

Two Example Remedial Action Schemes



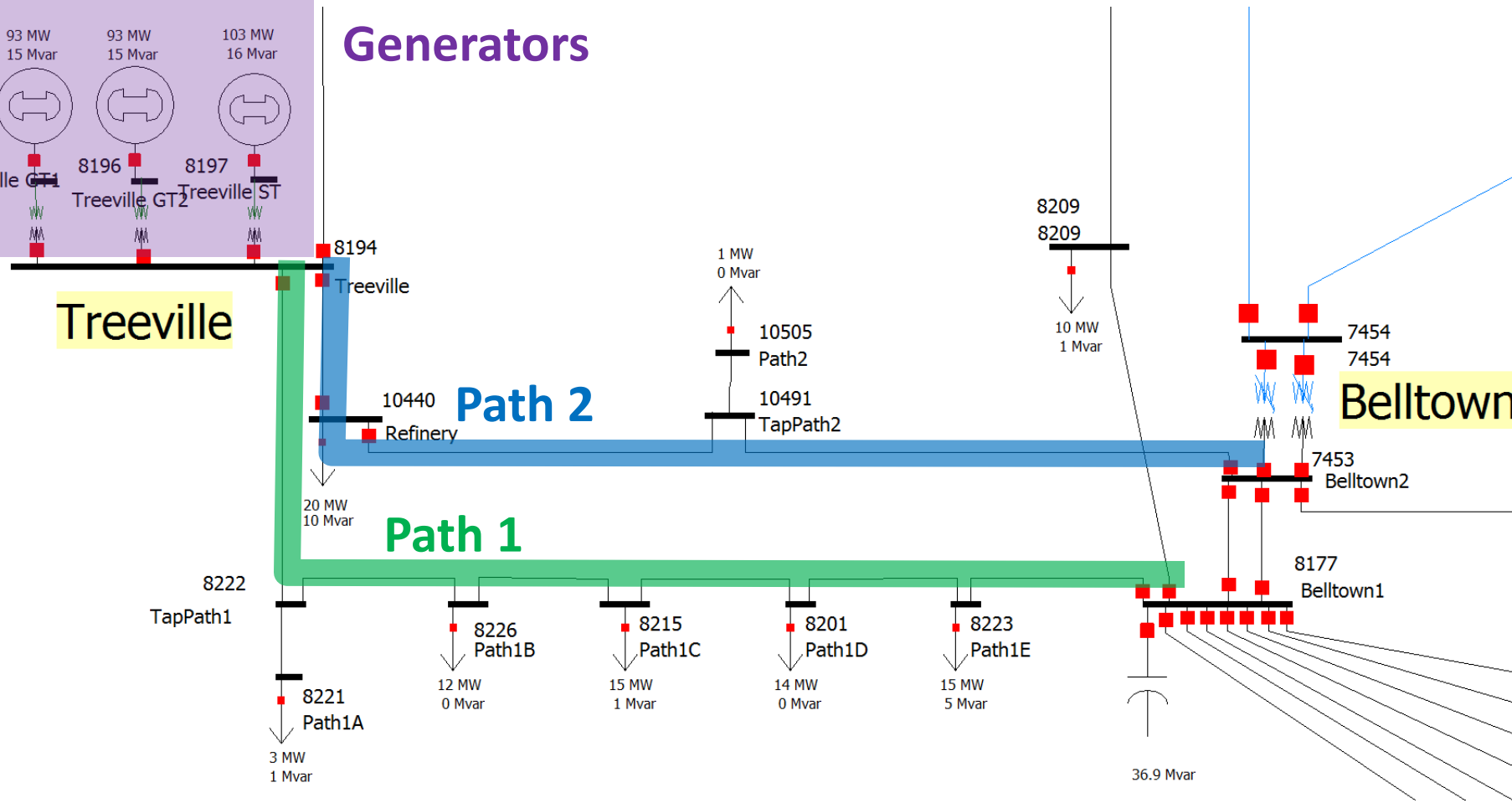
- Complex Thermal RAS – “Treeville” RAS
 - This is a real RAS, but we’ve made up names so we can put this presentation on public websites
 - Complex Thermal-based RAS
 - Ordering of actions using Time Delay matters
- One of Two Line Outage with Generation Dropping
 - Handling the base case condition matters
 - Injection Group Dropping
 - Lookup Table
 - Merit Order
 - TOPOLOGYCHECK important

Treeville RAS Close-up



Gas #1	Gas #2	Steam
93 MW 15 Mvar	93 MW 15 Mvar	103 MW 16 Mvar
8195 Treeville GT1	8196 Treeville GT2	8197 Treeville ST

Treeville Generators



Belltown

Note on Presentation



- For presentation of a concept, I will do the following
 1. Describe the RAS logic
 2. Show how that would be defined in a Dialog
 3. Show how that is represented in the RAS and Contingency File Format AUX file (text file)
- You'll see that the AUX file represents a bunch of tables
 - Power engineers are accustomed to tables of data about buses, gens, lines, areas, zones, owners, etc...
 - This is just a bunch of tables describing the logic, lookups, etc...

Treeville RAS Overview



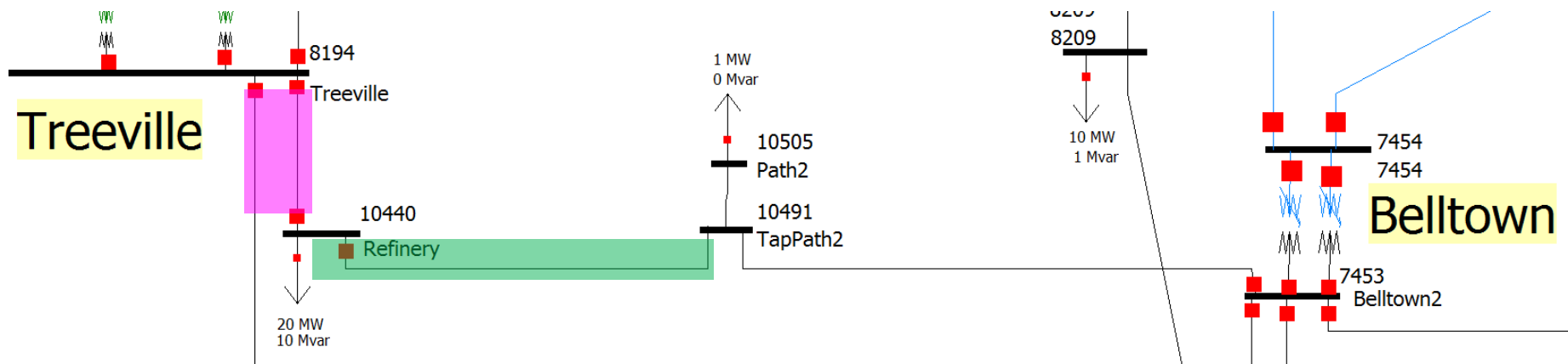
- 4 Separate Control Actions Possible
 1. Ramp Treeville generation down by 40 MW in two minutes
 2. Trip one Treeville gas combustion turbine
 3. Trip the all the Treeville generators
 4. Trip path of the 115 kV line going to the Refinery
- You will see Time Delay used for Actions 1-3
- Action 4 we'll cover first because it's so simple

Treeville RAS: Control Action #4



Refinery to TapPath2 > 110%
of seasonal facility rating \longrightarrow Trip the Treeville to Refinery Line

- If Green Line Overloads then Trip Pink Line



Treeville RAS Control Action #4: ModelCondition Dialog



Type =
Branch

Choose
Branch

Condition
for Branch

Define Model Conditions

Model Condition Name: Refinery to TapPath2 > 110%

Buttons: Save, Save As, Rename, Delete

Evaluate in Contingency Reference State
 Disable if True in Contingency Reference State

Element Type: Branch

49990 entries
Sort by: Name (selected), Number

Filter: Advanced, Branch

Use Area/Zone Filters Quick Define Remove

Search Next Search All

You can use wildcard characters * or ?

List of entries (selected entry highlighted in blue):
Path1D (8201) TO Path1C (8215) CKT 1 [115 kV] - [115 kV]
Path1D (8201) TO Path1E (8223) CKT 1 [115 kV] - [115 kV]
Path1E (8223) FROM Belltown1 (8177) CKT 1 [115 kV] - [115 kV]
Path1E (8223) FROM Path1D (8201) CKT 1 [115 kV] - [115 kV]
Path2 (10505) FROM TapPath2 (10491) CKT 1 [115 kV] - [115 kV]
Refinery (10440) FROM TapPath2 (10491) CKT 1 [115 kV] - [115 kV]
TapPath1 (8222) TO Path1B (8226) CKT 1 [115 kV] - [115 kV]

Meets the filter below Set Filter Same As

Select Filter Type: Branch

Pre-filter using Area/Zone/Owner Filters Logical Comparison: AND (selected), OR, Not AND, Not OR
 Enabled (normally checked)

Condition 1:
Find... Limit Monitoring\% at To Bus greater than or equal to 110 ABS
 Use Another Filter

Buttons: Add >>, Delete ...

Enable Field to Field Comparisons

Buttons: OK, Help, Cancel

Treeville RAS Control Action #4: RemedialAction



Choose Branch to Open

Model Criteria points
to ModelCondition

Contingency Element Dialog

Element Type
 Branch
 Generator
 Load
 Switched Shunt
 Bus
 Interface
 Injection Group
 Multi-Section Line
 Series Capacitor
 Phase Shifter
 3-Winding Transformer
 Line Shunt
 DC Line
 DC Converter
 Area
 Substation
 Abort
 Contingency Block

Choose the Element
Sort by Name Number

Search For Near Bus	Select Far Bus, CKT
9996 (9996) [115 kV]	TapPath2 (10491) [115 kV] CKT 1
9997 (9997) [115 kV]	Treeville (8194) [115 kV] CKT 1
9998 (9998) [115 kV]	
9999 (9999) [230 kV]	
Belltown1 (8177) [115 kV]	
Belltown2 (7453) [115 kV]	
Path1A (8221) [115 kV]	
Path1B (8226) [115 kV]	
Path1C (8215) [115 kV]	
Path1D (8201) [115 kV]	
Path1E (8223) [115 kV]	
Path2 (8250) [115 kV]	
Refinery (10440) [115 kV]	
TapPath1 (8222) [115 kV]	
TapPath2 (10491) [115 kV]	
Treeville (8194) [115 kV]	
Treeville GT1 (8195) [13.8 kV]	
Treeville GT2 (8196) [13.8 kV]	
Treeville ST (8197) [13.8 kV]	

Action Type
 Open
 Close
 Move
 Set To
 Change By

Amount
0
Constant
Find...
 Evaluate in Reference State
Make-up Power Sources ...

Status: POSTCHECK

Model Criteria: Refinery to TapPath2 > 110%

Inclusion Filter:

Time Delay: 0.000000 seconds

Comment: Control Action #4

Treeville RAS Control Action #4: File Format

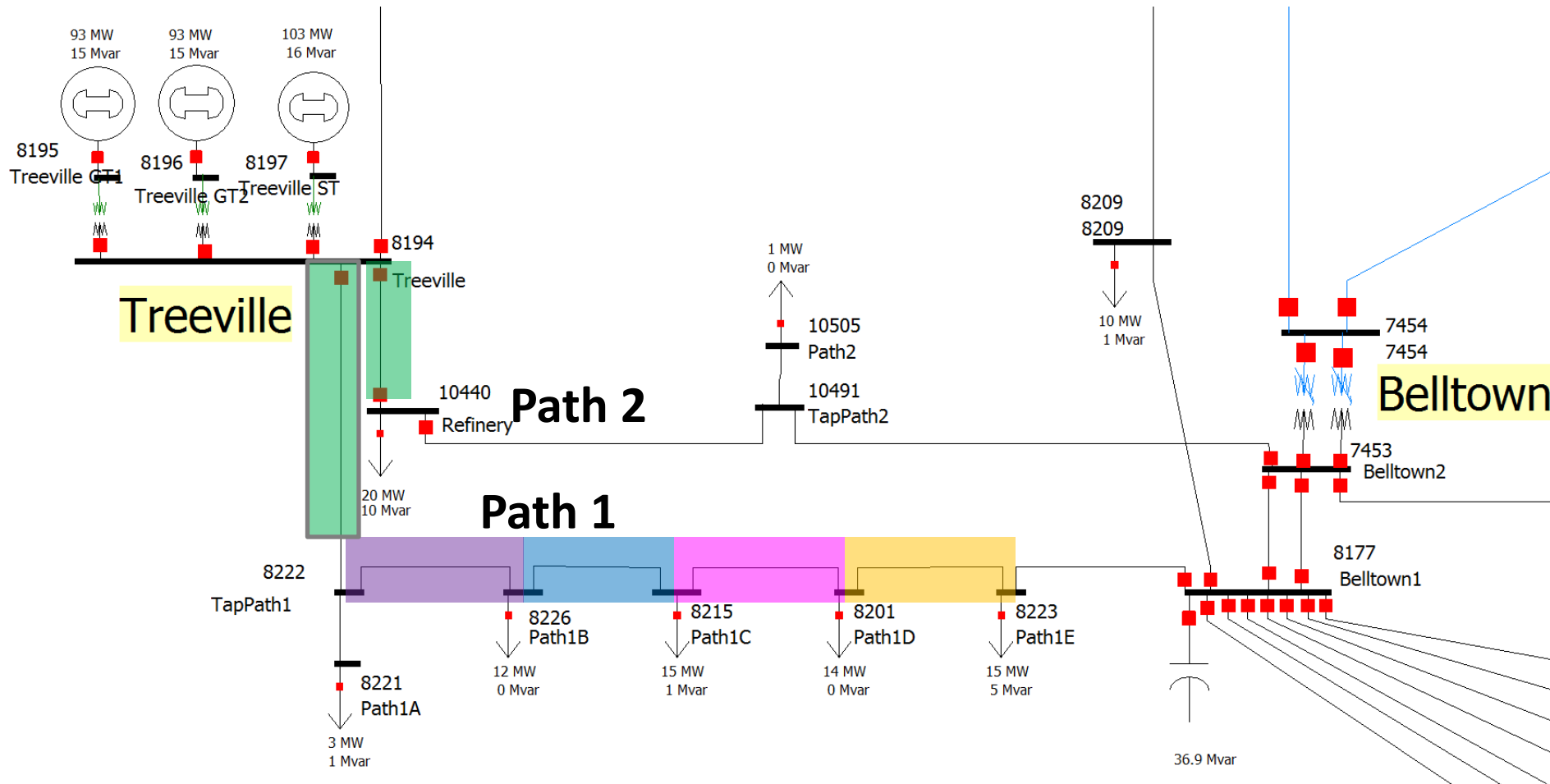


```
MODELCONDITION (Name, Object, FilterObjectType, FilterLogic,
                EvaluateInRef, DisableIfTrueInRef, Memo)
{
"Refinery Tap2 > 110%" "Branch '10491' '10440' '1'" "Branch" "AND" "NO" "NO" " " ""
}
MODELCONDITIONCONDITION (ModelCondition, CondNum, ObjectField,
                          ConditionType, Value, OtherValue, Absolute)
{
"Refinery Tap2 > 110%" 1 "Percent" ">=" "110" "" "NO" " "
}

REMEDIALACTION (Name, Skip, Memo)
{
"Treeville Generation Run-Back Scheme" "NO" " " ""
}
REMEDIALACTIONELEMENT (RemedialAction, Object, Action, Criteria, CriteriaStatus,
                       TimeDelay, InclusionFilter, Comment)
{
"Treeville Generation Run-Back Scheme" "BRANCH 10440 8194 1" "OPEN"
  "Refinery Tap2 > 110%" "POSTCHECK" 0 "" "Control Action #4"
}
}
```

Color Codes for Treeville RAS

Control Actions #1, #2, #3



Treeville RAS: Control Action #1



- Logic provided by utility that manages RAS

ModelConditions

Path 1A to 1B > 95%

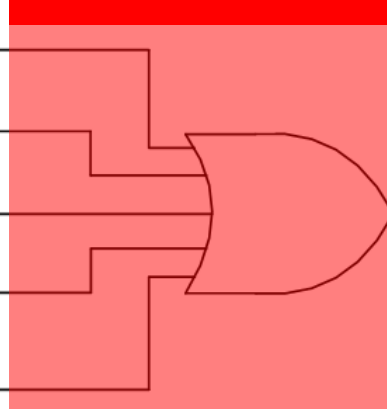
Path 1B to 1C > 95%

Path 1C to 1D > 95%

Path 1D to 1E > 95%

Path 2 > 102%

Model Filter



Model Expressions And RemedialAction

Proportionally Reduce Gas Turbine
Outputs by 40 MW (see not 1)

Set Steam Turbine Outputs for drop of
GT output (see not 2)

Time Delay = 120 s

Notes:

1. CT model expressions are $-(x1/(x1+x2)*40)$ for unit 1 and $-(x2/(x1+x2)*40)$ for unit 2 where $x1$ =actual MW output of unit 1 and $x2$ =actual MW output of unit 2.

2. ST model expression is $x5*((x1+x2-40)/(x3+x4))$ where $x1$ =actual MW output of unit 1, $x2$ =actual MW output of unit 2, $x3$ =Pmax of unit 1, $x4$ =Pmax of unit 2 and $x5$ =Pmax of steam unit.

Define Model Conditions: Path 1A to 1B > 95%



Type =
Branch

Choose
Branch

Model Condition Name: Path 1A to 1B > 95%

Buttons: Save, Save As, Rename, Delete

Evaluate in Contingency Reference State
 Disable if True in Contingency Reference State

Element Type: Branch

49990 entries
Sort by: Name (selected), Number

Filter: Advanced, Branch

Use Area/Zone Filters
Buttons: Quick, Define, Remove

Search Next
 Search All

You can use wildcard characters * or ?

Selected entry: Path1B (8226) FROM TapPath1 (8222) CKT 1 [115 kV]- [115 kV]

Meets the filter below: Set Filter Same As

Select Filter Type: Branch

Pre-filter using Area/Zone/Owner Filters
 Enabled (normally checked)

Logical Comparison: AND (selected), OR, Not AND, Not OR

Condition 1: Limit Monitoring\% at From Bus greater than or equal to 95

Use Another Filter

Buttons: Add >>, Delete ...

Enable Field to Field Comparisons

Buttons: OK, Help, Cancel

Condition
for Branch

Define Model Conditions: Path 2 > 102%



Type =
Branch

Choose
Branch

Define Model Conditions

Model Condition Name: Path 2 > 102%

Buttons: Save, Save As, Rename, Delete

Evaluate in Contingency Reference State
 Disable if True in Contingency Reference State

Element Type: Branch

49990 entries
Sort by: Name (selected), Number

Filter: Advanced, Branch

Use Area/Zone Filters Quick Define Remove

Search Next Search All

You can use wildcard characters * or ?

- Path1D (8201) TO Path1C (8215) CKT 1 [115 kV]- [115 kV]
- Path1D (8201) TO Path1E (8223) CKT 1 [115 kV]- [115 kV]
- Path1E (8223) FROM Belltown1 (8177) CKT 1 [115 kV]- [115 kV]
- Path1E (8223) FROM Path1D (8201) CKT 1 [115 kV]- [115 kV]
- Path2 (10505) FROM TapPath2 (10491) CKT 1 [115 kV]- [115 kV]
- Refinery (10440) TO Treosville (8194) CKT 1 [115 kV]- [115 kV]
- Refinery (10440) FROM TapPath2 (10491) CKT 1 [115 kV]- [115 kV]**
- TapPath1 (8222) TO Path1R (8226) CKT 1 [115 kV]- [115 kV]

Meets the filter below Set Filter Same As

Select Filter Type: Branch

Pre-filter using Area/Zone/Owner Filters Logical Comparison: AND (selected), OR, Not AND, Not OR

Enabled (normally checked)

Condition 1: Limit Monitoring\% at To Bus greater than 102 ABS

Use Another Filter

Buttons: Add >>, Delete ...

Enable Field to Field Comparisons

Buttons: OK, Help, Cancel

Condition
for Branch

Treeville RAS Control Action #1: ModelCondition File Format



```
MODELCONDITION (Name, Object, FilterObjectType, FilterLogic, EvaluateInRef,  
                DisableIfTrueInRef, Memo)
```

```
{  
"Path 1A to 1B > 95%" "Branch '8222' '8226' '1'" "Branch" "AND" "NO" "NO" " "  
"Path 1B to 1C > 95%" "Branch '8215' '8226' '1'" "Branch" "AND" "NO" "NO" " "  
"Path 1C to 1D > 95%" "Branch '8201' '8215' '1'" "Branch" "AND" "NO" "NO" " "  
"Path 1D to 1E > 95%" "Branch '8201' '8223' '1'" "Branch" "AND" "NO" "NO" " "  
"Path 2 > 102%" "Branch '10491' '10440' '1'" "Branch" "AND" "NO" "NO" " "  
}
```

```
MODELCONDITIONCONDITION (ModelCondition, CondNum, ObjectField, ConditionType, Value,  
                          OtherValue, Absolute)
```

```
{  
"Path 1A to 1B > 95%" 1 "Percent" ">=" "95" "" "NO" "  
"Path 1B to 1C > 95%" 1 "Percent" ">=" "95" "" "NO" "  
"Path 1C to 1D > 95%" 1 "Percent" ">=" "95" "" "NO" "  
"Path 1D to 1E > 95%" 1 "Percent" ">=" "95" "" "NO" "  
"Path 2 > 102%" 1 "Percent" ">" "102" "" "NO" "  
}
```

Treeville RAS Control Action #1: ModelFilter Dialog



OR Logic

List of Model
Conditions

The screenshot shows the 'Filter Conditions' dialog box. At the top, the 'Filter Name' is 'Path 1 > 95% OR Path 2 > 102%'. Below this are buttons for 'Save', 'Save As', 'Rename', 'Delete', and 'View Filter Logic'. The 'Logical Comparison' section has three radio buttons: 'AND', 'OR', and 'Not AND'. The 'OR' radio button is selected and highlighted with a red box. Below this is a list of model conditions, each with a checkbox, a 'Find...' button, a dropdown menu, and radio buttons for 'Condition', 'Filter', and 'Not'. The conditions are: 'Model Condition 2' (Path 1C to 1D > 95%), 'Model Condition 3' (Path 1A to 1B > 95%), 'Model Condition 4' (Path 1B to 1C > 95%), and 'Model Condition 5' (Path 2 > 102%). At the bottom are buttons for 'Add >>', 'Delete ...', 'Modify Model Conditions', 'OK', 'Help', and 'Cancel'.

Treeville RAS Control Action #1: ModelFilter File Format



```
MODELFILTER (Name,Logic,Memo)
```

```
{  
"Path 1 > 95% OR Path 2 > 102%" "OR" ""  
}
```

```
MODELFILTERCONDITION (ModelFilter,CondNum,Criteria,Logic)
```

```
{  
"Path 1 > 95% OR Path 2 > 102%" 1 "Path 1A to 1B > 95%" ""  
"Path 1 > 95% OR Path 2 > 102%" 2 "Path 1B to 1C > 95%" ""  
"Path 1 > 95% OR Path 2 > 102%" 3 "Path 1C to 1D > 95%" ""  
"Path 1 > 95% OR Path 2 > 102%" 4 "Path 1D to 1E > 95%" ""  
"Path 1 > 95% OR Path 2 > 102%" 5 "Path 2 > 102%" ""  
}
```

Treeville RAS Control Action #1: Model Expression

Move Steam Plant by the same net MW in proportion to Max MW

Reduce the net MW output of Gas Unit 1 and 2 by a 40 MW (move proportional to present output)



Define Model Expressions

Name: ST Output After Runback

Save Save As Rename Delete

Choose the Type of Expression

Expression Lookup Table

x1= Define... Gen Treeville GT1 (8195) #1 : Generator's present MW output

x2= Define... Gen Treeville GT2 (8196) #2 : Generator's present MW output

x3= Define... Gen Treeville GT1 (8195) #1 : Generator's maximum MW limit

x4= Define... Gen Treeville GT2 (8196) #2 : Generator's maximum MW limit

x5= Define... Gen Treeville ST (8197) #L : Generator's maximum MW limit

x6= Define... Choose a Model Field

x7= Define... Choose a Model Field

x8= Define... Choose a Model Field

function (x1, x2, x3, x4, x5, x6, x7, x8) =
x5*((x1+x2-40)/(x3+x4))

OK Help Cancel

Define Model Expressions

Name: GT2 Run Back Value

Save Save As Rename Delete

function (x1, x2, x3, x4, x5, x6, x7, x8) =
-(x2/(x1+x2)*40)

Define Model Expressions

Name: GT1 Run Back Value

Save Save As Rename Delete

function (x1, x2, x3, x4, x5, x6, x7, x8) =
-(x1/(x1+x2)*40)

Treeville RAS Control Action #1: ModelExpression File Format



```
MODELEXPRESSION (Name,Type,Expression,Memo,  
    Object1,x1,BlankZero1,Object2,x2,BlankZero2,  
    Object3,x3,BlankZero3,Object4,x4,BlankZero4,  
    Object5,x5,BlankZero5,Object6,x6,BlankZero6,  
    Object7,x7,BlankZero7,Object8,x8,BlankZero8)  
{  
"GT1 Run Back Value"      "Expression" "-(x1/(x1+x2)*40)" ""  
    "Gen '8195' '1'" "MW" "YES" "Gen '8196' '2'" "MW" "YES"  
    "" "" "NO " "" "" "NO " "" "" "NO " "" "" "NO " "" "" "NO "  
  
"GT2 Run Back Value"      "Expression" "-(x2/(x1+x2)*40)" ""  
    "Gen '8195' '1'" "MW" "YES" "Gen '8196' '2'" "MW" "YES"  
    "" "" "NO " "" "" "NO " "" "" "NO " "" "" "NO " "" "" "NO "  
  
"ST Output After Runback" "Expression" "x5*((x1+x2-40)/(x3+x4))" ""  
    "Gen '8195' '1'" "MW" "YES" "Gen '8196' '2'" "MW" "YES"  
    "Gen '8195' '1'" "MWMax" "YES" "Gen '8196' '2'" "MWMax" "YES"  
    "Gen '8197' 'L'" "MWMax" "YES" "" "" "NO " "" "" "NO " "" "" "NO "  
}
```

Treeville RAS Control Action #1: RemedialAction Gas Units



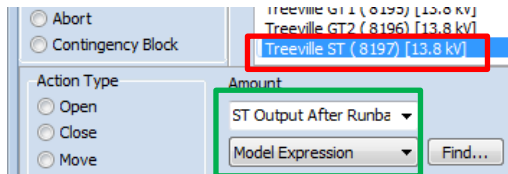
Choose Generator Unit 2

Model Expression for Unit 2

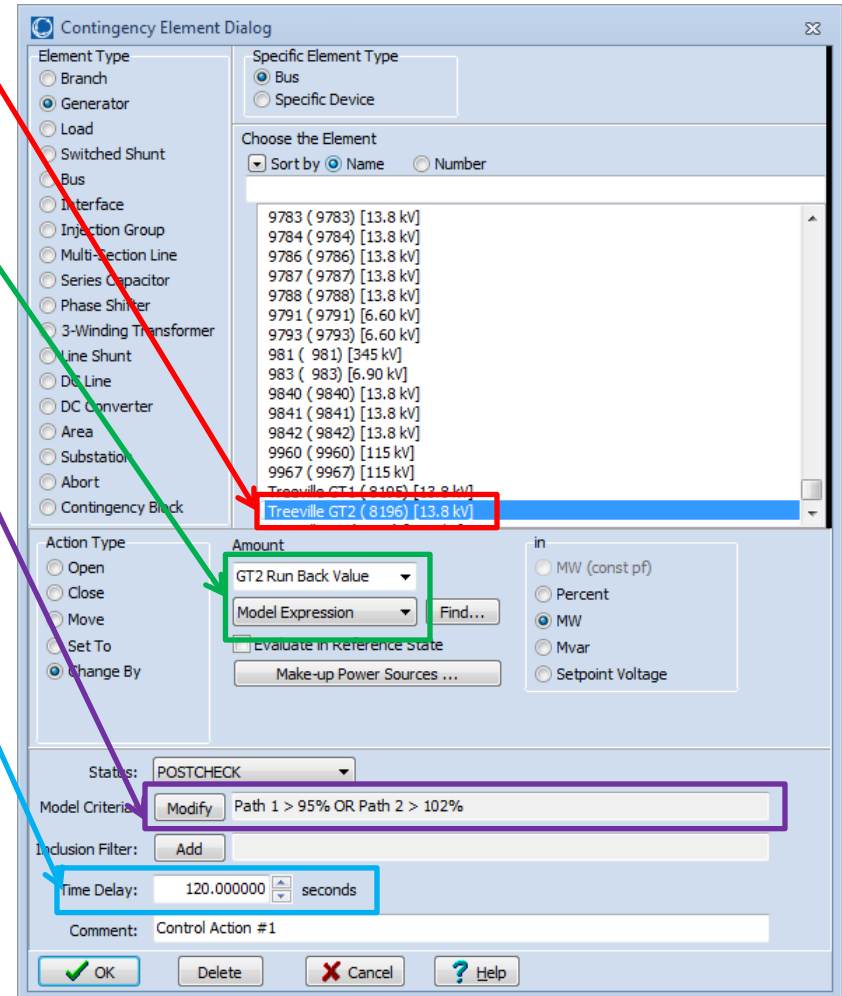
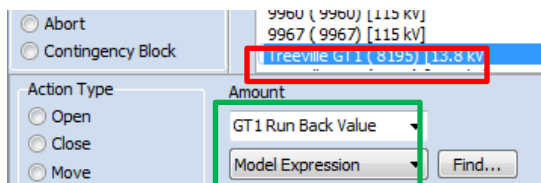
Model Criteria points to ModelFilter

Time Delay

Same but for Steam Unit



Same but for Unit 1



Treeville RAS Control Action #1: ModelExpression File Format



```
REMEDIALACTION (Name,Skip,Memo)
```

```
{  
"Treeville Generation Run-Back Scheme" "NO " "  
}
```

```
REMEDIALACTIONELEMENT (RemedialAction,Object,Action,Criteria,  
CriteriaStatus,TimeDelay,InclusionFilter,Comment)
```

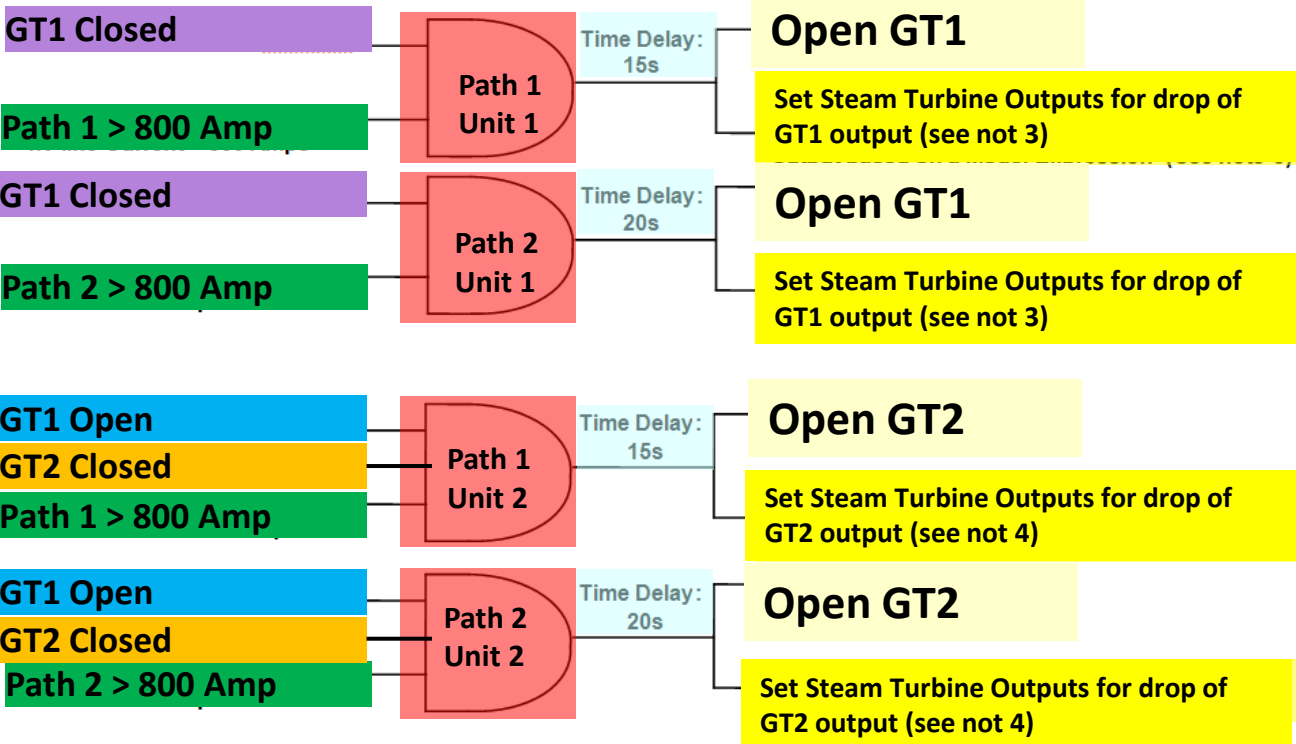
```
{  
"Treeville Generation Run-Back Scheme" "GEN 8195" "CHANGEBY 'GT1 Run Back Value' MW"  
    "Path 1 > 95% OR Path 2 > 102%" "POSTCHECK" 120.000000 "" "Control Action #1"  
  
"Treeville Generation Run-Back Scheme" "GEN 8196" "CHANGEBY 'GT2 Run Back Value' MW"  
    "Path 1 > 95% OR Path 2 > 102%" "POSTCHECK" 120.000000 "" "Control Action #1"  
  
"Treeville Generation Run-Back Scheme" "GEN 8197" "SETTO 'ST Output After Runback' MW"  
    "Path 1 > 95% OR Path 2 > 102%" "POSTCHECK" 120.000000 "" "Control Action #1"  
}
```

Treeville RAS: Control Action #2



ModelConditions

Time Delay
= 15 or 20 s



ModelExpressions RemedialActions

3. ST model expression is $x_5 * ((x_2) / (x_3 + x_4))$ where x_1 =actual MW output of unit 1, x_2 =actual MW output of unit 2, x_3 =Pmax of unit 1, x_4 =Pmax of unit 2 and x_5 =Pmax of steam unit .

4. ST model expression is $x_5 * ((x_1) / (x_3 + x_4))$ where x_1 =actual MW output of unit 1, x_2 =actual MW output of unit 2, x_3 =Pmax of unit 1, x_4 =Pmax of unit 2 and x_5 =Pmax of steam unit .

Set Steam Turbine Outputs for drop of GT1 output (see not 3)

ModelFilters

Treeville RAS Control Action #2:

ModelCondition ModelFilter



```

MODELCONDITION (Name, Object, FilterObjectType, FilterLogic, EvaluateInRef, DisableIfTrueInRef, Memo)
{
"GT1 Closed"      "Gen '8195' '1'"          "Gen" "AND" "NO" "NO" " " ""
"GT1 Open"        "Gen '8195' '1'"          "Gen" "AND" "NO" "NO" " " ""
"GT2 Closed"      "Gen '8196' '2'"          "Gen" "AND" "NO" "NO" " " ""
"Path 1 > 800 A"  "Branch '8222' '8194' '1'"  "Branch" "AND" "NO" "NO" " " ""
"Path 2 > 800 A"  "Branch '10440' '8194' '1'" "Branch" "AND" "NO" "NO" " " ""
}
MODELCONDITIONCONDITION (ModelCondition, CondNum,
    ObjectField, ConditionType, Value, OtherValue, Absolute)
{
"GT1 Closed"      1 "Status" "startswith" "C" "" "NO "
"GT1 Open"        1 "Status" "startswith" "O" "" "NO "
"GT2 Closed"      1 "Status" "startswith" "C" "" "NO "
"Path 1 > 800 A"  1 "AmpsMax" ">" "800" "" "NO "
"Path 2 > 800 A"  1 "AmpsMax" ">" "800" "" "NO "
}

```

```

MODELFILTER (Name, Logic, Memo)
{
"Path 1 Unit 1"  "AND" ""
"Path 2 Unit 1"  "AND" ""
"Path 1 Unit 2"  "AND" ""
"Path 2 Unit 2"  "AND" ""
}

```

```

MODELFILTERCONDITION (ModelFilter, CondNum, Criteria, Logic)
{
"Path 1 Unit 1"  1 "GT1 Closed"      ""
"Path 1 Unit 1"  2 "Path 1 > 800 A" ""
"Path 2 Unit 1"  1 "GT1 Closed"      ""
"Path 2 Unit 1"  2 "Path 2 > 800 A" ""
"Path 1 Unit 2"  1 "GT1 Open"        ""
"Path 1 Unit 2"  2 "GT2 Closed"      ""
"Path 1 Unit 2"  3 "Path 1 > 800 A" ""
"Path 2 Unit 2"  1 "GT1 Open"        ""
"Path 2 Unit 2"  2 "GT2 Closed"      ""
"Path 2 Unit 2"  3 "Path 2 > 800 A" ""
}

```

Treenville RAS Control Action #2: ModelExpression, RemedialAction



```

MODELEXPRESSION (Name,Type,Expression,Memo,Object1,x1,BlankZero1,Object2,x2,BlankZero2,Object3,x3,
BlankZero3,Object4,x4,BlankZero4,Object5,x5,BlankZero5,Object6,x6,BlankZero6,
Object7,x7,BlankZero7,Object8,x8,BlankZero8)
{
"ST Output for GT1 Outage" "Expression" "x5*((x2)/(x3+x4))" ""
    "Gen '8195' '1'" "MW" "YES" "Gen '8196' '2'" "MW" "YES"
    "Gen '8195' '1'" "MWMax" "YES" "Gen '8196' '2'" "MWMax" "YES"
    "Gen '8197' 'L'" "MWMax" "YES" "" "" "NO" "" "" "" "NO" "" "" "" "NO" ""
"ST Output for GT2 Outage" "Expression" "x5*((x1)/(x3+x4))" ""
    "Gen '8195' '1'" "MW" "YES" "Gen '8196' '2'" "MW" "YES"
    "Gen '8195' '1'" "MWMax" "YES" "Gen '8196' '2'" "MWMax" "YES"
    "Gen '8197' 'L'" "MWMax" "YES" "" "" "NO" "" "" "" "NO" "" "" "" "NO" ""
}
REMEDIALACTION (Name,Skip,Memo)
{
"Treenville Generation Run-Back Scheme" "NO" "" ""
}
REMEDIALACTIONELEMENT (RemedialAction,Object,Action,Criteria,CriteriaStatus,TimeDelay,InclusionFilter,
Comment)
{
"Treenville Generation Run-Back Scheme" "GEN 8195 1" "OPEN"
    "Path 1 Unit 1" "POSTCHECK" 15.000000 "" "Control Action #2A"
"Treenville Generation Run-Back Scheme" "GEN 8196 2" "OPEN"
    "Path 1 Unit 1" "POSTCHECK" 15.000000 "" "Control Action #2A"
"Treenville Generation Run-Back Scheme" "GEN 8195 1" "OPEN"
    "Path 2 Unit 1" "POSTCHECK" 20.000000 "" "Control Action #2B"
"Treenville Generation Run-Back Scheme" "GEN 8196 2" "OPEN"
    "Path 2 Unit 1" "POSTCHECK" 20.000000 "" "Control Action #2B"
"Treenville Generation Run-Back Scheme" "GEN 8197" "SETTO 'ST Output for GT1 Outage' MW"
    "Path 1 Unit 2" "POSTCHECK" 15.000000 "" "Control Action #2A"
"Treenville Generation Run-Back Scheme" "GEN 8197" "SETTO 'ST Output for GT2 Outage' MW"
    "Path 1 Unit 2" "POSTCHECK" 15.000000 "" "Control Action #2A"
"Treenville Generation Run-Back Scheme" "GEN 8197" "SETTO 'ST Output for GT1 Outage' MW"
    "Path 2 Unit 2" "POSTCHECK" 20.000000 "" "Control Action #2B"
"Treenville Generation Run-Back Scheme" "GEN 8197" "SETTO 'ST Output for GT2 Outage' MW"
    "Path 2 Unit 2" "POSTCHECK" 20.000000 "" "Control Action #2B"
}

```


Treeville RAS: Control Action #3



Time Delay= 0, 48 or 90 s

Path 1 > 800 Amps

Path 2 > 800 Amps

Path 1A to 1B > 100%

Path 1B to 1C > 100 %

Path 1C to 1D > 100 %

Path 1D to 1E > 100 %

Control Action #3A
Time Delay: 48s

Control Action #3B
Time Delay: 90s

Control Action #3C
Time Delay: 0s

Open GT1
Open GT2
Open ST

ModelFilters

RemedialActions

ModelConditions

U

Treenville RAS Control Action #2: ModelCondition ModelFilter



```

MODELCONDITION (Name, Object, FilterObjectType, FilterLogic, EvaluateInRef, DisableIfTrueInRef, Memo)
{
"Path 1 > 800 A"          "Branch '8222' '8194' '1'" "Branch" "AND" "NO" "NO" " "
"Path 2 > 800 A"          "Branch '10440' '8194' '1'" "Branch" "AND" "NO" "NO" " "
"Path 1A to 1B > 100%"   "Branch '8222' '8226' '1'" "Branch" "AND" "NO" "NO" " "
"Path 1B to 1C > 100%"   "Branch '8215' '8226' '1'" "Branch" "AND" "NO" "NO" " "
"Path 1C to 1D > 100%"   "Branch '8201' '8215' '1'" "Branch" "AND" "NO" "NO" " "
"Path 1D to 1E > 100%"   "Branch '8201' '8223' '1'" "Branch" "AND" "NO" "NO" " "
}
MODELCONDITIONCONDITION (ModelCondition, CondNum,
    ObjectField, ConditionType, Value, OtherValue, Absolute)
{
"Path 1 > 800 A" 1 "AmpsMax" ">" "800" "" "NO "
"Path 2 > 800 A" 1 "AmpsMax" ">" "800" "" "NO "
"Path 1A to 1B > 100%" 1 "Percent" ">" "100" "" "NO "
"Path 1B to 1C > 100%" 1 "Percent" ">=" "100" "" "NO "
"Path 1C to 1D > 100%" 1 "Percent" ">=" "100" "" "NO "
"Path 1D to 1E > 100%" 1 "Percent" ">=" "100" "" "NO "
}

```

```

MODELFILTER (Name, Logic, Memo)
{
"Path 1 > 100%" "OR" ""
}
MODELFILTERCONDITION
(ModelFilter, CondNum, Criteria, Logic)
{
"Path 1 > 100%" 1 "Path 1A to 1B > 100%" ""
"Path 1 > 100%" 2 "Path 1B to 1C > 100%" ""
"Path 1 > 100%" 3 "Path 1C to 1D > 100%" ""
"Path 1 > 100%" 4 "Path 1D to 1E > 100%" ""
}

```

Treeville RAS Control Action #2: ModelExpression, RemedialAction



```
REMEDIALACTION (Name,Skip,Memo)
```

```
{  
"Treeville Generation Run-Back Scheme" "NO " ""  
}
```

```
REMEDIALACTIONELEMENT (RemedialAction,Object,Action,  
Criteria,CriteriaStatus,TimeDelay,InclusionFilter,Comment)
```

```
{  
// Trip GT1  
"Treeville Generation Run-Back Scheme" "BRANCH 8195 8194 1" "OPEN" "Path 1 > 800 A"  
"POSTCHECK" 90.000000 "" "Control Action #3B"  
"Treeville Generation Run-Back Scheme" "BRANCH 8195 8194 1" "OPEN" "Path 2 > 800 A"  
"POSTCHECK" 48.000000 "" "Control Action #3A"  
"Treeville Generation Run-Back Scheme" "BRANCH 8195 8194 1" "OPEN" "Path 1 > 100%"  
"POSTCHECK" 0 "" "Control Action #3C"  
// Trip GT2  
"Treeville Generation Run-Back Scheme" "BRANCH 8196 8194 1" "OPEN" "Path 1 > 800 A"  
"POSTCHECK" 90.000000 "" "Control Action #3B"  
"Treeville Generation Run-Back Scheme" "BRANCH 8196 8194 1" "OPEN" "Path 2 > 800 A"  
"POSTCHECK" 48.000000 "" "Control Action #3A"  
"Treeville Generation Run-Back Scheme" "BRANCH 8196 8194 1" "OPEN" "Path 1 > 100%"  
"POSTCHECK" 0 "" "Control Action #3C"  
// Trip ST  
"Treeville Generation Run-Back Scheme" "BRANCH 8197 8194 1" "OPEN" "Path 1 > 800 A"  
"POSTCHECK" 90.000000 "" "Control Action #3B"  
"Treeville Generation Run-Back Scheme" "BRANCH 8197 8194 1" "OPEN" "Path 2 > 800 A"  
"POSTCHECK" 48.000000 "" "Control Action #3A"  
"Treeville Generation Run-Back Scheme" "BRANCH 8197 8194 1" "OPEN" "Path 1 > 100%"  
"POSTCHECK" 0 "" "Control Action #3C"  
}
```

Treeville RAS:

Note On Time Delay Parameter



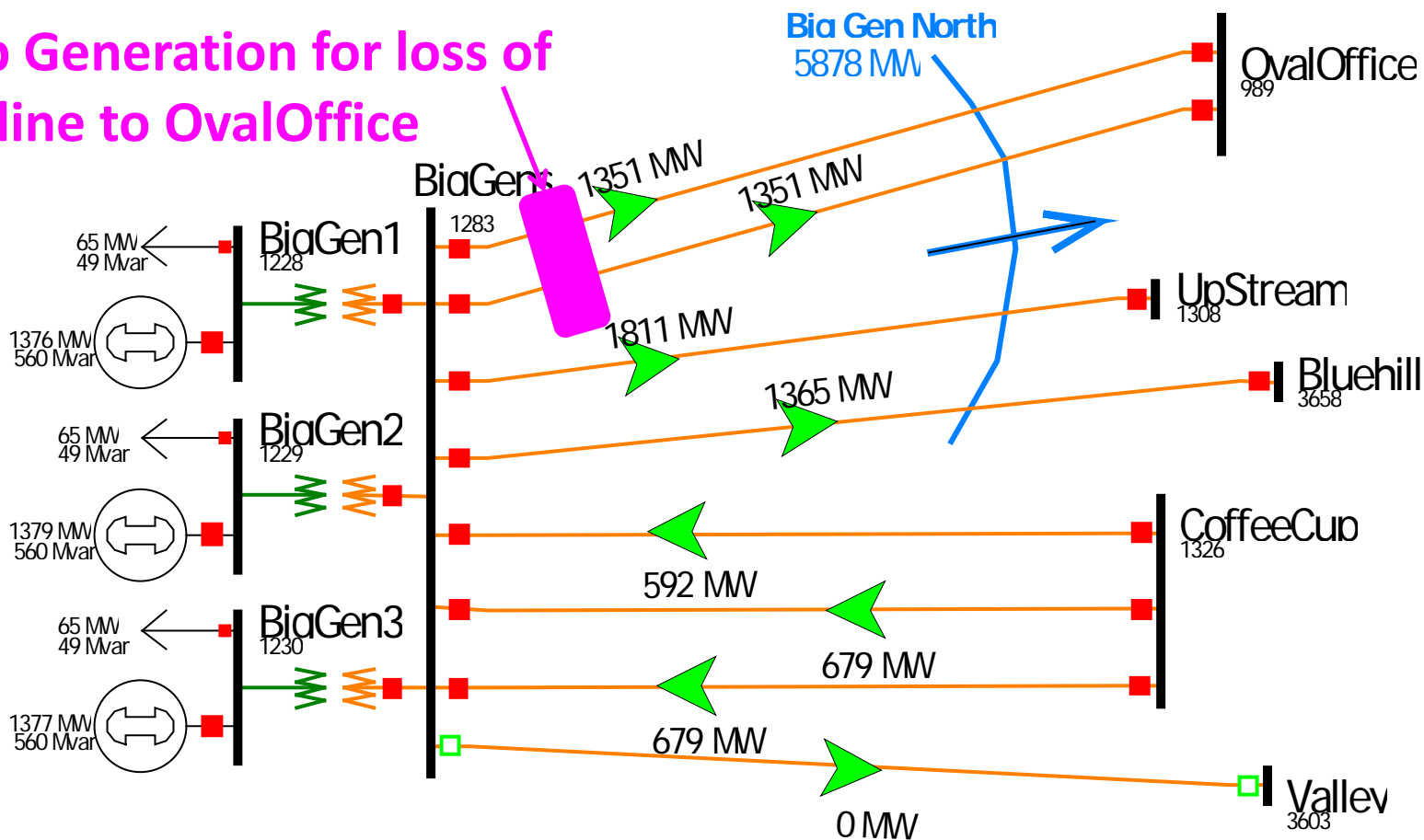
- For the Treeville RAS actions, there are time-delays assigned which are important
- Time Delays are associated with monitoring current on two branches leaving Treeville
 - Action #1: 120 seconds for 102% overload
 - Action #2: 15 or 20 seconds for over 800 Amps then trip only one gas plant (and modify steam)
 - Action #3: 48 or 90 seconds for over 800 Amps then trip both gas plants and steam plants
- Need to do Action #2 first which trips only one generator
 - That may make unnecessary Action #3 which trips all the generators at Treeville
- Details Matter!

Example #2: Double Line Outage with Generation Dropping



- Consider system below

Drop Generation for loss of one line to OvalOffice



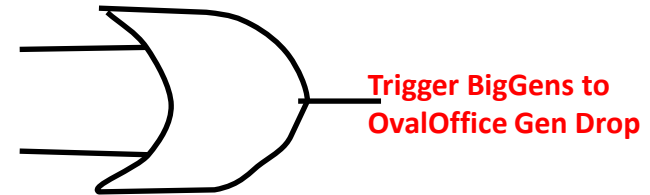
BigGens to OvalOffice Gen Drop



- RAS is triggered when either of lines from BigGens to OvalOffice are opened by the contingency
 - If one line is out in the initial system (for example for maintenance), the RAS will also trigger if the second line is opened during the contingency
- When the RAS is triggered, it will trip generation from the 3 BigGens units based on a lookup table which is a function of MW flow on the interface “Big Gen North”

BigGens – OvalOffice
Circuit 1 Open

BigGens – OvalOffice
Circuit 2 Open



Big Gen North MW Flow	Generation Change
0	0
3000	-500
4000	-1200
5000	-2000

BigGens to OvalOffice Gen Drop: ModelCondition Dialog



Disable if TRUE in Contingency Reference State

Type =
Branch

Choose
Branch

Condition
for Branch

BigGens to OvalOffice Gen Drop: ModelFilter Dialog



Filter Conditions

Filter Name: One Of BigGens to OvalOffice Opened

Save Save As Rename Delete View Filter Logic

Logical Comparison

AND OR Not AND Not OR

Model Condition 1
Find... BigGens to OvalOffice 1 Opened Condition Filter Not

Model Condition 2
Find... BigGens to OvalOffice 2 Opened Condition Filter Not

Add >> Delete ... Modify Model Conditions

OK Help Cancel

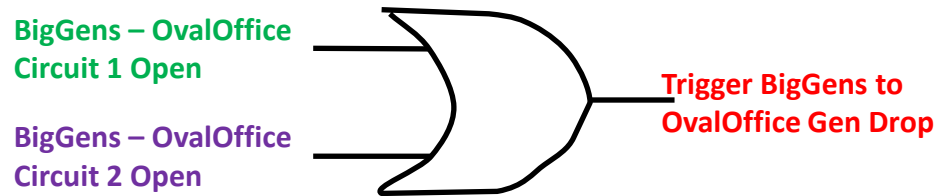
OR Logic

List of Model
Conditions

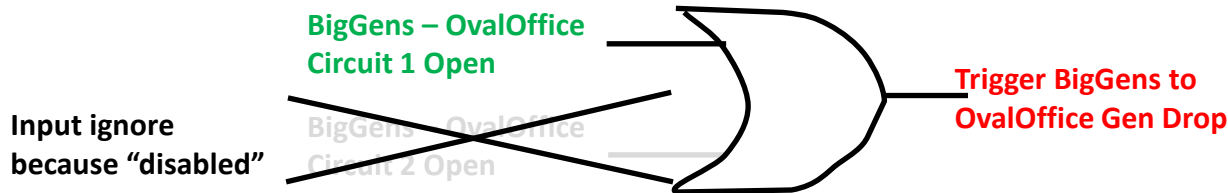
Disable if TRUE in Contingency Reference State Meaning



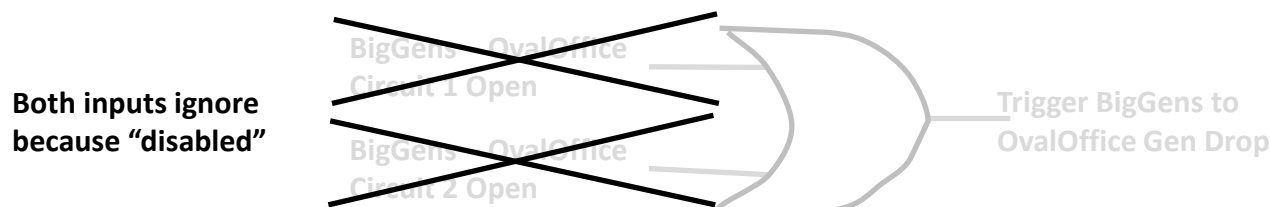
- If both lines are inservice then logic looks like



- If only circuit 1 is inservice then logic changes to



- If both lines are out of service then all inputs to the model filter are all "disabled" and thus it's output is considered "Disabled"
 - If the model filter is fed into another filter that input is disabled
 - If model filter is used directly, it returns FALSE



BigGens to OvalOffice Gen Drop: ModelCondition, ModelFilter File



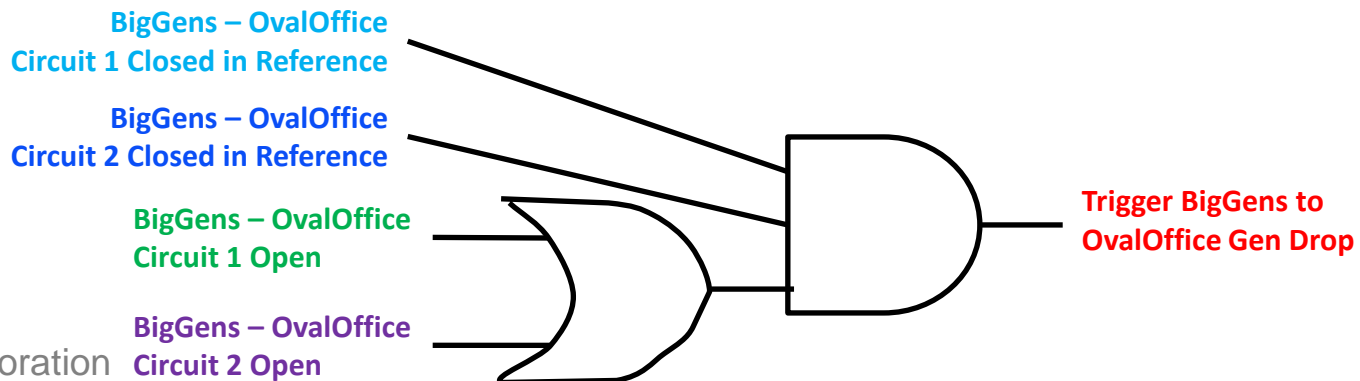
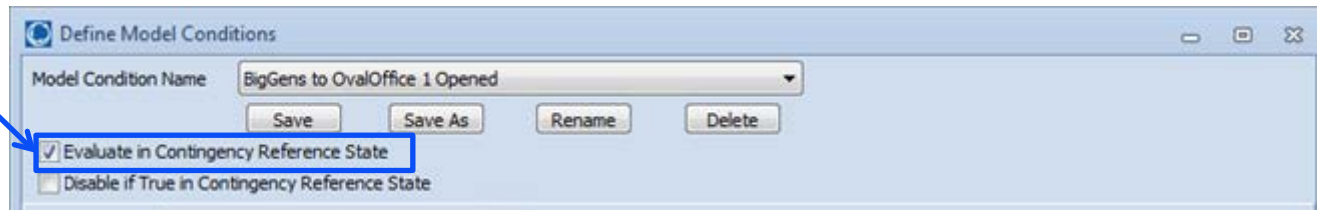
```
MODELCONDITION (Name, Object, FilterObjectType, FilterLogic, EvaluateInRef, DisableIfTrueInRef, Memo)
{
  "BigGens to OvalOffice 1 Opened" "Branch '1283' '989' '1'" "Branch" "AND" "NO" "YES" ""
  "BigGens to OvalOffice 2 Opened" "Branch '1283' '989' '2'" "Branch" "AND" "NO" "YES" ""
}
MODELCONDITIONCONDITION (ModelCondition, CondNum, ObjectField, ConditionType, Value,
                          OtherValue, Absolute)
{
  "BigGens to OvalOffice 1 Opened" 1 "Status" "startswith" "O" "" "NO "
  "BigGens to OvalOffice 2 Opened" 1 "Status" "startswith" "O" "" "NO "
}
MODELFILTER (Name, Logic, Memo)
{
  "One Of BigGens to OvalOffice Opened" "OR" ""
}
MODELFILTERCONDITION (ModelFilter, CondNum, Criteria, Logic)
{
  "One Of BigGens to OvalOffice Opened" 1 "BigGens to OvalOffice 1 Opened" ""
  "One Of BigGens to OvalOffice Opened" 2 "BigGens to OvalOffice 2 Opened" ""
}
```

Different Logic for Reference State Outage



- What if RAS should only be triggered if both lines are in service initially?
 - Thus if one was out in the reference state you would not trigger the RAS

Evaluate in Contingency Reference State



Different Logic for Reference State Outage: File Format



```

MODELCONDITION (Name, Object, FilterObjectType, FilterLogic, EvaluateInRef, DisableIfTrueInRef, Memo)
{
"BigGens to OvalOffice 1 ClosedRef" "Branch '1283' '989' '1'" "Branch" "AND" "YES" "NO" ""
"BigGens to OvalOffice 2 ClosedRef" "Branch '1283' '989' '2'" "Branch" "AND" "YES" "NO" ""
"BigGens to OvalOffice 1 Opened" "Branch '1283' '989' '1'" "Branch" "AND" "NO" "YES" ""
"BigGens to OvalOffice 2 Opened" "Branch '1283' '989' '2'" "Branch" "AND" "NO" "YES" ""
}
MODELCONDITIONCONDITION (ModelCondition, CondNum, ObjectField, ConditionType, Value,
                          OtherValue, Absolute)
{
"BigGens to OvalOffice 1 ClosedRef" 1 "Status" "startswith" "C" "" "NO" ""
"BigGens to OvalOffice 2 ClosedRef" 1 "Status" "startswith" "C" "" "NO" ""
"BigGens to OvalOffice 1 Opened" 1 "Status" "startswith" "O" "" "NO" ""
"BigGens to OvalOffice 2 Opened" 1 "Status" "startswith" "O" "" "NO" ""
}
MODELFILTER (Name, Logic, Memo)
{
"One Of BigGens to OvalOffice Opened" "OR" ""
"NewFilterName" "OR" ""
}
MODELFILTERCONDITION (ModelFilter, CondNum, Criteria, Logic)
{
"One Of BigGens to OvalOffice Opened" 1 "BigGens to OvalOffice 1 Opened" ""
"One Of BigGens to OvalOffice Opened" 1 "BigGens to OvalOffice 2 Opened" ""
"NewFilterName" 1 "BigGens to OvalOffice 1 ClosedRef" ""
"NewFilterName" 2 "BigGens to OvalOffice 2 ClosedRef" ""
"NewFilterName" 3 "One Of BigGens to OvalOffice Opened" ""
}

```

Implementing Gen Drop: Lookup Table, Model Expression



- 1D Lookup Table using a ModelExpression

Choose 1D or 2D lookup

X1 = MW Flow on
Interface Big Gen North

Big Gen North MW Flow	Generation Change
0	0
3000	-500
4000	-1200
5000	-2000

Lookup Table

Define Model Expressions

Name: BigGen Drop Lookup

Save Save As Rename Delete

Choose the Type of Expression

Expression Lookup Table

Lookup Type

1D Lookup 2D Lookup

Number of x1 Points: 4

Number of x2 Points: 1

x1 = Define... Interface Big Gen North (501) : MW Flow

x2 = Define... Choose a Model Field

x1	Value
0.0000	0.0000
3000.0000	-500.0000
4000.0000	-1200.0000
5000.0000	-2000.0000

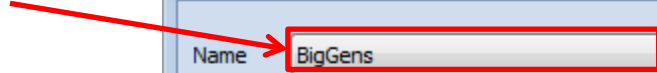
OK Help Cancel

Injection Group Load Dropping



- First you must define an Injection Group

Name



Injection Groups

Name: BigGens

Gens: 3 % MW Gen Part.: 100.00
Loads: 0 % MW Load Part.: 0.00
Shunts: 0 % MVR Load Part.: 0.00
% MVR Shunt Part.: 0.00

Participation Points: Custom

Insert Points (or right-click to insert or delete points)

	Point Type	Number	Name	ID	AutoCalc?	Initial Value	ParFac
1	GEN	1228	BigGen1	1	NO	SPECIFIED	1.00
2	GEN	1229	BigGen2	1	NO	SPECIFIED	2.00
3	GEN	1230	BigGen3	1	NO	SPECIFIED	3.00

? Help OK X Cancel

List of Participation Points



BigGens to OvalOffice Gen Drop: ModelExpression, InjectionGroup



```
MODELEXPRESSION (Name,Type,Expression,Memo,  
Object1,x1,BlankZero1,Object2,x2,BlankZero2,Object3,x3,BlankZero3,  
Object4,x4,BlankZero4,Object5,x5,BlankZero5,Object6,x6,BlankZero6,  
Object7,x7,BlankZero7,Object8,x8,BlankZero8)  
{  
"BigGen Drop Lookup" "Lookup" "" ""  
"Interface 'Big Gen North'" "MW" "YES"  
"" "" "NO " "" "" "NO " "" "" "NO " "" "" "NO "  
"" "" "NO " "" "" "NO " "" "" "NO "  
<SUBDATA LookupTable>  
  x1      value  
    0.0    0.0  
 3000.0  -500.0  
 4000.0  -1200.0  
 5000.0  -2000.0  
</SUBDATA>  
}
```

Model Expression

```
INJECTIONGROUP (Name)  
{  
"BigGens"  
}  
PARTPOINT (GroupName,Object,AutoCalcMethod,PartFact,AutoCalc)  
{  
"BigGens" "Gen '1228' '1'" "SPECIFIED" 1.00000 "NO "  
"BigGens" "Gen '1229' '1'" "SPECIFIED" 2.00000 "NO "  
"BigGens" "Gen '1230' '1'" "SPECIFIED" 3.00000 "NO "  
}
```

Injection Group

Details, Details, Details: Gen Tripping using Lookup Table



- RAS will refer to an Injection Group to do generation (or load) tripping
 - Tripping is done in the order of highest participation factor as assigned by PartPoints in injection group
- Trip based on **Lookup table**... Details matter
 - When should lookup calculation be done?
 - Often “gen drop arming levels” are based on system conditions before any event happens
 - Must base calculation on the **Reference State** as the interface flows may change during the contingency solution process
 - Tripping is done one unit at a time
 - Ordering is done using an injection group using “**Merit Order**”
 - Choice
 - **Do not EXCEED amount** of lookup table
 - Allow to EXCEED amount
- In this example it may be that the double line outage results in unsolvable power flow solution → **TOPOLOGYCHECK**

BigGens to OvalOffice Gen Drop: RemedialAction



The screenshot shows the 'Contingency Element Dialog' with the following settings and annotations:

- Element Type:** Injection Group (selected). Annotation: **Choose Injection Group** (red text).
- Choose the Element:** BigGens (selected). Annotation: **Open Merit Order** (yellow text).
- Action Type:** Change By (selected). Annotation: **Change by ModelExpression** (blue text).
- Amount:** BigGen Drop Lookup, Model Expression, Evaluate in Reference State (checked). Annotation: **Reference** (magenta text).
- in:** MW (selected), Use Merit Order (checked), Open in Merit Order (checked). Annotation: **Open in Merit Order** (yellow text).
- Do Not Exceed Amount** (selected). Annotation: **Do Not Exceed Amount** (brown text).
- Status:** TOPOLOGYCHECK (selected). Annotation: **CriteriaStatus = TOPOLOGYCHECK** (green text).
- Model Criteria:** Both BigGens to OvalOffice Opened. Annotation: **Model Criteria points to ModelFilter** (purple text).

BigGens to OvalOffice Gen Drop: ModelExpression, InjectionGroup



```
REMEDIALACTION (Name,Skip,Memo)
{
"BigGen OvalOffice Gen Drop" "NO " ""
}
```

```
REMEDIALACTIONELEMENT (RemedialAction,Object,Action,
Criteria,CriteriaStatus,TimeDelay,InclusionFilter,Comment)
{
"BigGen OvalOffice Gen Drop"
"INJECTIONGROUP 'BigGens'"
"CHANGEBY 'BigGen Drop Lookup' MWMERITORDEROPEN REF"
"Both BigGens to OvalOffice Opened" "TOPOLOGYCHECK" 0 "" ""
}
```

TOPOLOGYCHECK

Criteria based on *Status Only*



- Persistent problem in contingency runs when using RAS
 - RAS is configured to open 2,000 MW of generation when Line X trips
 - Before 2012, this was achieved by configuring a *POSTCHECK* action that looks at the branch status and trips generation if the branch is out of service
 - Works most of the time, but...
 - What if the outage of Line X results in an unsolvable steady state power flow solution?
 - Basically means that the RAS scheme is actually preventing a voltage collapse from occurring
 - This means that the *POSTCHECK* action is never evaluated because the power flow solution failed.
- Solution: *TOPOLOGYCHECK* actions

Summary



- Communication
 - Develop relationships with folks in your company who maintain RAS and Relays
 - Communicate across utilities and WECC members
- Fundamental pieces of RAS are simple
 - But... the details of how they are put together are very particular
 - And... these details matter
- RAS file format structure is being maintained *incrementally* by PowerWorld
 - http://www.powerworld.com/files/PowerWorld_RASFileFormat.pdf