

Agenda Item 2.2

PSPC Meeting 277

May 13, 2010

# Straw Proposal for Calculation of Tie Benefits Contribution of Individual Tie(s)

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# Outline

- Summary of the past discussions on the topic
- Stakeholder's input
- Straw proposal
- Application examples
- Next Step

# Summary of the past discussions on Calculation of Tie Benefits Contribution of Individual Tie(s)

# Summary of Past Discussions

- Many different interconnection states exist based on the interconnection status of individual tie(s)
  - a total of  $2^n$  interconnection states,  $n$  = number of ties
- Tie benefits contribution of an individual tie(s) can be evaluated under different scenarios
  - By comparison of any pair of related interconnection states
    - Only difference between the two states is one with the target tie(s) and the other without
  - Tie benefits contribution is quantified as equivalent MW that would bridge the LOLE delta between the two states
  - What is measured is different
  - Results are different

# All Interconnection States

- A total of 16 interconnection states if 4 ties are considered:
  - HQ-Phase II, Maritimes, NYAC, and NYDC
  - Results are based on 2010 ARA 3 tie benefit study

States	Description	Interconnection Status				
		HQ-Phase II	Maritimes	NY-AC	NY-DC	LOLE
1	Cut None	✓	✓	✓	✓	0.100
2	Cut All	x	x	x	x	0.313
3	Cut HQ-Phase II	x	✓	✓	✓	0.171
4	Cut Maritimes	✓	x	✓	✓	0.141
5	Cut NY-AC	✓	✓	x	✓	0.104
6	Cut NY-DC	✓	✓	✓	x	0.101
7	Cut HQ-Phase II & Maritimes	x	x	✓	✓	0.224
8	Cut HQ-Phase II & NY-AC	x	✓	x	✓	0.180
9	Cut HQ-Phase II & NY-DC	x	✓	✓	x	0.173
10	Cut Maritimes & NY-AC	✓	x	x	✓	0.149
11	Cut Maritimes & NY-DC	✓	x	✓	x	0.143
12	Cut NY-AC & NY-DC	✓	✓	x	x	0.109
13	Cut HQ-Phase II & Maritimes & NY-AC	x	x	x	✓	0.249
14	Cut HQ-Phase II & Maritimes & NY-DC	x	x	✓	x	0.229
15	Cut HQ-Phase II & NY-AC & NY-DC	x	✓	x	x	0.191
16	Cut Maritimes & NY-AC & NY-DC	✓	x	x	x	0.157

✓ - Interconnection available; x – interconnection unavailable

# Total Tie Benefits Evaluation

## Total Tie Benefits

Interconnection States Compared	1 vs 2
LOLE delta (days/year)	0.213
Equivalent Tie Benefits (MW)	1,525

# All Possible Evaluation Scenarios for Individual Ties

- There are 8 scenarios (A-H) that can be used for evaluating tie benefits contribution of individual tie(s), if NYAC and NYDC are considered two different ties.

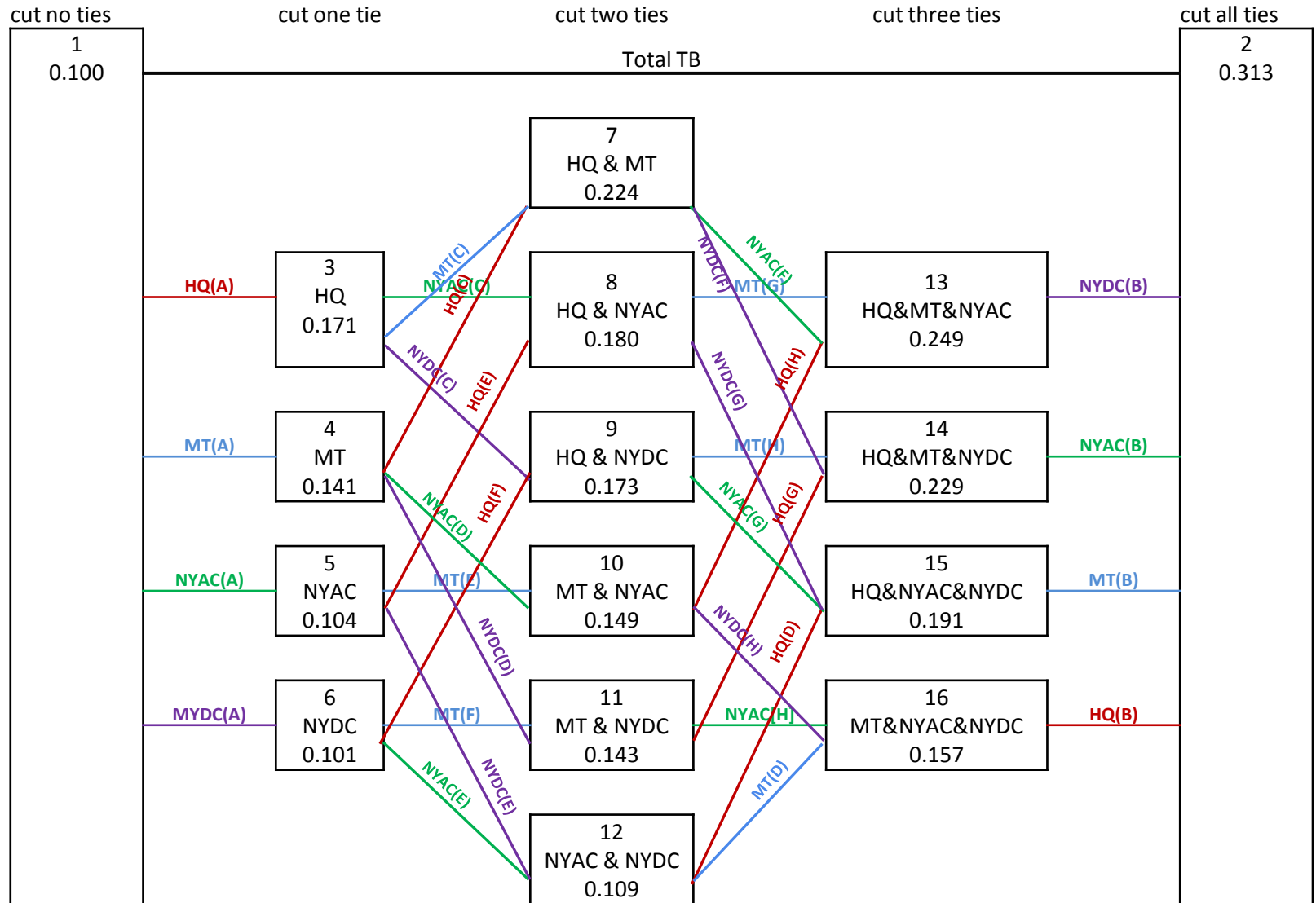
HQ-Phase II Tie Benefit	A	B	C	D	E	F	G	H	Average of A to H
	Current method	LIPA/2002 TB							
Interconnection States Compared	1 vs 3	2 vs 16	4 vs 7	12 vs 15	5 vs 8	6 vs 9	10 vs 13	11 vs 14	
LOLE delta (days/year)	0.071	0.156	0.082	0.082	0.076	0.073	0.100	0.086	0.091
Equivalent Tie Benefit (MW)	795	880	660	835	820	805	680	660	767

Maritimes Tie Benefit	A	B	C	D	E	F	G	H	Average of A to H
	Current method	LIPA/2002 TB							
Interconnection States Compared	1 vs 4	2 vs 15	3 vs 7	12 vs 16	5 vs 10	6 vs 11	8 vs 13	9 vs 14	
LOLE delta (days/year)	0.041	0.122	0.052	0.048	0.045	0.043	0.069	0.055	0.059
Equivalent Tie Benefit (MW)	510	620	385	535	530	520	425	370	487

NY AC Tie Benefit	A	B	C	D	E	F	G	H	Average of A to H
	Current method	LIPA/2002 TB							
Interconnection States Compared	1 vs 5	2 vs 14	3 vs 8	4 vs 10	6 vs 12	7 vs 13	9 vs 15	11 vs 16	
LOLE delta (days/year)	0.005	0.084	0.009	0.008	0.008	0.026	0.018	0.014	0.021
Equivalent Tie Benefit (MW)	75	390	85	90	120	140	150	130	148

NY DC Tie Benefit	A	B	C	D	E	F	G	H	Average of A to H
	Current method	LIPA/2002 TB							
Interconnection States Compared	1 vs 6	2 vs 13	3 vs 9	4 vs 11	5 vs 12	7 vs 14	8 vs 15	10 vs 16	
LOLE delta (days/year)	0.001	0.063	0.002	0.002	0.005	0.005	0.011	0.008	0.012
Equivalent Tie Benefit (MW)	15	280	25	25	65	35	90	75	76

# Relationship between Evaluation Scenarios



# Stakeholder's Input for Development of Calculation Methodology

# Stakeholder's Input

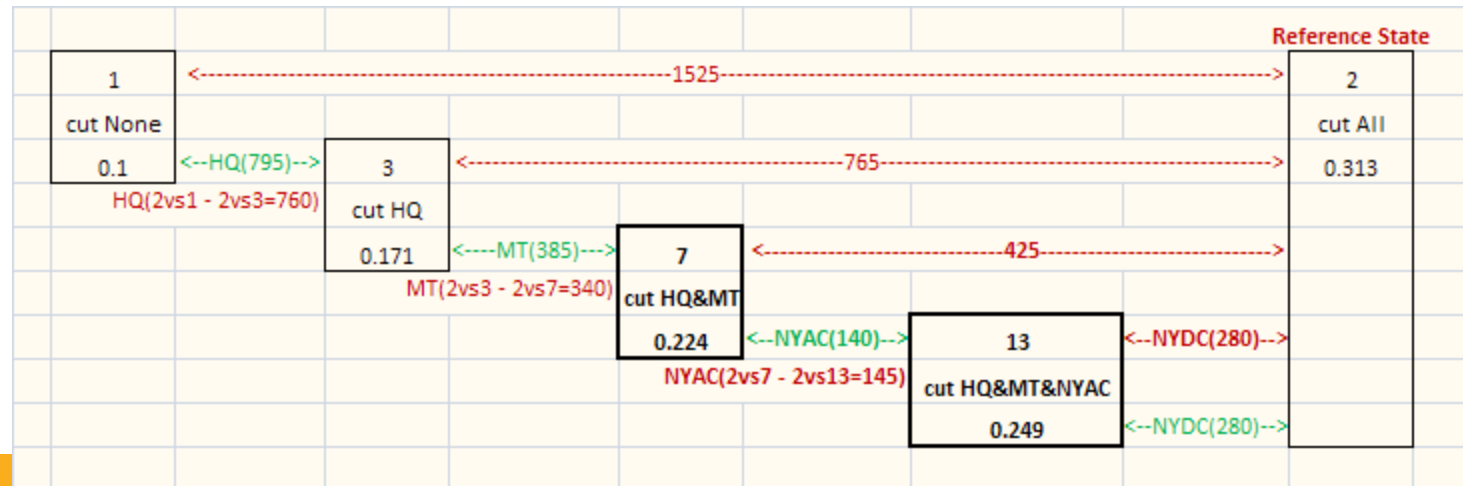
- A new calculation mechanism proposed by Waine Whittier of NESCOE would help reduce computation efforts on the calculation of the equivalent tie benefits values between different interconnection states.
- Features stakeholders considered essential on the calculation methodology
  - Should be able to recognize the different treatments given by policy to different tie(s)
  - Should be able to distinguish the tie benefits contributions associated with different external control areas

# Proposed Calculation Mechanism

- Calculation mechanisms for determining the equivalent tie benefits value between different interconnection states
  - Current method
    - Work with the two interconnection states of interest directly
    - Quantified as the MW to bridge the LOLE difference of the two states
  - Waine Whittier's proposed method
    - Introduce a reference state
    - First calculate the equivalent tie benefits value between each interconnection state and the reference state
    - The equivalent tie benefits value between any pair of states is then determined by simple subtraction

# Whittier's Proposed Calculation Mechanism, *cont.*

- Example: for determining tie benefits value of NYAC by comparing state 7 and 13
  - Current method is to find MW that needs to be added in state 13 to reduce its LOLE from 0.249 days/year to 0.224 days/year of state 7, and the result is 140 MW.
  - Waine Whittier's proposed method
    - Assumes state 2 as the reference state
    - First calculate the equivalent tie benefits value between state 7 and 2, state 13 and 2.
      - $7 \text{ vs. } 2 = 425 \text{ MW}; 13 \text{ vs. } 2 = 280 \text{ MW}$
    - The equivalent tie benefits value between state 7 and 13
      - $7 \text{ vs. } 13 = (7 \text{ vs. } 2) - (13 \text{ vs. } 2) = 425 - 280 = 145 \text{ MW}$



# Whittier's Proposed Calculation Mechanism, *cont.*

- Advantages of Waine Whittier's method
  - higher computation efficiency as number of interconnections increases

No. of External Ties	No. of Interconnection States	No. of simulation required to determine equivalent tie benefits	
		Current Method	Waine Whittier's Method
2 ties	4	$2(\text{ties}) * 2(\text{scenarios per tie}) = 4$	3
3 ties	8	$3(\text{ties}) * 4(\text{scenarios per tie}) = 12$	7
4 ties	16	$4(\text{ties}) * 8(\text{scenarios per tie}) = 32$	15
N ties	$2^N$	$N(\text{ties}) * 2^{N-1}(\text{scenarios per tie})$	$2^N - 1$

- Tie benefits associated with different groupings of ties can also be easily determined.
- Results are more consistent
  - Rounding errors reduced

# Whittier's Proposed Calculation Mechanism, *cont.*

- Selection of reference interconnection state
  - State 2 (without any interconnection) is considered the best
    - The equivalent MW of tie benefits added to New England would distort the allocation of assistance among the competing control areas if other interconnection states are chosen.
- ISO would recommend using Waine Whittier's method and the state without any interconnection as reference state to calculate the equivalent tie benefits values between different interconnection states

# Calculation Results using Waine Whittier's Method

State	Description	Interconnection Status				LOLE	State 2 as Reference	
		HQ-Phase II	Maritimes	NY-AC	NY-DC		Tie Benefits Measured for	MW
1	Cut None	✓	✓	✓	✓	0.100	Total	1525
2	Cut All	x	x	x	x	0.313	Reference	0
3	Cut HQ-Phase II	x	✓	✓	✓	0.171	MT&NYAC&NYDC	765
4	Cut Maritimes	✓	x	✓	✓	0.141	HQ&NYAC&NYDC	1025
5	Cut NY-AC	✓	✓	x	✓	0.104	HQ&MT&NYDC	1455
6	Cut NY-DC	✓	✓	✓	x	0.101	HQ&MT&NYAC	1515
7	Cut HQ-Phase II & Maritimes	x	x	✓	✓	0.224	NYAC&NYDC	425
8	Cut HQ-Phase II & NY-AC	x	✓	x	✓	0.180	MT&NYDC	695
9	Cut HQ-Phase II & NY-DC	x	✓	✓	x	0.173	MT&NYAC	745
10	Cut Maritimes & NY-AC	✓	x	x	✓	0.149	HQ&NYDC	945
11	Cut Maritimes & NY-DC	✓	x	✓	x	0.143	HQ&NYAC	1005
12	Cut NY-AC & NY-DC	✓	✓	x	x	0.109	HQ&MT	1390
13	Cut HQ-Phase II & Maritimes & NY-AC	x	x	x	✓	0.249	NYDC	280
14	Cut HQ-Phase II & Maritimes & NY-DC	x	x	✓	x	0.229	NYAC	390
15	Cut HQ-Phase II & NY-AC & NY-DC	x	✓	x	x	0.191	MT	620
16	Cut Maritimes & NY-AC & NY-DC	✓	x	x	x	0.157	HQ	880

✓ - Interconnection available; x – interconnection unavailable

# Comparison of Results

<b>HQ-Phase II Tie Benefit</b>		A	B	C	D	E	F	G	H
Scenarios Compared		1 vs 3	2 vs 16	4 vs 7	12 vs 15	5 vs 8	6 vs 9	10 vs 13	11 vs 14
LOLE delta (days/year)		0.071	0.156	0.082	0.082	0.076	0.073	0.100	0.086
Equivalent Tie Benefit (MW)	Current Method	795	880	660	835	820	805	680	660
	Waine Whittier's Method	760	880	600	770	760	770	665	615

<b>Maritimes Tie Benefit</b>		A	B	C	D	E	F	G	H
Scenarios Compared		1 vs 4	2 vs 15	3 vs 7	12 vs 16	5 vs 10	6 vs 11	8 vs 13	9 vs 14
LOLE delta (days/year)		0.041	0.122	0.052	0.048	0.045	0.043	0.069	0.055
Equivalent Tie Benefit (MW)	Current Method	510	620	385	535	530	520	425	370
	Waine Whittier's Method	500	620	340	510	510	510	415	355

<b>NY AC Tie Benefit</b>		A	B	C	D	E	F	G	H
Scenarios Compared		1 vs 5	2 vs 14	3 vs 8	4 vs 10	6 vs 12	7 vs 13	9 vs 15	11 vs 16
LOLE delta (days/year)		0.005	0.084	0.009	0.008	0.008	0.026	0.018	0.014
Equivalent Tie Benefit (MW)	Current Method	75	390	85	90	120	140	150	130
	Waine Whittier's Method	70	390	70	80	125	145	125	125

<b>NY DC Tie Benefit</b>		A	B	C	D	E	F	G	H
Scenarios Compared		1 vs 6	2 vs 13	3 vs 9	4 vs 11	5 vs 12	7 vs 14	8 vs 15	10 vs 16
LOLE delta (days/year)		0.001	0.063	0.002	0.002	0.005	0.005	0.011	0.008
Equivalent Tie Benefit (MW)	Current Method	15	280	25	25	65	35	90	75
	Waine Whittier's Method	10	280	20	20	65	35	75	65

# Straw Proposal for Calculation of Tie Benefits Contribution of Individual Tie(s)

# Straw Proposal

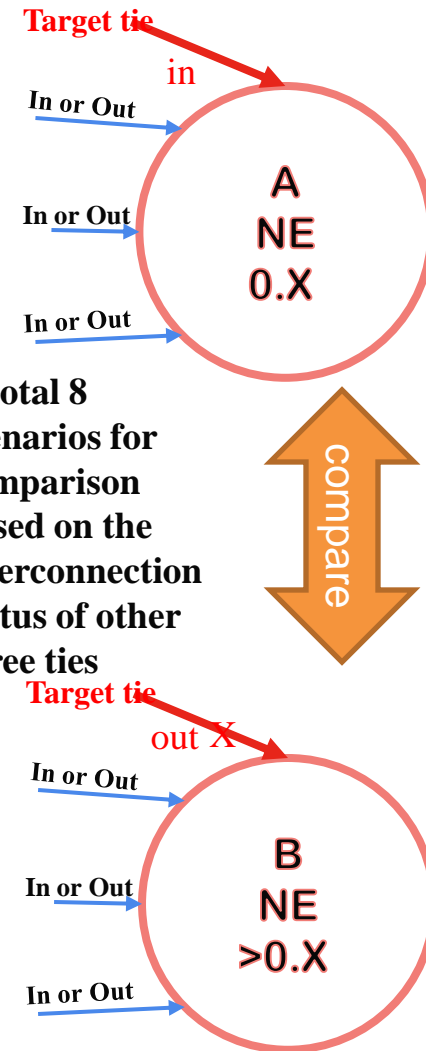
- Major features of straw proposal for calculation of tie benefits contribution of individual tie(s)
  - Summation of tie benefits contributions assigned to individual tie(s) should be equal to the total tie benefits determined for all ties treated as a whole
  - Take into consideration the tie benefits impacts under different scenarios
  - recognize the different treatments given by policy to different tie(s)
  - distinguish the tie benefits contributions associated with different external control areas
  - Allocation process is in a “branching hierarchy”

# Tie Benefits Calculation for Tie(s) with Different Treatments

- This is not a discussion on how tie(s) should be treated in assignment of individual tie benefits
- It is on how does the calculation methodology recognize the differences in ties if they are treated differently in assignment of individual tie benefits.
- Possible treatments
  - “equal rights”
    - All ties are treated equally
  - “prior rights”
    - One group of ties are given “prior rights” to obtain the biggest share of tie benefits, while the other group of ties are given “incremental rights” for the incremental benefits

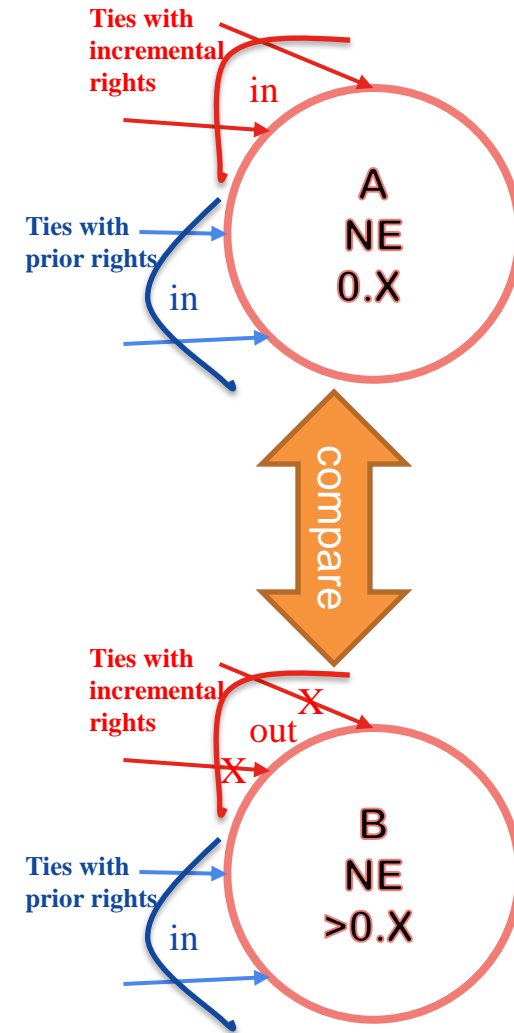
# Tie Benefits Calculation for Tie(s) with Different Treatments, cont.

- Calculation for ties with “equal rights”
  - Consider tie benefits impacts under all possible interconnection states. The number of scenarios for evaluation is dependent on the numbers of ties
    - 2 ties topology: 2 scenarios
    - 3 ties topology: 4 scenarios
    - 4 ties topology: 8 scenarios
    - N ties topology:  $2^{n-1}$  scenarios
  - Allocation process utilizes the simple average of the tie benefits contributions calculated for all the possible interconnection states for each tie

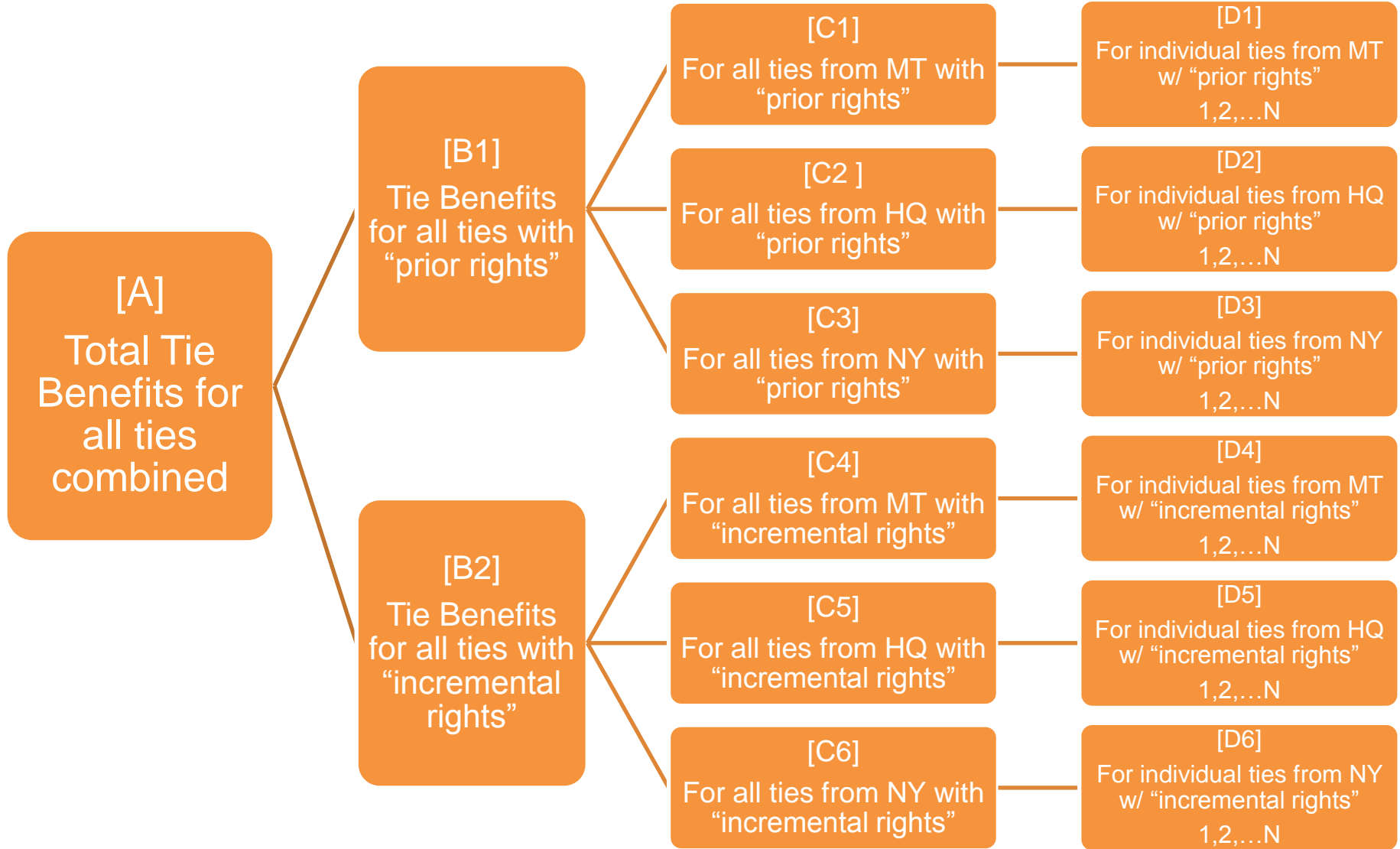


# Tie Benefits Calculation for Tie(s) with Different Treatments, cont.

- Allocation of tie benefits to individual ties with “prior rights” and “incremental rights”
  - Only one specific interconnection state can be used
  - Tie benefits contribution for the tie(s) with “incremental rights” is determined by comparing the states of
    - 1) having both ties with both “prior rights” and ties with “incremental rights”
    - 2) having only ties with “prior rights”
  - Similar to current method for calculating individual tie benefits
  - Tie benefits contribution for the tie(s) with “prior rights” is balance
    - $TB_{prior} = TB_{total} - TB_{incr}$



# Hierarchy of Computation



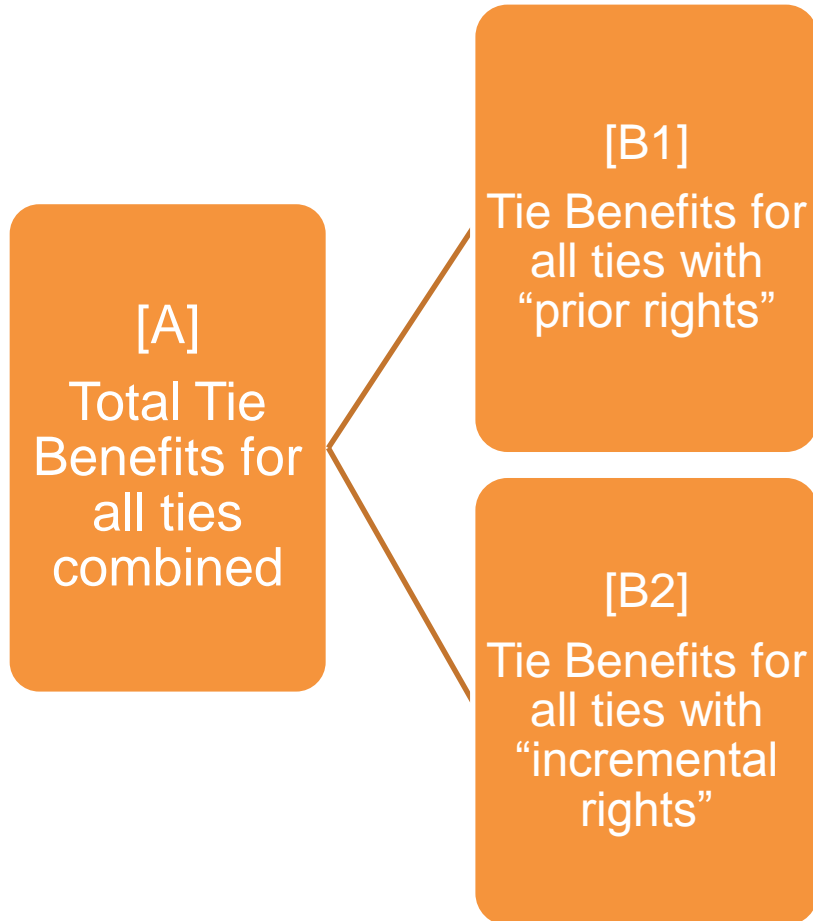
# First Layer of Hierarchy

## - Calculate Total Tie Benefits from all ties combined

- Calculated by comparing the interconnection state with all ties in and the state with all ties out.
- Equivalent tie benefit value,  $TB_{total}$ , is the MW that would bridge the LOLE gap between these two states.

# Second Layer of Hierarchy

## - Allocation to Ties with “Prior Rights” and Ties “Incremental Rights”

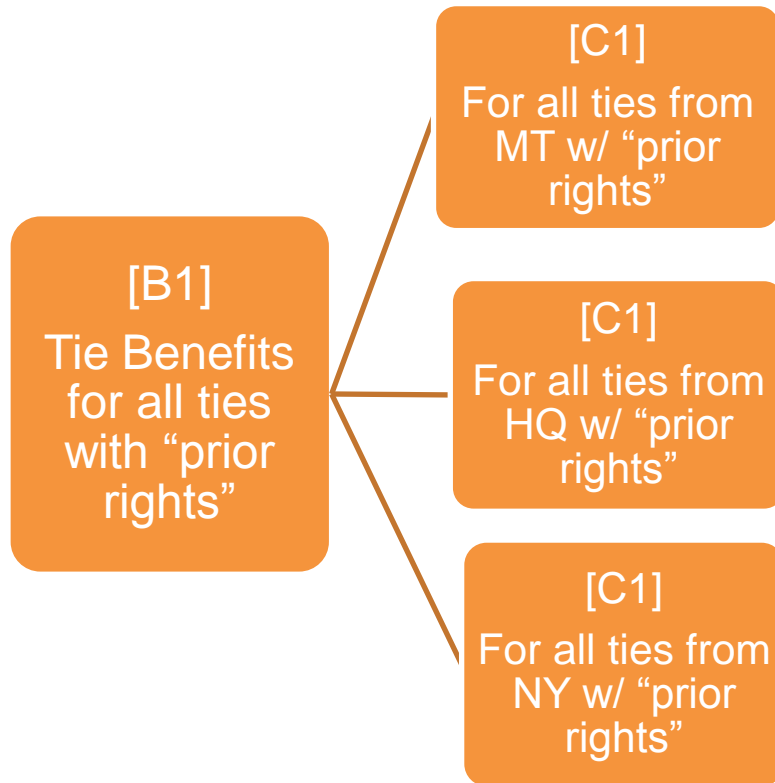


- Tie benefits contribution for all ties with “incremental rights” is first calculated using the “incremental method” outlined in slide 21, TB\_incr.
- Tie benefits contributions for all ties with “prior rights”, TB\_prior, is then determined as:

$$TB\_prior = TB\_total - TB\_incr$$

# Third Layer of Hierarchy

## - Allocation to Ties with “Prior Rights” from Individual External Control Areas

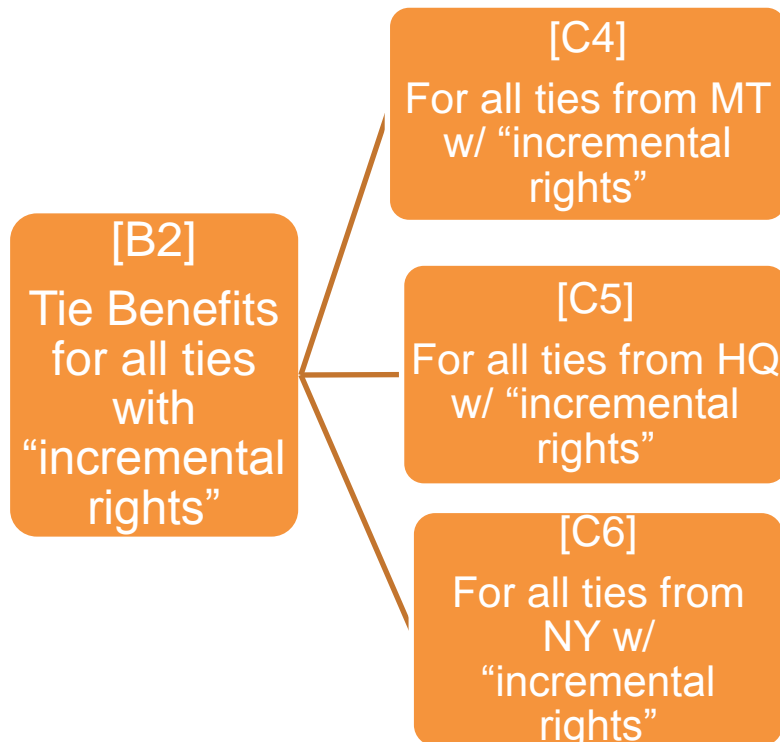


- Allocate tie benefits contribution of all ties with “prior rights”, TB\_prior, to individual external control areas, TB\_prior\_CA-MT, TB\_prior\_CA-HQ, and TB\_prior\_CA-NY

- Ties with “prior rights” from each external control area are treated as a whole
- Use “average of all possible states” approach outlined in slide 20
  - ✓ 4 scenarios for each external area if each area has tie(s) w/ “prior rights”
- $TB\_prior = TB\_prior\_CA-MT + TB\_prior\_CA-HQ + TB\_prior\_CA-NY$

# Third Layer of Hierarchy

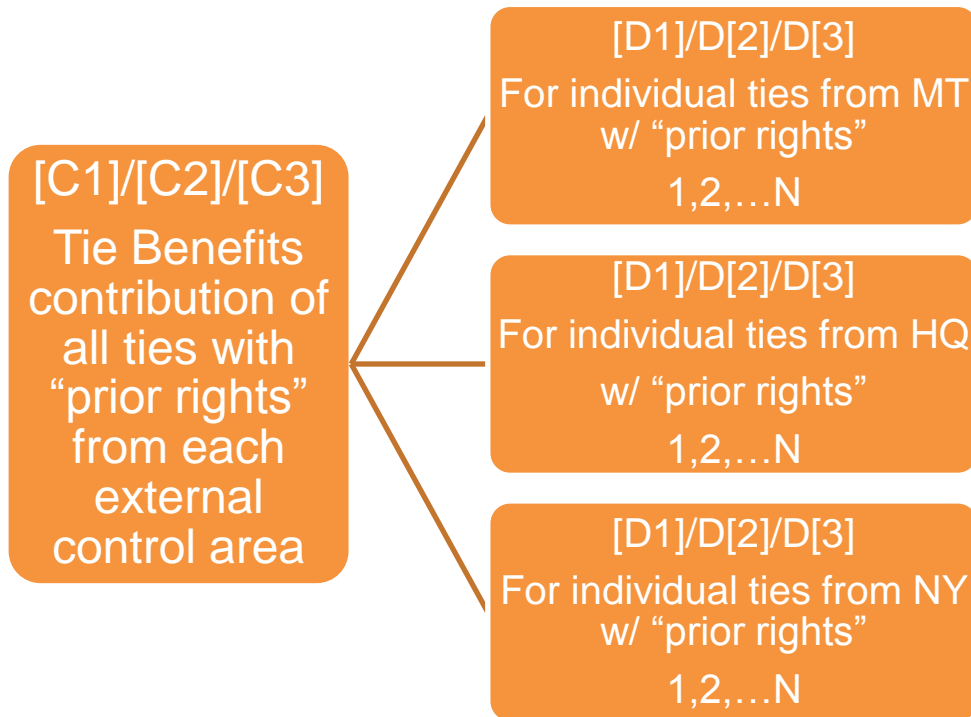
## - Allocation to Ties with “Incremental Rights” from Individual External Control Areas



- Allocate tie benefits contribution of all ties with “incremental rights”,  $TB_{incr}$ , to individual external control areas,  $TB_{incr\_CA-MT}$ ,  $TB_{incr\_CA-HQ}$ , and  $TB_{incr\_CA-NY}$ 
  - Ties with “incremental rights” from each external control area are treated as a whole
  - Use “average of all possible states” approach outlined in slide 20
    - ✓ 4 scenarios for each external area if each area has tie(s) w/ “prior rights”
  - $TB_{incr} = TB_{incr\_CA-MT} + TB_{incr\_CA-HQ} + TB_{incr\_CA-NY}$

# Fourth Layer of Hierarchy

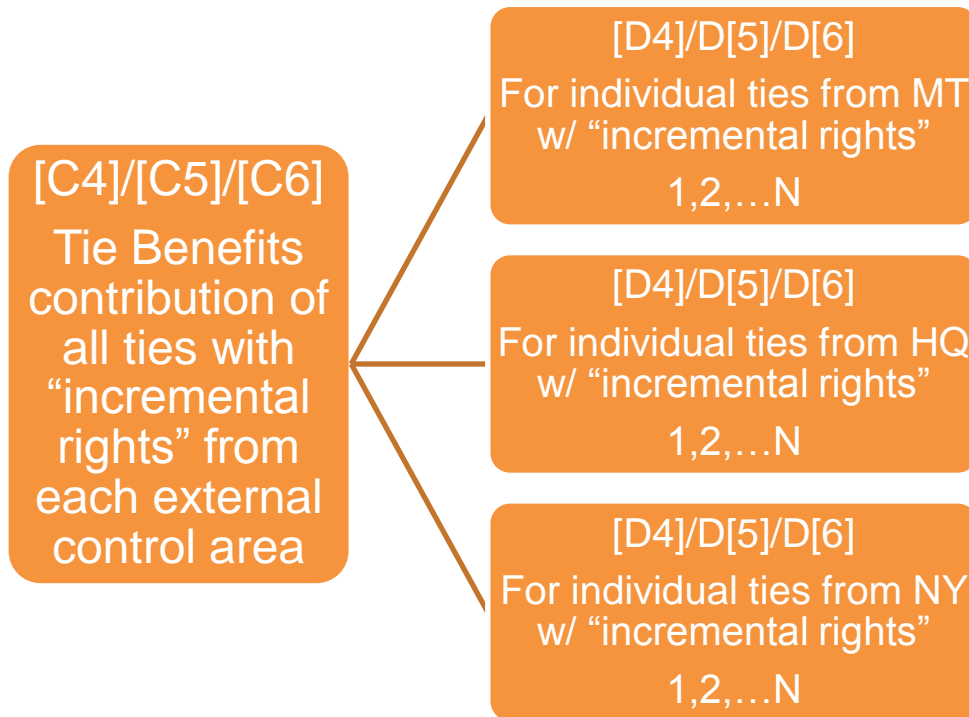
## - Allocation to Individual Ties with “prior rights” from an External Control Area



- Allocate tie benefits contribution of all ties with “prior rights” from each external control area to individuals.
- “average of all possible states” approach is used
- $TB\_prior\_CA-“X” = TB\_prior\_CA-“X”\_1 + TB\_prior\_CA-“X”\_2 + \dots + TB\_prior\_CA-“X”\_N$

# Fourth Layer of Hierarchy

## - Allocation to Individual Ties with “Incremental Rights” from an External Control Area, *cont.*



- Allocate tie benefits contribution of all ties with “incremental rights” from each external control area to individuals.
- “average of all possible states” approach is used
- $TB\_incr\_CA-“X”$   
 $= TB\_incr\_CA-“X”\_1 +$   
 $TB\_incr\_CA-“X”\_2 +$   
 $\dots +$   
 $TB\_incr\_CA-“X”\_N$

# Application Examples

# Application Examples

- Use 2010 ARA3 tie benefit study as a base
- Waine Whittier's proposed calculation mechanism is used to calculate the equivalent tie benefits between different interconnection states
  - Results are tabulated in side 15
- Step-by-step calculation for several hypothetical examples with different treatments assigned to tie(s)

# Example One

- All ties have “equal rights”
  - HQ Phase II, Maritimes, NYAC, and NYDC
- First Layer of Hierarchy – Calculate total Tie Benefits for all ties combined
  - Interconnection state 1 (with all ties in) and 2 (with all ties out) is compared
  - Equivalent tie benefits,  $TB_{total} = 1,525$  MW
- Second Layer of Hierarchy – Allocate Total Tie Benefits to ties with “prior rights” and “incremental rights”
  - Since no ties are assumed to have “incremental rights” and “prior rights”  
 $TB_{incr} = 0$  MW  
 $TB_{prior} = TB_{total} = 1,525$  MW

# Example One, *cont.*

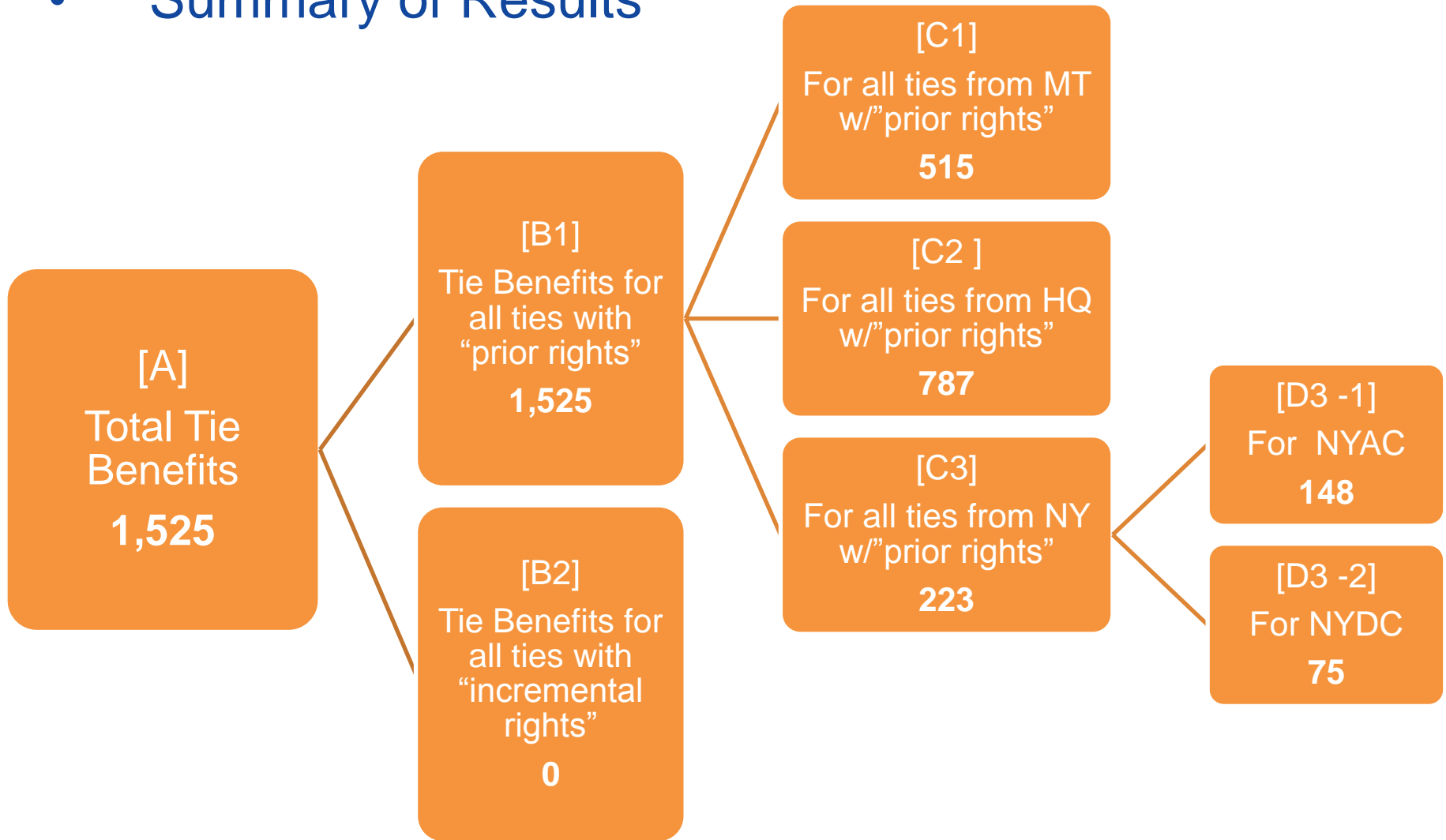
- Third Layer of Hierarchy - Allocation to Ties from an External Control Area
  - “average of all possible states” approach is used
    - NYAC and NYDC are treated as a whole
  - MT:
    - $\underline{1 \text{ vs. } 4} = 1,525 - 1,025 = 500$ ;  $\underline{2 \text{ vs. } 15} = 620 - 0 = 620$
    - $\underline{3 \text{ vs. } 7} = 765 - 425 = 340$ ;  $\underline{12 \text{ vs. } 16} = 1,390 - 880 = 510$
    - average = 493 MW*
  - HQ:  $\underline{1 \text{ vs. } 3} = 760$ ;  $\underline{2 \text{ vs. } 16} = 880$ ;  $\underline{4 \text{ vs. } 7} = 600$  ;  $\underline{12 \text{ vs. } 15} = 770$   
*average = 753 MW*
  - NY:  $\underline{1 \text{ vs. } 12} = 135$ ;  $\underline{2 \text{ vs. } 7} = 425$ ;  $\underline{3 \text{ vs. } 15} = 145$ ;  $\underline{4 \text{ vs. } 16} = 145$   
*average = 213 MW*
  - Allocation (  $493+753+213=1459 \neq 1525(\text{TB\_total})$  )
    - $\text{TB\_prior\_CA-MT} = 1,525 * 493/(493+753+213) = \mathbf{515 \text{ MW}}$
    - $\text{TB\_prior\_CA-HQ} = 1,525 * 753/(493+753+213) = \mathbf{787 \text{ MW}}$
    - $\text{TB\_prior\_CA-NY} = 1,525 * 213/(493+753+213) = \mathbf{223 \text{ MW}}$

# Example One, *cont.*

- Fourth Layer of Hierarchy – Allocation to Individual Ties of an External Control Area
  - Allocation required only for NY
  - “average of all possible states” approach is used
    - 8 scenarios for each ties based on the interconnection status of other ties
  - NYAC:  
 $\underline{1 \text{ vs. } 5} = 70$ ;  $\underline{2 \text{ vs. } 14} = 390$ ;  $\underline{3 \text{ vs. } 8} = 70$ ;  $\underline{4 \text{ vs. } 10} = 80$   
 $\underline{6 \text{ vs. } 12} = 125$ ;  $\underline{7 \text{ vs. } 13} = 145$ ;  $\underline{9 \text{ vs. } 15} = 125$ ;  $\underline{11 \text{ vs. } 16} = 125$   
*average = 141 MW*
  - NYDC:  
 $\underline{1 \text{ vs. } 6} = 10$ ;  $\underline{2 \text{ vs. } 13} = 280$ ;  $\underline{3 \text{ vs. } 9} = 20$ ;  $\underline{4 \text{ vs. } 11} = 20$   
 $\underline{5 \text{ vs. } 12} = 65$ ;  $\underline{7 \text{ vs. } 14} = 35$ ;  $\underline{8 \text{ vs. } 15} = 75$ ;  $\underline{11 \text{ vs. } 16} = 65$   
*average = 71 MW*
  - Allocation ( $141+71=212 \neq 223$ (TB\_prior\_CA-NY), difference due to rounding)
    - TB\_prior\_CA-NY\_NYAC =  $223 * 141/(141+71) = 148 \text{ MW}$
    - TB\_prior\_CA-NY\_NYDC =  $223 * 71/(141+71) = 75 \text{ MW}$

# Example One, *cont.*

- Summary of Results



# Example Two

- Some ties have “prior rights”, and some ties have “incremental rights”
  - All AC ties (Maritimes and NYAC) assumed to have “prior rights”
  - All DC ties (HQ and NYDC) assumed to have “incremental rights”
- First Layer of Hierarchy – Calculate total Tie Benefits for all ties combined
  - Interconnection state 1 (with all ties in) and 2 (with all ties out) is compared
  - Equivalent tie benefits,  $TB_{total} = 1,525$  MW

## Example Two, *cont.*

- Second Layer of Hierarchy – Allocation of Total Tie Benefits to ties with “prior rights” and “incremental rights”
  - “incremental method” is used
  - Equivalent tie benefits for all ties with “incremental rights” (HQ and NYDC combined) are determined by comparing interconnection state 1 (all ties in) and state 9 (without HQ and NYDC)  
 $TB_{incr} = 780 \text{ MW}$
  - Tie benefits for all ties with “prior rights” (Maritimes and NYAC combined) then become  
 $TB_{prior} = 1,525 - 780 = 745 \text{ MW}$

## Example Two, *cont.*

### • Third Layer of Hierarchy - Allocation of “Prior Rights” Tie Benefits to External Control Areas

- “average of all possible states” approach is used. These include
  - States where ties w/ “incremental rights” are unavailable
  - States where ties w/ “prior rights” are either available or unavailable
    - Since only two control areas have ties with “prior rights”, two scenarios for each control area
- MT: (red-unavailable, green-available)  
 $15 \text{ vs. } 2 = [\text{HQ, NYDC, MT, NYAC}] \text{ vs. } [\text{HQ, NYDC, MT, NYAC}] = 620$   
 $9 \text{ vs. } 14 = [\text{HQ, NYDC, MT, NYAC}] \text{ vs. } [\text{HQ, NYDC, MT, NYAC}] = 745 - 390 = 355$   
*average = 488 MW*
- NY(NYAC): (red-unavailable, green-available)  
 $14 \text{ vs. } 2 = [\text{HQ, NYDC, MT, NYAC}] \text{ vs. } [\text{HQ, NYDC, MT, NYAC}] = 390$   
 $9 \text{ vs. } 15 = [\text{HQ, NYDC, MT, NYAC}] \text{ vs. } [\text{HQ, NYDC, MT, NYAC}] = 745 - 620 = 125$   
*average = 258 MW*
- Allocation (  $488+258 = 746 \neq 745(\text{TB\_prior})$ , difference due to rounding)
  - $\text{TB\_prior\_CA-MT} = 745 * 488 / (488+258) = \mathbf{487 \text{ MW}}$
  - $\text{TB\_prior\_CA-NY} = 745 * 258 / (488+258) = \mathbf{258 \text{ MW}}$

## Example Two, *cont.*

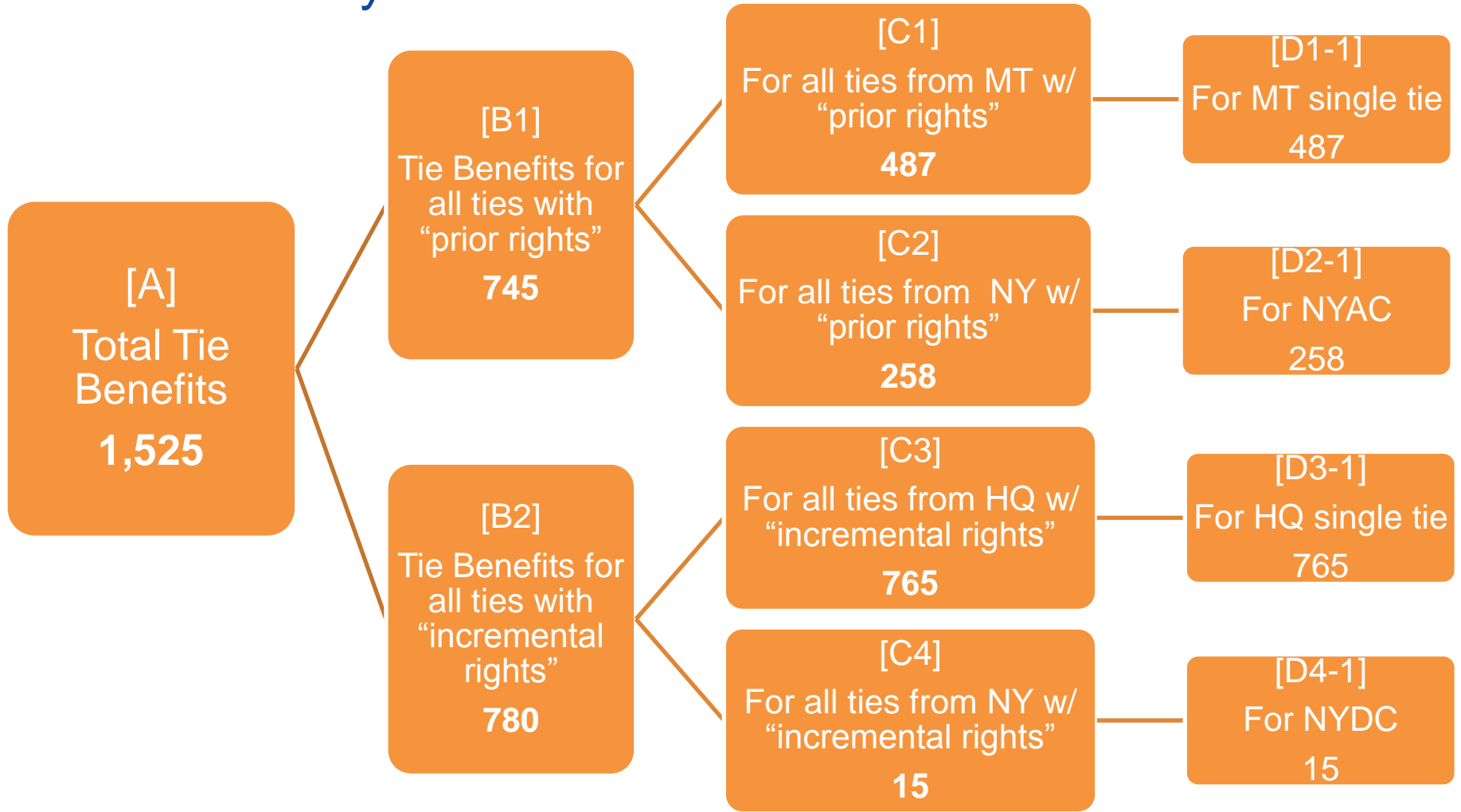
- Third Layer of Hierarchy - Allocation of “Incremental Rights” Tie Benefits to External Control Areas
  - “average of all possible states” approach is used. These include
    - States where ties w/ “prior rights” are available
    - States where ties w/ “incremental rights” are either available or unavailable
      - Since only two control areas have ties with “incremental rights”, two scenarios for each control area
  - HQ: (red-unavailable, green-available)  
 $\underline{6 \text{ vs. } 9} = [\text{HQ, NYDC, MT, NYAC}] \text{ vs. } [\text{HQ, NYDC, MT, NYAC}] = 1515 - 745 = 770$   
 $\underline{1 \text{ vs. } 3} = [\text{HQ, NYDC, MT, NYAC}] \text{ vs. } [\text{HQ, NYDC, MT, NYAC}] = 1525 - 765 = 760$   
*average = 765 MW*
  - NY(NYDC): (red-unavailable, green-available)  
 $\underline{1 \text{ vs. } 6} = [\text{HQ, NYDC, MT, NYAC}] \text{ vs. } [\text{HQ, NYDC, MT, NYAC}] = 1525 - 1515 = 10$   
 $\underline{3 \text{ vs. } 9} = [\text{HQ, NYDC, MT, NYAC}] \text{ vs. } [\text{HQ, NYDC, MT, NYAC}] = 765 - 745 = 20$   
*average = 15 MW*
  - Allocation (  $765 + 15 = 780$ , exactly the same as the value of TB\_incr)
    - TB\_incr\_CA-HQ = **765 MW**
    - TB\_incr\_CA-NY = **15 MW**

## Example Two, *cont.*

- Fourth Layer of Hierarchy – Allocation to Individual Ties from each External Control Area
  - “Prior Rights” Tie Benefits
    - Both MT and NY have only one tie with “prior rights”, no further allocation is required  
 $TB\_prior\_CA-MT\_tie1 = 487 \text{ MW}$   
 $TB\_prior\_CA-NY\_NYAC = TB\_prior\_CA-NY = 258 \text{ MW}$
  - “Incremental Rights” Tie Benefits
    - Both HQ and NY have only one tie with “incremental rights”, no further allocation is required  
 $TB\_incr\_CA-HQ\_tie1 = 765 \text{ MW}$   
 $TB\_incr\_CA-NY\_NYDC = TB\_incr\_CA-NY = 15 \text{ MW}$

# Example Two, *cont.*

- Summary of Results



# Next Step

- ISO is looking into further improvement of computation efficiency on the calculation of equivalent tie benefits between different interconnection states
  - When the number of ties modeled increases, it will still require significant computation efforts even with Wayne Whittier's proposed calculation mechanism.
  - LOLE index can possibly be used to directly calculate the equivalent tie benefits between different interconnection states without having to conduct MARS simulations.
    - Tie benefits and LOLE index are closely related.
    - Their relationship may be described by some mathematical functions, e.g. exponential

