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Allocating Variability and Reserve Requirements

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UWIG FALL TECHNIICAL WORKSHOP

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Aggregation Benefits (Old News)

- Net reduction in:
  - Peak load
    - Capacity requirement
  - Contingency reserves
    - Spin, Non, Supplemental
    - Reserve sharing groups
  - Variability
    - Regulation
    - Load following / ramping
  - Uncertainty
    - Load forecast
    - Wind & solar forecasts
  - *The amount of reduction depends on the correlation among individuals*
- Increased utilization of responsive resources:
  - Generation;
  - Responsive load;
  - Shared across balancing areas (BAs).

❖ *All of this is well established and (relatively) easy to calculate.*

Allocating **Aggregation Benefits is More Difficult**

- No single mathematically "correct" allocation method:
  - Many methods are not "fair";
  - At least two different methods are "fair", depending on the desired results.
- Many methods have undesirable consequences that are not immediately obvious.

❖ Desired properties:

- Total allocated = Total required *(easy);*
- Independent of subaggregations *(hard);*
- Independent of order BAs are added to system *(hard).*

Attractive Allocation Methods: *Incremental*

- B joins A;
- B holds A harmless and covers all the additional reserve requirements;
- Can be OK if you are deliberately favoring B:
  - B brings jobs, tax advantages, environmental benefits, …
- Gives the entire aggregation benefit to B:
  - Example of A and B with identical reserve requirements (assuming uncorrelated requirements):
    - A stand-alone reserve requirements = 100 MW;
    - B stand-alone reserve requirements = 100 MW;
    - Total stand-alone reserve requirements = 141 MW;
    - A allocated reserve requirement = 100 MW (A held harmless);
    - B allocated reserve requirement = 41 MW (B supplying its full share).
  - Clearly B is getting the better deal:
    - Harder to see but just as true if A and B have different stand-alone requirements.
- Things get more complex when C joins – order is important.

Attractive Allocation Method: *Proportional*

- Simply ratio each component:

$$B_{Allocation} = B_{Stand-Alone} * \frac{System_{Actual-Total}}{\sum_{A}^{Z} Individual_{Stand-Alone}}$$

- Does get the correct total;
- Has different results if J & K combine to make B first vs. if reserves are allocated directly to J & K;
- Disproportionate allocation to small entities.

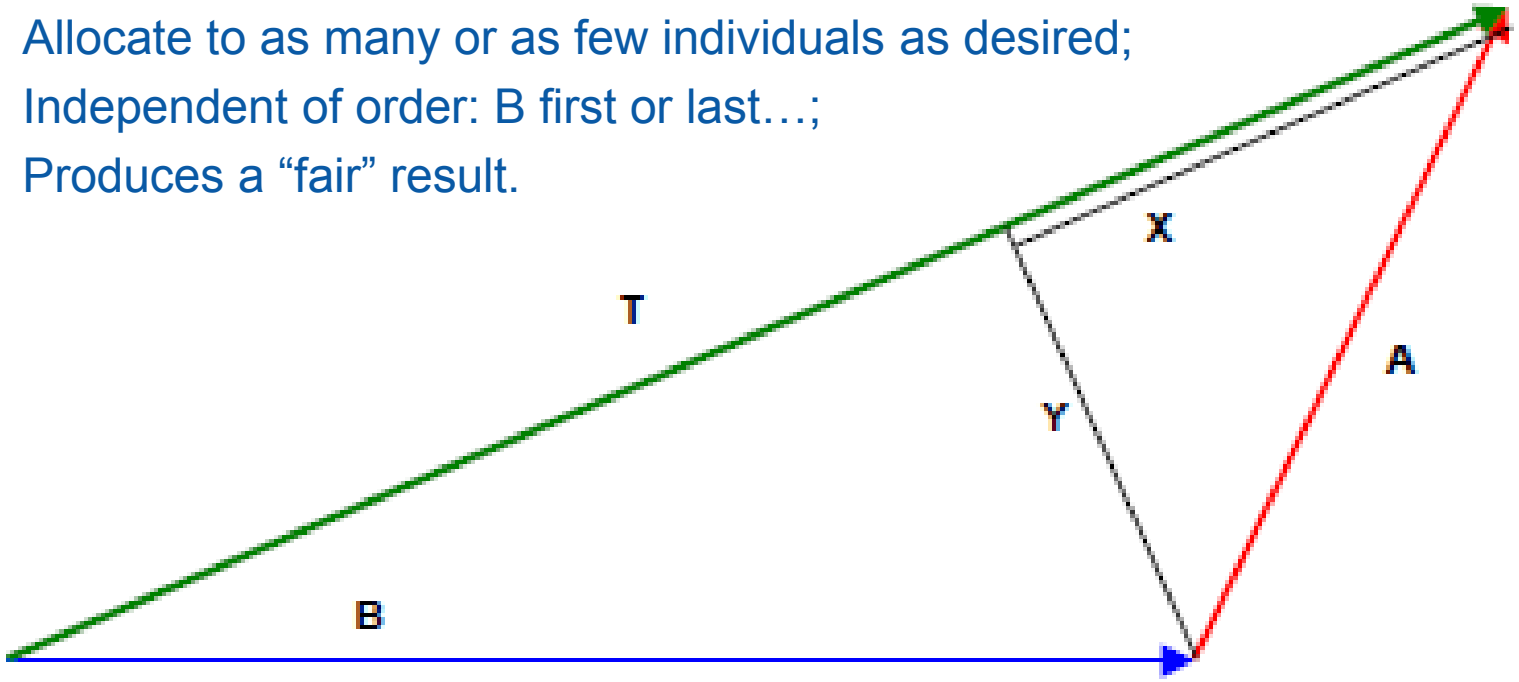
Proportional Allocation Gives Different Answers for Different Sub-Aggregations

- Area B could be allocated 30, 26, or 25.
- Identical area K could be allocated 30, 42, or 80.

			Sub-Regional Aggregation				*Another Set*			
BA	Actual Regulation (MW)	Proportional Regulation Allocation (MW)	Sub Region	Aggregate Regulation (MW)	Proportional Sub-regional Regulation Allocation (MW)	Proportional Allocation Within the Sub-region (MW)	BA	Aggregate Regulation (MW)	Proportional Sub-regional Regulation Allocation (MW)	Proportional Allocation Within the Sub-region (MW)
A	100	30				26	A			25
B	100	30				26	B			25
C	100	30	X	224	131	26	C			25
D	100	30				26	D			25
E	100	30				26	E	316	252	25
F	100	30				29	F			25
G	100	30	Y	200	117	29	G			25
H	100	30				29	H			25
I	100	30				29	I			25
J	100	30	Z	141	83	42	J			25
K	100	30				42	K	100	80	80
Sum	1100	***332***		565	332	***332***			332	***332***
Actual	***332***									

Geometric Look at Variability & Reserves

- A & B variability adds statistically to T:
  - Perfectly correlated: A & B are aligned;
  - Perfectly uncorrelated: A & B at 90^{o}.
- Allocating based on correlation with T has desirable properties:
  - Independent of sub-aggregations;
  - Allocate to as many or as few individuals as desired;
  - Independent of order: B first or last…;
  - Produces a “fair” result.



ORNL's Vector Allocation is Straightforward

- Required data:
  - Total system reserve requirement;
  - Individual entity's stand-alone reserve requirement;
  - Total system reserve requirement without the individual.

$$\sigma_{i\_allocation} = \frac{\left(\sigma_{Total}^2 + \sigma_i^2 - \sigma_{Total-i}^2\right)}{2 * \sigma_{Total}}$$

ORNL Vector Allocation Method

- Allocation is independent of sub-aggregations.

Individual BA			*Sub-Region*				*Alternate Sub-Region*			
BA	Actual Regulation (MW)	Vector Allocation (MW)	Sub Region	Actual Regulation (MW)	Vector Allocation (MW)	Individual BA in Sub Region	Sub Region	Actual Regulation (MW)	Vector Allocation (MW)	Individual BA in Sub Region
A	100	30	X	224	151	30	A-J	316	302	30
B	100	30				30				30
C	100	30				30				30
D	100	30				30				30
E	100	30				30				30
F	100	30	Y	200	121	30				30
G	100	30				30				30
H	100	30				30				30
I	100	30				30				30
J	100	30	Z	141	60	30				30
K	100	30				30	K	100	30	30
Sum	1100	332		565	332	332		416	332	332

Preliminary Regulation Allocation Results

	Sum	1177	1781	2385	1191	50%		1191	50%		1545	1191		1191	
		Actual			Vector Allocated			Proportional Allocation			Actual	Proportional Allocation			
		Load	Wind	Net	Net						Net				
	FootPrint	943	728	1191	1191	100%	1191	1191			1191	1191		1191	
Sub-Region	BA	BA	BA	BA	BA		Sub-Region	BA			Sub-Region			BA	
CG	AVA	26	30	43	16	37%	317	22	50%		438	337	77%	25	58%
	BPA	99	362	381	216	57%		190	50%					219	58%
	CHPD	11	10	16	5	29%		8	50%					9	58%
	COPD	13	0	13	4	28%		6	50%					7	58%
	DOPDA	7	0	7	2	32%		3	50%					4	58%
	GCPD	12	25	29	5	16%		14	50%					17	58%
	PSE	59	5	59	46	78%		29	50%					34	58%
	SCL	25	0	25	17	68%		13	50%					15	58%
	TPWR	13	0	13	7	55%		7	50%					8	58%
WC	AZPS	76	304	316	155	49%	548	158	50%		662	511	77%	135	43%
	EPE	21	11	25	12	49%		12	50%					10	43%
	IID	12	3	13	6	47%		6	50%					6	43%
	NEVP	58	34	71	35	49%		36	50%					31	43%
	PNM	30	125	129	39	30%		65	50%					55	43%
	PSCO	99	130	166	93	56%		83	50%					71	43%
	SMUD	24	57	63	17	27%		31	50%					27	43%
	SPP	24	82	86	26	30%		43	50%					37	43%
	SRP	66	15	69	41	59%		34	50%					30	43%
	TEP	33	0	33	19	56%		17	50%					14	43%
	TID	8	6	11	2	21%		5	50%					4	43%
	WAPA	82	194	212	104	49%		106	50%					90	43%
NTTG	IPC	40	75	87	33	38%	244	43	50%		338	260	77%	45	52%
	NWEA	27	35	45	17	37%		23	50%					24	52%
	PACE	96	206	229	122	53%		115	50%					120	52%
	PACW	49	57	76	35	46%		38	50%					40	52%
	PGE	57	15	60	38	63%		30	50%					31	52%
BCTC	BCTC	107	0	107	83	77%	83	54	50%		107	83	77%	83	77%

Multiple Reserves

- Combine load, wind, and solar within each BA:
  - Physical aggregation.
- Correlation may differ for each reserve;
- Allocation may differ for each reserve:
  - Regulation;
  - Spin;
  - Non-spin.

Conclusions

- Aggregation provides benefits because individual requirements are not 100% correlated;
- Method needed to allocate reduced requirement among participants;
- Differences between allocation results are subtle:
  - Not immediately obvious which method is “better”;
  - Many are numerically “correct”: they sum to the physical requirement;
  - Many are not “fair”:
    - Results depend on sub-aggregation and/or the order individuals are included.
- Vector allocation method is simple and fair.

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