Regulation Market

Web-based Training

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SENIOR ENGINEER PERFORMANCE AND INTEGRATION

OPERATIONAL PERFORMANCE, TRAINING AND INTEGRATION

Disclaimer for Customer Training

ISO New England (ISO) provides training to enhance participant and stakeholder understanding.

Because not all issues and requirements are addressed by the training, participants and other stakeholders should not rely solely on this training for information but should consult the effective *Transmission, Markets and Services Tariff* ("Tariff") and the relevant *Market Manuals*, *Operating Procedures* and *Planning Procedures* ("Procedures").

In case of a discrepancy between training provided by ISO and the Tariff or Procedures, the meaning of the Tariff and Procedures shall govern.

Course Objectives

- Provide an overview of the key concepts and the basic features of the Regulation Market

- Explain the basics of Regulation

- Explain recent changes to the Regulation Market with specific emphasis on:
  - The new Energy Neutral Regulation Signal
  - The selection process of Regulating Resources
  - Monitoring of the performance of Regulating Resources

Intended audience: Regulation Market participants and those considering participation in the Regulation Market

Acronyms

ACE - Area Control Error (units in: MW)

AGC - Automatic Generation Control

ARR - Automatic Response Rate (units in: MW/minute)

ATRM - Alternative Technology & Regulation Market

ATRR - Alternative Technology Regulating Resources

CON – Conventional (AGC setpoint)

CPS - Control Performance Standard

ENC – Energy Neutral Continuous (AGC setpoint)

ENT – Energy Neutral Trinary (AGC setpoint)

FERC - Federal Energy Regulatory Commission

IPO - Instantaneous Perfect Output (units in: MW)

NERC - North American Electric Reliability Corporation

NFE - Narrow Failure Envelope

Acronyms

NSE - Narrow Scoring Envelope

ONFGP – Outside Narrow Failure Grace Period

OWFGI– Outside Wide Failure Grace Intervals

RHL - Regulation High Limit (units in: MW)

RIPS - Regulation Interval Performance Score

RLL - Regulation Low Limit (units in: MW)

RSI - Regulation Settlement Interval (one hour)

WBS - Wide Band Score

WFE - Wide Failure Envelope

WSE - Wide Scoring Envelope

Changes to ISO-NE Documents

- Market Rule 1
  - Section I.2.2 Definitions
  - Section III.14 Regulation Market

- Manuals
  - Manual 11, Sections 1.2, 2.5, 5.1, 5.2 have general info
  - M-REG

What is Regulation?

Resources under automatic control

Receive signals approximately every 4 seconds
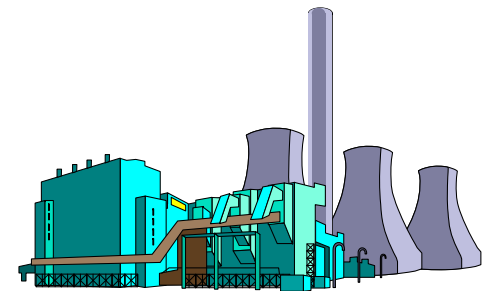
Independent of economic cost signal

Provide fine tuning that is necessary for

- system-frequency control
- maintenance of scheduled interchange.
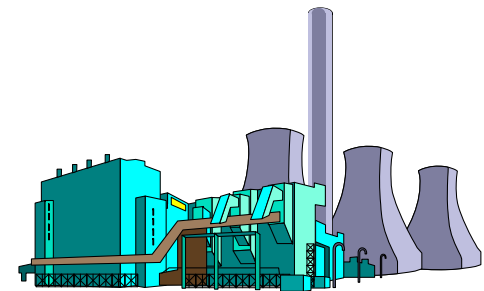
What is Regulation?

- Resources under Regulation Control respond to minute-to-minute changes in load.

- ISO's Success determined by compliance
  with NERC Control Performance Standards
  - CPS1, CPS2 Criteria
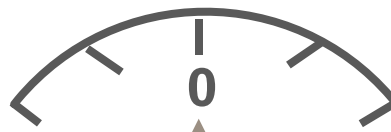
The Energy Balance

Frequency Bias
Obligation

Losses

Load

Exports

Imports

Power
Generated

DEMAND

Area Control Error
MW

0

SUPPLY
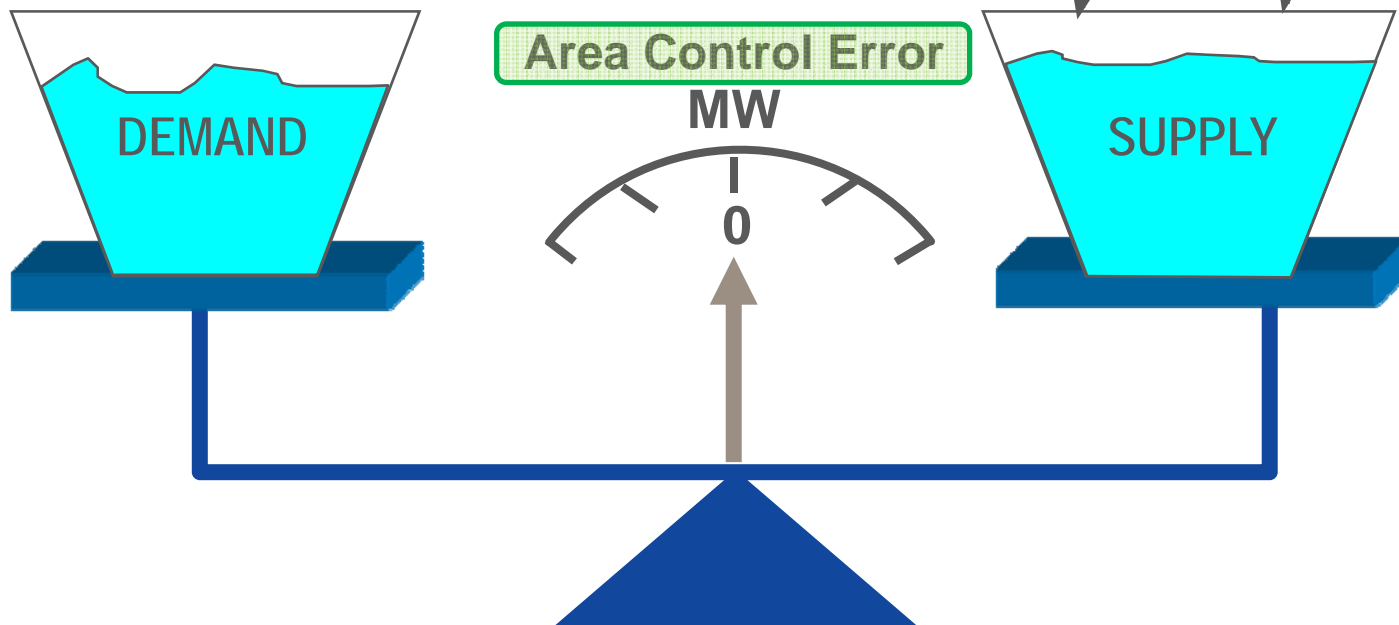
The Energy Balance

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Imports

Power Generated

DEMAND

Area Control Error

MW

0

SUPPLY

The Energy Balance

Frequency Bias
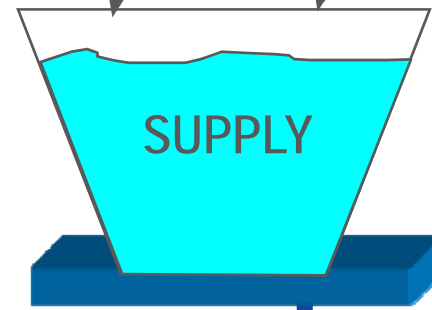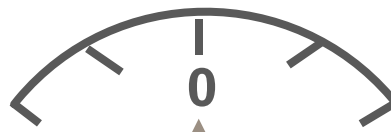Obligation

Losses

Exports

Load

Imports

Power
Generated

DEMAND

Area Control Error
MW

0

SUPPLY
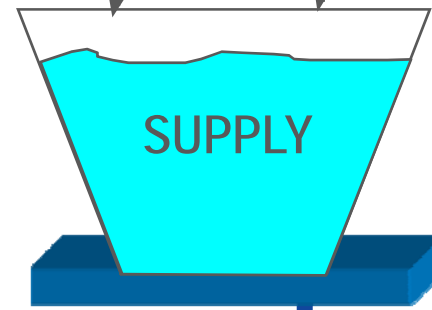
Basic Features

ISO Regulation requirements defined (month, day type, hour)

- Capacity

- Service

Posted to ISO website
(http://www.iso-ne.com/isoexpress/web/reports/operations/-
/tree/daily-regulation-requirement)

During abnormal conditions, the ISO may deviate from these
requirements for reliability

Regulation Market Resource Selection

Resources are selected based on a least-cost algorithm based on:

- Regulation Offer
    - Regulation Capacity Offer
    - Regulation Service Offer

- Estimated Energy Opportunity Cost

- Opportunity Cost Sensitivities due to the shape of the Resource's Supply Offer price curve

- Operational requirements related to reliability

Input: Regulation Offer

- Entered into eMarket

- Daily offers provide default values that carry over

- Hourly offers supplant the daily offer, but do not carry over

- Unit regulating status
  - Available
  - Unavailable

- Physical offer data
  - Automatic Response Rate (ARR) in MW/minute to nearest tenth (e.g., 3.9 MW/minute)
  - Regulation High Limit (MW)
  - Regulation Low Limit (MW)

- Economic offer data
  - Regulation Capacity offer price
    - Floor at $0/MW and Cap at $100/MW
  - Regulation Service offer Price
    - Floor at $0/MW-mile and Cap at $10/MW-mile

- Dispatch Methodology (ATRRs only – must choose 1 of 3 possibilities)
  - CON
    - Conventional AGC Setpoint – default
  - Energy Neutral
    - Energy Neutral Continuous AGC Setpoint
   - Energy Neutral Trinary AGC Setpoint

Two Regulation Signals

- Two Regulation dispatch signals are available for ATRRs
  - Conventional signal as has previously existed
  - New statistically Energy Neutral signal created by high-pass filtering

- The sum of the AGC setpoints of the Energy Neutral regulation resources modifies the AGC setpoints for conventionally dispatched resources.

- Two sub-groups within the Energy Neutral Dispatch category
  - Energy Neutral Trinary
    - Trinary means that the dispatch and expected response is either full power charge, full power discharge, or midpoint.
    - All ENT dispatched resources will simultaneously be sent to their Regulation High Limits, Regulation Low Limits, or Regulation midpoints
  - Energy Neutral Continuous
    - The Energy Neutral fleet AGC target is distributed by participation factors (which includes offered Automatic Ramp Rate (ARR) in MW/minute).
    - Dispatch is then apportioned across ENC dispatched resources.
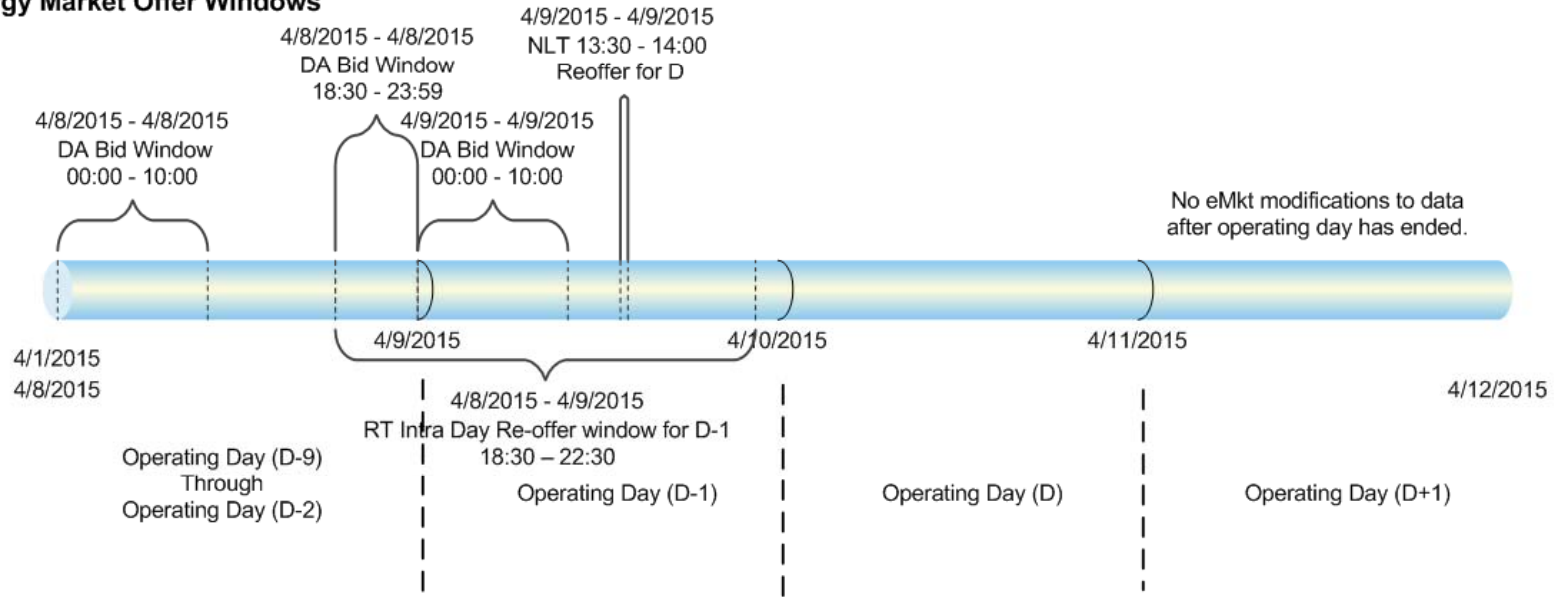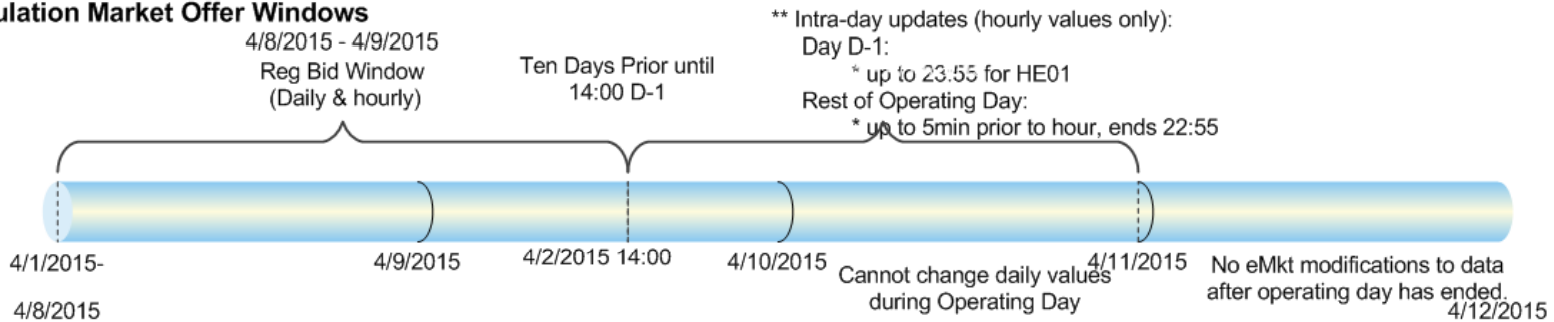
ACE
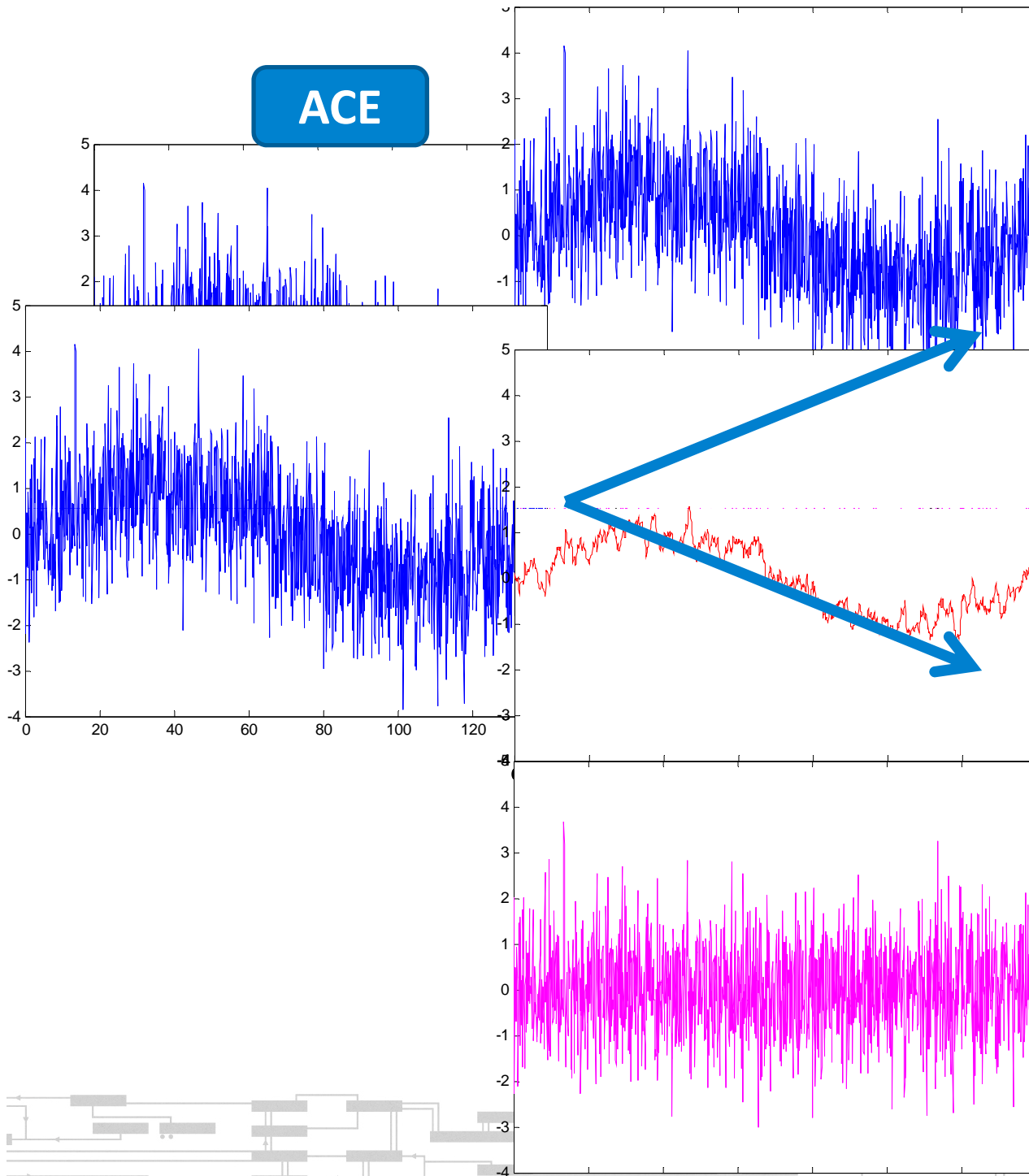
-Pass filter results

High-pass filter results

Summary of eMkt Submission Windows
taking effect 3/31/2015
(from the perspective of a single operating day)

Energy Market Offer Windows

4/9/2015 - 4/9/2015
NLT 13:30 - 14:00
Reoffer for D

4/8/2015 - 4/8/2015
DA Bid Window
18:30 - 23:59

4/8/2015 - 4/8/2015
DA Bid Window
00:00 - 10:00

4/9/2015 - 4/9/2015
DA Bid Window
00:00 - 10:00

No eMkt modifications to data
after operating day has ended.

4/1/2015
4/8/2015

4/9/2015

4/10/2015

4/11/2015

4/12/2015

Operating Day (D-9)
Through
Operating Day (D-2)

4/8/2015 - 4/9/2015
RT Intra Day Re-offer window for D-1
18:30 – 22:30

Operating Day (D-1)

Operating Day (D)

Operating Day (D+1)

Regulation Market Offer Windows

4/8/2015 - 4/9/2015
Reg Bid Window
(Daily & hourly)

Ten Days Prior until
14:00 D-1

** Intra-day updates (hourly values only):
Day D-1:
* up to 23.55 for HE01
Rest of Operating Day:
* up to 5min prior to hour, ends 22:55

4/1/2015-

4/9/2015

4/2/2015 14:00

4/10/2015   Cannot change daily values
during Operating Day

4/11/2015

No eMkt modifications to data
after operating day has ended.

4/8/2015

4/12/2015

** Intra-Day Updates (hourly values only):
Gen: financial parameters only
ATRR (non-gen): financial and physical parameters

December 15, 2014
eMarket Data Exchange Specification Ver 10 dtd Dec. 2014

http://www.iso-ne.com/support/user_guides/index.html

Ramp Constrained
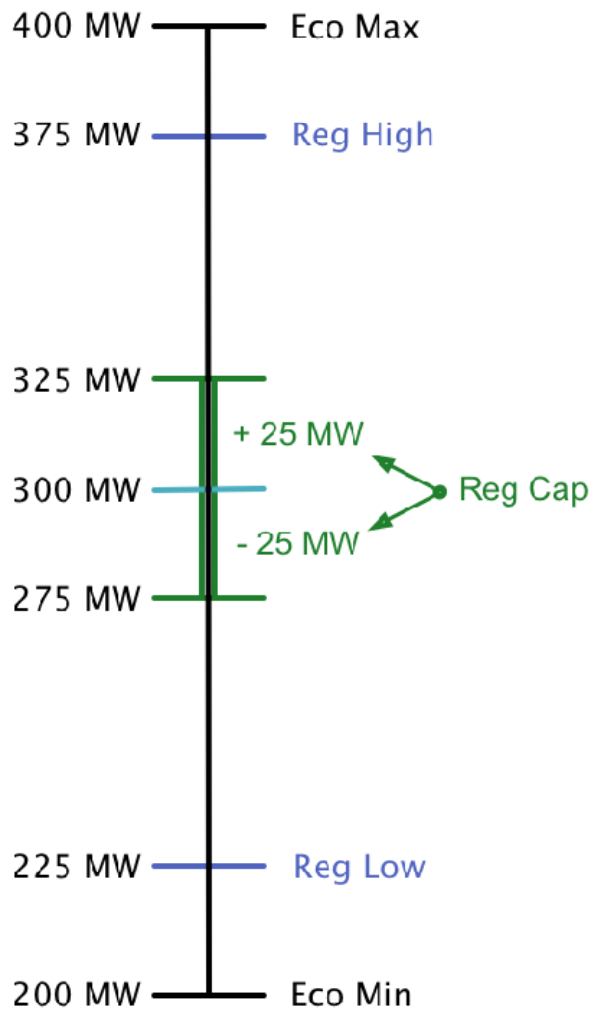
Regulation Capacity

Lesser of

- 5 x ARR
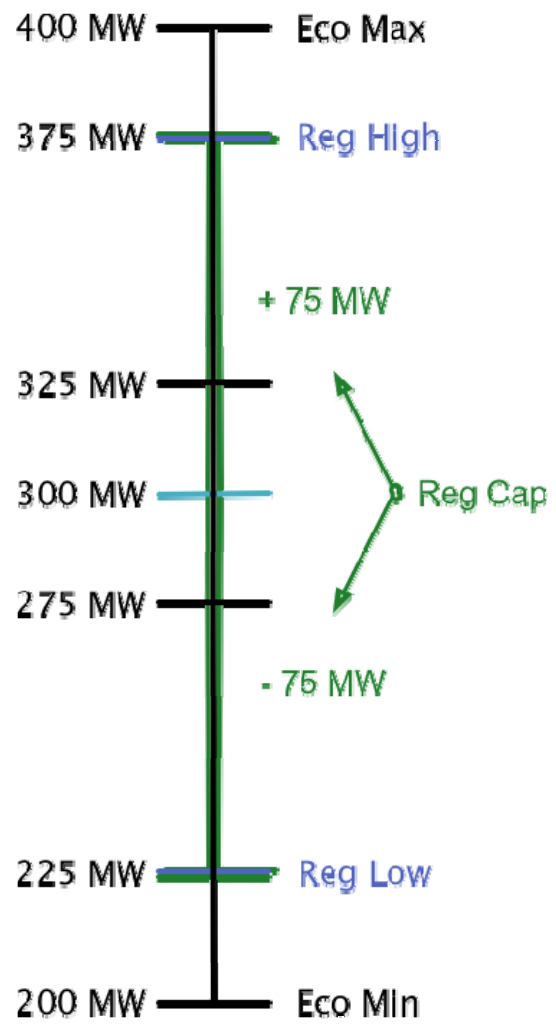
- $\dfrac{(Reg\ High - Reg\ Low)}{2}$

Generator "A"

$$ARR = 5\ \dfrac{MW}{minute}$$

$$5\,x\,ARR = 5\,x\,5 = \pm 25\ MW$$

$$\dfrac{(Reg\ High - Reg\ Low)}{2} = \dfrac{(375 - 225)}{2} = \pm 75\ MW$$
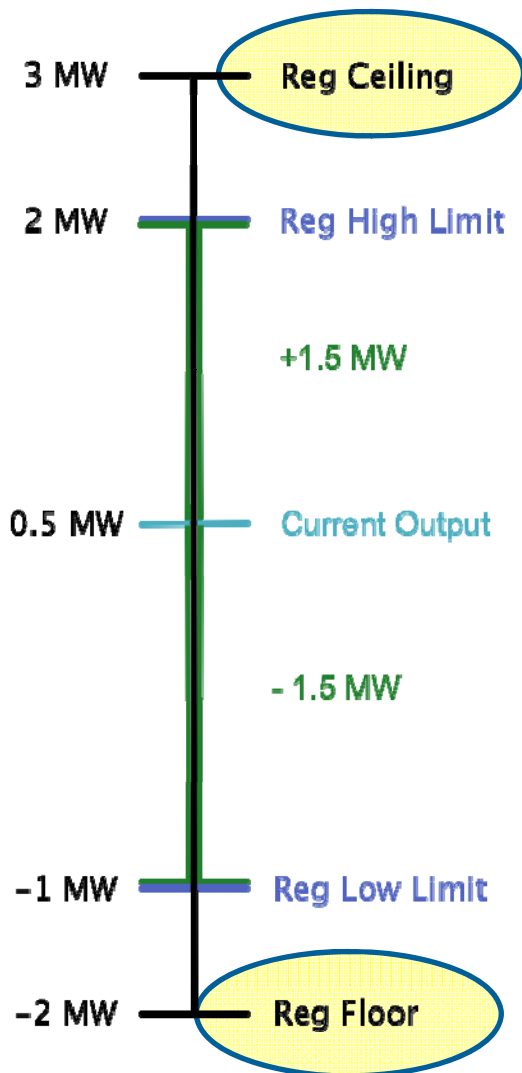
Range Constrained

400 MW ———— Eco Max	
375 MW ———— Reg High	
	+ 75 MW
325 MW ————	
300 MW ————	Reg Cap
275 MW ————	
	- 75 MW
225 MW ———— Reg Low	
200 MW ———— Eco Min	

Regulation Capacity

Lesser of

- 5 x ARR

- $\dfrac{(Reg\ High - Reg\ Low)}{2}$

Generator "B"

$$ARR = 20\ \dfrac{MW}{minute}$$

$$5\ x\ ARR = 5\ x\ 20 = \pm\,100\ MW$$

$$\dfrac{(Reg\ High - Reg\ Low)}{2} = \dfrac{(375 - 225)}{2} = \pm\,75\ MW$$

Range Constrained - ATRR

3 MW — **Reg Ceiling**

2 MW — Reg High Limit

+1.5 MW

0.5 MW — Current Output

- 1.5 MW

-1 MW — Reg Low Limit

-2 MW — **Reg Floor**
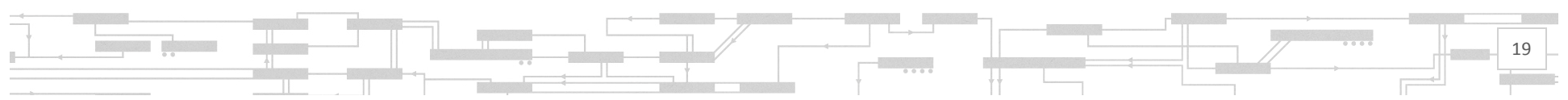
Regulation Capacity

Lesser of

- 5 x ARR

- $\dfrac{(Reg\ High - Reg\ Low)}{2}$

ATRR "A"

$$ARR = 10\ \frac{MW}{minute}$$

$$5\ x\ ARR = 5\ x\ 10 = \pm\,50\ MW$$

$$\frac{(Reg\ High - Reg\ Low)}{2} = \frac{[2 - (-1)]}{2} = \pm\,1.5\ MW$$

Basic Features

- All resources must offer economically

  - i.e. self-scheduling for regulation is no longer allowed*

  - * except for the new Regulation test environment where resources will always be selected (if Participant declares available)
  - Resources in the regulation test environment must still submit availability information via eMarket

- Regulation test environment is

  - Short-term (i.e. weeks)
  - Until sufficient operational information has been collected to
    - Verify reasonable operating parameters
    - Or determine that resource does not meet eligibility for Regulation Market

Estimated Regulation Opportunity Cost Calculation

- Economic Level represents where a resource would have been generating if not providing Regulation Service
  - based on energy offer curve & forecast LMP; between EcoMin & EcoMax

- Estimated Actual Generation is an estimation of the actual generation while successfully providing Regulation Service.

  - based on energy offer curve & forecast LMP; between (RHL-Reg Cap), (RLL + Reg Cap)

- Estimated Opportunity Cost is the MW weighted average offer (minus forecasted LMP) associated with the MW between the economic level and Estimated Actual Generation.

Regulation Market Resource Selection

For the purposes of least-cost Resource selection, the following penalty factors are used for any violation of the Regulation requirements constraint:

- $100/MW plus the Energy Component of the Real-Time Locational Marginal Price at the reference point for each megawatt of Regulation Capacity shortfall

- $10/MW for each megawatt of Regulation Service shortfall

These penalty factors are used to allow the selection process to undershoot the requirements by a small amount, if meeting the requirements would be excessively costly.

Regulation Market Eligibility

Each Resource must…

- be completely electrically located within ISO-NE Control Area

- have a Control System capable of Regulation

- be able to receive AGC set point

- demonstrate minimum performance standards & exhibit satisfactory performance on dynamic evaluations

- adequately telemeter MW output to ISO-NE Control Center

- have a minimum ARR of 1MW/minute

- meet ISO-NE OP-14 and OP-18 standards

Regulation Market Eligibility (cont.)

Generating Resource must…

- Have a 10 MW minimum regulation capacity

- Utilize Unit-specific minimum range sized to assure feasible Regulation range

ATRR must…

- Have a 1MW minimum regulation capacity*
  *Aggregation of sub-resources is allowed
  – Select a dispatch methodology (CON, ENC, or ENT)

Regulation Market Resource Selection

A Resource may be omitted from providing Regulation due to operational restrictions, including, but not limited to:

- Binding transmission constraints

- Planned shutdown prior to the end of the settlement interval

- Known or anticipated system operating conditions

- Not dispatchable

Basic Features

- Regulation Clearing Price for Capacity (RCPc) is Real-Time, hourly values are computed from the average 5 minute samples

- Regulation Clearing Price for Service (RCPs) is Real-Time, hourly values are computed from the average of 5 minute samples

- No self-scheduled regulation

Basic Features

- Three Payments

  - Regulation Capacity Payment

  - Regulation Service Payment

  - Regulation Make Whole Payment

- Alternative Technology Regulation Pilot Program (a.k.a. the Pilot Program) is retired

http://www.iso-ne.com/static-assets/documents/2014/11/regulation_market_settlements_04_15_2014.pdf

Regulation Monitoring - Goals

Goals of the Regulation Performance Monitoring System (RegMon):

- Encourage offers with performance parameters that (over time) match observed performance characteristics

- Encourage offers with performance parameters that provide sufficient sustainability to achieve consistently high performance scores

- Avoid penalizing apparent performance deviations that result from normal resource characteristics that are understood, but not modeled in the Regulation (AGC) dispatch, such as:
  – Response delay time
  – Ramp rates that vary over the resource's regulating range.

Regulation Monitoring - Goals

If observed performance closely matches AGC Setpoints (which are derived from offer parameters), Regulation Interval Performance Score will be 100%

Regulation Monitoring – Market Rule Guidance

- "The performance of a Resource providing Regulation will be monitored in Real-Time. " (Section III.14.7)

- Achieved by comparing actual Regulation MW to the AGC signal in a systematic manner

- If a resource movement is inconsistent with the AGC Setpoint, it will not get credit for the rest of the hour (Section III.14.7)

- Specific guidance on measurement process includes:

  – Tolerance band(s) based on offered Automatic Response Rate and Regulation Capacity

  – Grace periods to allow reasonable time lags

  – ARR : allow uncertainty up to +/- 20% of offered ARR

  – Regulation Capacity: allow uncertainty up to +/- 15% of the calculated Regulation Capacity.

- Two different Parameter sets are used in order to more accurately track the performance of resources following the two types of dispatch methodologies
  - One for Conventionally dispatched resources
  - One for Energy Neutral Dispatched resources

- Two parameter sets are required due to fundamental differences in the nature of the Conventional and Energy Neutral AGC setpoints

- Otherwise the performance monitoring of the resources following these two different dispatch methodologies is exactly the same.
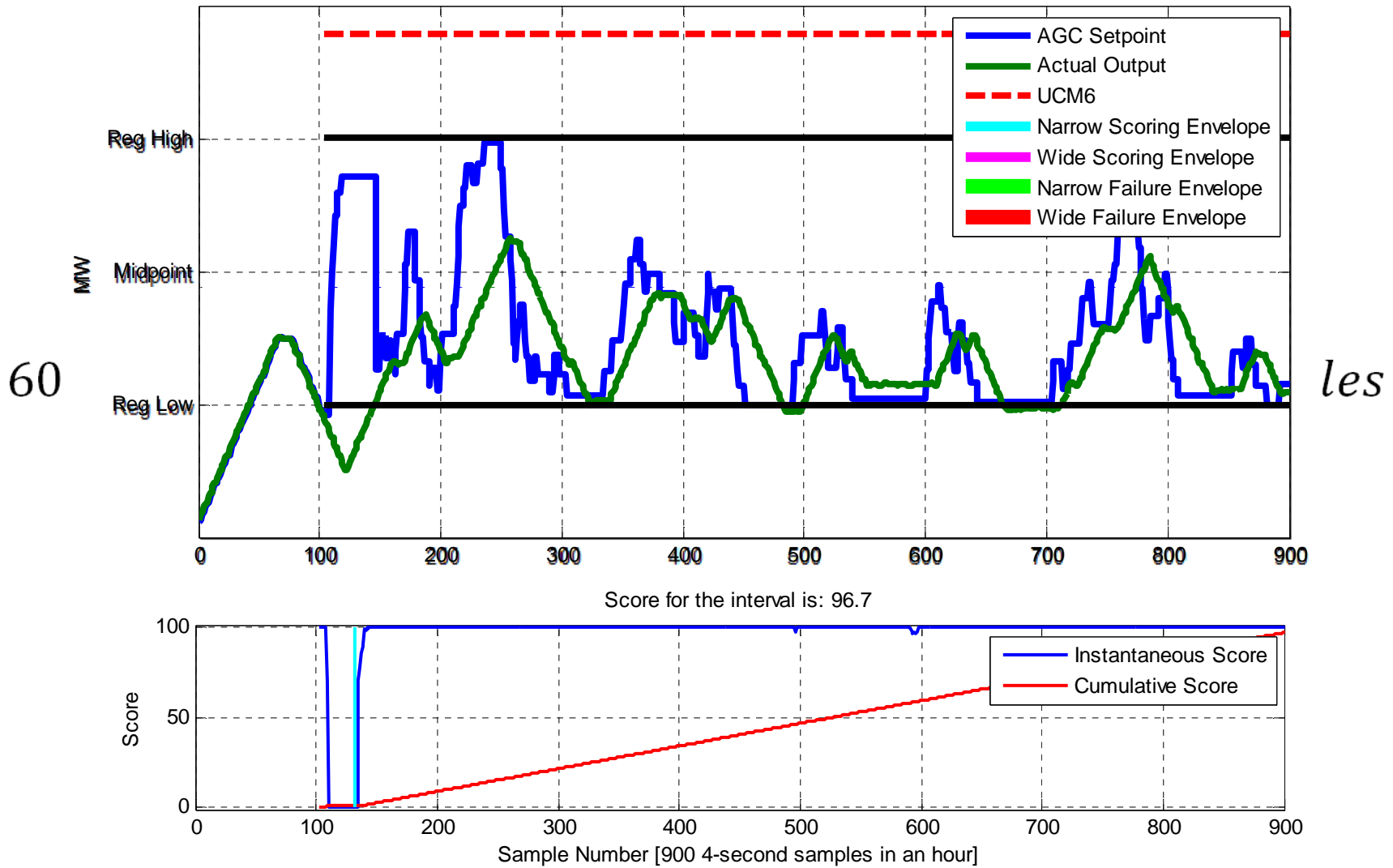
Regulation Monitoring – Implementation

- RegMon conducts on-line performance monitoring of regulating resources

  - It runs continuously and calculates scores every hour using that hour's measurements plus a few minutes of measurements before (for initialization)

  - It scores the performance of each resource's actual tracking of the AGC setpoint for every instant that the resource was assigned to perform regulation (i.e. Unit Control Mode 6)

  - It scores all resources providing regulation during the hour

- Using a single algorithm/software solution that implements the Market Rule requirements, the ISO can support an accurate, transparent RIPS

- The RIPS adjusts compensation for the regulation settlement period (an hour) in proportion to the score

Performance Envelopes

WSE —

NSE —

NSE —
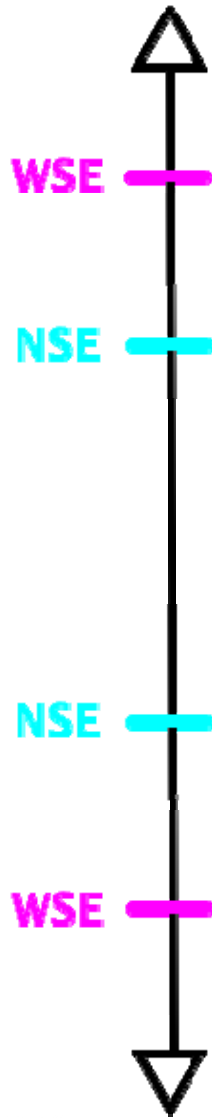
Four continuously-updated
performance envelopes for
each regulating resource
- NSE (shown here)
- WSE (shown here)
- NFE
- WFE

WSE —

Performance Envelopes
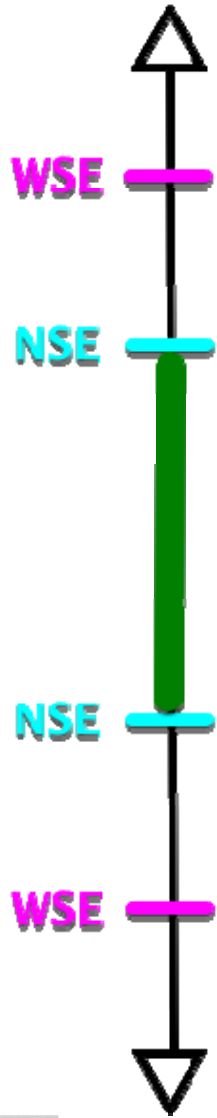
Actual output inside the NSE receives an instantaneous score of 100%

Performance Envelopes

WSE

NSE

NSE

WSE
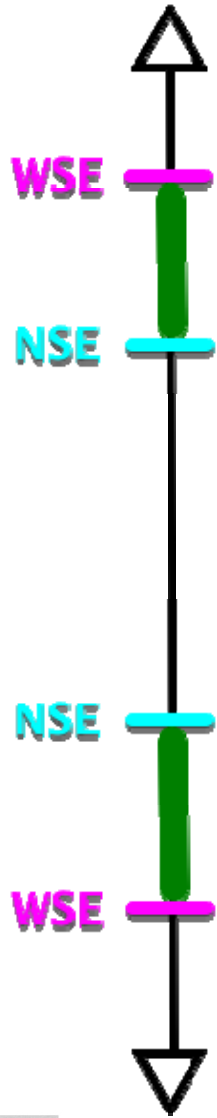
Actual output outside the NSE
but within the WSE receives a
pro-rated score between WBS
and 100%

Performance Envelopes

WSE

NSE

Actual output that touches the edge of the WSE will receive an instantaneous score equal to the WBS

NSE

WSE

Performance Envelopes

WSE

NSE

NSE

WSE
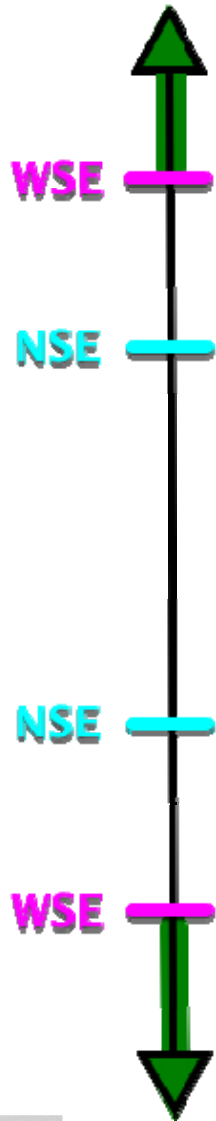
Actual output outside the WSE will receive an instantaneous score of 0%

Regulation Monitoring – method overview

Sample of AGC Performance Monitoring

For example:

2 minutes
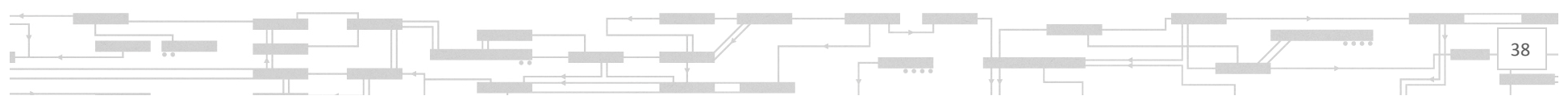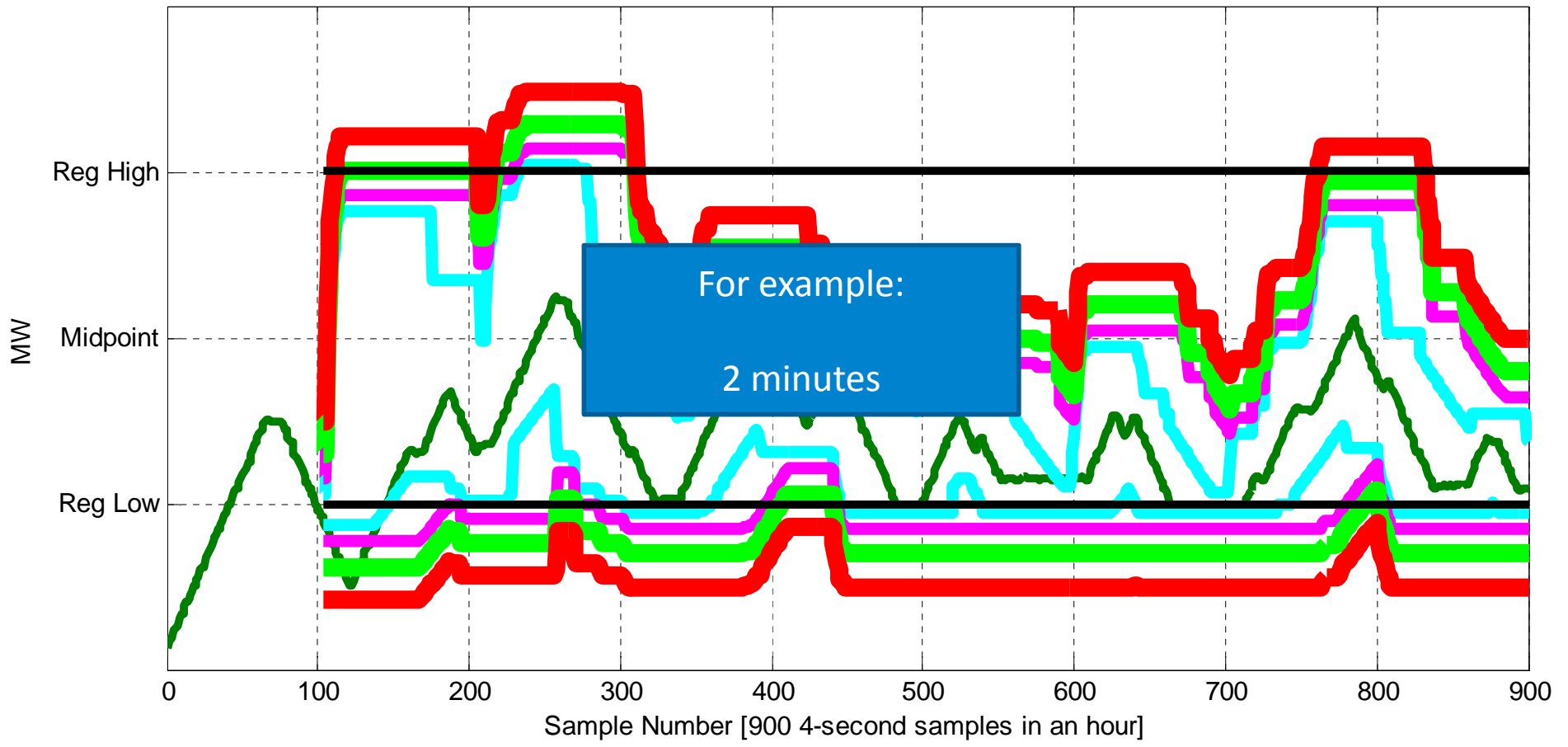
Regulation Monitoring – Two exceptions

- Acceptable Overshoot
  - AGC Setpoint is at or above (less than) the high regulating limit (low regulating limit) and the resource's output is at or above (less than) high regulating limit (low regulating limit)
  - Acceptable Overshoot gets a 100%
  - Acceptable Overshoot will not override failure

- UCM6 grace period
  - First few minutes a resource is in UCM6 will not count towards failure, provided that it has been _OFF_ UCM6 for extended duration e.g. at least an hour.

Regulation Monitoring – Finalizing Scores

- Except during acceptable overshoot, output outside the wide scoring envelope will get a 0 score for that AGC cycle.

- Regulation Interval Performance Score (RIPS) = arithmetic average of the instantaneous scores of all time intervals on UCM 6 within the regulation settlement interval

- RIPS will linearly scale both:
  - total requested movement (mileage): service payment calculated in Settlements
  - also the integrated regulation capacity: capacity payment calculated in Settlements

Regulation Monitoring – developing parameters

- ISO is finalizing the parameters that control the performance and failure envelopes and times

- Appropriate parameters for the Regulation Performance Monitor will be
  - Developed using historical data
  - Guided by the overarching goal of
    - creating a performance monitoring system that reflects real world resource response
    - while still having the kind of regulation performance that we need for system reliability.

- The parameters will not be resource specific – they will apply to the entire fleet of regulation resources that choose to participate in the regulation market.

- Two different Parameter sets are used in order to more accurately track the performance of resources following the two types of dispatch methodologies
  - One for Conventionally dispatched resources
  - One for Energy Neutral Dispatched resources

- Two parameter sets are required due to fundamental differences in the nature of the Conventional and Energy Neutral AGC setpoints

- Otherwise the performance monitoring of the resources following these two different dispatch methodologies are exactly the same.

Regulation Monitoring – developing parameters

- These parameters may change over time as the needs and characteristics of the system evolve – advance notice will be provided

- The parameters used in the illustrative examples to follow are initial estimates

- The parameters will be announced before the 755 Regulation Market upgrade is implemented.

- Will be posted at: http://www.iso-ne.com/isoexpress/web/reports/operations/-/tree/daily-regulation-requirement

Regulation Monitoring – Figure 1

Sample of AGC Performance Monitoring

Regulation Monitoring – Figure 2

Sample of AGC Performance Monitoring
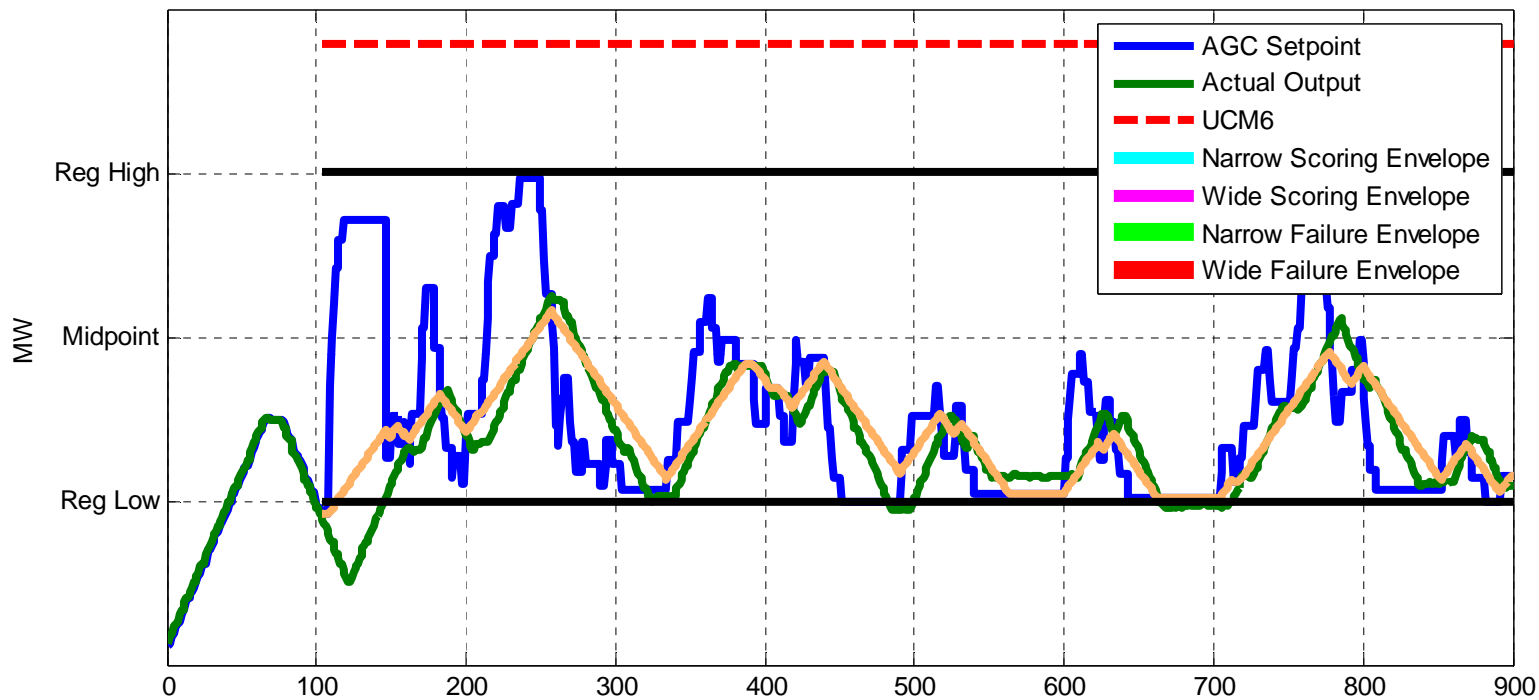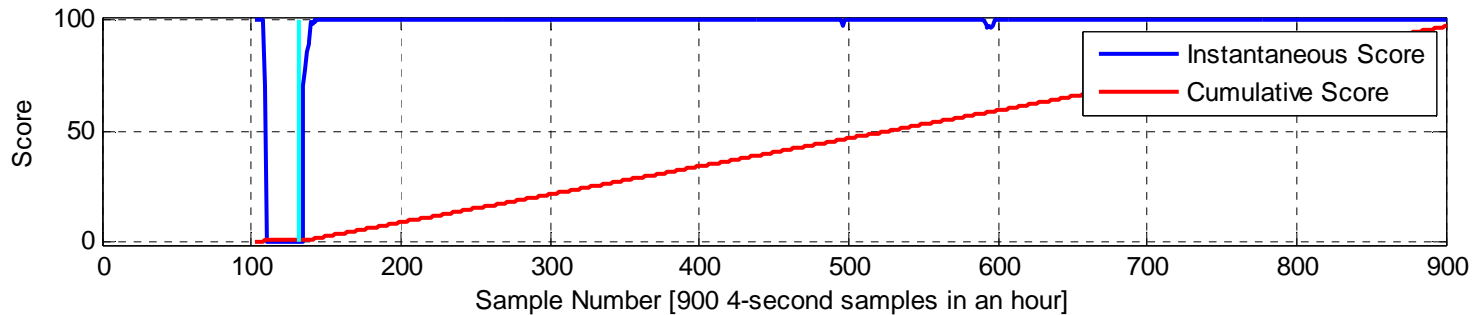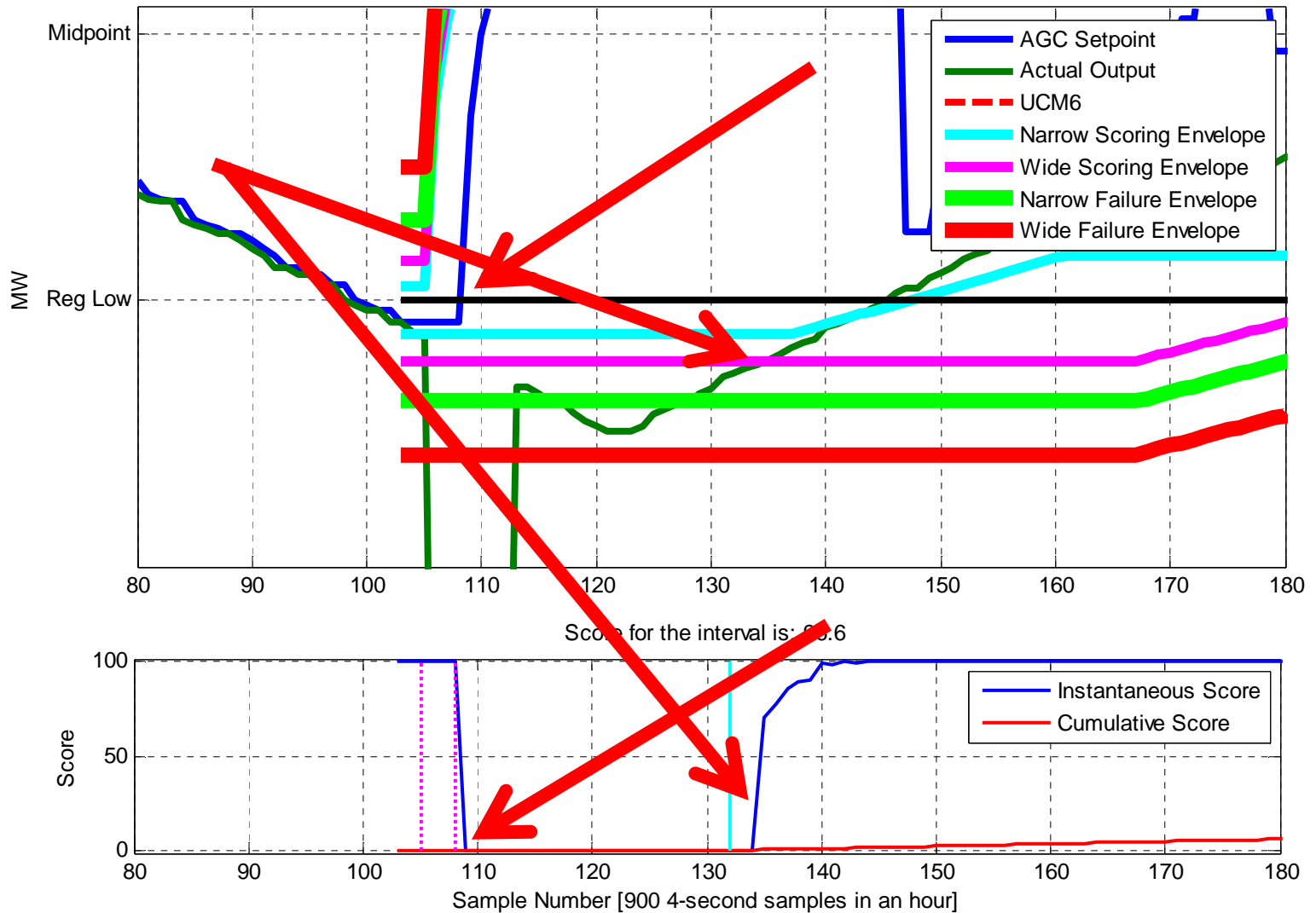
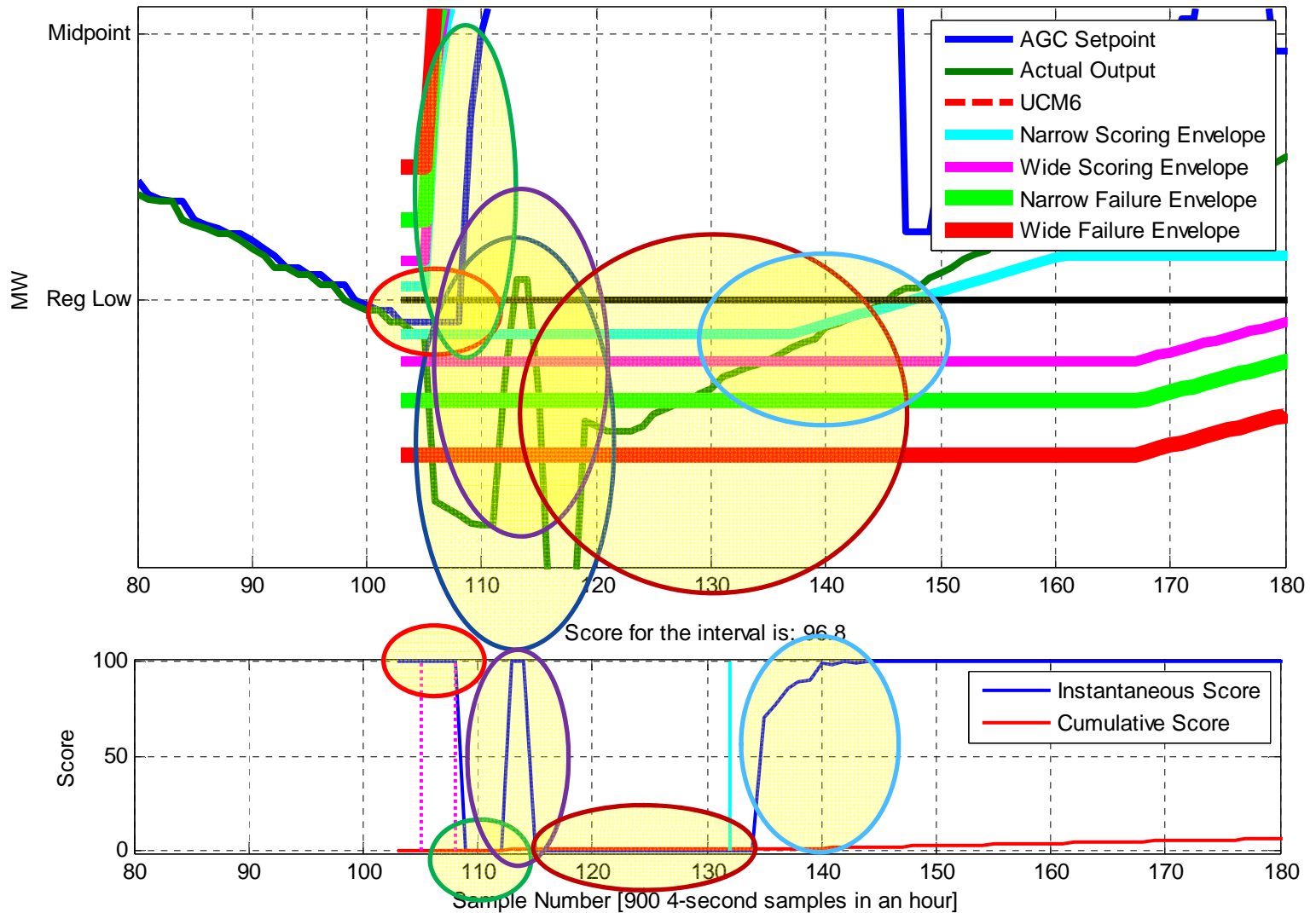# Regulation Monitoring – Figure 3

Sample of AGC Performance Monitoring
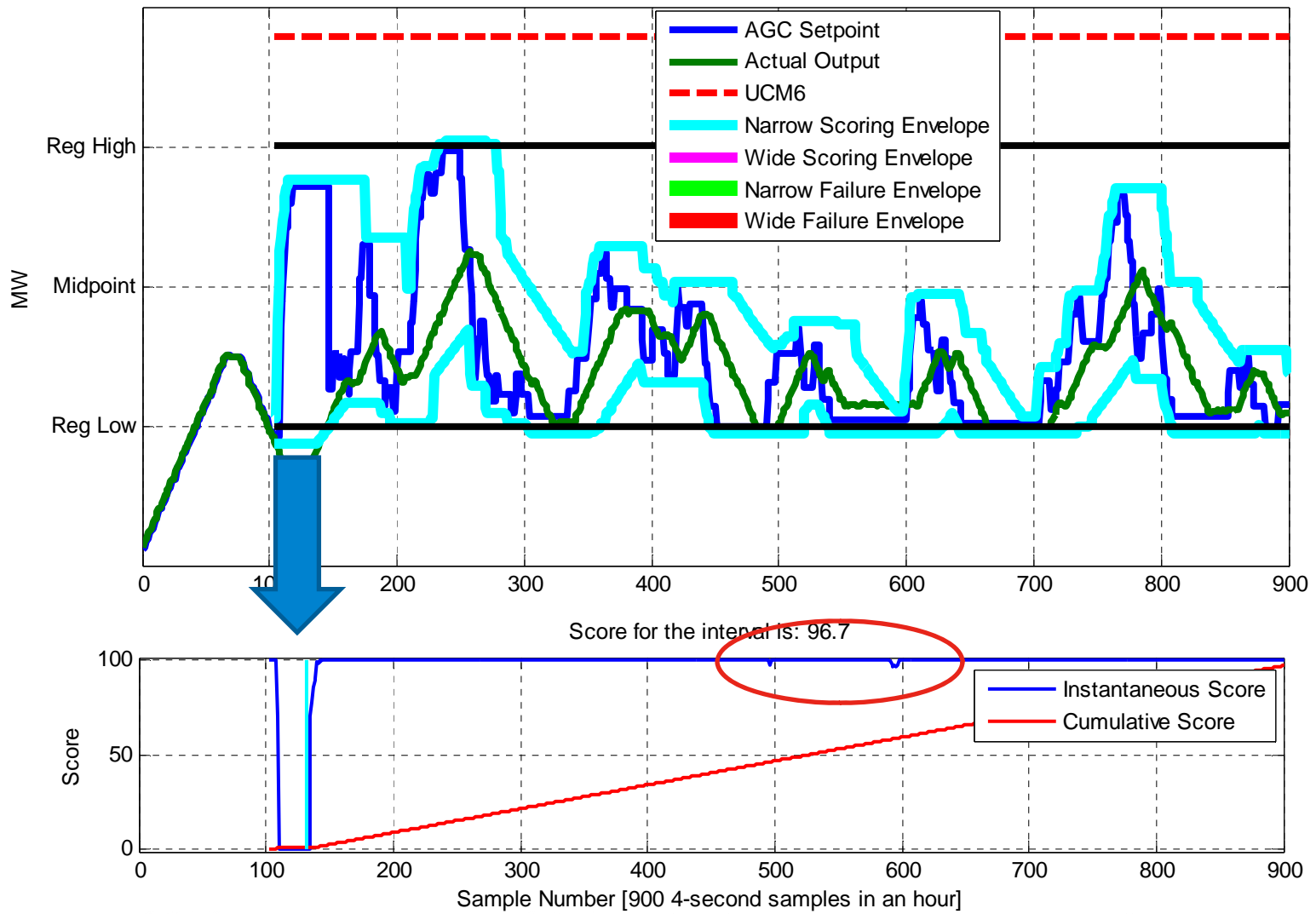
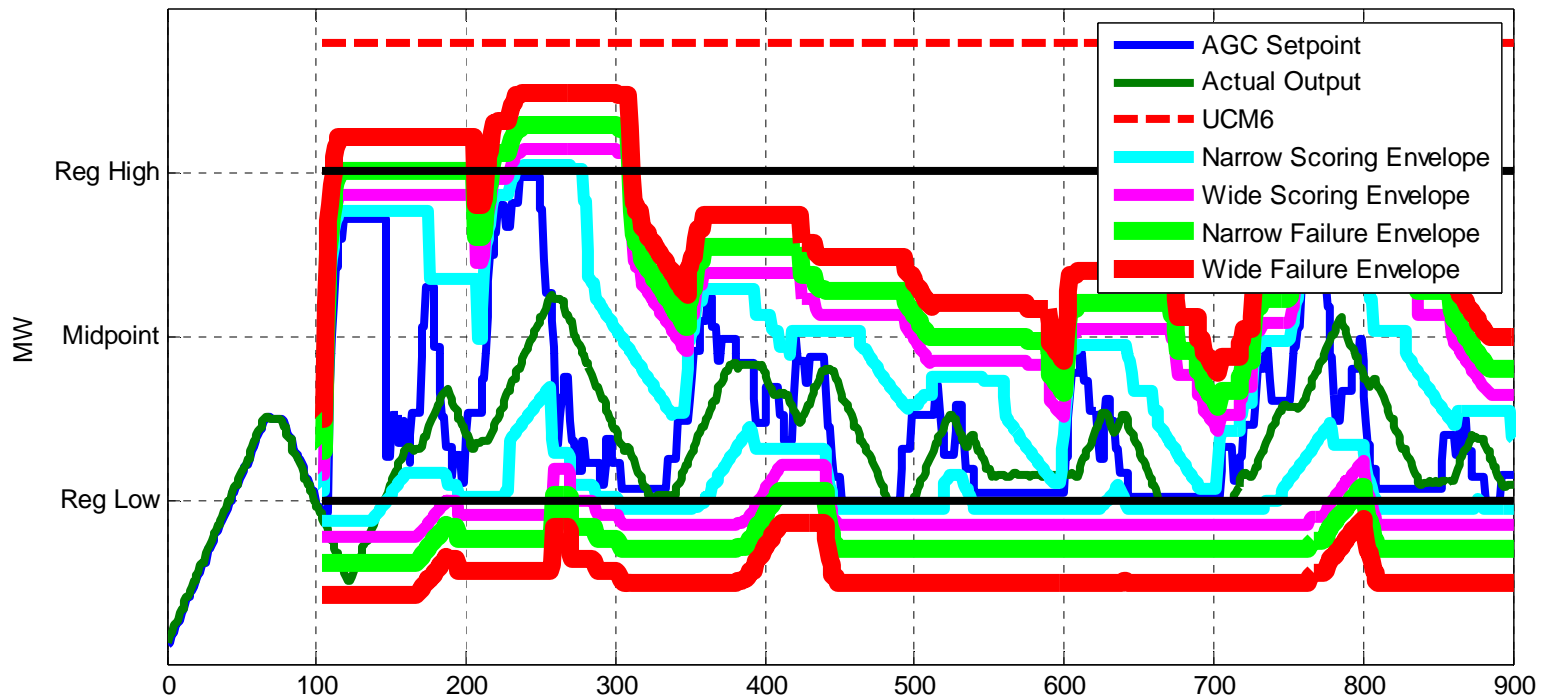# Regulation Monitoring – Figure 4

Sample of AGC Performance Monitoring
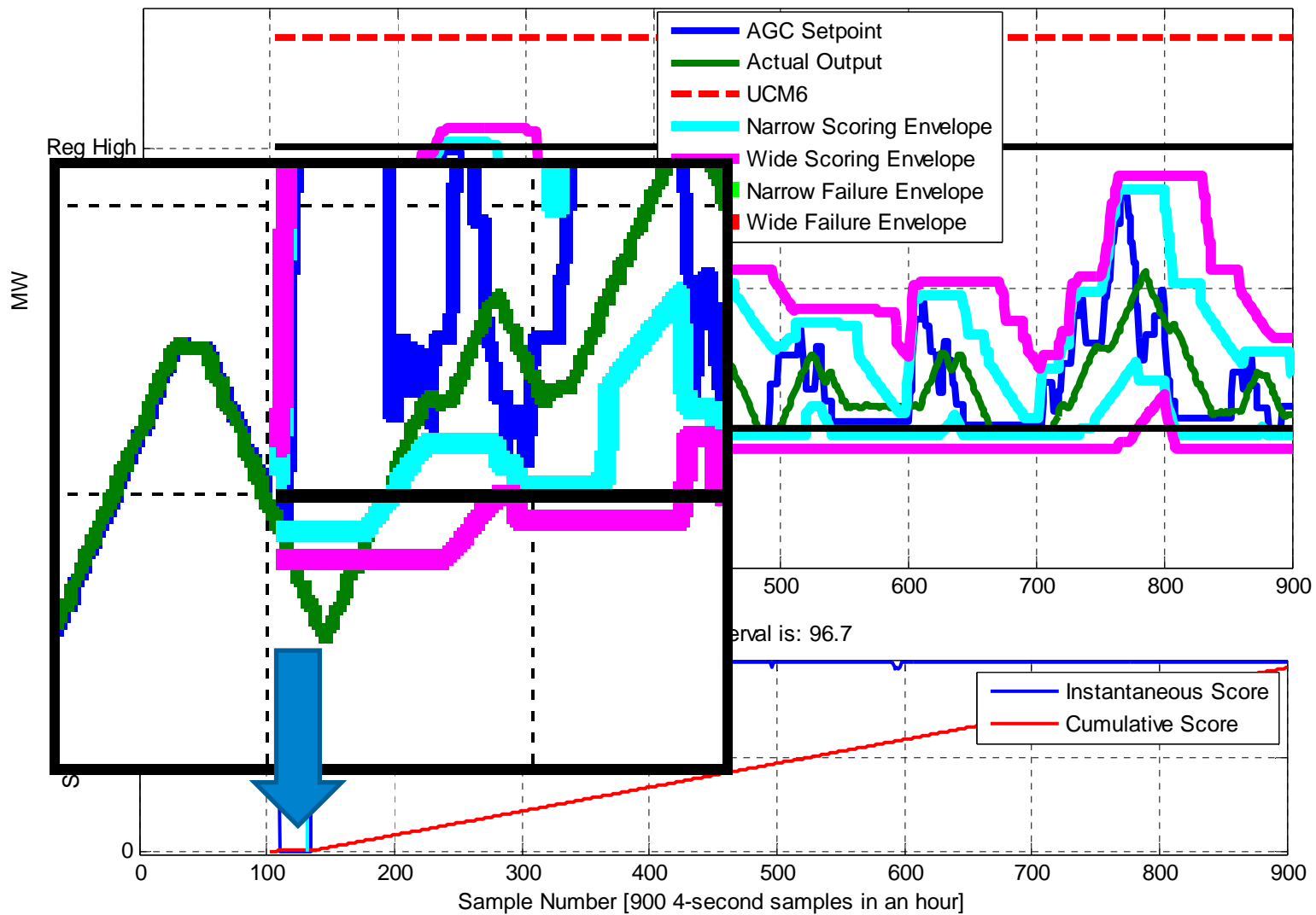
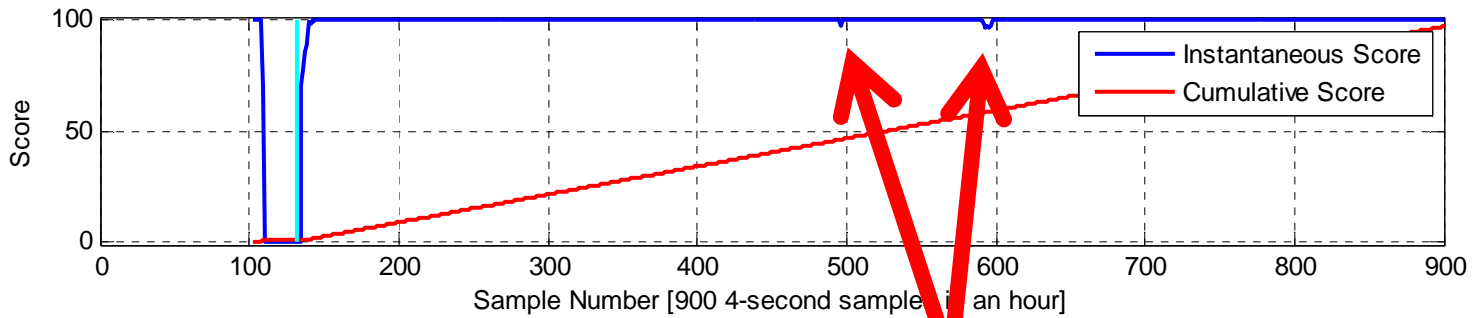# Regulation Monitoring – Figure 5

Sample of AGC Performance Monitoring
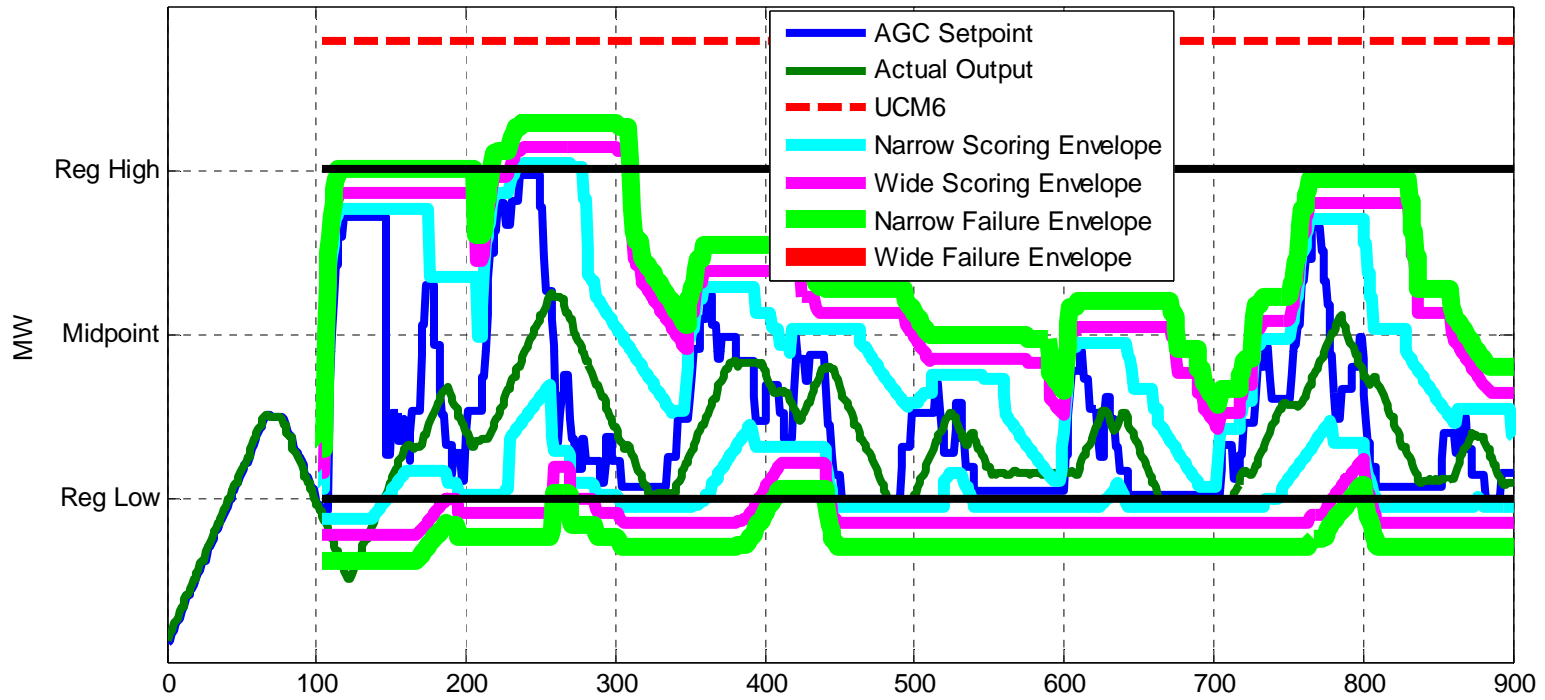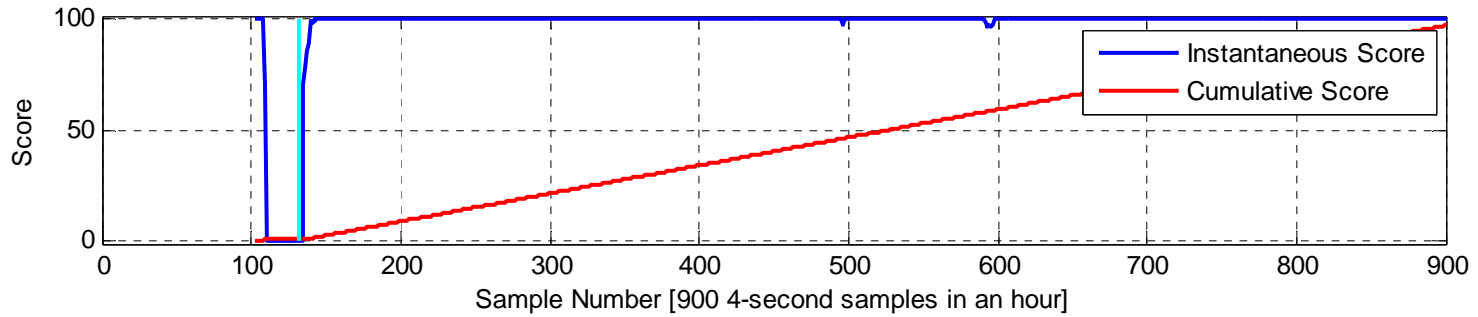
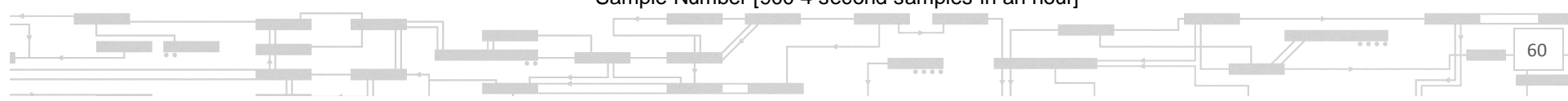# Regulation Monitoring – Figure 6

Sample of AGC Performance Monitoring
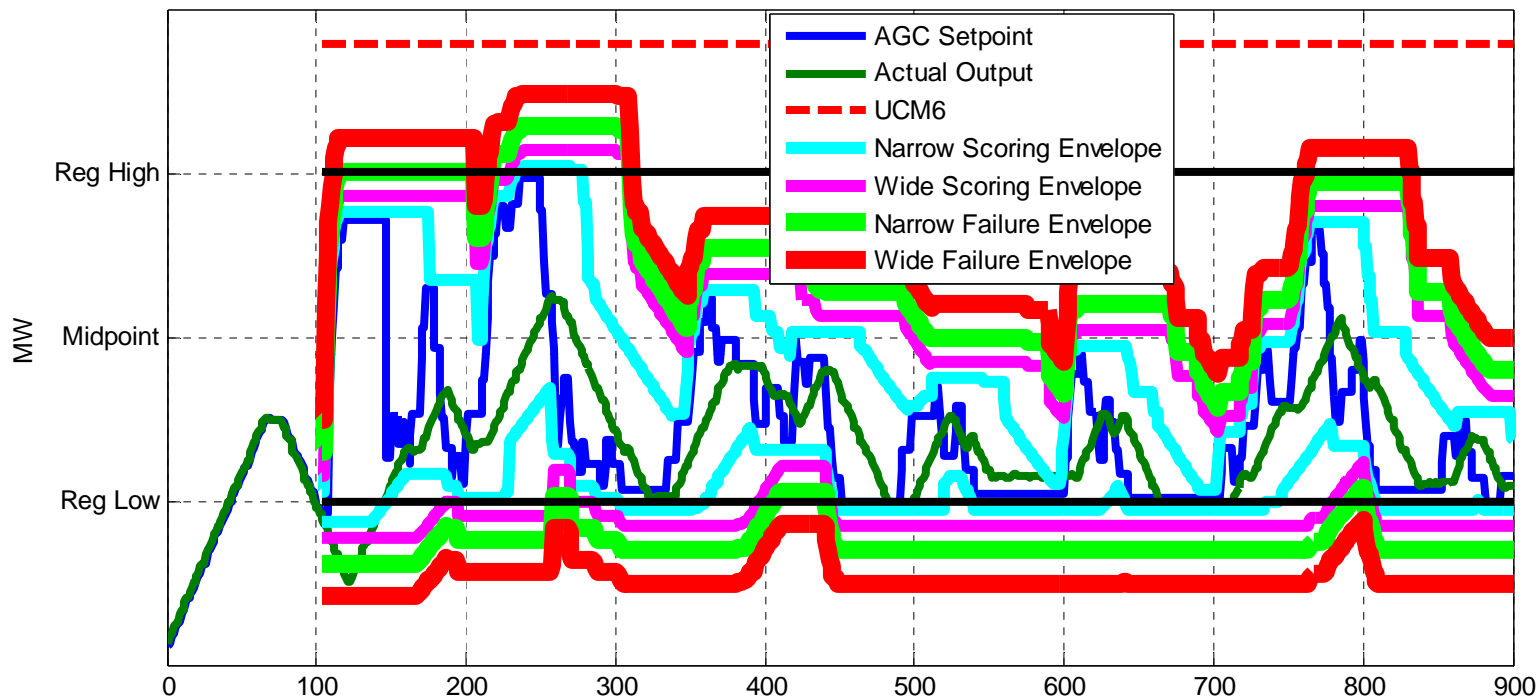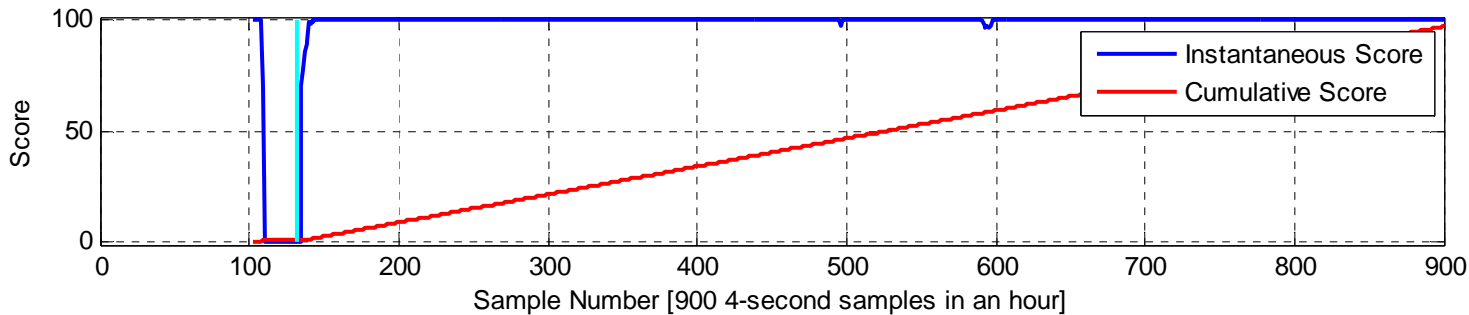
Regulation Monitoring – Figure 7

Sample of AGC Performance Monitoring
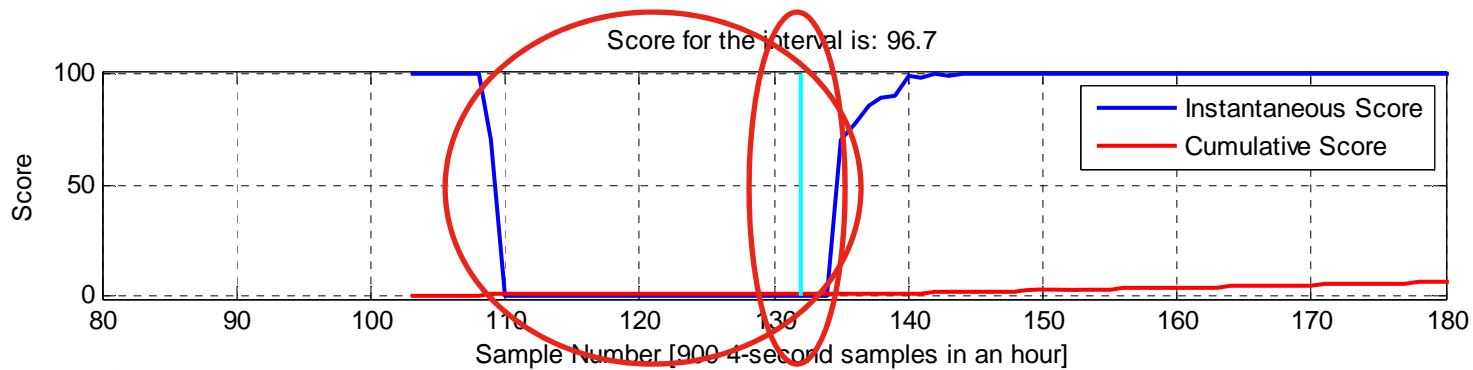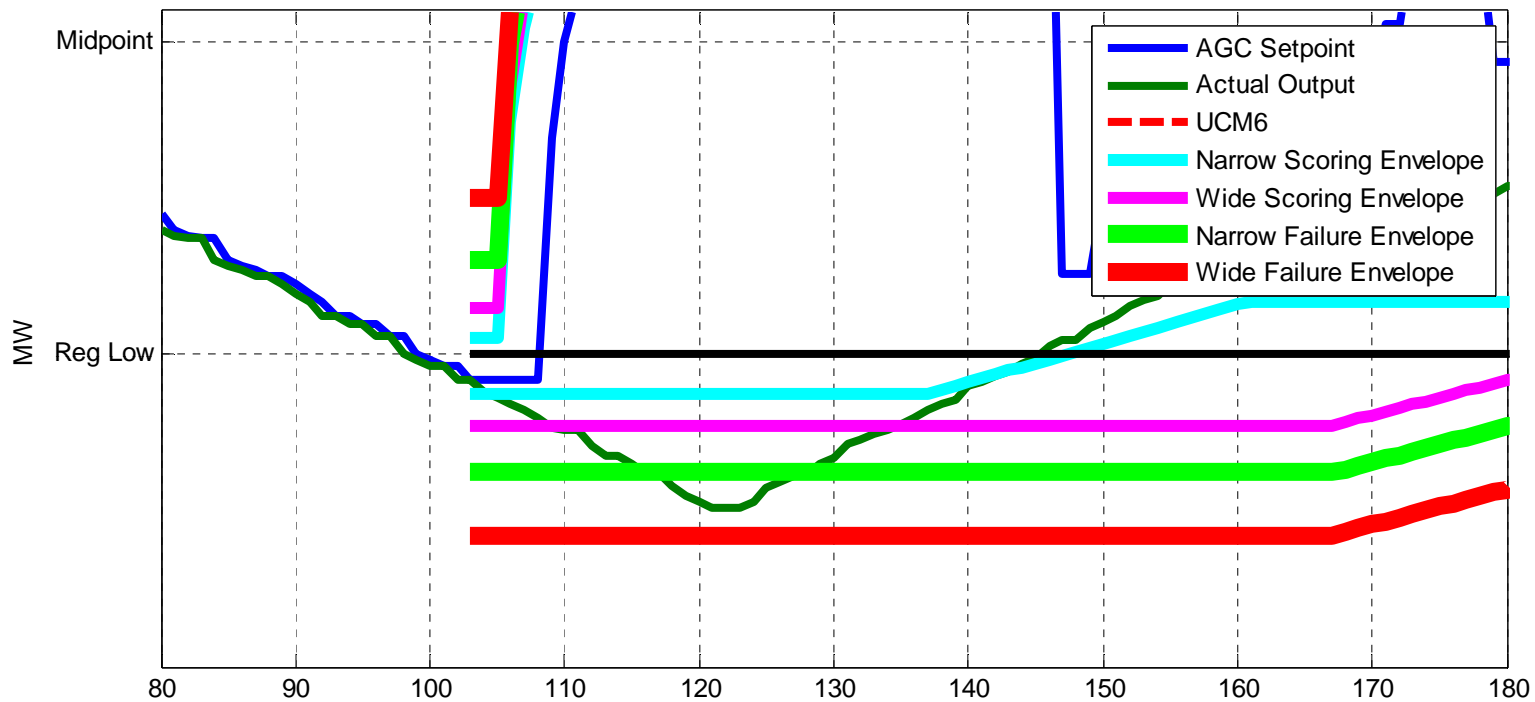
Regulation Monitoring – Figure 8

Sample of AGC Performance Monitoring
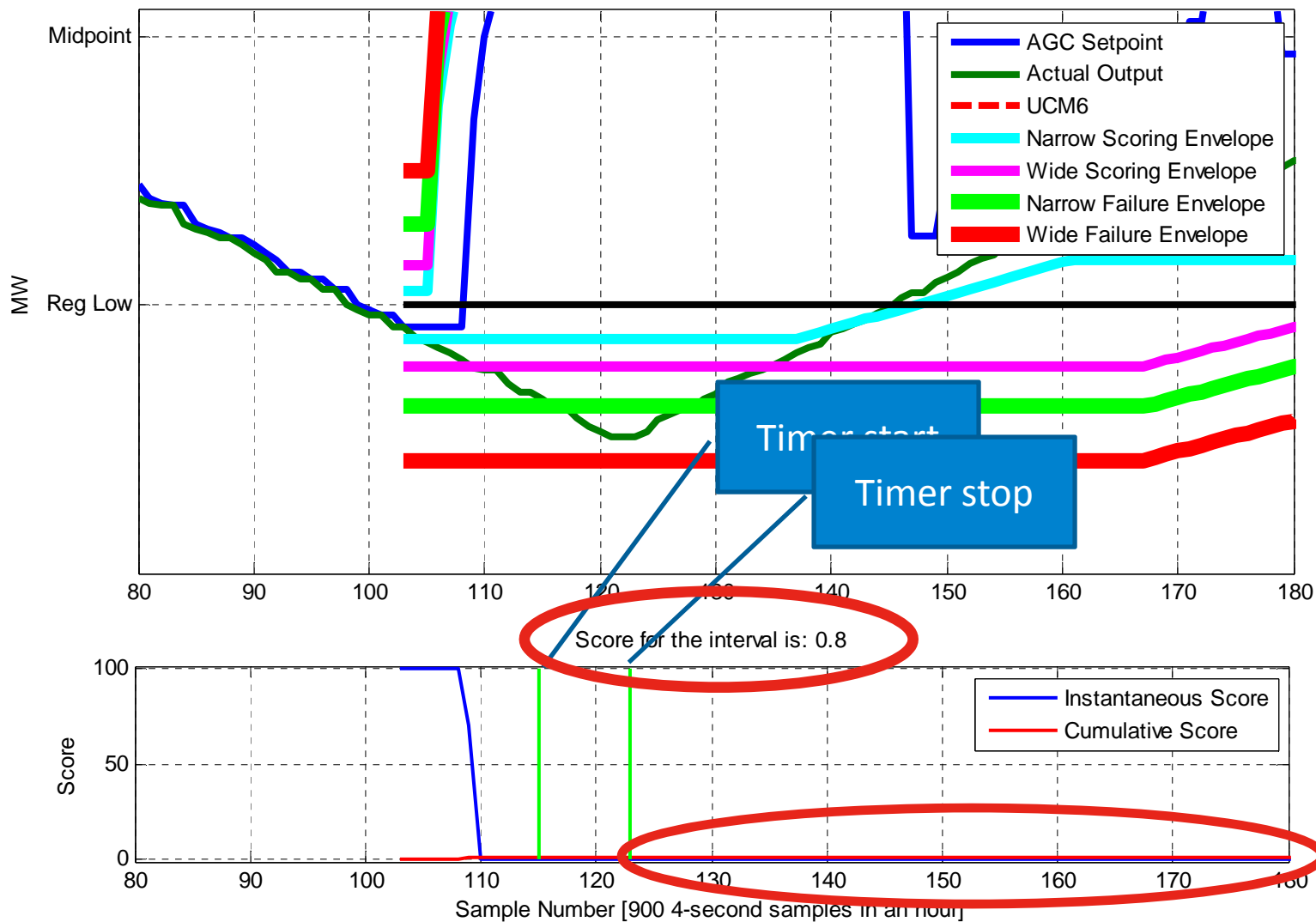
Regulation Monitoring – Figure 9

Sample of AGC Performance Monitoring
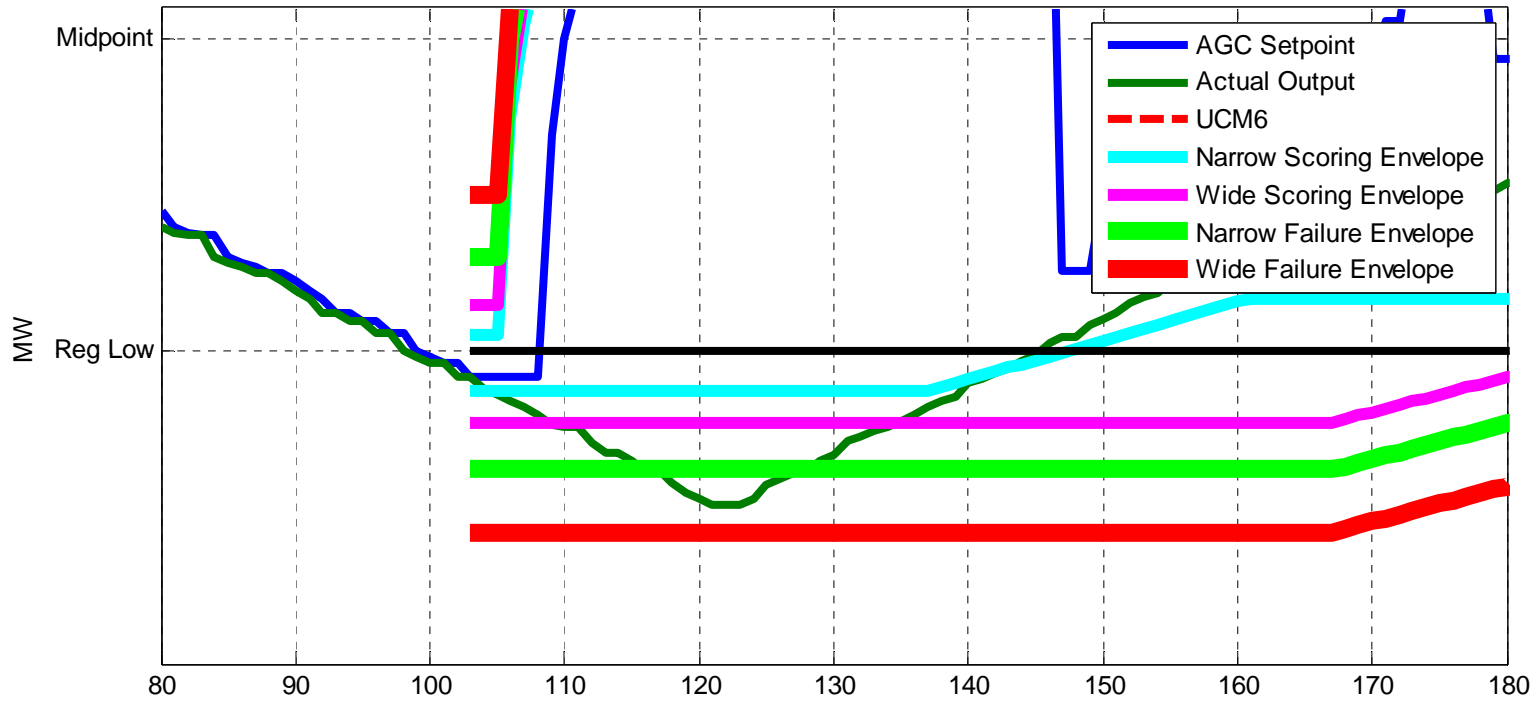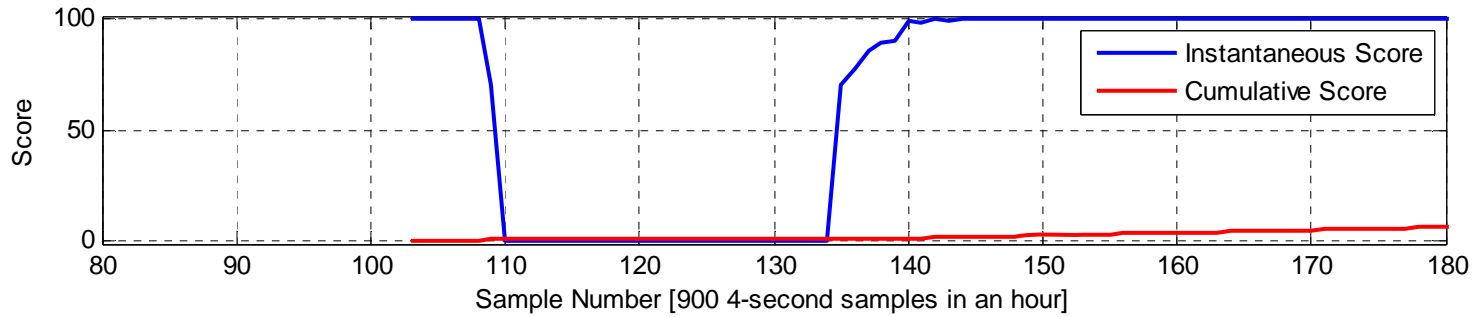
Regulation Monitoring – Figure 10

Sample of AGC Performance Monitoring

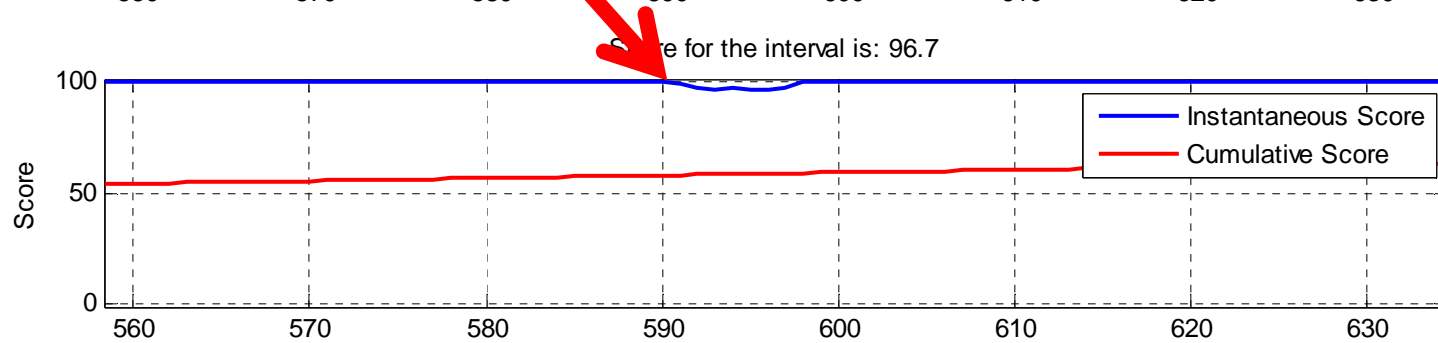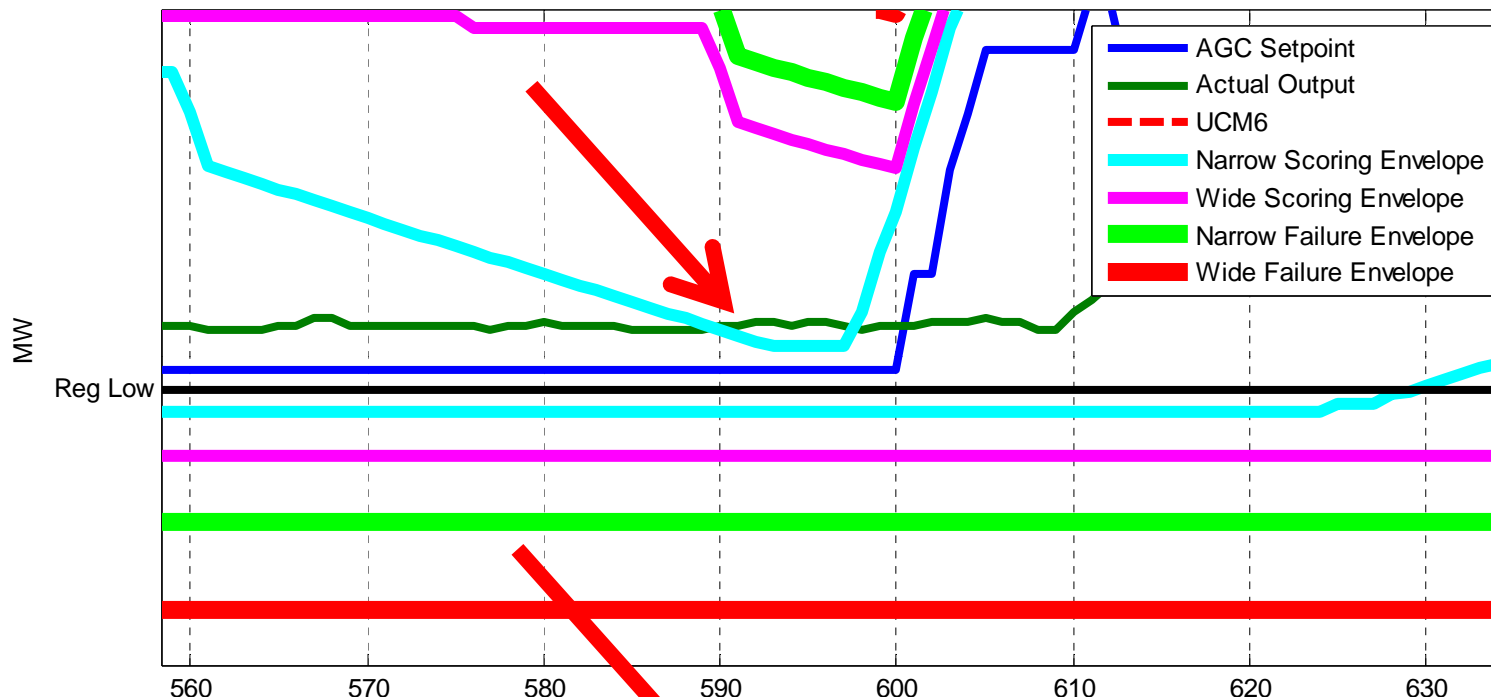# Regulation Monitoring – Figure 10

Sample of AGC Performance Monitoring

Legend:
- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

- Instantaneous Score
- Cumulative Score

Midpoint
MW
Reg Low
Score
100
50
0

Sample Number [900 4-second samples in an hour]
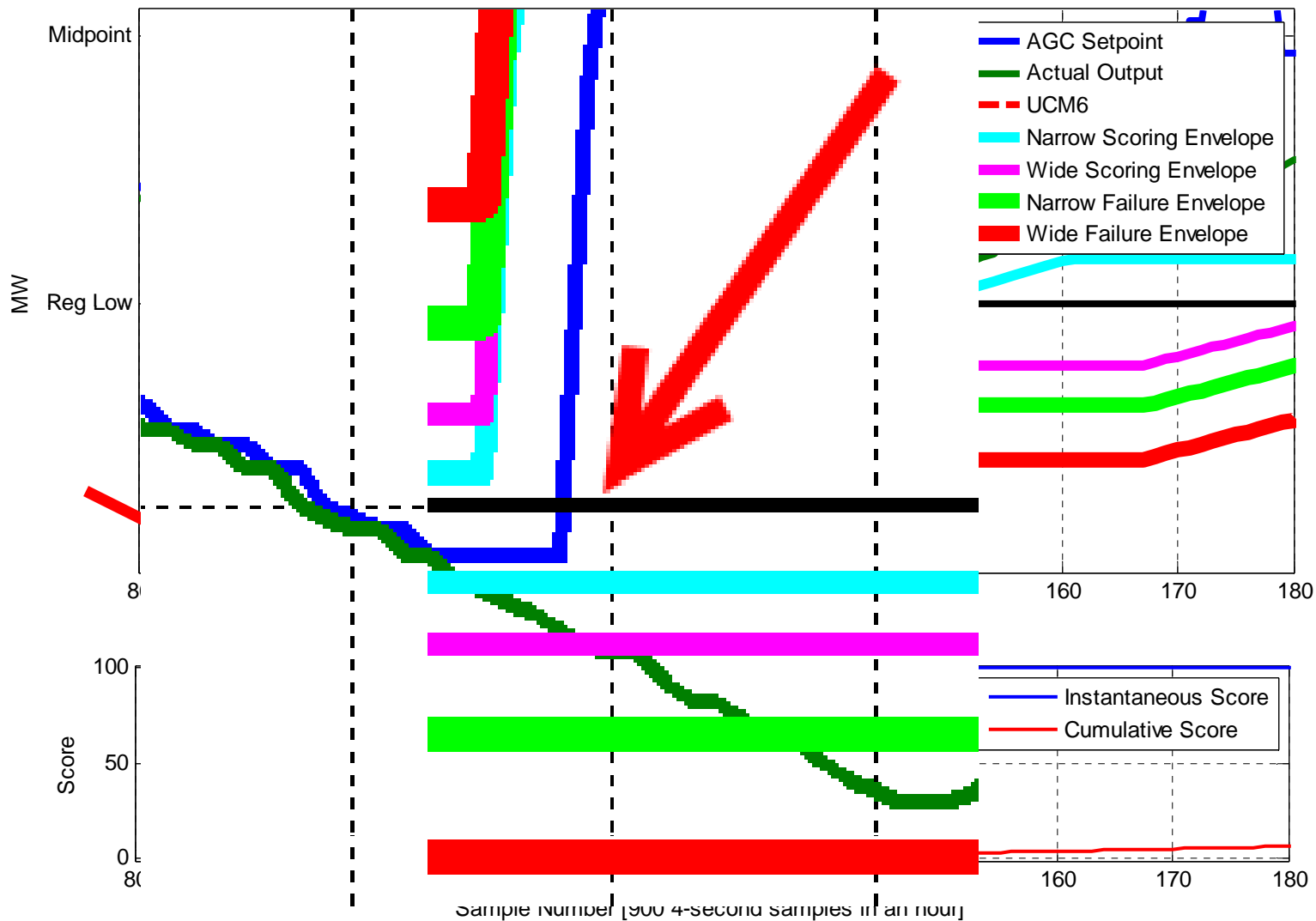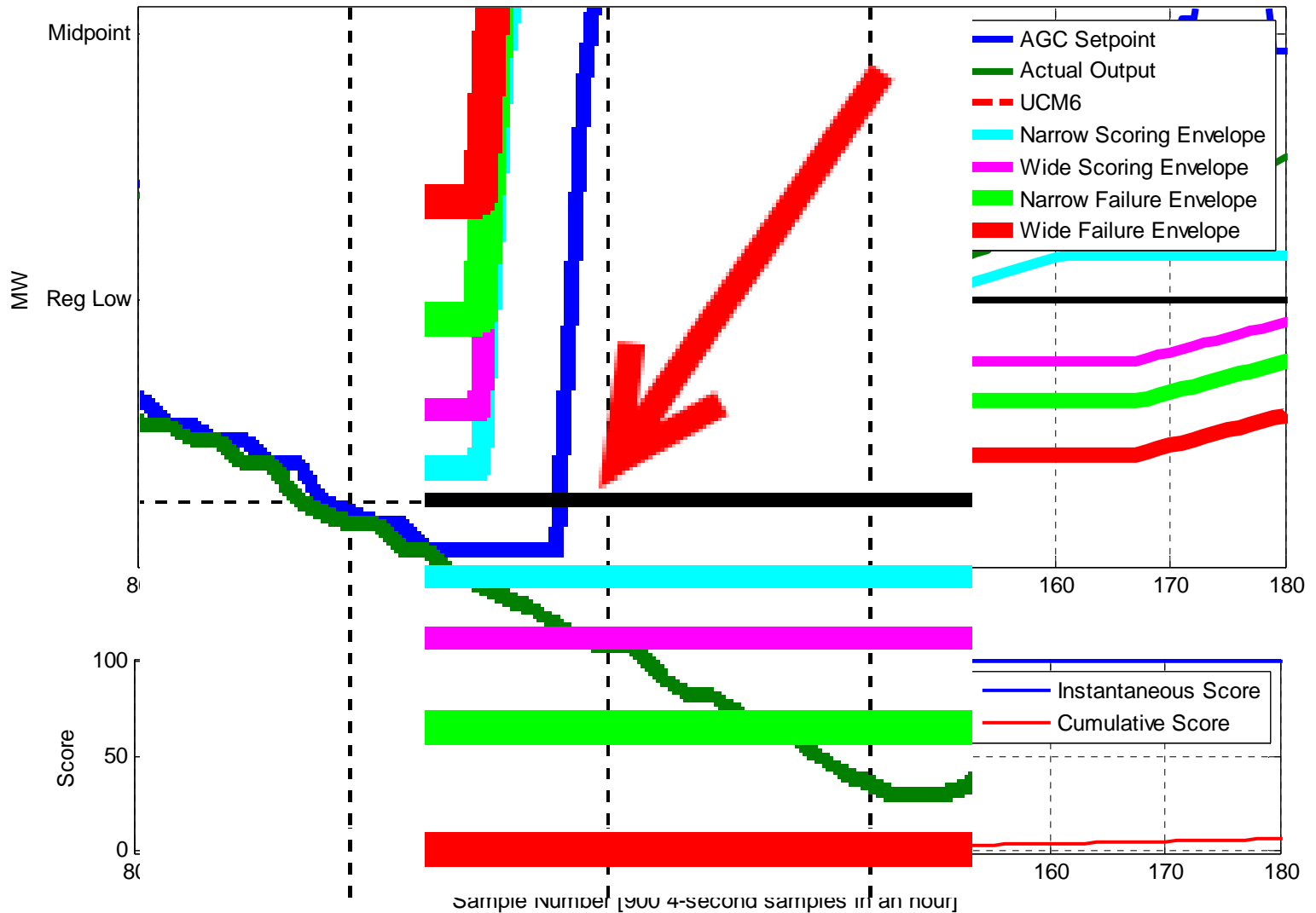
Regulation Monitoring – Figure 11
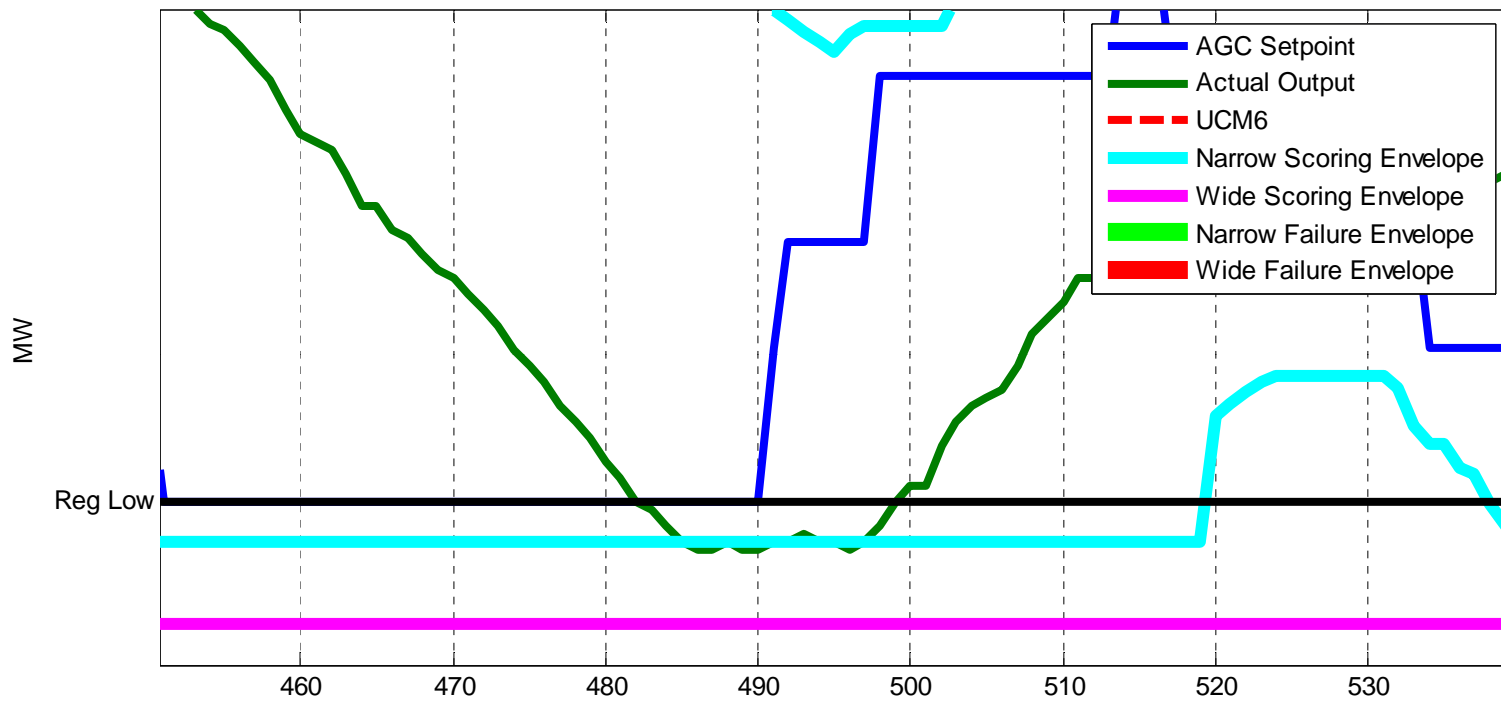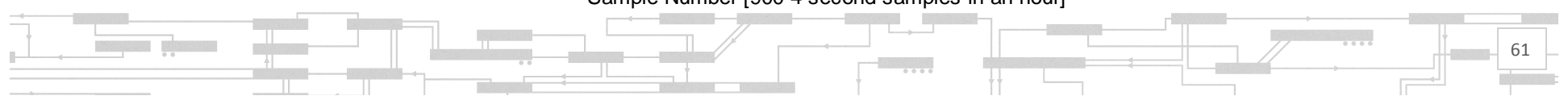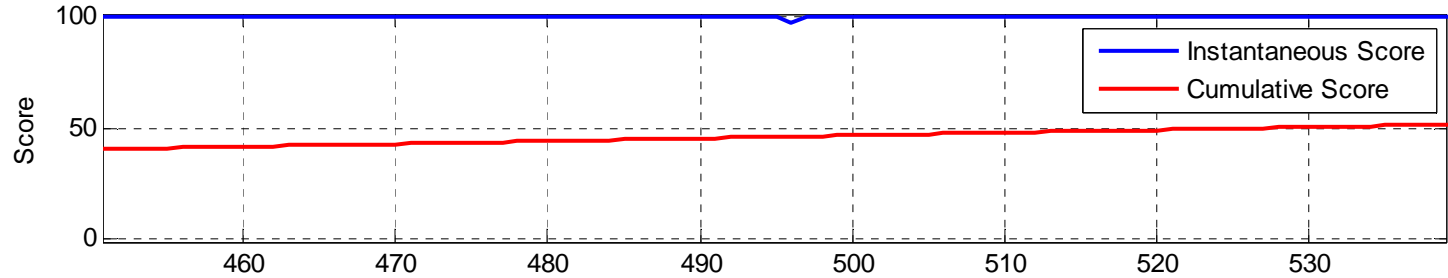

Sample of AGC Performance Monitoring

Score for the interval is: 96.6
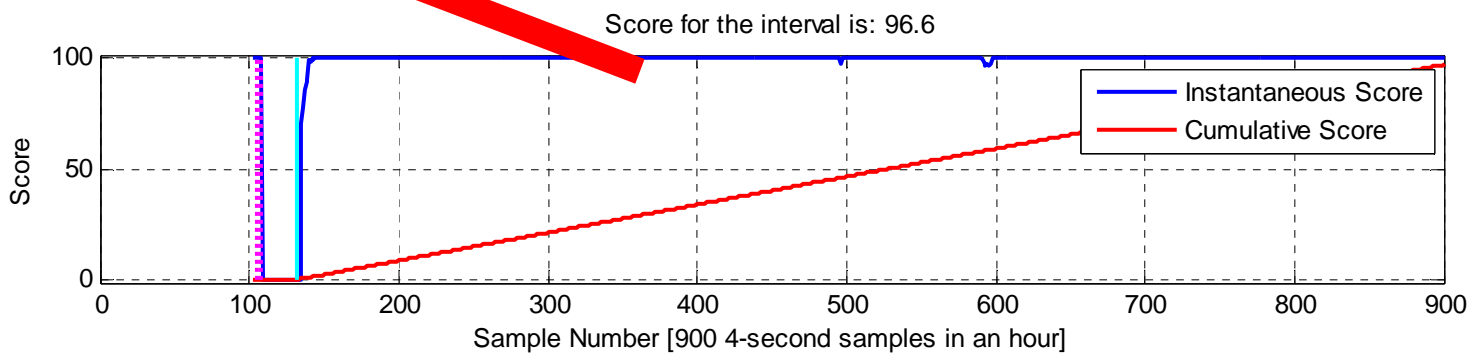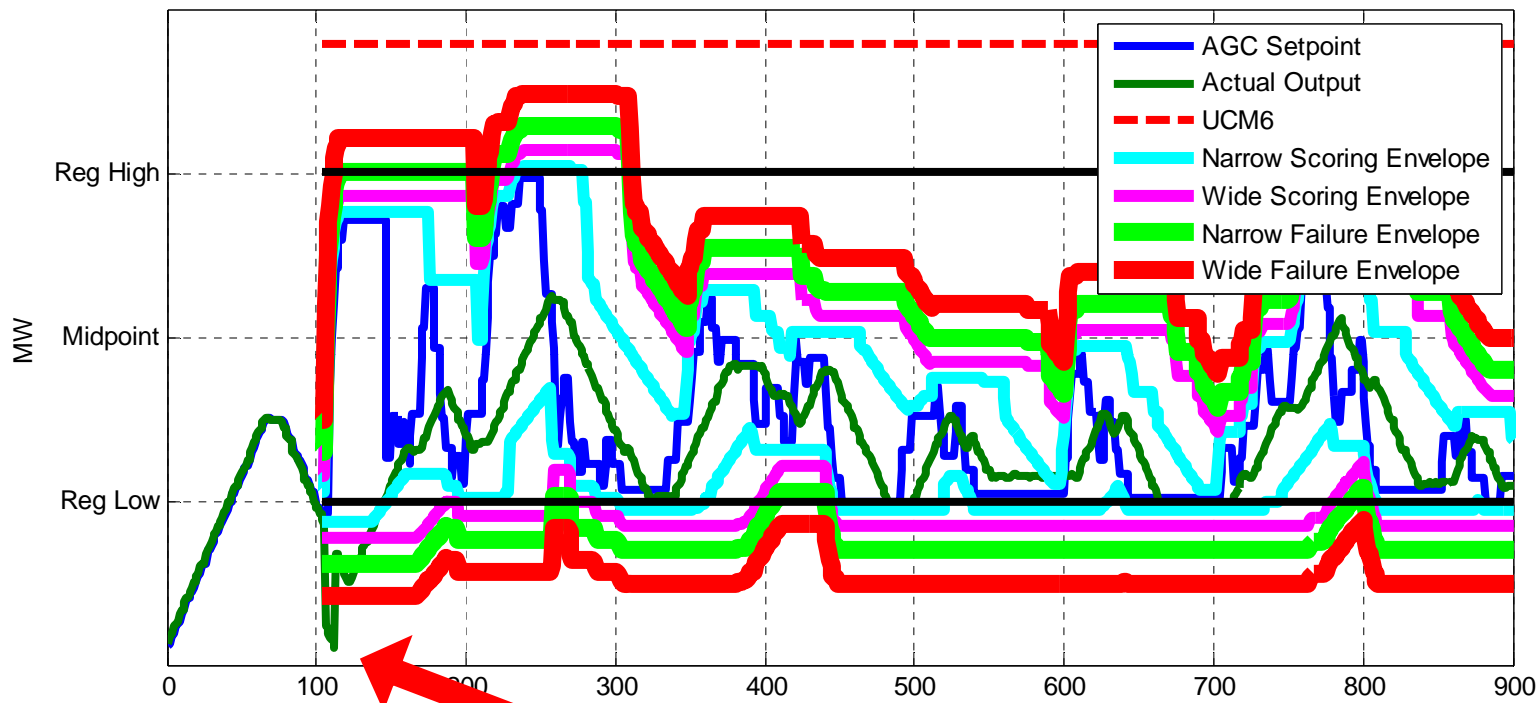
Regulation Monitoring – Figure 12

Sample of AGC Performance Monitoring

Legend:
- AGC Setpoint
- Actual Output
- UCM6
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Score for the interval is: 96.7

- Instantaneous Score
- Cumulative Score

Sample Number [900 4-second samples in an hour]
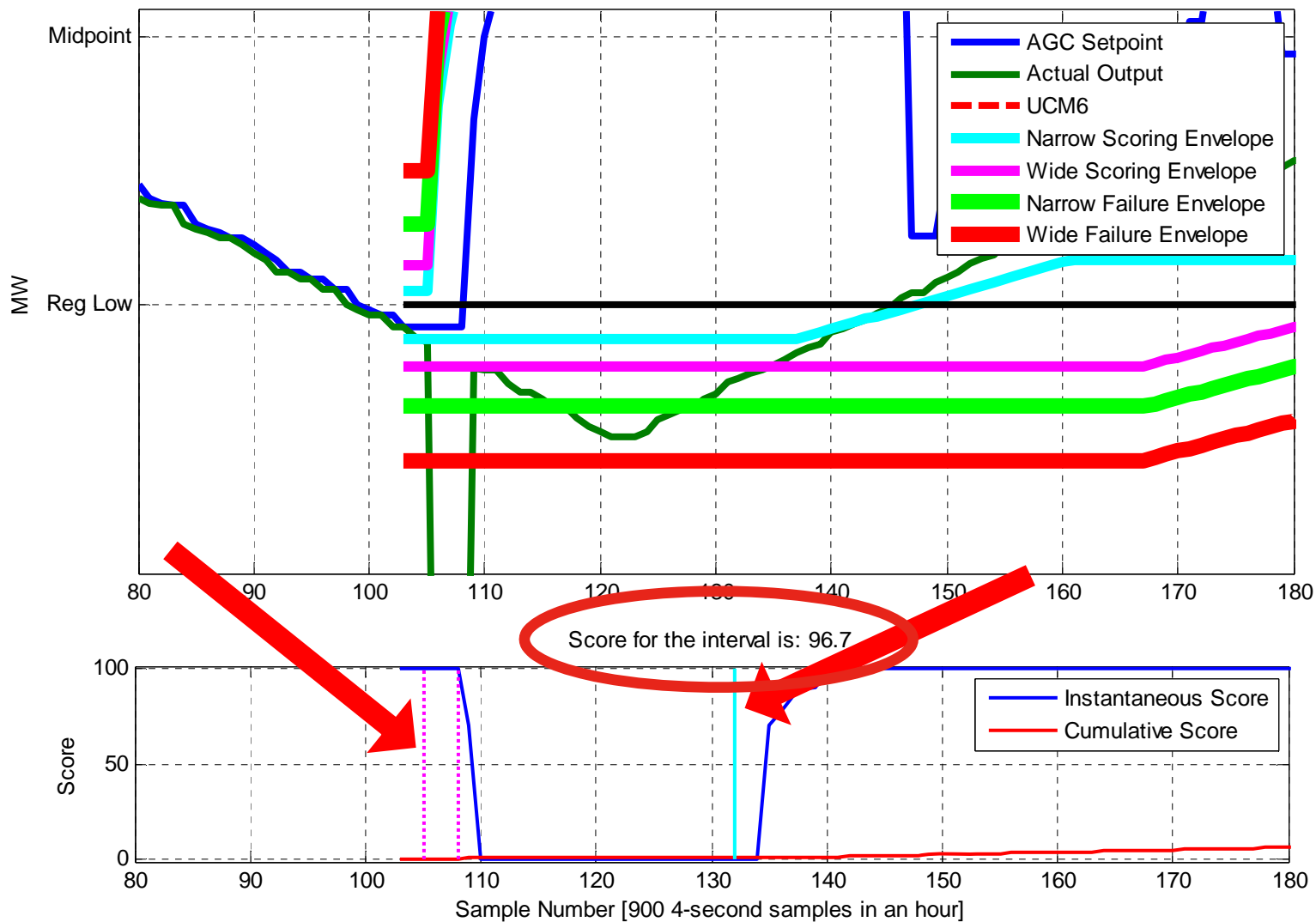
Regulation Monitoring – Figure 13

Sample of AGC Performance Monitoring
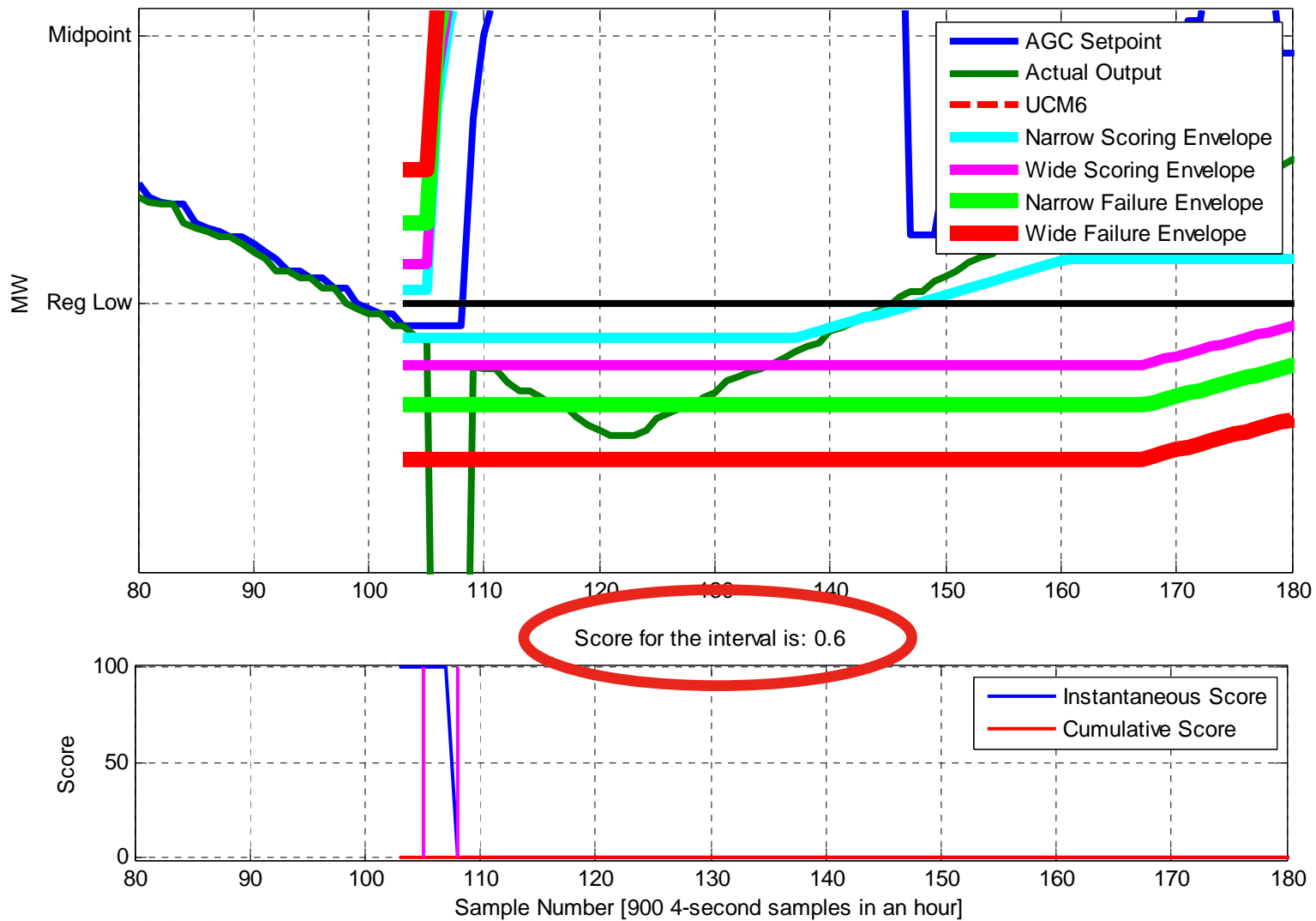
Regulation Monitoring – Figure 14

Sample of AGC Performance Monitoring

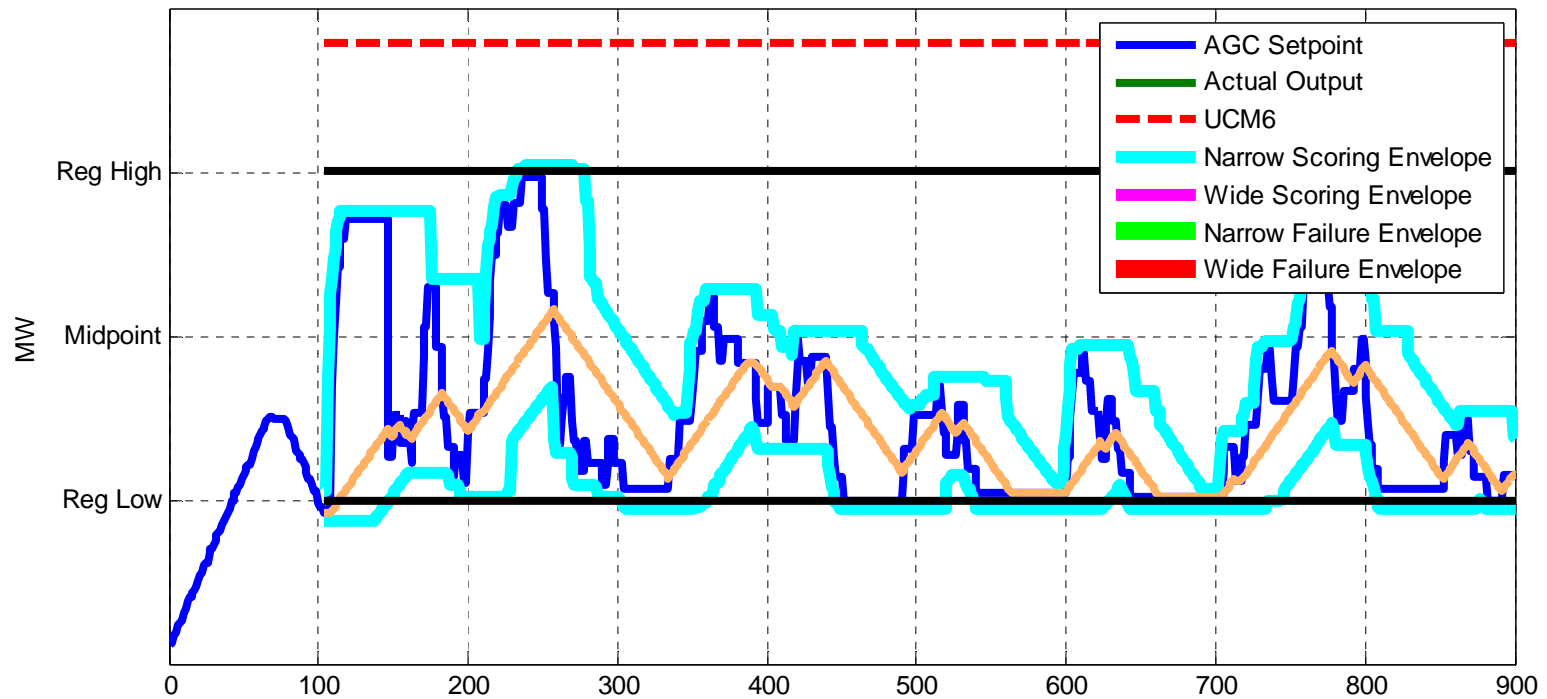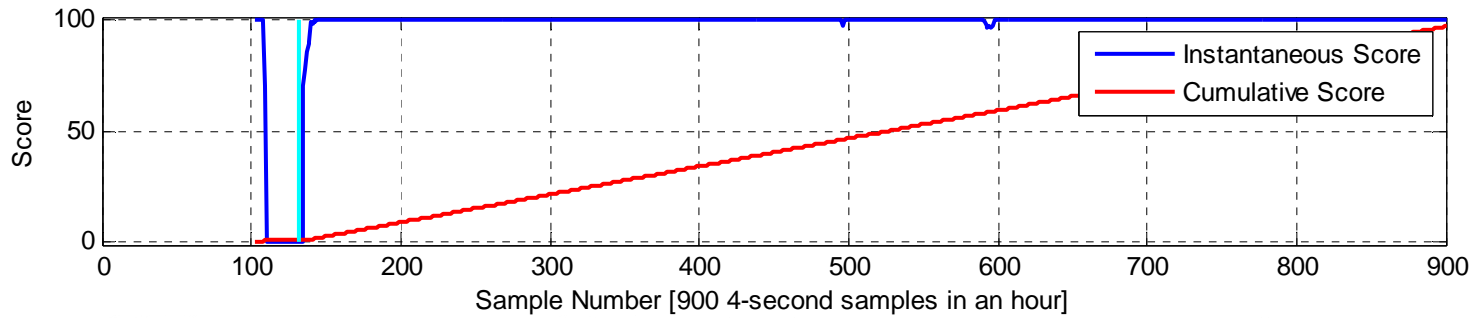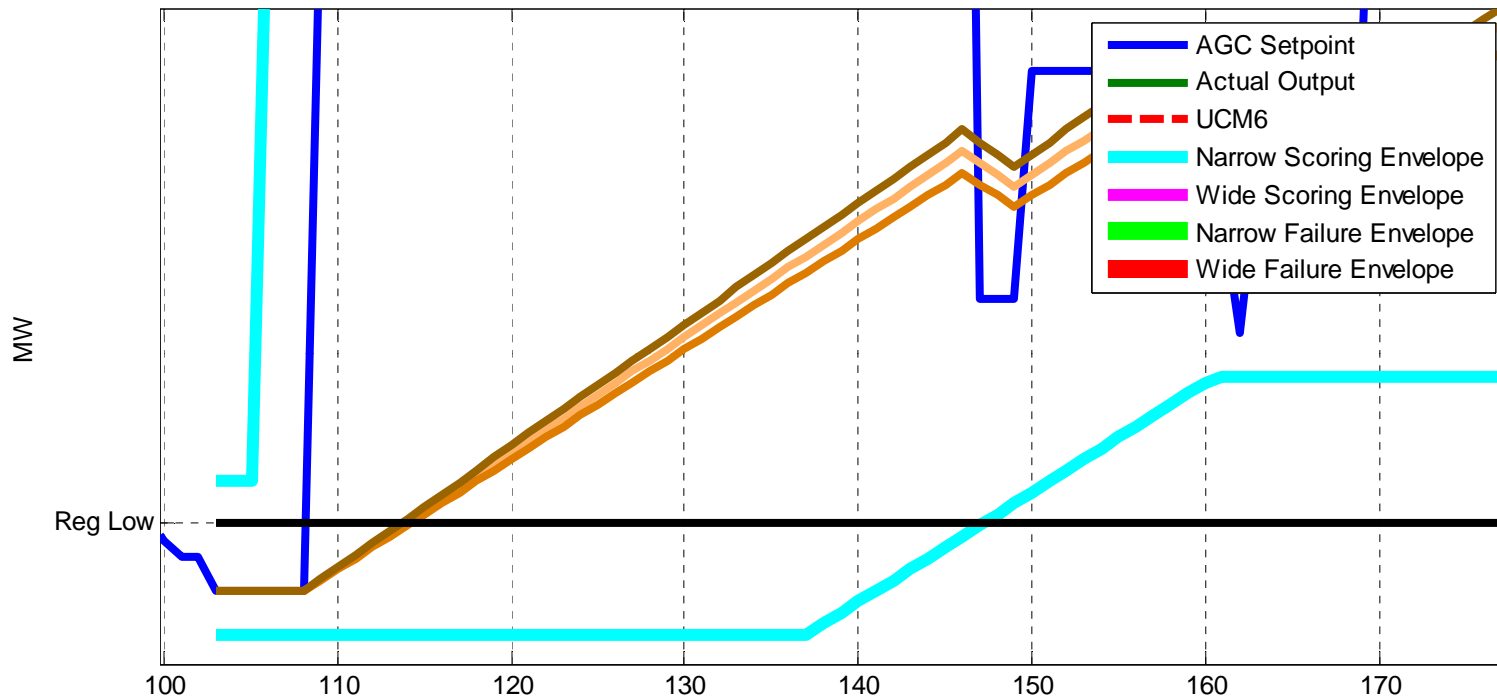# Regulation Monitoring – Figure 15

Sample of AGC Performance Monitoring

Regulation Monitoring – Figure 16

Sample of AGC Performance Monitoring

Regulation Monitoring – Figure 17

Sample of AGC Performance Monitoring

Regulation Monitoring – Figure 18
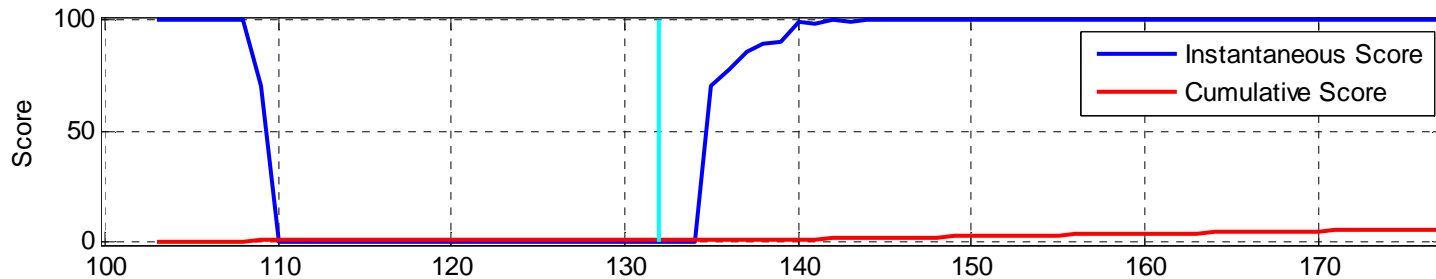

Sample of AGC Performance Monitoring

Regulation Monitoring – Figure 19 (Envelope Creation)
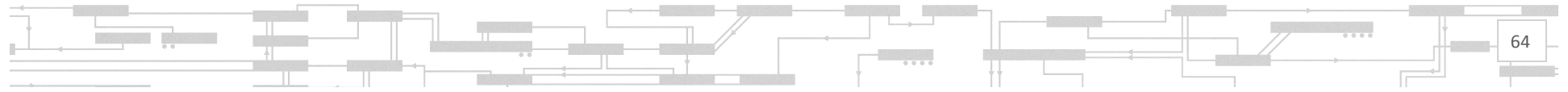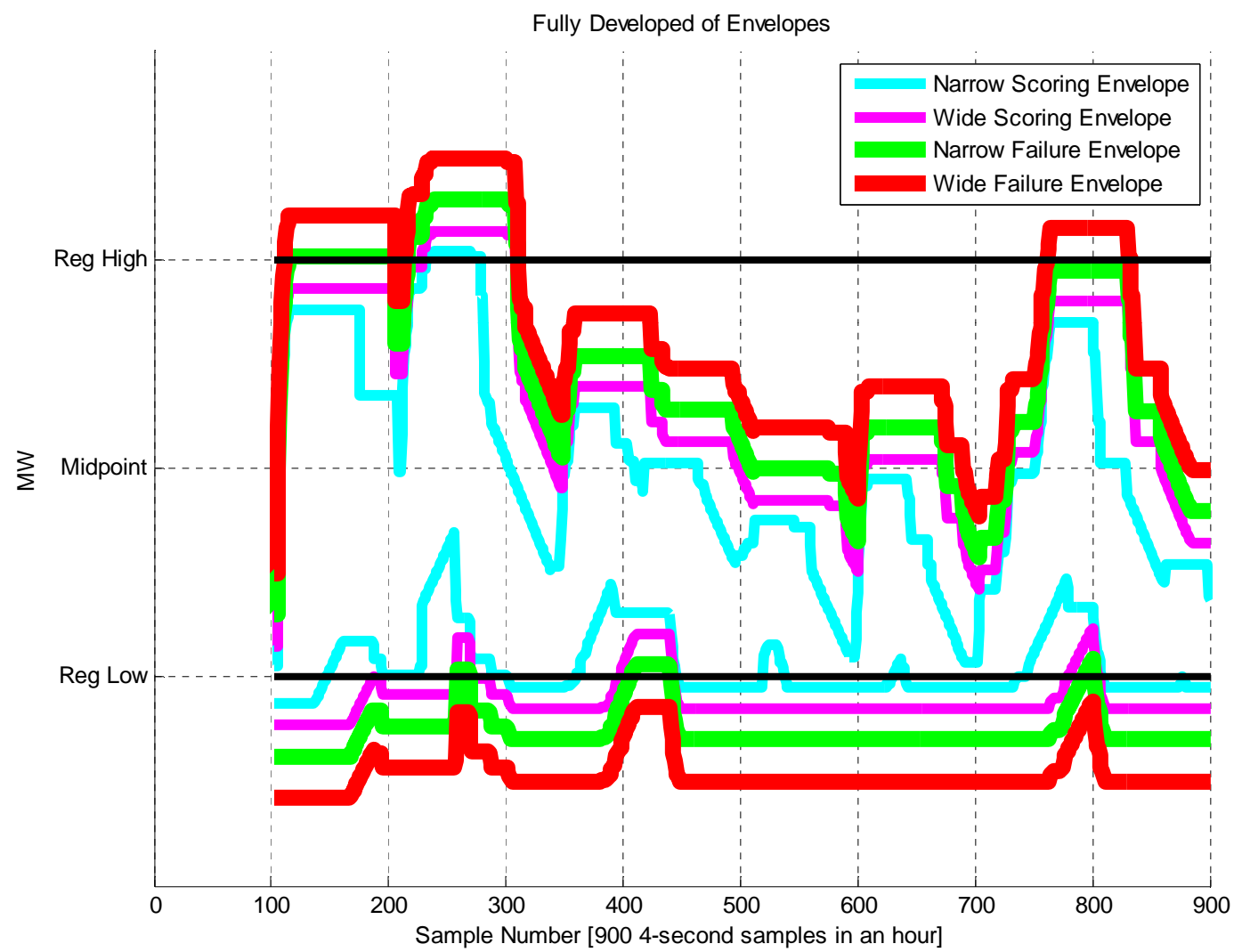

Sample of AGC Performance Monitoring

Score for the interval is: 96.7

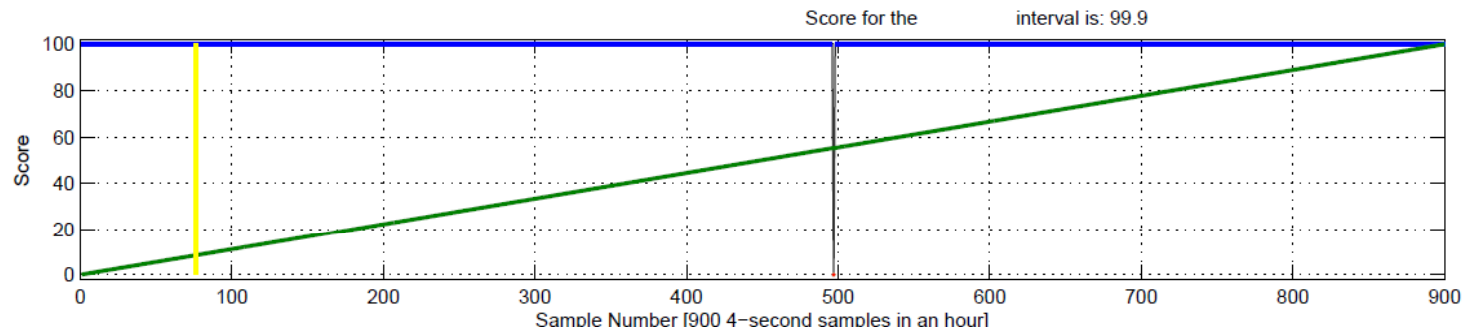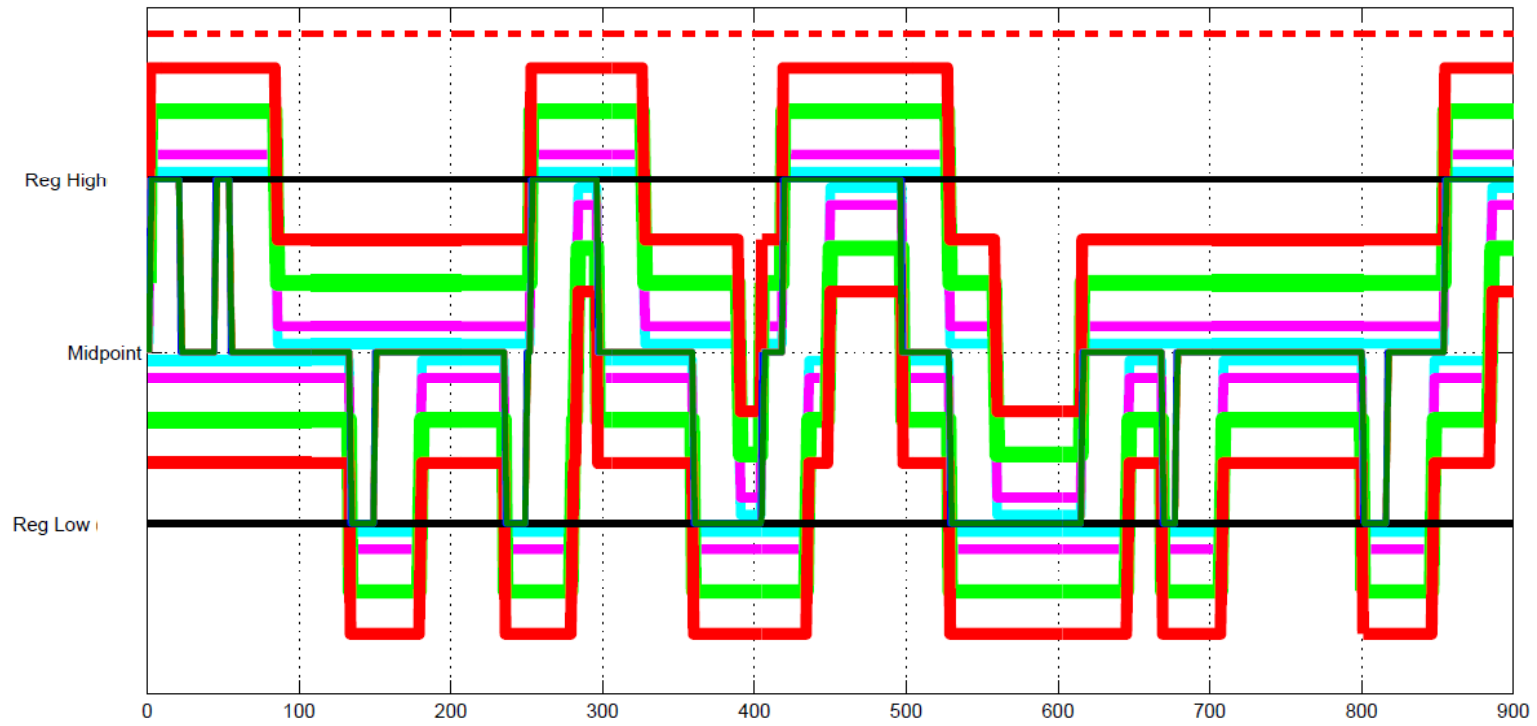Sample Number [900 4-second samples in an hour]

Regulation Monitoring – Figure 20 (Envelope Creation)

Sample of AGC Performance Monitoring

Regulation Monitoring – Figure 21 (Envelope Creation)

Fully Developed of Envelopes

Legend:
- Narrow Scoring Envelope
- Wide Scoring Envelope
- Narrow Failure Envelope
- Wide Failure Envelope

Y-axis: MW (Reg High, Midpoint, Reg Low)

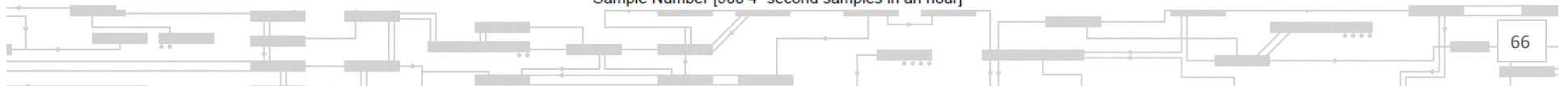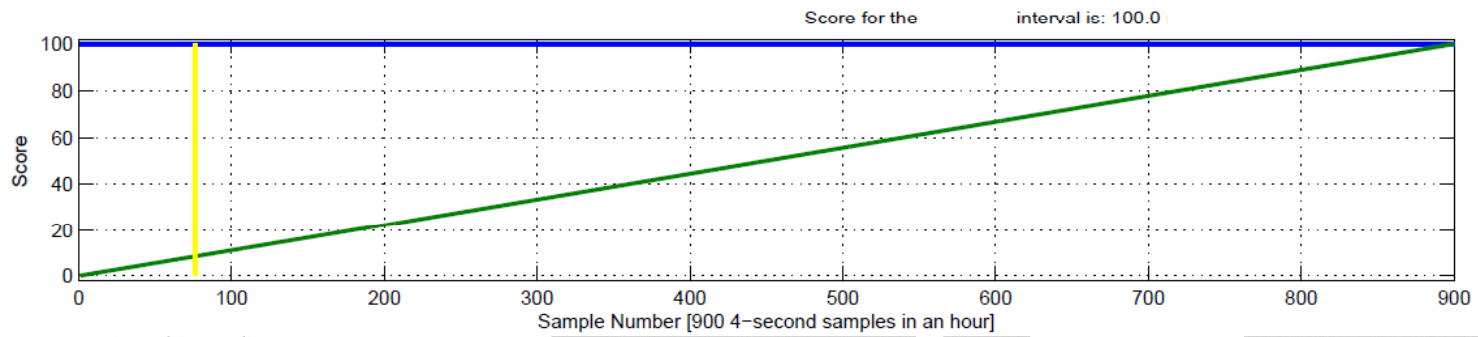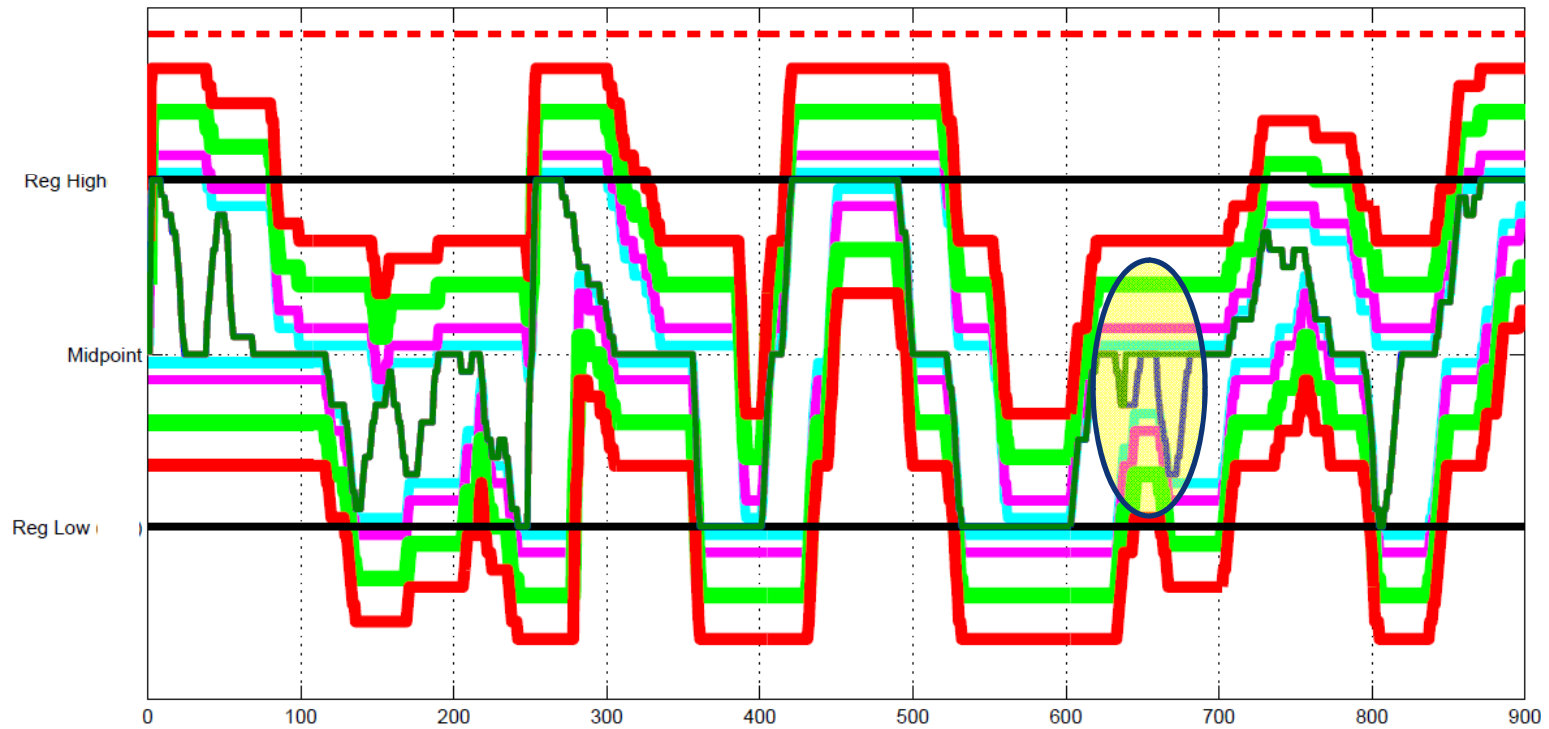X-axis: Sample Number [900 4-second samples in an hour]

Example for ENT

Example for ENC

Course Objectives

- Provide an overview of the key concepts and the basic features of the Regulation Market

- Explain the basics of Regulation

- Explain recent changes to the Regulation Market with specific emphasis on:
  - The new Energy Neutral Regulation Signal
  - The selection process of Regulating Resources
  - Monitoring of the performance of Regulating Resources

Intended audience: Regulation Market participants and those considering participation in the Regulation Market

Customer Support

- Ask ISO
  - Self-service interface for submitting inquiries
  - Accessible through the SMD Applications Homepage
  - Requires a valid digital certificate with the role of Ask ISO/External User
  - Contact your security administrator for assistance

- Phone: (413) 540-4220
  - Monday through Friday, 8:00 A.M. to 5:00 P.M. Eastern Time
  - Recorded/monitored conversations

- Email: custserv@iso-ne.com

- Pager: (877) 226-4814
  - Outside of the regular business hours, Customer support can be reached for emergency inquiries by pager