WECC WORKSHOP

AUTO TIME ERROR CORRECTION

WELCOME

Randy Beckwith

- Introductions
- Arrangements
  - Breaks
  - Vendor get togethers?
- Sign Up Sheet on Registration Form
- Question Forms
- Sign Up Sheet for Extra Help

ACTION ITEMS

- CMOPS has approved three OC Handbook changes
  - ACE Equation
  - II Payback Procedure
  - TE Control Procedure
- OC approved February 2002
- BOD approved October 2002
  - This workshop sets the effective date.

BACKGROUND

Warren McReynolds

- TOO MANY MANUAL TIME ERROR CORRECTIONS - > 50 per month
- CMOPS assigned PWG to RECOMMEND CORRECTIVE ACTION
- PWG Recommended going after the root cause of Time Error

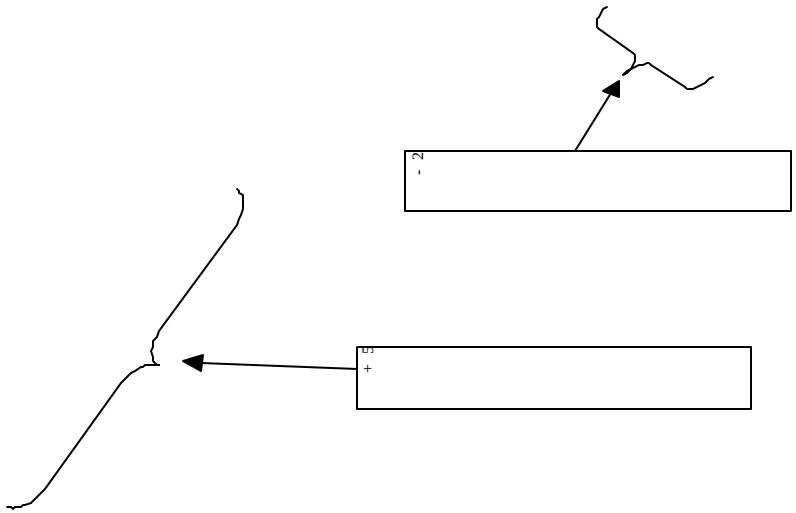
ROOT CAUSES of TE

- Errors in Measurement
  - Frequency
  - Net Interchange
- Errors in Schedules
  - Frequency
  - Net Interchange Schedules
- Inadequate Control System or Telecommunications
- Energy Conversion Units Responsive to AGC dispatch
  - Not available
  - Not assigned

SO WHAT?

- Time Error Costs Money
- 23 minutes of accumulated TE in 2000
  - 425,500 MWh of correction
  - means 425,500 MWh of poor performance in the first place

TE is still Accumulating



Terminology

- Bias is a negative number
  - Subscript n is your control area
  - Subscript s is the WECC
  - Subscript i are the other control areas
- ε is time error
- I is interchange or inadvertent interchange
- II is inadvertent interchange
- B or β is frequency bias setting
- L_{10} is the NERC CPS2 10-minute ACE limit

Let's Decompose Time Error

- $\varepsilon_n = -(6 / B_s) * (I_n - BII - \beta_n * \varepsilon_s / 6)$

WECC TE

WECC Bias

- It is a function of the WECC & your:

  Frequency Bias

  &

  Inadvertent Interchange

- The second term is found in AIE surveys
- If you can control your Inadvertent Interchange, you can control yourTE

Let's Decompose Inadvertent

- The component of area (n) inadvertent interchange caused by the regulating deficiencies of area (n) itself is called:
- PRIMARY INADVERTENT INTERCHANGE

- $I_{nn} = [(B_s - \beta_n) / B_s] * (I_n - BII - \beta_n * \varepsilon_s / 6)$

  - I_n is $NI_A - NI_S$
  - The second term is found in AIE surveys
  - BII is bilateral inadvertent interchange payback for inadvertent accumulated prior to February 4, 2003.

Secondary Inadvertent Interchange

- The component of area inadvertent interchange caused by the control area (i)
  - I_{ni} is II in area n caused by area i (must decompose I_{ii})
  - I_{in} is II in area i caused by area n (must decompose I_{nn})
  - I_{ni} is not equal to I_{in}

- $I_{ni} = -[Y_n / (1-Y_i)] * I_{ii}$
- $I_{in} = -[Y_i / (1-Y_n)] * I_{nn}$
  - where $Y_n = \beta_n / B_s$ and $Y_i = \beta_i / B_s$

Primary Time Error & Primary II are Mathematically Interchangeable

- You cause your own Primary II and
- You respond with Secondary II from your Frequency Bias Obligation

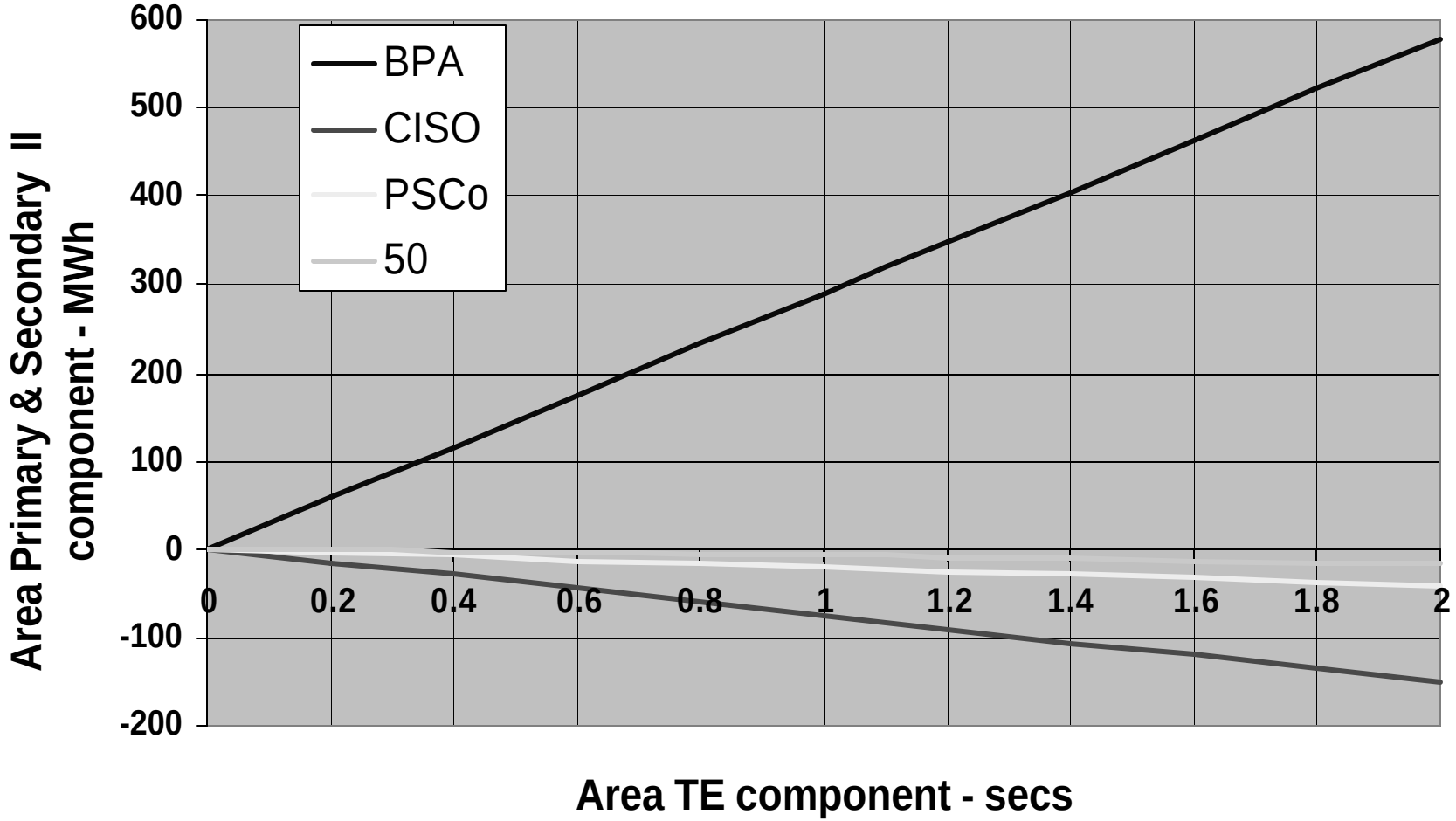
$$I_{nn} = -(B_s - \beta_n)\,\varepsilon_n \,/\, 6$$

$$I_{in} = (\beta_i \,/\, 6)\,\varepsilon_n$$

$$I_n = I_{nn} + \Sigma\, I_{in}$$

- Whenever any one of the three components, ε_n , I_{nn} , or I_{in} , is zero, the others will also be zero.

Western System Bias Relationship on TE & II



Sign Relationships

- ε_n is not necessarily of the same sign as ε_s
- I_{nn} is not necessarily of the same sign as I_n
- ε_n and I_{nn} are always the same sign
- I_{in} in all remote areas i are always of the opposite sign to ε_n and I_{nn}

How do you alter decomposed I_n and ε_n ?

- Area n component ε_n may be obscured in ε_s by ε_i components of areas i, but it can only be altered by area n.
- Area n primary component I_{nn} may be obscured in I_n by I_{ni} secondary components caused by areas i, but it can only be altered by area n.
- Area n components ε_n and I_{nn} , and components I_{in} in all areas i are all linearly related, and all curves defining these relations pass through the zero-zero origin, so that when one is zero, all are zero.

So What do we do with this Information?

- Since you know who did what to whom, you could develop a settlement process
  - Requires all II accounts fully reconciled
  - Requires all frequency bias settings are known
  - Requires N*(N-1) matrix for every hour
- Single Step Corrective Control
  - Already have necessary information - ε_s, I_n, B_s, $\beta_{n\cdots}$
  - Simple hourly accounting process to compute I_{nn} for on-peak and off-peak.
  - Simple hourly accounting process to track ΔTE
  - No need to compute secondary inadvertent interchange

Add Auto TE / II Payback to ACE

- This is a single step correction approach
  - Use of existing II accounting to compute a correction term:
  - $\Sigma II_{primary}$ / [(1 - Y) * H]
    - $Y = \beta / B_{wecc}$
    - H = correction time period in hours
    - $\Sigma II_{primary} = II_{primary} + (1-Y) * (II_{actual} - BII - \beta * \Delta TE/6)$
    - Track On/Off Peak $\Sigma II_{primary}$
  - Correction Term must be $\leq |L_{10}|$ or $|0.2* \beta|$

ACE Equation

Bart McManus

- Review of the ACE equation modes
- Start from existing equation
  - Modified TE control
  - Tie Line Bias + TE control
  - Turned off TE control Oct. 1, 1997
- Transition to Auto TE Control
  - Auto Unilateral $II_{primary}$ payback

ACE in Flat TL mode

(constant interchange)

- $NI_A - NI_S$ → Net Interchange Deviation
- $-T_{ob}$ → Bilateral II Payback
- $+I_{ME}$ → Compensation

Used when frequency error equipment is out of service

ACE in Constant Frequency mode

- $-10\beta (F_A - F_S)$ → Frequency Bias Obligation
- I_{ME} → Compensation

Used during islanded operation or black out restoration

ACE in TLB + TD mode

Revised July 26, 1989

Exclude from CPS

- $T_1 - T_0$ → Net Interchange Deviation
- $-10*B_f*(F_1 - F_0)$ → Frequency Bias Obligation
- $-s*(0.3B_t * t_d)$ → Modified Time Error Obligation
- $-T_{ob}$ → Bilateral II Payback
- $+ C$ → Compensation

WECC Switched to TLB

October 1, 1997

- The TD portion did not coordinate with CPS1 or CPS2
- It did not have provisions for tracking on-peak & off-peak TE (EPRI report on CPS)
- It did not have bounds like the Eastern Interconnection uses for Unilateral II Payback to coordinate with CPS2.

ACE in TLB + TD mode

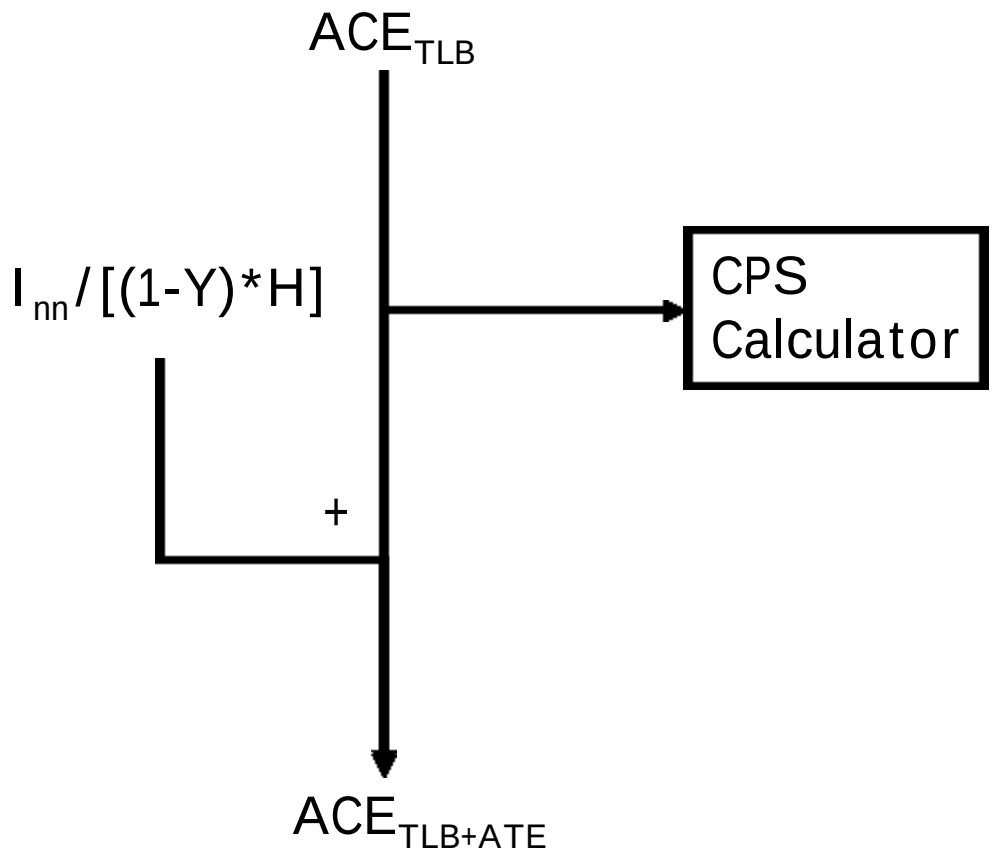
Revised 2002

Exclude from CPS

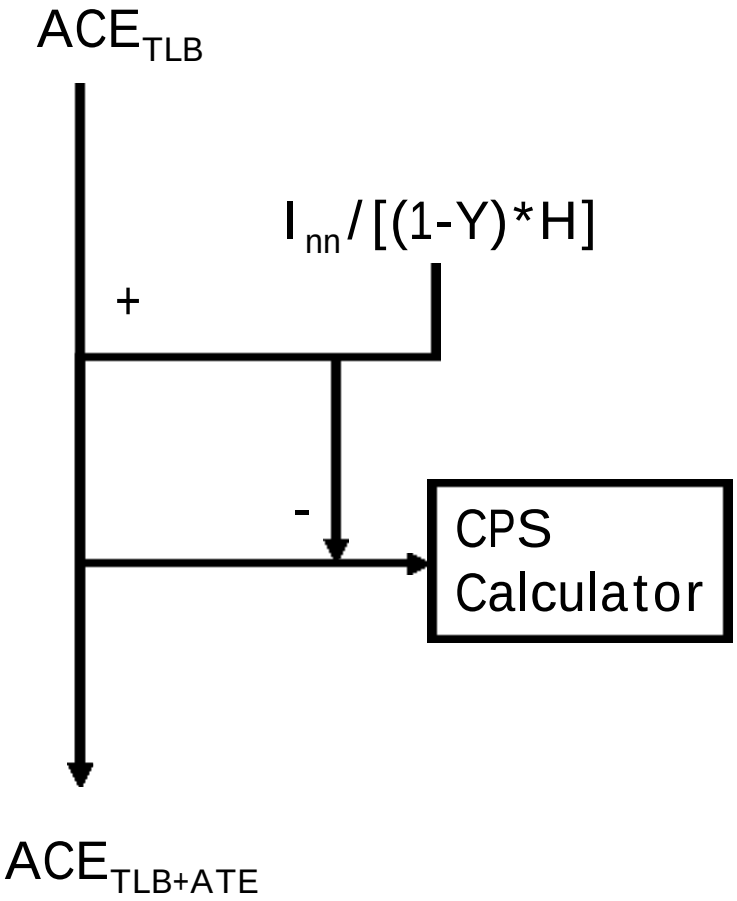
- $NI_A - NI_S$ → Net Interchange Deviation
- $-10\beta (F_A - F_S)$ → Frequency Bias Obligation
- $+II_{primary}/[(1-Y)*H]$ → Auto TE Obligation (Unilateral II Payback)
- $-T_{ob}$ → Bilateral II Payback
- $+I_{ME}$ → Compensation

Coordination with CPS

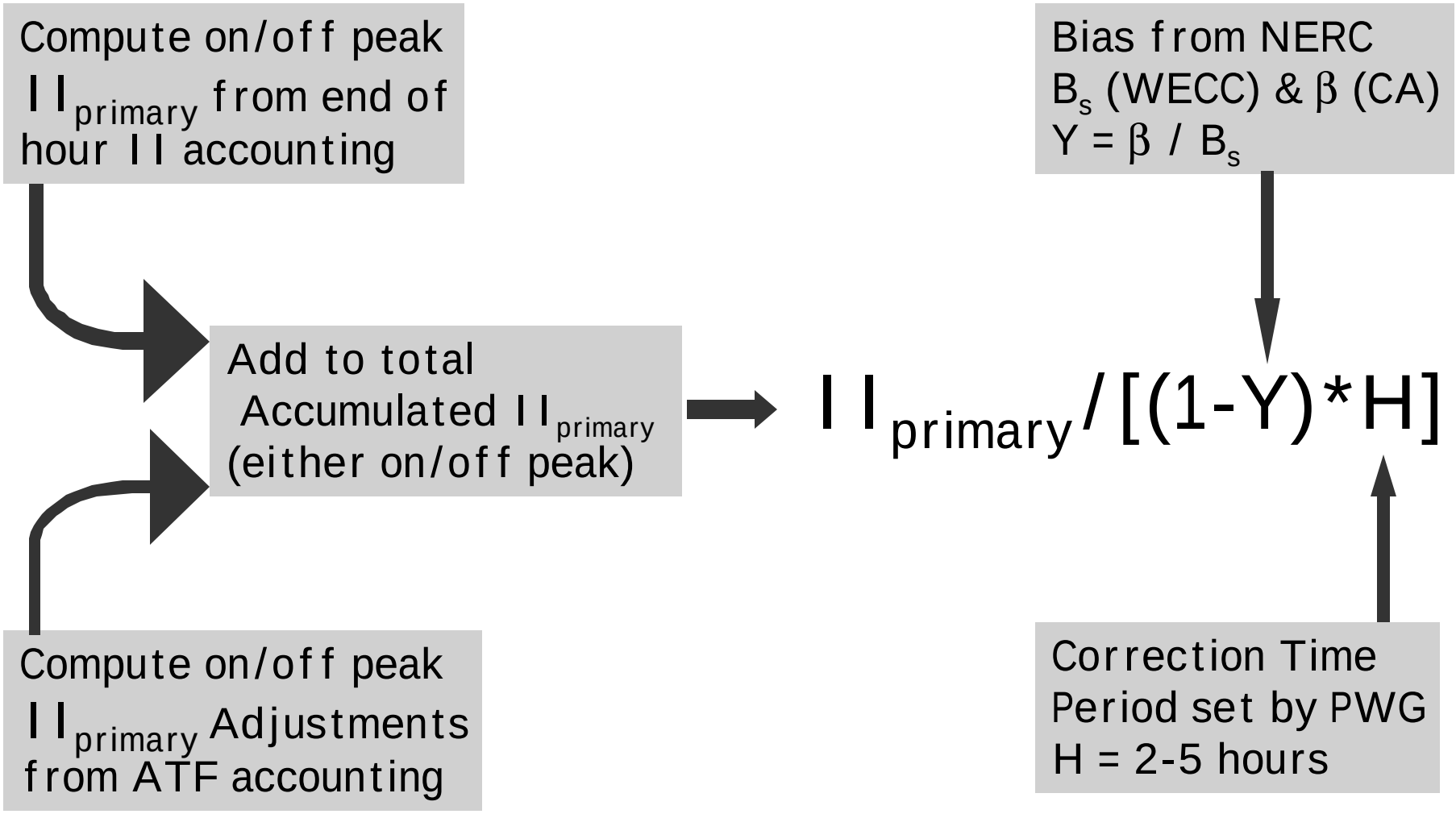
Functional Model



Alternative Model



Where do the terms come from?



Setting Control Limits

NERC Policy 1.F (Unilateral Paybacks)

$I I_{primary} / [(1-Y)*H]$ is limited to L_{10}

Will this limit my CPS control room?

- Assume 1000 MW generator trip and recovery ramps back within DCS period.
- 1000 MW in 15-minutes is 125 MWh
- Poisson probability says happens 1 in 3 years in the WECC for control areas & reserve sharing groups.
- You may have a few hours of maximum payback obligation that causes CPS2 violations
- If this happens, change the ATE limit to 0.2*Bias

Setting Rate of Payback – H

Set by Performance WG

- To avoid hunting
  - Set rate to be slow enough to allow completion of hourly accounting
  - ~3 hours
- To keep TE & II bounded
  - Set rate to reduce $II_{primary}$ balances in a timely manner (~ 5 hours)

Computing Primary II Hourly

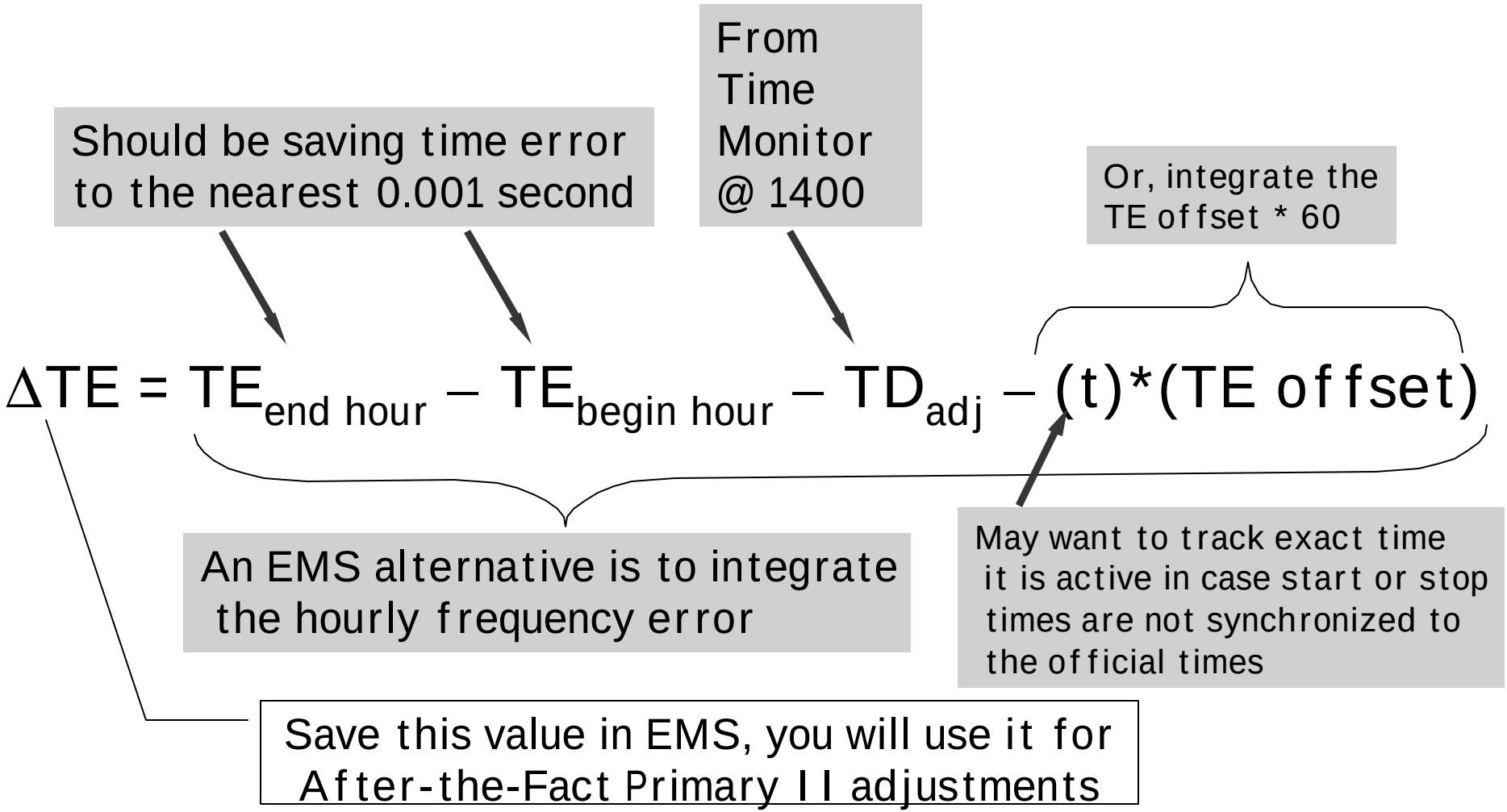
Don Badley

- During Hourly Control Area Checkout
  - Complete your hourly Inadvertent Interchange determination.
  - It is possible that some errors will creep in when checkout is incomplete. Continue your standard practice to complete hourly verification as best you can.
- Use II result to compute Primary II

Components of Primary II

- Last hour's total II (same as always)
- Last hour's accumulated Primary II_{nn}
- Change in TE from previous hour (use your local TE from your local frequency error source). Time Monitor does not provide hourly TE.
- TE adjustments to match WECC Time Monitor (to synch with 1400 notice)
- Manual TE offset (-0.02, 0.0, +0.02)
- Number of minutes of manual TE correction you did last hour (0, 30, 60)

Compute Last Hour's TE Change



Alternative ΔTE Computation

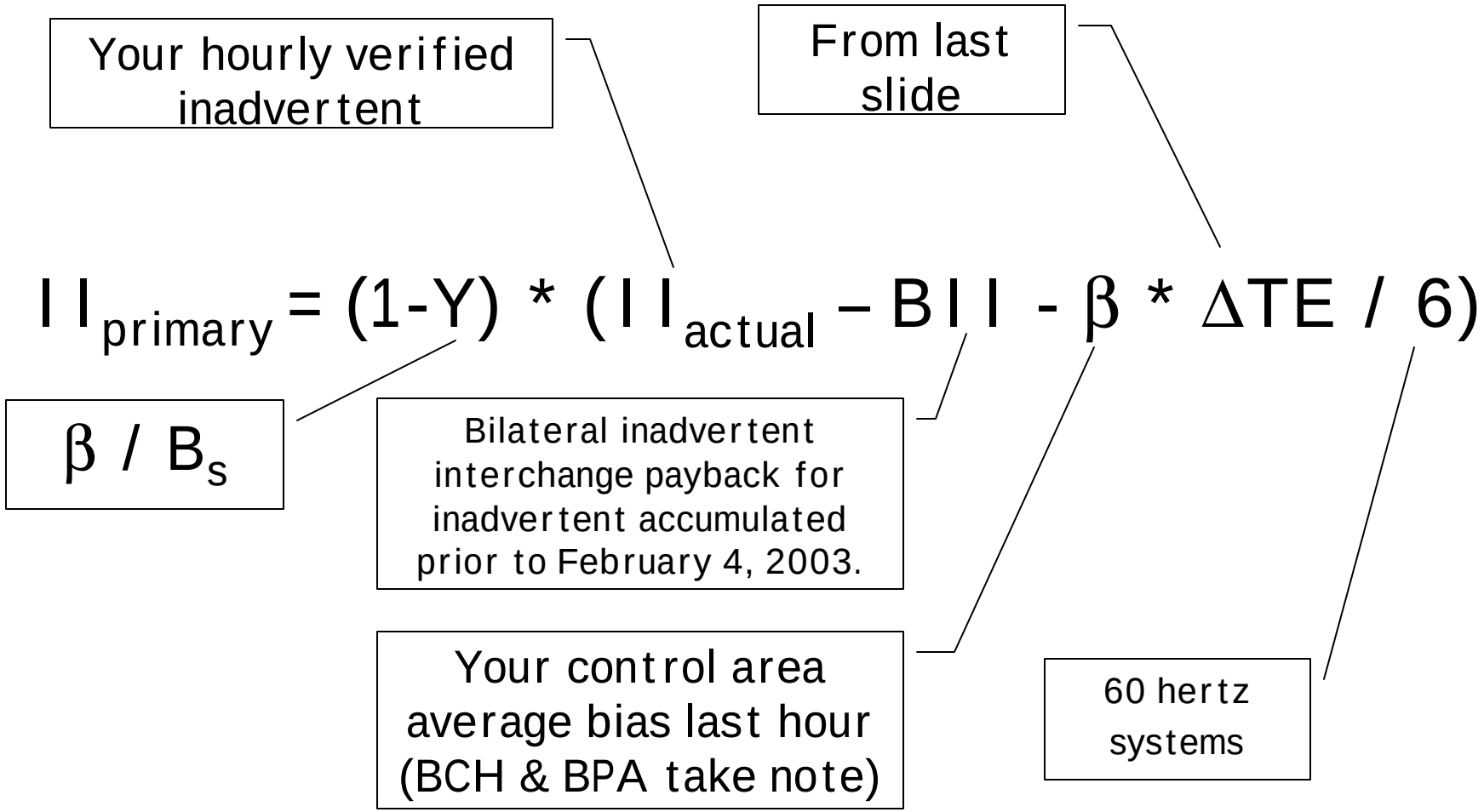
$$\Delta TE = 1/60 \int \Delta F$$

for clock-hour time error change

$$TE = TE_{adjust} + 1/60 \int \Delta F$$

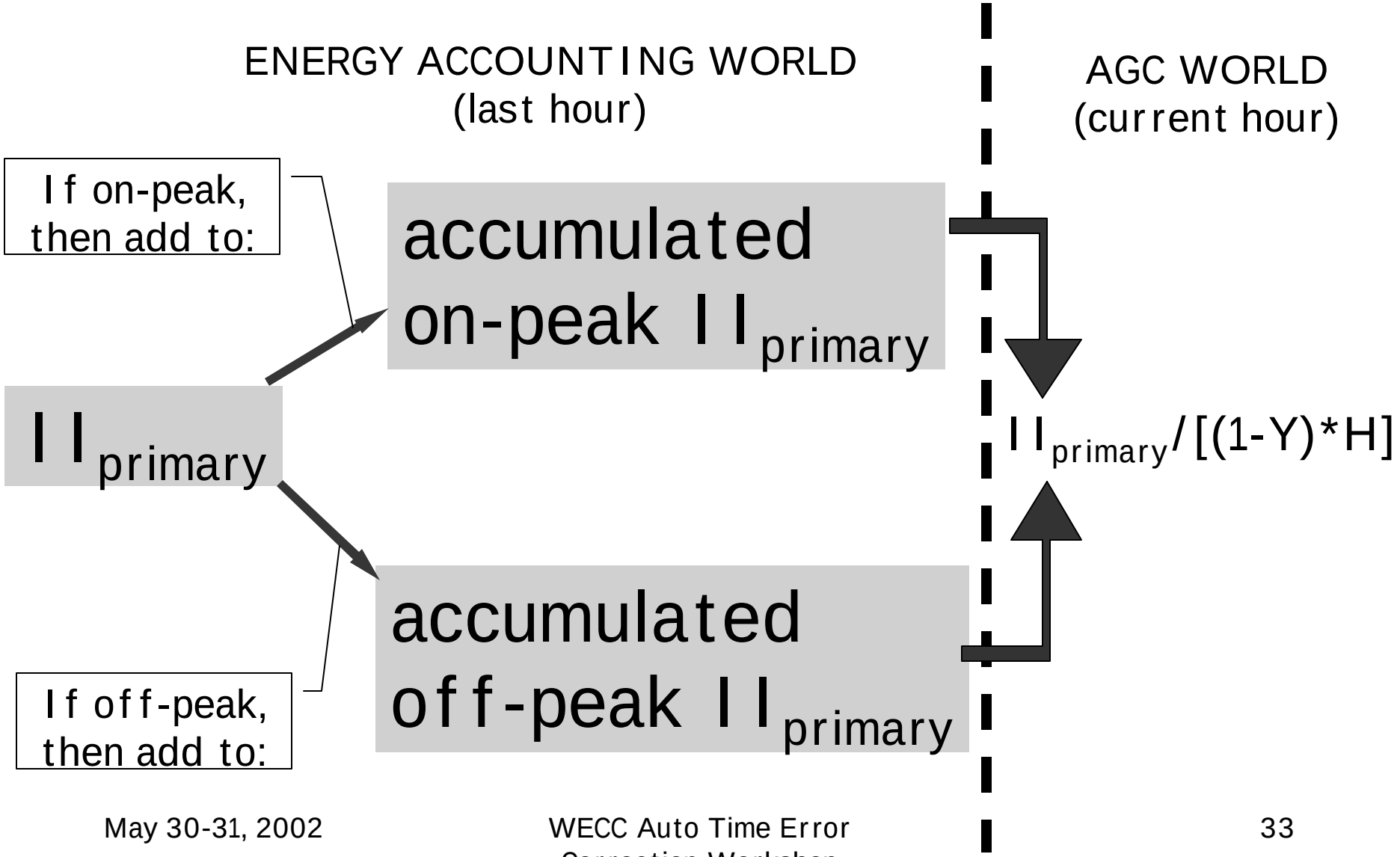
for continuous time error (useful to compare calibration of frequency source to WECC Time Monitor)

Compute Last Hour's Primary II



Accumulate Primary II

(separated into on-peak or off-peak totals)



Accumulate Primary II

(words in case the picture is confusing)

- If last hour was on-peak, then add last hour's Primary II to the accumulated on-peak Primary II.
- If last hour was off-peak, then add last hour's Primary II to the accumulated off-peak Primary II.
- Send appropriate accumulated on/off peak Primary II to AGC.

Go to the Spreadsheet Example

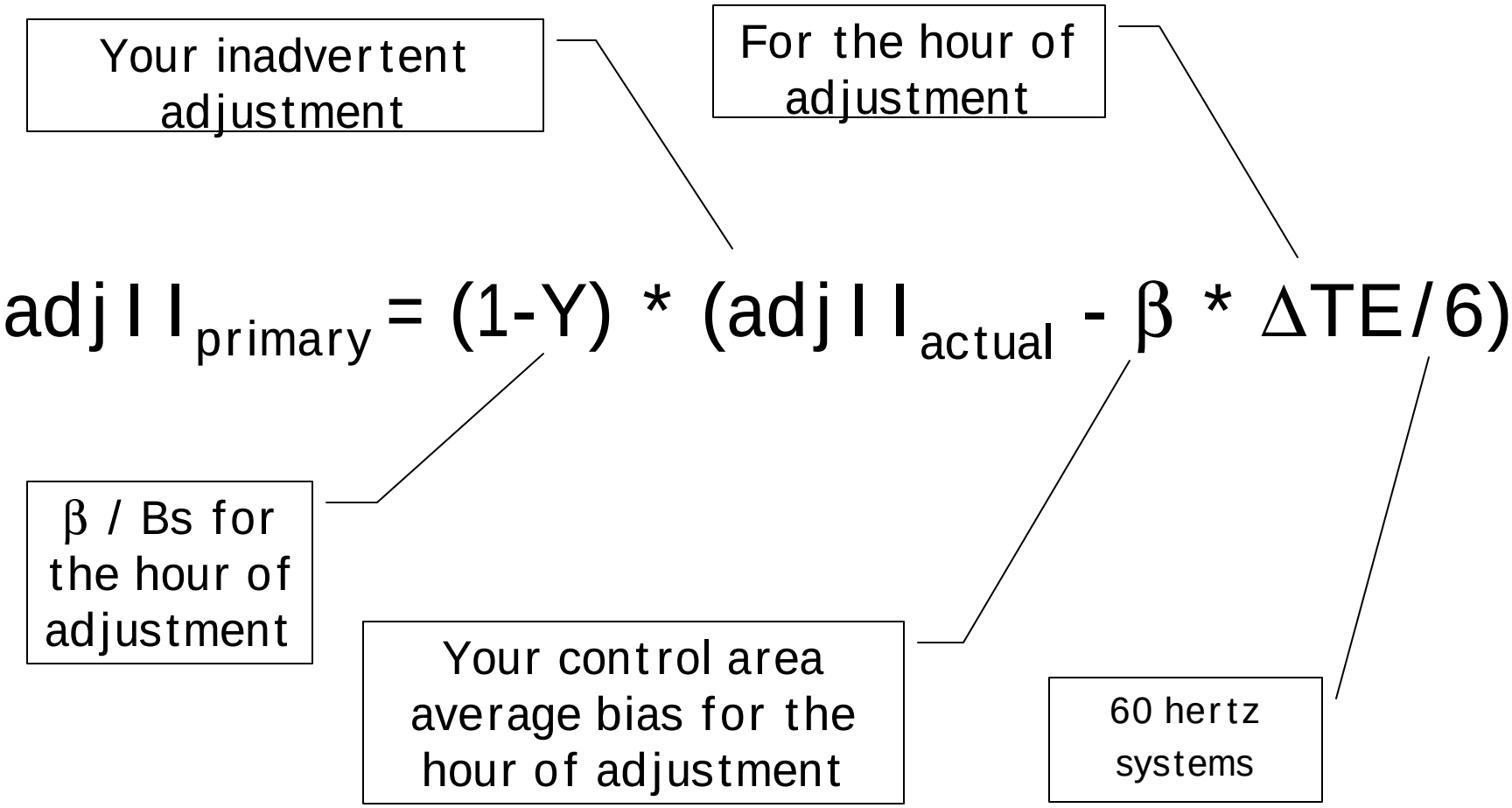
- Shows one 24 hour period referenced to Pacific Time Zone
- Input your CA bias
- Input your CA hourly II
- Input the clock-hour TE
- Input any TE adjustments to match CISO
- Input any manual TE adjustments
- Result is hourly Primary II
- Add any after-the-fact adjustments
- Add to accumulated on/off peak Primary II
- Send to AGC

After-the-Fact Primary II Adjustments

- For each hour requiring adjustment:
  - Retrieve that hour's ΔTE saved previously
  - Retrieve that hour's β / B_s saved previously
  - Use the same spreadsheet equation from hourly II accounting,
  - Compute the equivalent Primary II adj.
- All meter adjustments are 100% Primary II
- Accumulate the hourly on/off-peak Primary II adjustments and forward to AGC

Compute Adjusted Primary II

(skip hours that have no adjustments)

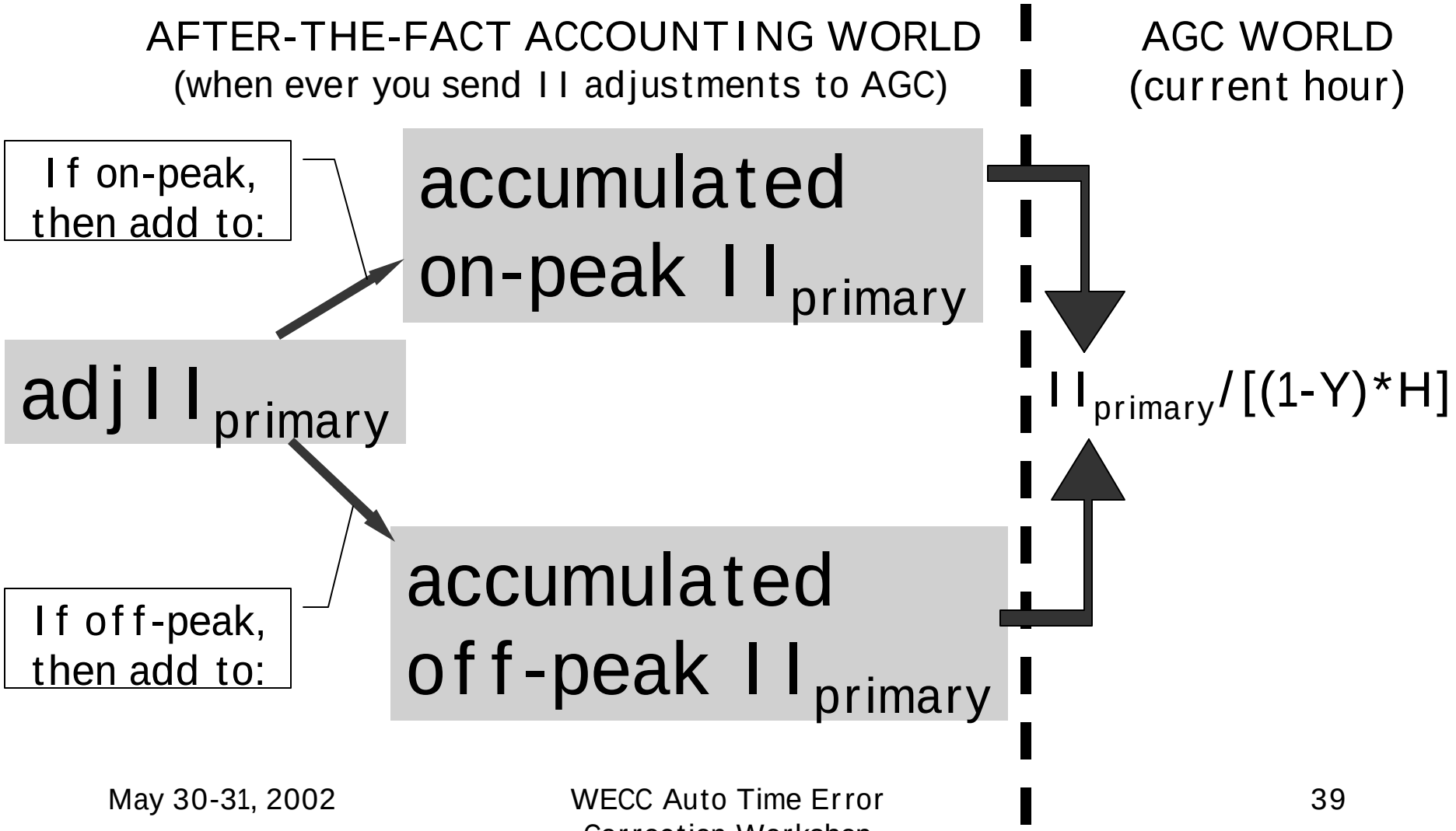


Compute Meter Error Adjusted Primary I I

$$adjII_{primary} = adjII_{actual}$$

Bring Forward Adjusted Primary II for all hours

(separated into on-peak or off-peak totals)



Spreadsheet Example

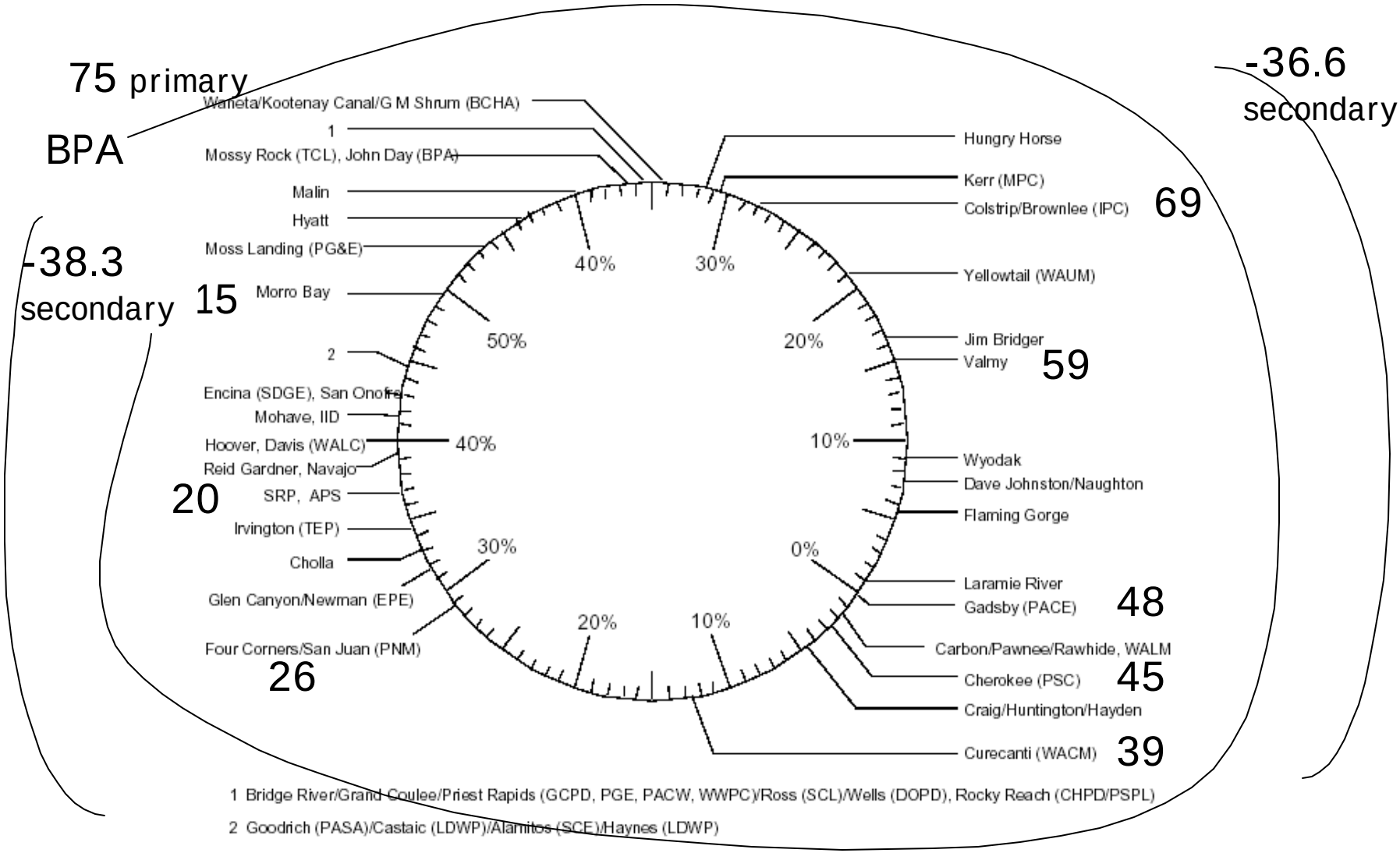
- Use the same spreadsheet (Adjustments tab)
- Substitute your adjustments into the hourly inadvertent interchange column for the year & month & hour of adjustment
- Since the Adjusted Time Error and bias are already saved, the Primary II adjustment is computed directly.

Miscellaneous Items

all

- Loop Flow
- Legacy Systems
- Interfaces between AGC and Accounting
  - Helpful tool to determine I_{ME}
- Temporary Short Cuts until I can make changes
  - Does size of control area bias matter?
  - Does variable bias mess up the accounting?
- Do we turn off Auto TE during manual TE?

Does Unilateral II affect Loop Flow?



My AGC is too Old to Change

- Try these approaches:
  - From your spreadsheet:
    - Compute Hourly Primary II
    - Add it to your Accumulated Primary II
    - Factor in the L_{10} & H limits
- Then add the correction to:
  - Eastern Interconnection Unilateral payback

Meter Error Correction Term

- $NI_A - NI_S$
- $-10\beta (F_A - F_S)$
- $+II_{primary}/[(1-Y)*H]$
- $-T_{ob}$
- $+I_{ME}$

Stay on TLB control mode to omit this term

Can use this term if not part of CPS

How Can Meter Error Correction Determined?

Review of Hourly ACE

- Dispatchers have an hourly ACE tool to determine “Regulator Error”
- Helpful for figuring how much “compensation” to add to meter error term in ACE
- Spreadsheet tool.

Most Vendor AGC has the Eastern Interconnection Unilateral Payback term

- $NI_A - NI_S$
- $- 10\beta (F_A - F_S)$
- $+ II * 0.20 * \beta$
  - limited to L_{10}
- $- T_{ob}$
- $+ I_{ME}$

The rate of correction is 20% of bias. The Primary II has to be substituted as the accumulated (limited) II. Will require investigation into your AGC's specific features

My Accounting System is very customized

- Although the spreadsheet lays out the method
  - You can integrate the follow-on computation manually or automatically
  - Remember to “Paste Special” values only after each hour.
  - If you do not archive hourly ΔTE, there may be some help using daily on/off peak average TE.

Can I cut some Corners?

- If After-the-Fact adjustments are small
  - Adjusting AGC with the non-converted inadvertent interchange will result in a two step correction
  - That means new Primary II is created and will be corrected in the next accounting

What about Variable Bias?

- Using the NERC reported average bias
  - Makes for easier computation
  - Less information to save
  - Differences that do occur will result in two step correction
  - Similar to the after-the-fact impact

When Bias is Very Small

- The Y term is very small, that makes my Primary II almost the same as hourly II
  - Yes, in the short run.
  - As long as you correct continuously, the two will be very nearly equal
  - Control Areas having difficulty controlling properly will see Primary II build up regardless of bias size.

Manual TE Corrections

- Keep computing your Primary II
- Keep correcting for your Accumulate Primary II

Closure

Randy Beckwith

- Probably more detail than you wanted
- Avenues presented to change your AGC and accounting systems

OR

- Transitional approaches to continue to use what you have

Setting the Effective Date

- Feedback from you today
- Who wants more help today?
- Who wants more help at their control center?
- Last change to ACE equation was implemented in 6 months.

Action Items

- Remove old TE correction from ACE
- Add $II_{primary}$ correction to ACE
- Modify Hourly Accounting to compute $II_{primary}$, on-peak $II_{primary,}$, off-peak $II_{primary}$
- Modify ATF Accounting, if necessary, to compute $adjII_{primary}$
- Continue BII paybacks prior to effective date.
- Freeze I_n totals once Auto TE becomes effective and use BII paybacks only for remaining balances
- Set Effective Date – February 4, 2003 0900 PST

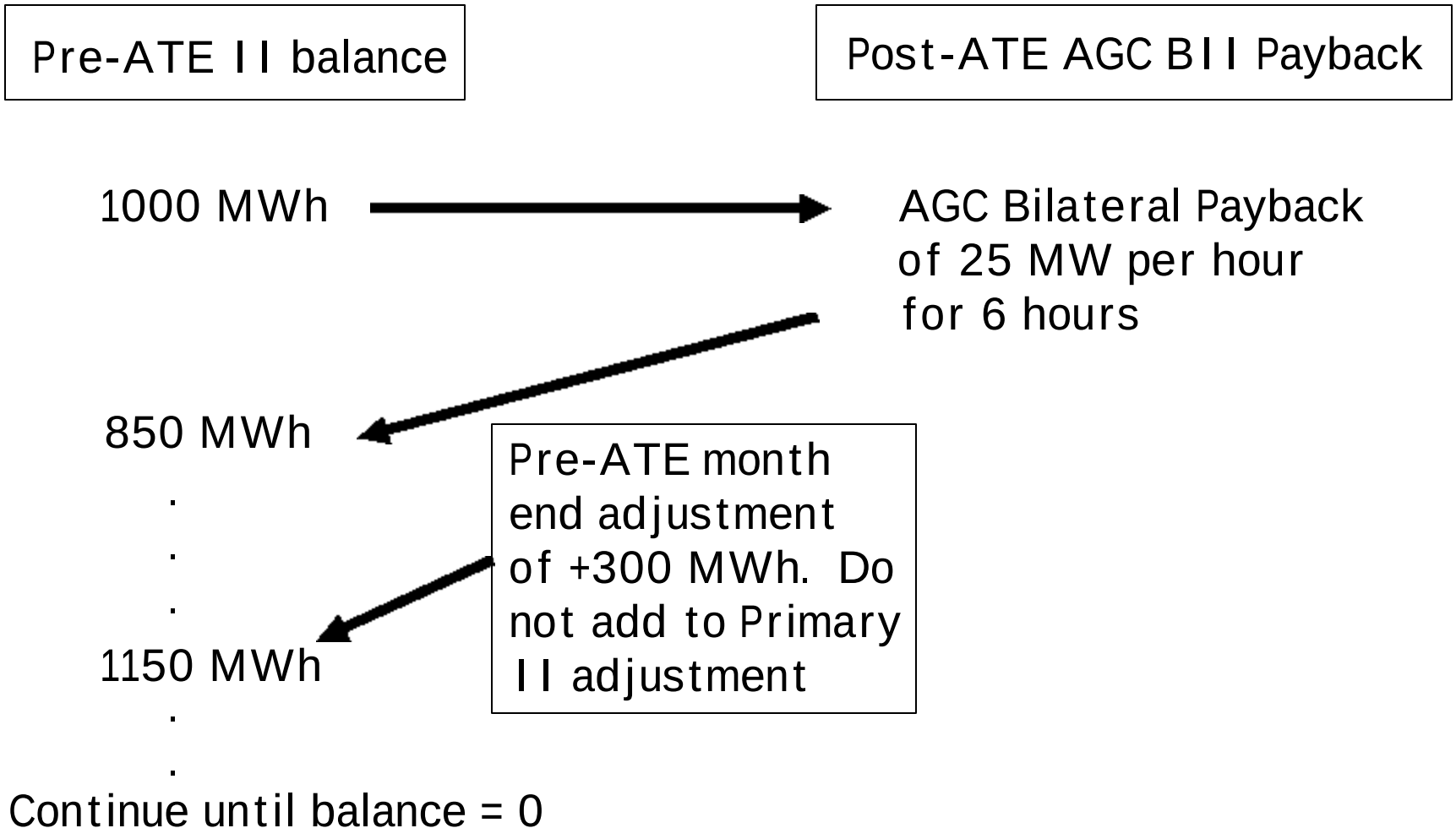
AGC sends clock-hour data to Hourly Accounting

- Time Error (x.xxx seconds) from your frequency source
- Time Error adjustment when the 1400 Pacific time notice results in dispatcher changing your local time error setting
- Total seconds of WECC manual time error correction (0.00, ±0.60, ±1.20)
- Control Area frequency bias setting
- WECC frequency bias setting
- Integrated Primary II correction last hour
- Bilateral II payback in MWh

Hourly Accounting sends last hour's results to AGC

- Hourly Primary Inadvertent Interchange (xxx.xx MWh)
- Accumulated Primary Inadvertent Intechange (on-peak, off-peak)
- Remaining MWh balance of Pre-February 4th Inadvertent Interchange

Continue Bilateral II Payback



WAVIERS

- Every Control Area must begin Primary II computation at the same time to avoid trapped Pre-ATE Inadvertent Interchange.
- Use workaround in AGC to begin Auto Time Error corrections.
- Always call your Performance WG representative for assistance

On-Site Help

- Wlmcreynolds@bpa.gov
- 360 418 8705

- Bamcmanus@bpa.gov
- 360 418 2309