

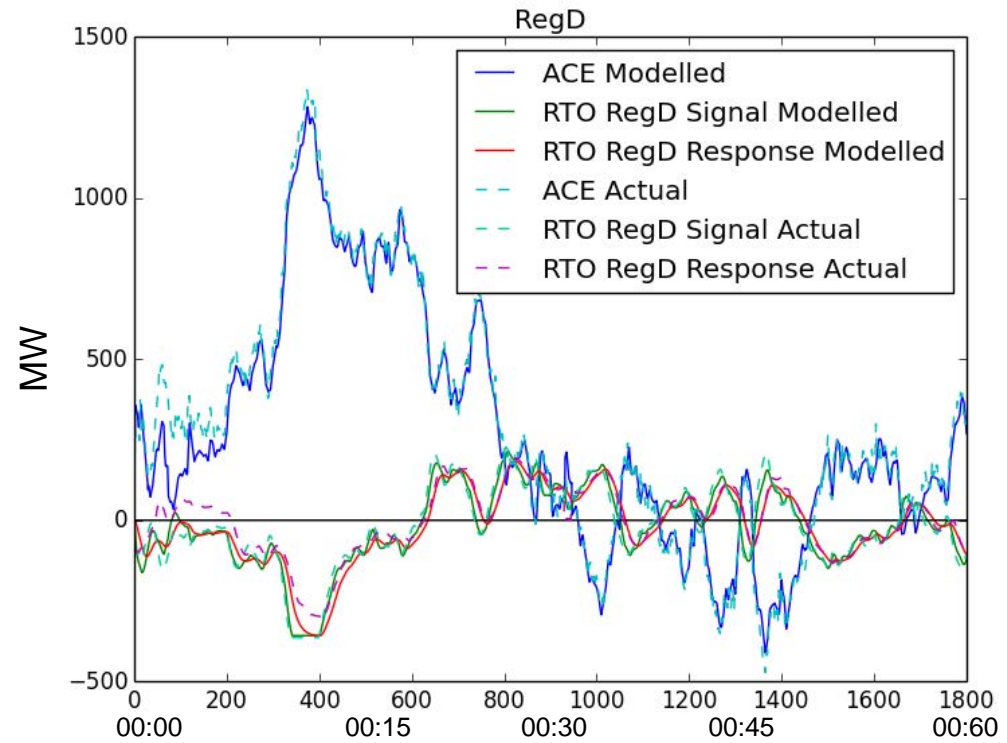
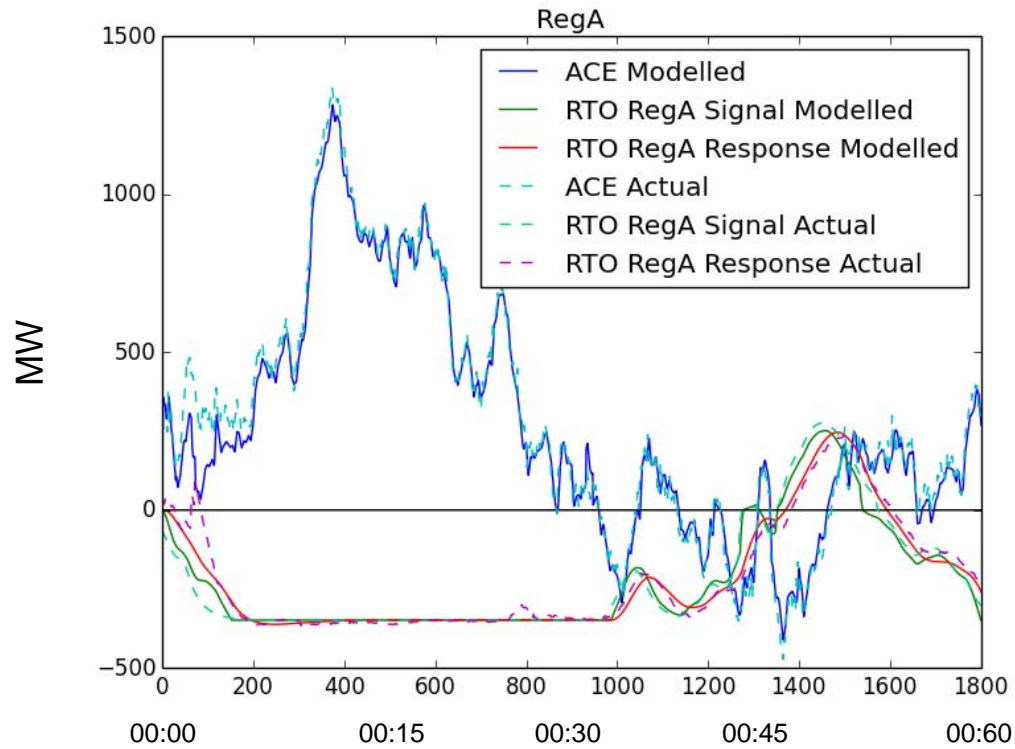


PJM Regulation Study

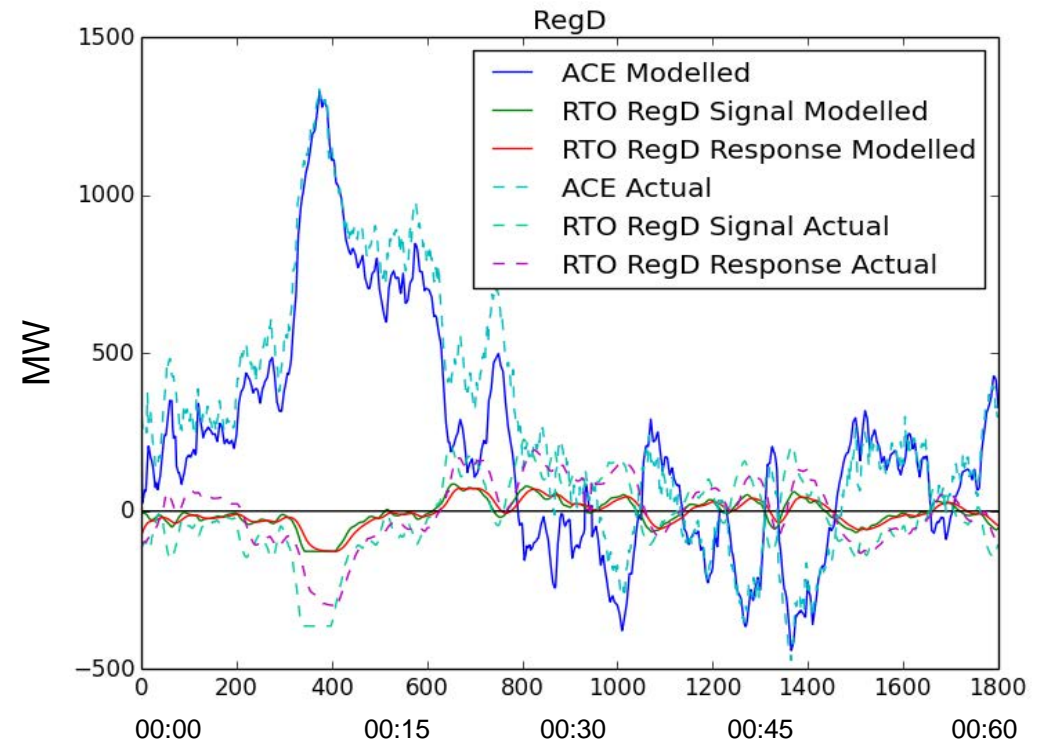
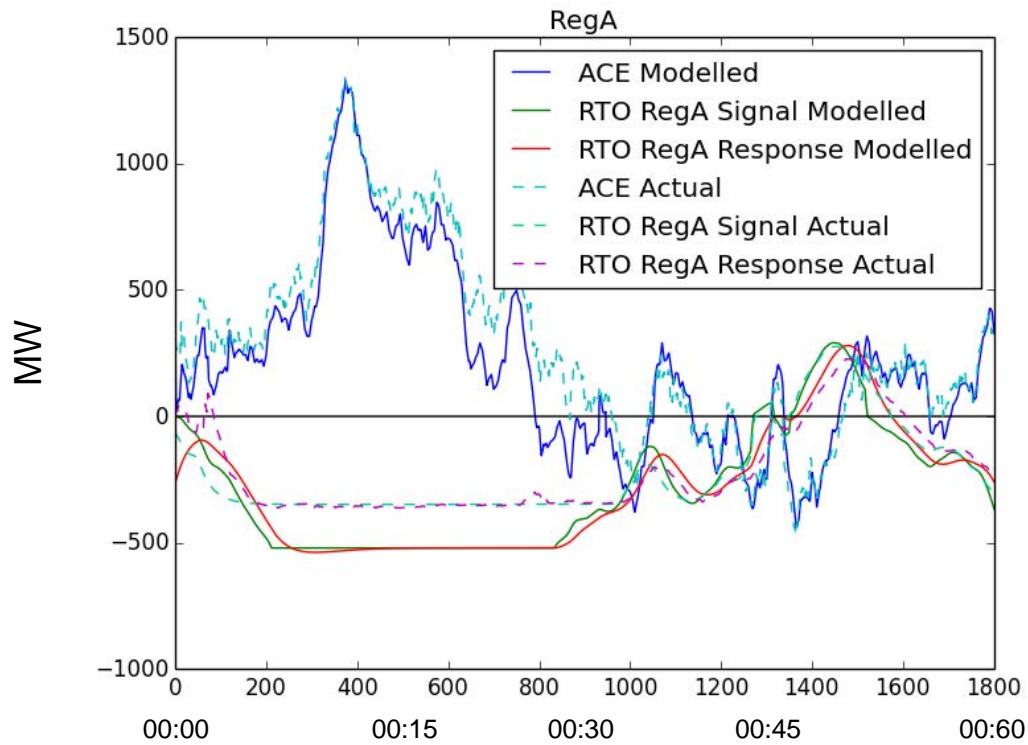
October 16, 2015

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- June 02, 2015 HB13 EPT
- Less than 1% error with respect to calculated CPS1 score
- Modelled ACE very closely matches actual recorded ACE during hour
- Regulation resources simulated based on historical performance



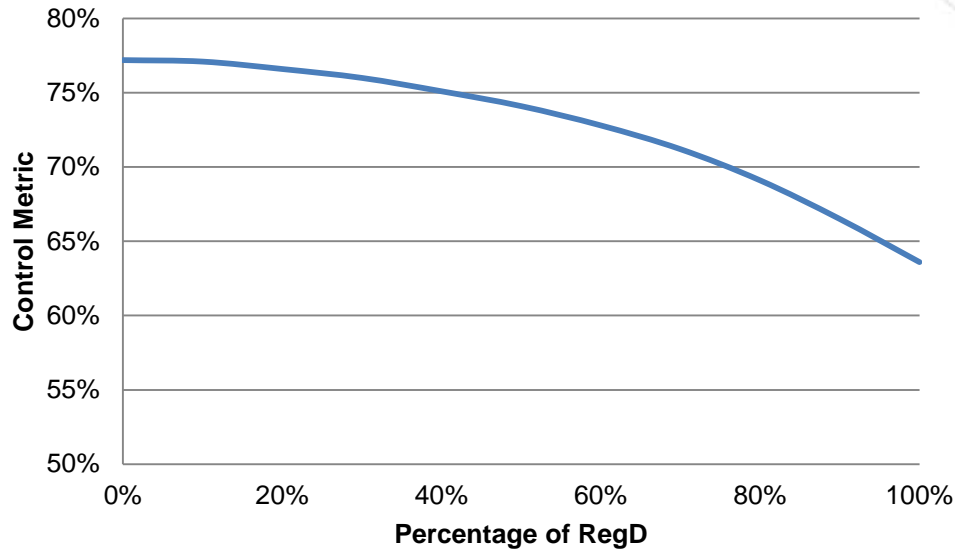
- Control Metric Improvement from 74% to 76.7%
- Large increase in control during large ACE excursion
- Decrease in control when ACE is more neutral (second half of hour)

RegA = 521.0 Raw MW

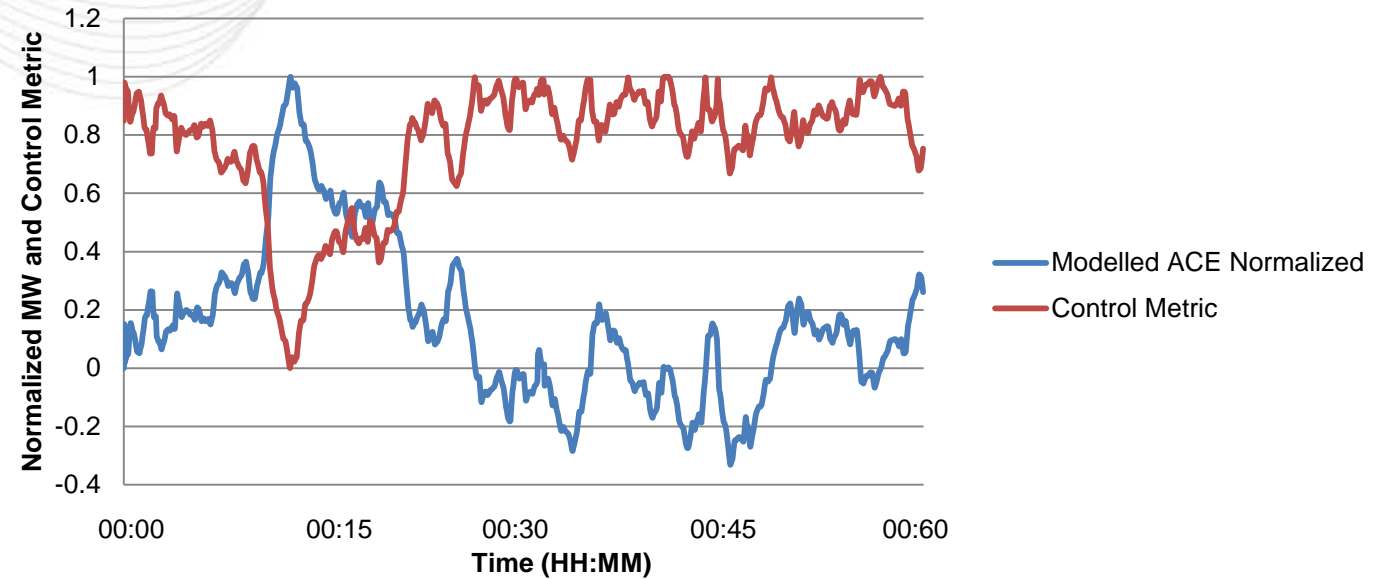
RegD = 127.3 Raw MW

RegD % = 19.6%

ACE Control as RegD % Increases



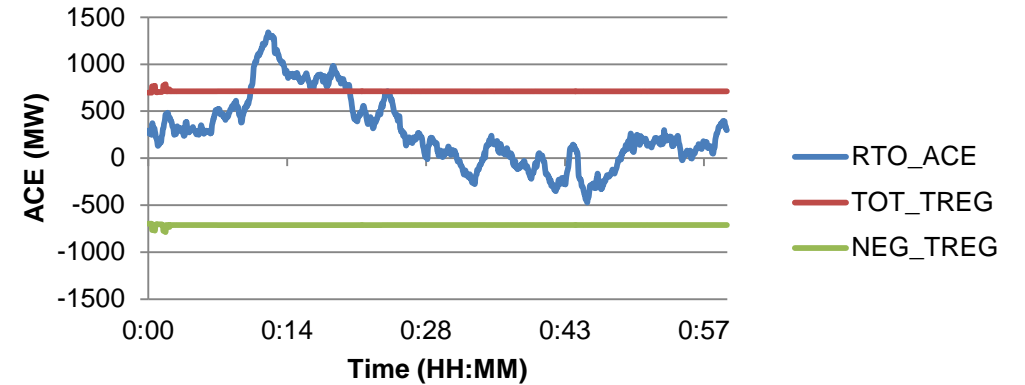
Normalized ACE for Control Metric



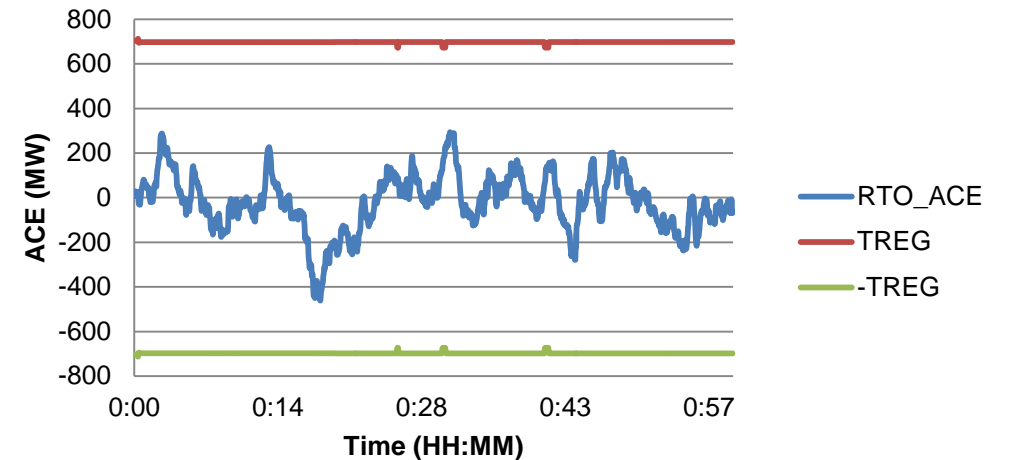
- Control Metric calculated based on June 02, 2015 HB13 EPT data
- Total regulation MW held constant at 700 raw MW while % of RegD changed from 0 to 100
- Higher Control Metric = Better Control (100% = ACE at 0)
- Control Metric purely based on amount of deviation of ACE from 0
 - CPS1 is partly based on frequency error which does not change in current simulation software

- Investigated various regulation hours
 - Hours with large ACE excursion
 - Hours where ACE is neutral
- Run hours through Python simulation tool
 - Vary Regulation D from 0% to 100% and observe Control Metric
- Determine optimal mix for reliable system control
 - Needed for interim solution

Large ACE Excursion

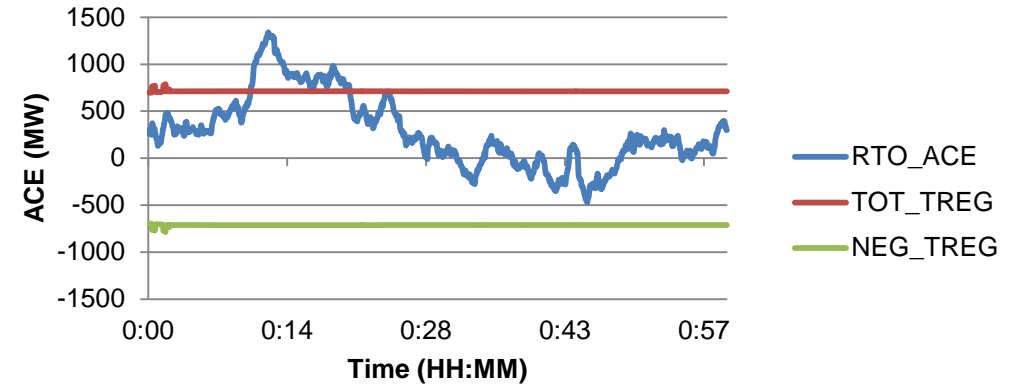


ACE More Neutral

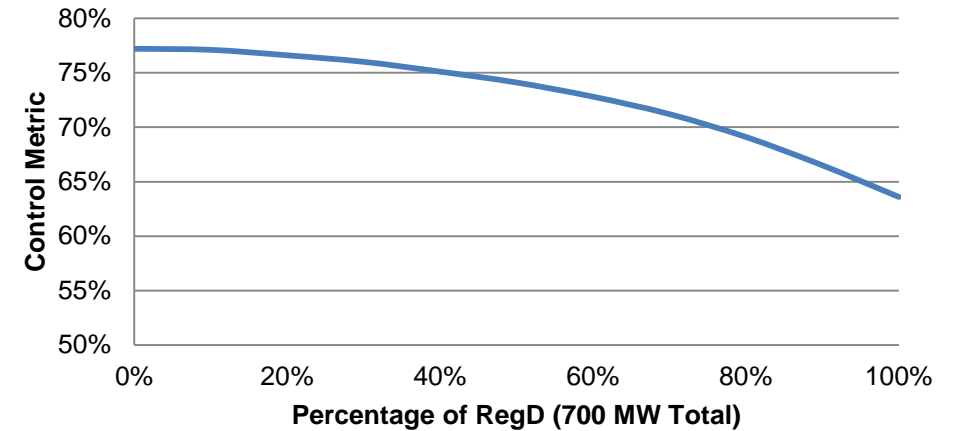


- During large ACE excursion, less RegD needed for optimal control
 - After approximately 20% of RegD we see diminishing returns as more RegA is swapped for RegD resources
- Why is this true?
 - During ACE excursions greater than 15 minutes, RegD signal will turn against ACE control
 - With adjustment to RegD signal neutrality this curve would change

Large ACE Excursion

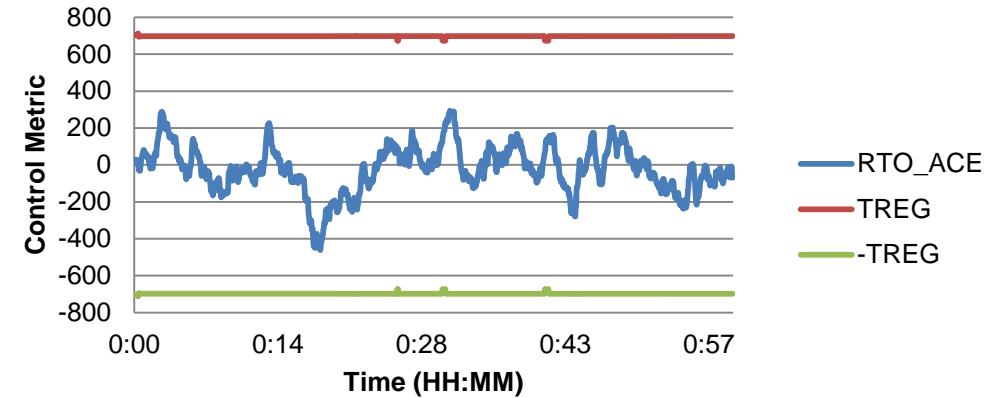


ACE Control as RegD % Increases

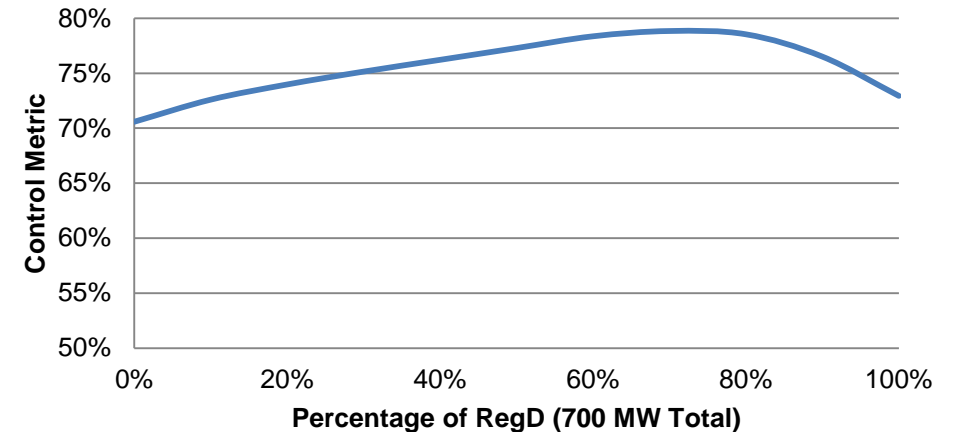


- During more neutral ACE movement, more RegD needed for optimal control
 - With 78% of the MW consisting of RegD there is optimal control
- After 78%?
 - Because the neutrality component still exists, there is a saturation point where too much RegD is controlling ACE (> 78% RegD)

ACE More Neutral



ACE Control as RegD % Increases



- Continue to Analyze Alternate Solutions
 - No Neutrality
 - Adjustments to Time Constants of Filters
 - Regulation Signal Tuning
- Results are Recorded
 - Will turn into documented procedure for studies

