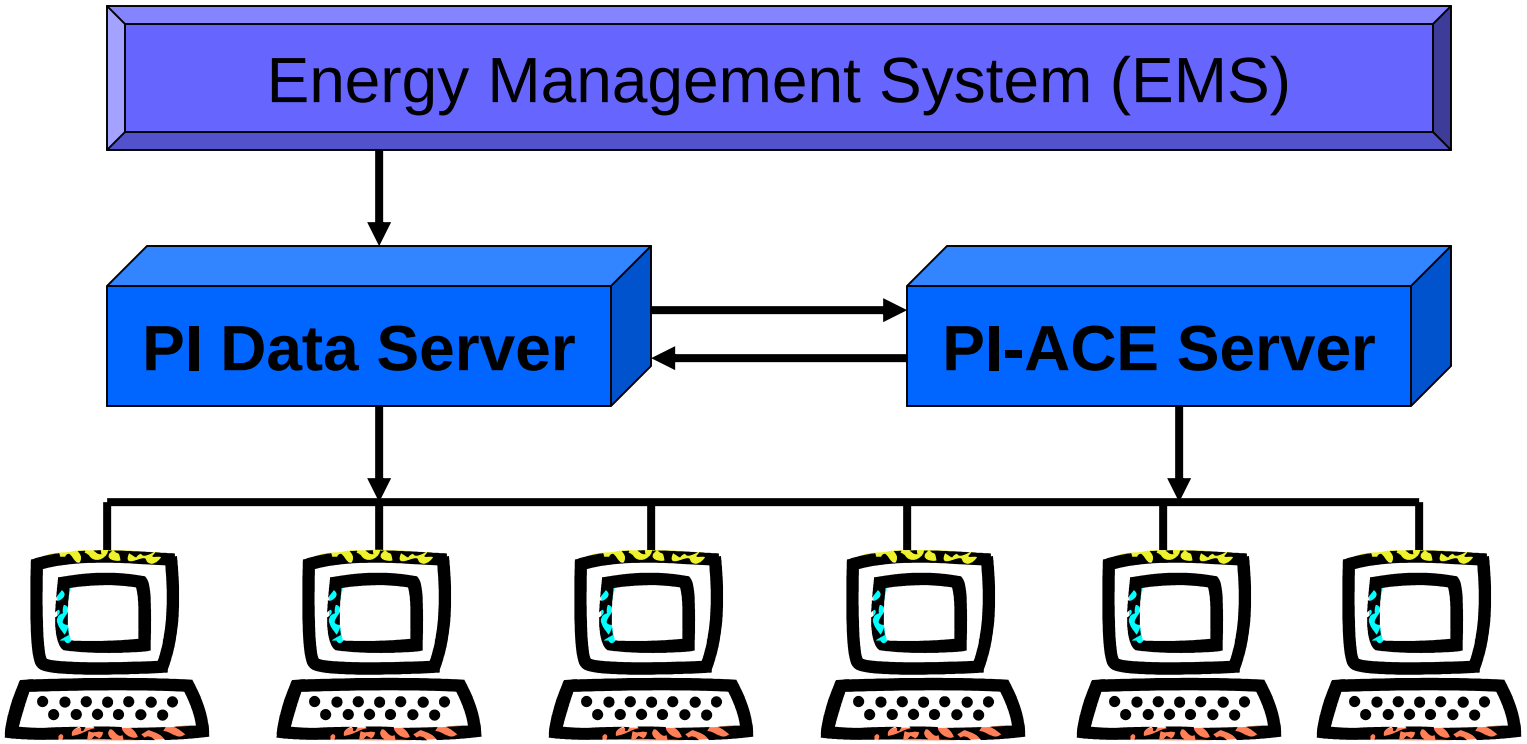


Craig Covering…

- California ISO Server Structure
  - (Data and Module Database)
- PI-ACE Tip: Adding Multiple Similar Contexts
- Our last year: Successes and Failures
- Future PI-ACE Plans

ISO PI Infrastructure

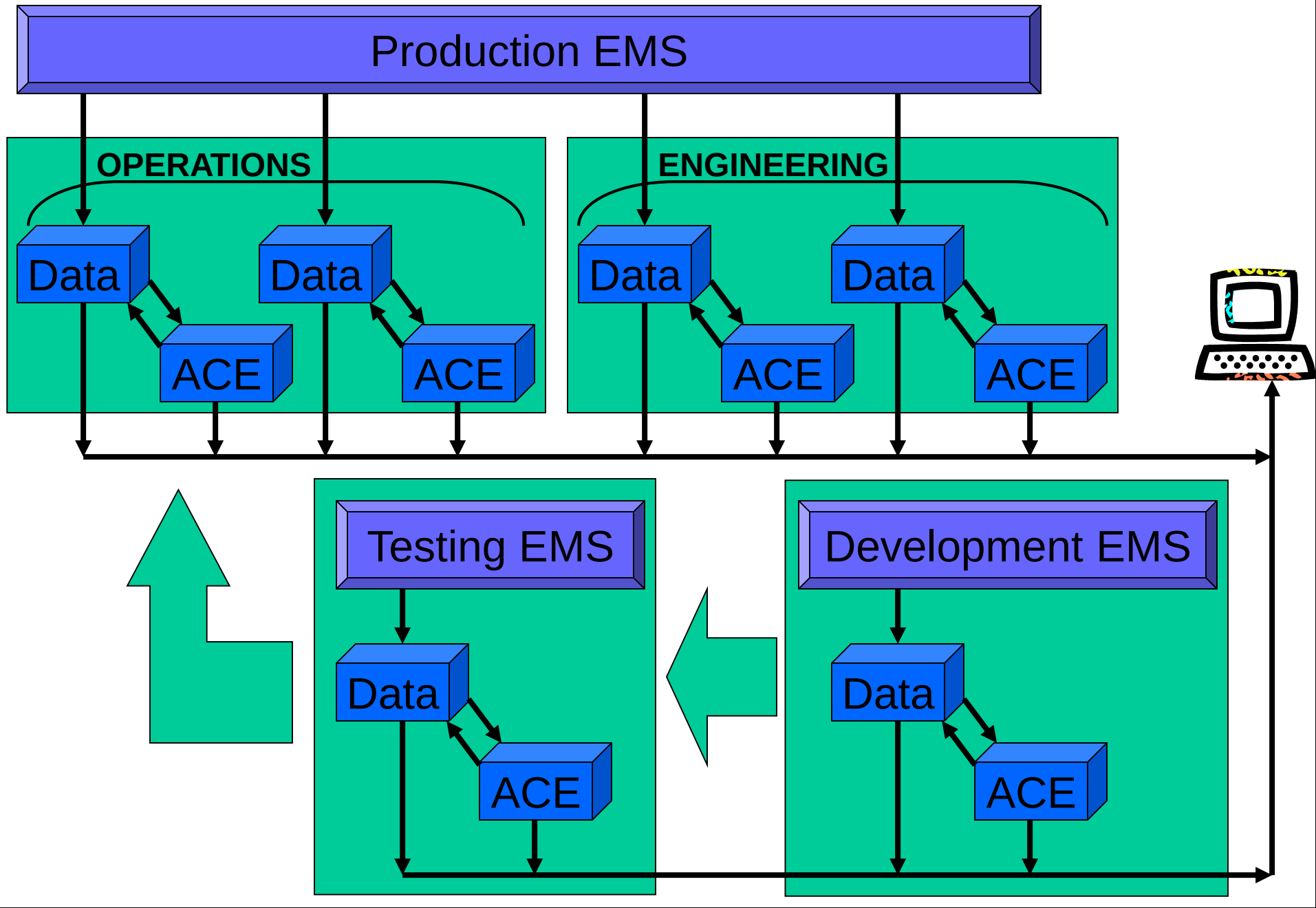
- Paired PI Data servers with PI ACE servers
- Majority of data provided via EMS
- PI-ACE Server also Provides Module Database



Server Specifications

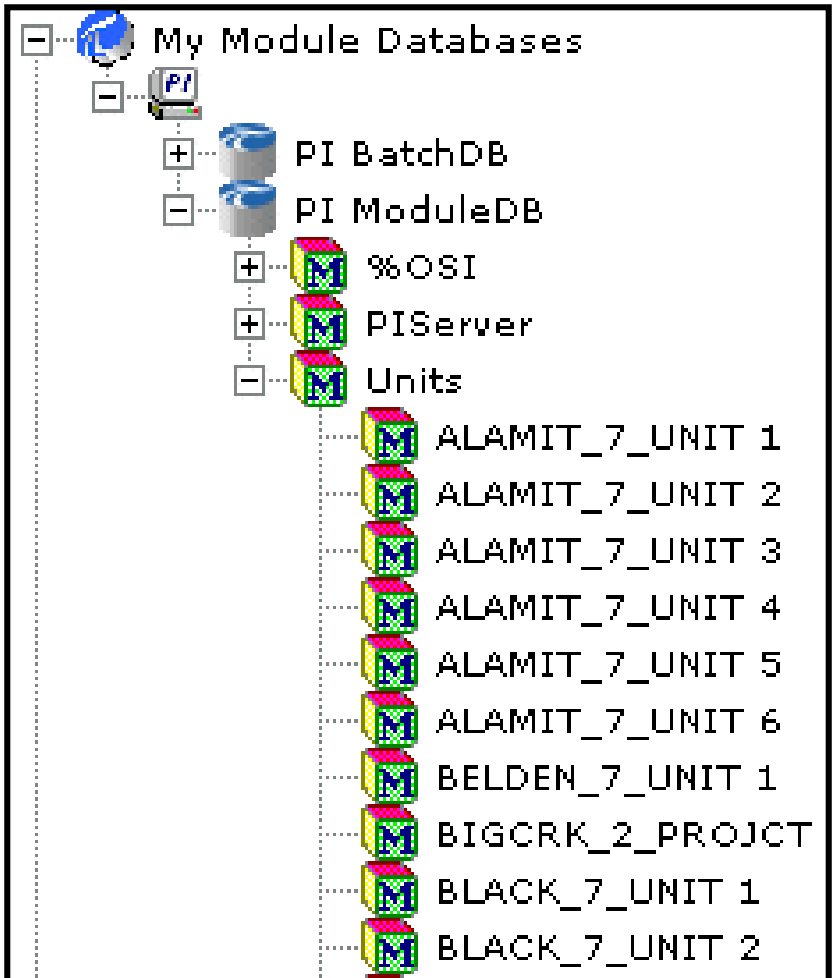
Component	PI Data Servers	PI-ACE Servers
System	HP DL 580	HP DL 380
CPU's	4 x 700Mhz	2 x 2.1 Ghz
Memory	1 Gigabytes	2 Gigabytes
Controller	Built into Mother Board	Built into Mother Board
Outside Network	100 Megabit Full Duplex	100 Megabit Full Duplex
Backup Network	FDDI	N/A
Disk Storage	HP HSG80 Controller Brocade Silkworm 2800 300 Gigabytes	2 x 18 GB Mirrored

ISO PI Infrastructure



PI-Module Database Structure

- 94 Units on Automatic Generation Control (AGC)
- Each unit modeled in PI-Module Database

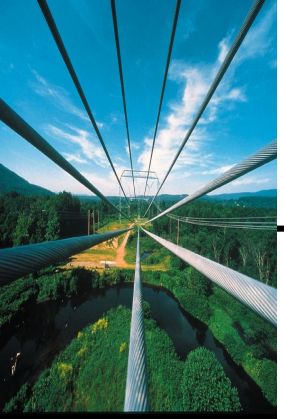


PI-Module Database Structure

- Aliases created for key Unit measurements:

Sub-Modules | PI Aliases | PI Properties

PIAlias Name	Tag Name
BSEPT_GEN_MW	Effective POP for BLACK_7_UNIT 2
Effective High Reg Limit	Effective High Reg Limit for BLACK_7_UNIT 2
Effective Low Reg Limit	Effective Low Reg Limit for BLACK_7_UNIT 2
EFFECTIVE_POP	Effective POP for BLACK_7_UNIT 2
EXPECTED_GENERATION	Expected Generation for BLACK_7_UNIT 2.CV
HGHRG_GEN_MW	Effective High Reg Limit for BLACK_7_UNIT 2
LOWRG_GEN_MW	Effective Low Reg Limit for BLACK_7_UNIT 2
PROVIDED_REGULATION_10MIN_AVG	Provided Regulation 10min Avg for BLACK_7_UNIT 2.CV
PROVIDED_REGULATION_1HR_AVG	Provided Regulation 1hr Avg for BLACK_7_UNIT 2.CV
SCE	Supplier Control Error for BLACK_7_UNIT 2.CV
SCE_10MIN_AVG	Supplier Control Error 10min Avg for BLACK_7_UNIT 2.CV
SCE_1HR_AVG	Supplier Control Error 1hr Avg for BLACK_7_UNIT 2.CV
SETPT_GEN_MW	BLACK .UNIT 2 SETPT_GEN_MW7 .AV
SETPT_GEN_MW_Q	BLACK .UNIT 2 SETPT_GEN_MW7 .AQ
SYSEMSDataUpToCurrentSecond	SYSEMSDataUpToCurrentSecond.CV
SYSPIDATAUPTODATE	SYSPIDataUpToCurrentSecond.CV



PI-Module Database Structure

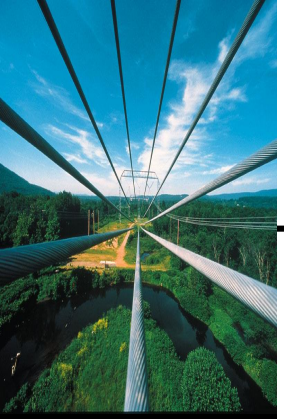
- Aliases needed for our calculation:

Measurement		Module DB Alias
Generation	-	UNMW_GEN_MW
Set Point	-	SETPT_GEN_MW
On/Off AGC Control	-	UAGC_GEN
Down Ramp Rate	-	Unit Reg Ramp Down Rate
Up Ramp Rate	-	Unit Reg Ramp Up Rate
Expected Generation	-	Expected Generation
Standard Control Error	-	SCE
Standard Deviation (10min)	-	SCE 10min StdDev
Data Status	-	SYSDataUpToCurrentSecond

PI-ACE Tip: Adding Multiple Similar Contexts

```
Dim piUnitMods As PISDK.PIModules
Dim piUnitMod As PISDK.PIModule
Dim piNamedValues As NamedValues
Dim bAddContextStatus As Boolean

For Each piUnitMod In piUnitMods
   'Set up NamedValues for context
   Set piNamedValues = New NamedValues
   piNamedValues.Add "Type", 0       'Schedule Type
   piNamedValues.Add "Offset", 0     'Offset
   piNamedValues.Add "Period", 60    'Period (seconds)
   piNamedValues.Add "Priority", 3   'Priority
   bAddContextStatus = CreatePIACEModule( _
      "\\server\ACECompliance\GenerationPerformance\" & _
      "\\localhost\Units\" & piUnitMod.Name)
   bAddContextStatus = AddPIACEContextSchedule( _
      "\\server\ACECompliance\GenerationPerformance\" & _
       "\\localhost\Units\" & piUnitMod.Name, piNamedValues)
Next
```



Last Year Successes

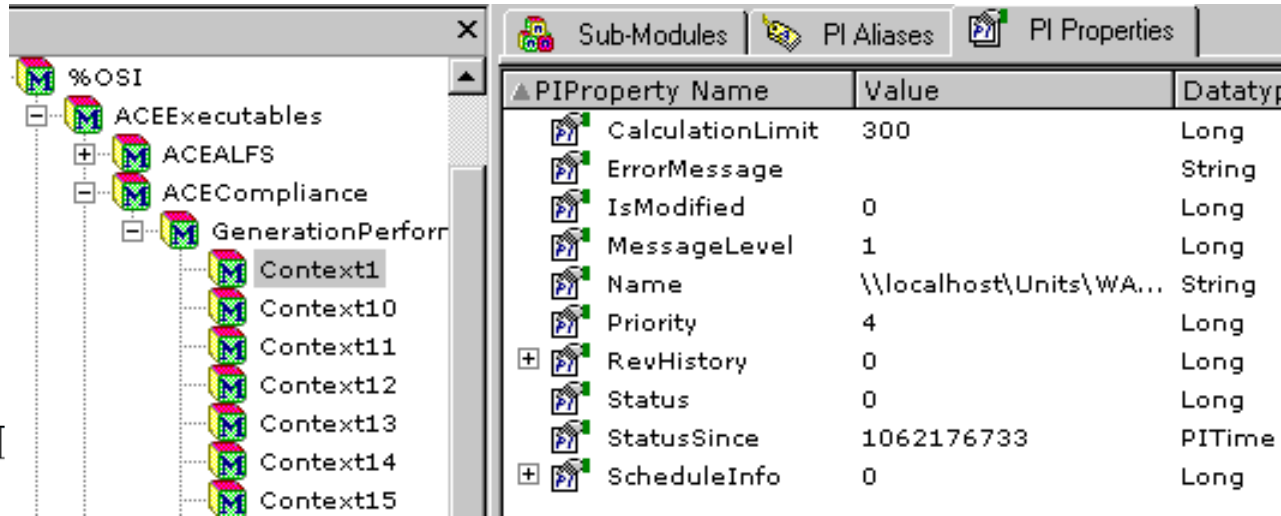
- Implemented PI-ACE server infrastructure
- Setup and started 94 calculation to monitor unit quality performance
- Monitored AGC unit performance

Last Years Failures and Solutions

- Calculation contexts failed and had to be re-started by hand
- Changed 2 configurations stop failures:

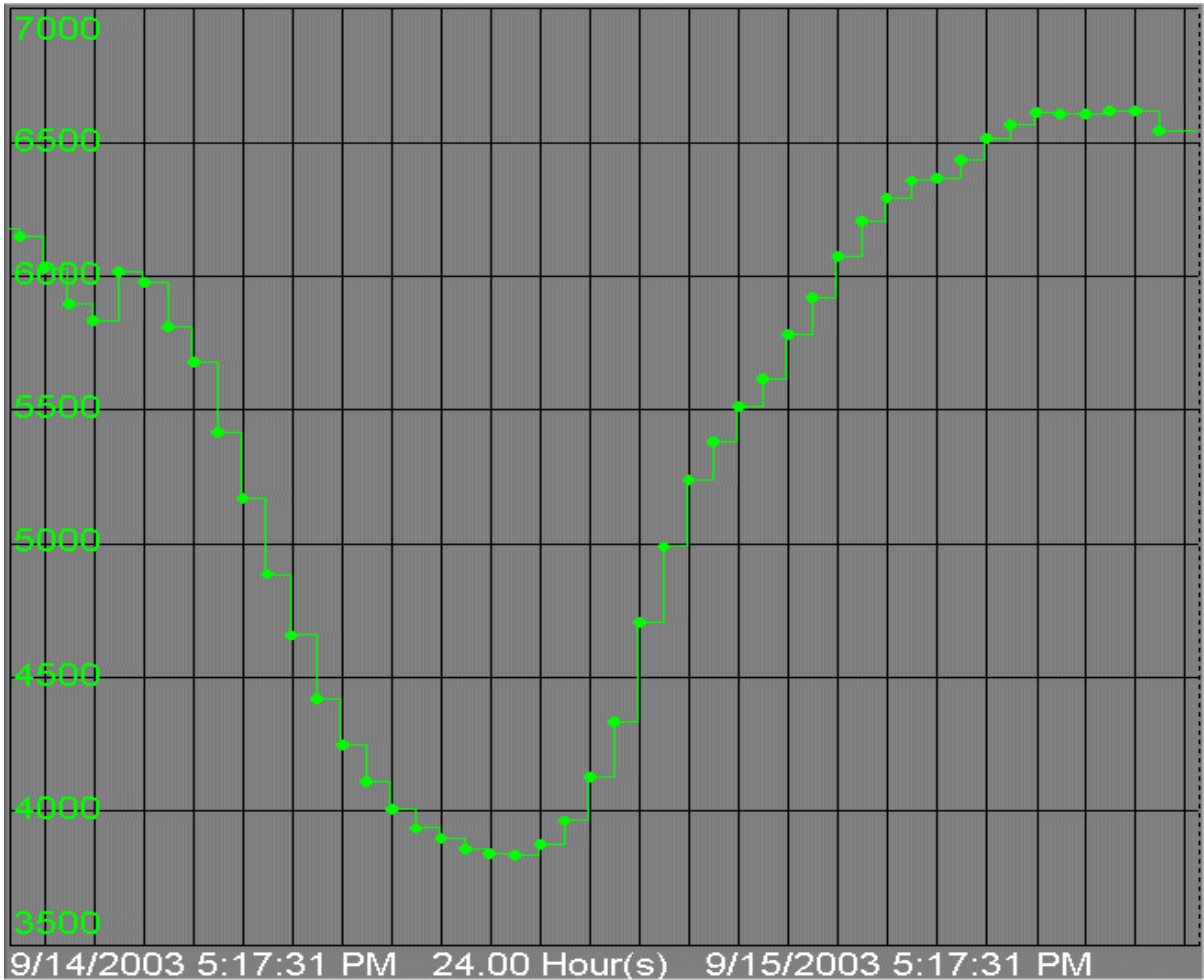
  - Modified and improved the ACE code

  - Increased the “CalculationLimit” ACE property from the default (5min) to 60min

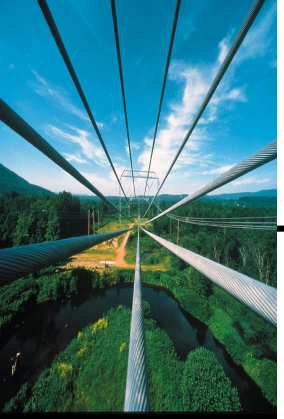


Future Plans for PI-ACE

- Calculate load curves for our load forecasting
- Post results to web…



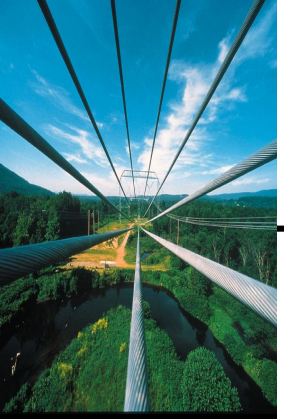
CALIFORNIA ISO
California Independent System Operator



Future Plans for PI-ACE

Regulation Performance Metric

- Improve PI-ACE calculation that produces the performance metric result
- Create standard daily/hourly reports detailing AGC unit performance
- Tie the metric results into our AGC market



Discussion