<u>Defining Flow Paths with Multiple Links</u>

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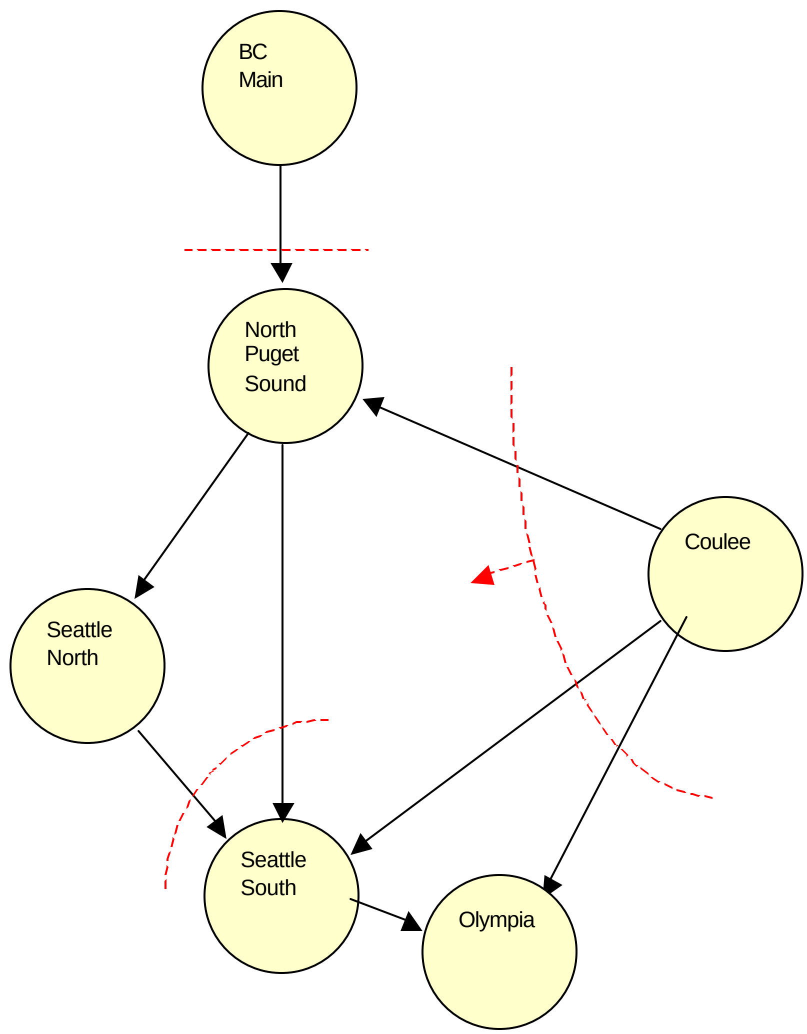
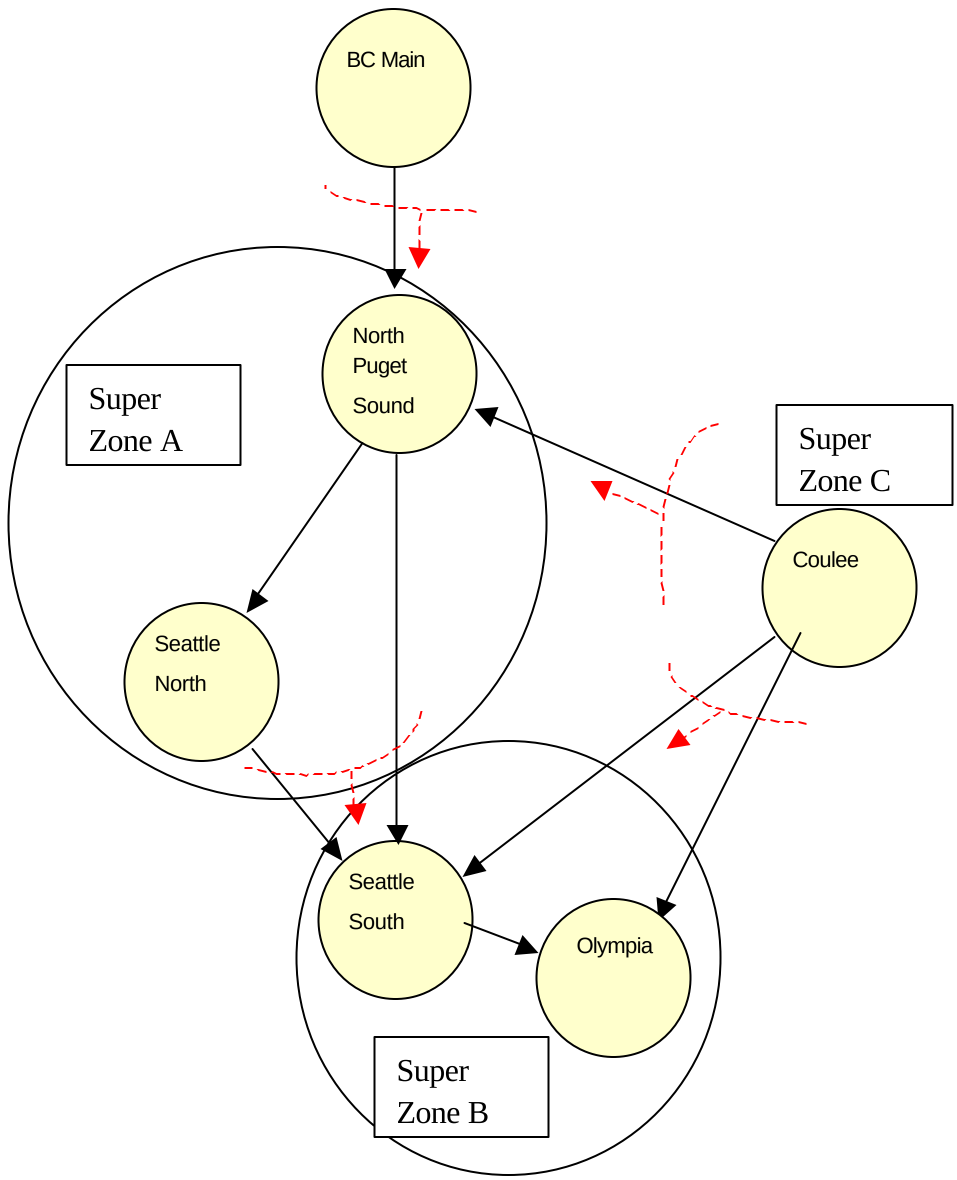
The question of flow path definition has not yet been adequately addressed in the CMCG. Specifically, the content group has not yet come to a consensus definition of flow paths, zones, and the relationship between the two. Many appear to be operating under the assumption that there is a necessary relationship between flow paths and zones, i.e., that zones are geographic regions defined by the intersection of flow paths. While this may yet turn out to be the best definition of a zone, it is not the only definition possible. Ray Brush and Mike Ryan did some work earlier that demonstrated that zones can be defined in a manner that is unrelated to the selection of commercially significant flow paths on which congestion is managed through FTRs. This work deserves more extensive consideration by the CMCG.

The concept that Ray and Mike presented at a previous meeting was that a single flow path can be defined across multiple links connecting zones. Put another way, a geographic area bounded by flow path intersections can contain many zones, distinguished from each other by engineering criteria such as coherency. Consider the following simplified model:

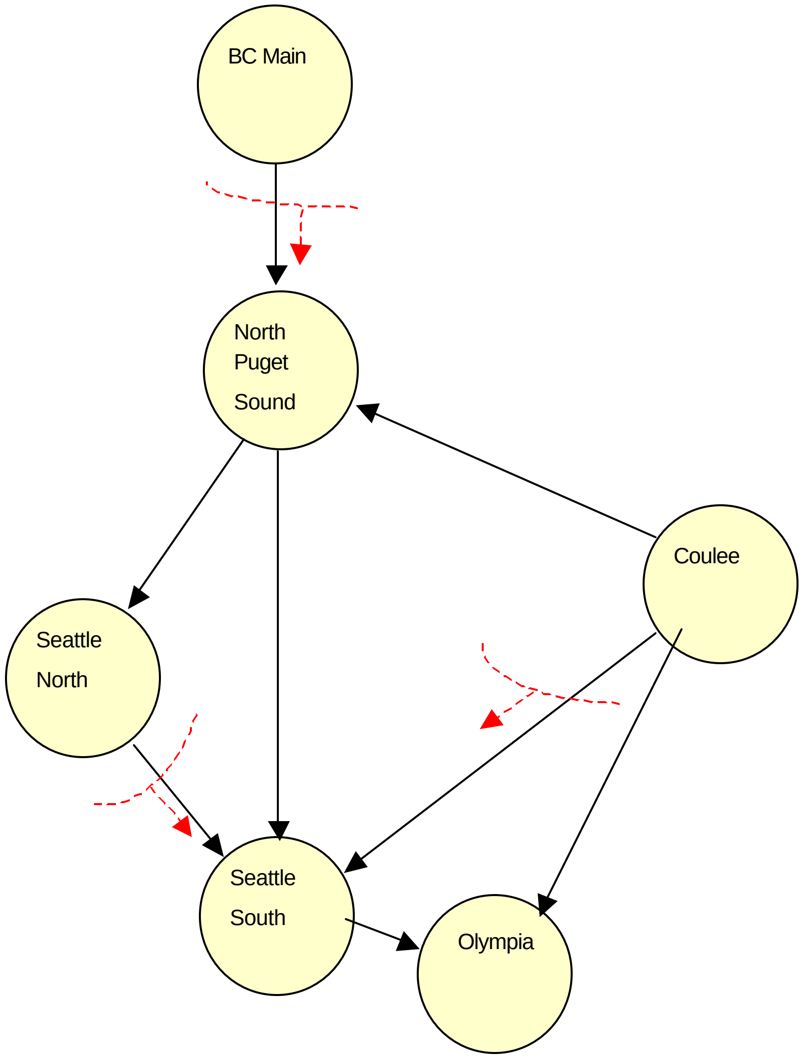


In this model, the black arrows can be thought of as "links" connecting zones. The Coulee zone is connected directly to the Olympia, Seattle South and North Puget Sound zones. However, for congestion management purposes, some of these links could be combined into a composite constraint, much as is done today. In this example, the paths west of Coulee are combined into a single flow path, "West of Cascades North".

There are at least two other alternative models for defining flowpaths:



This model places a constraint on aggregating links into flow paths, by saying that no flow connect more than "Super Zones", where Super Zones are defined as areas bounded by flow path intersections. In this example, the West of Cascades North flow path must be divided into two because of the South of SnoKing flow path.



This model doesn't attempt to aggregate links into combination flow paths, but instead uses a single link as a representative constraint for a group of links.

Whether any of these methods is more desirable than defining each link as a flow path will depend on the nature of the binding N-1 constraint and the ability of the RTO to guarantee the simultaneous rating of the path. That is, if the RTO is going to operate the system under limits that look like combined ratings over multiple links, the best commercial model may be one that mimics this practice. If a single network element can be used to represent the actual constraint, the third method above might be the most useful.

It may be that a combination of the above techniques provides the best tradeoff between complexity and accuracy. The key point is that defining flow paths as links between connected zones, or conversely defining zones by the intersection of managed flow paths, is unnecessarily constraining and may preclude alternative solutions that have other positive characteristics.

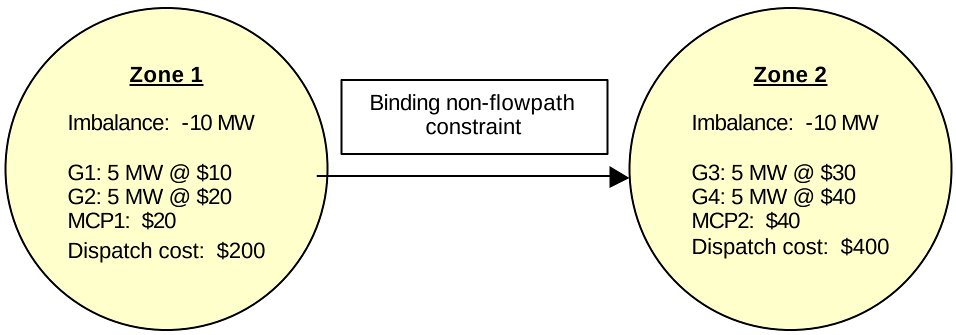
I can think of several advantages to defining zones separately from flow paths.

- Less (or at least no more) complexity. Defining flow paths as multiple links reduces the number of flow paths that must be managed by the market without changing the number of zones. Alternatively, additional zones could be defined without adding complexity. This results in a commercial model that more accurately maps flows to flow paths.
- Less politics. Defining zones based on coherency rather than commercial interests is more likely to result in a commercial model that is robust and difficult to game.
- Less engineering work needed prior to startup. Mapping existing path ratings to specific "links" or circuits may require a new approach to path rating. While this approach may ultimately prove to be more efficient (or not), it may be better to start by managing constraints in a way that is more familiar and exploring alternatives on a more reasonable timetable.
- Better management of interactions among parallel paths. Assigning existing path ratings to specific links raises the question of whether there are new nomogram relationships that must be identified, and if so, what kind of complexity that adds to the commercial model. Defining a single rating for two closely related paths may be a better way to manage flows across both paths.
- Better balancing energy settlements. If balancing energy is settled based on zonal spot prices, more zones will result in more accurate balancing energy settlements, and lower energy prices, in the presence of non-flowpath congestion. (See example).

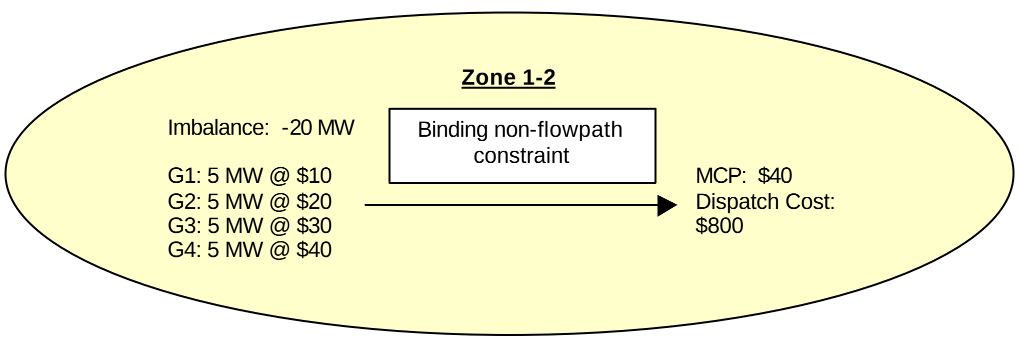
Engineering concepts such as nomograms and path ratings are less important in defining the commercial model for RTO West than they are today – path ratings don't represent a firm operating limit, but rather the point to which RTO West will guarantee schedules. RTO West would continue to operate the system to applicable path ratings. Nevertheless, the more divorced the RTO West congestion management model is from engineering realities, i.e., the way RTO West will have to operate the system, the less accurate the price signals will be and the more costs will be uplifted. The best model may be one with many zones, but relatively few flow paths.

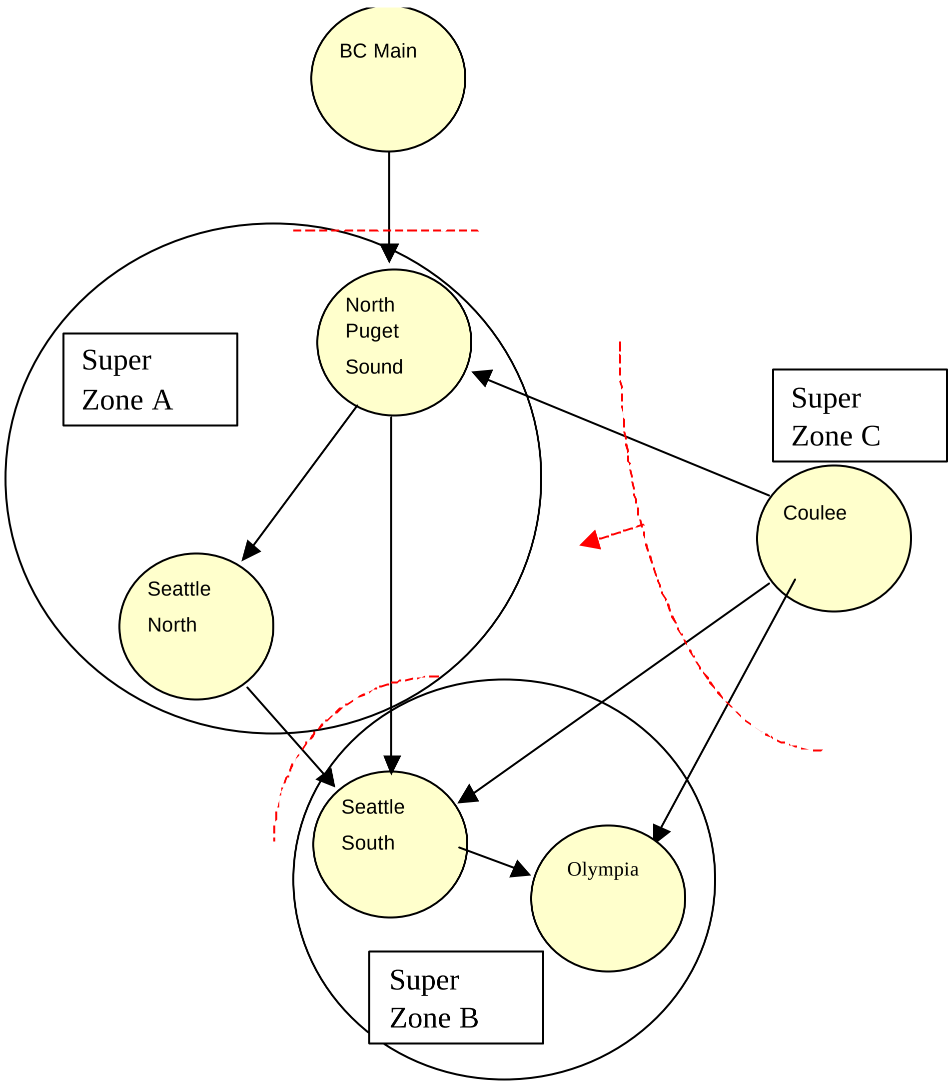
Effect of Zone Definition on Balancing Energy Settlements – Example

To see how zone definition can affect balancing energy settlements, consider the following example of two zones, each with a 10 MW imbalance and with binding non-flowpath congestion in the forward direction. It is assumed that RTOW pays a single zonal clearing price for balancing energy. In either case, RTOW dispatches 5 MW from each of the four units. The first example results in prices of $20/MWh in Zone 1 and $40/MWh in Zone 2.



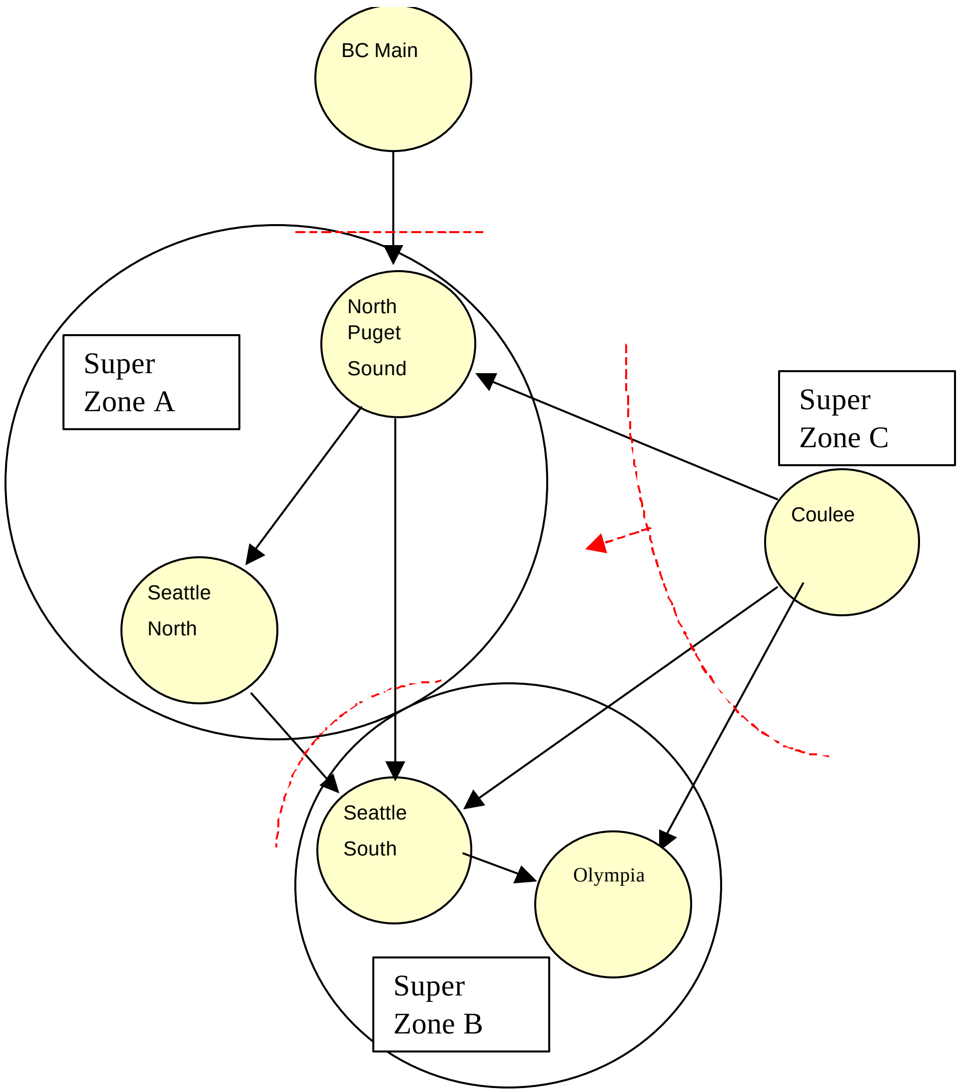
If the zones are combined, however, RTO West must now pay $40 to all generators, because that is the price is necessary to dispatch the $40 unit. This results in higher balancing energy prices and increased dispatch costs in Zone 1. Note that the dispatch doesn't change, because the binding constraint keeps more power from moving west to east in both examples. The only change is the balancing energy price used for settlements.





Schedule: Coulee - Seattle South
Amount: 3000 MW

True Network Model (assume this is the true model)				
Links	**Ratings**	**FDF**	**Flow**	**Overload**
BC-NPS	1000	0.000	0	
NPS-SeaN	1000	0.083	250	
NPS-SeaS	1000	0.167	500	
SeaN-SeaS	1000	0.083	250	
SeaS-Oly	1000	-0.250	-750	
Coulee-NPS	1000	0.250	750	
Coulee-SeaS	1000	0.500	1500	500
Coulee-Oly	1000	0.250	750	
Flowgate Model I (Path Definiton Option I)				
Flowpaths	**Ratings**			
BC South	1000	0.000	0	
W Casc. N	3000	1.000	3000	
S SnoKing	2000	-0.083	-250	
Flowgate Model II (Path Definiton Option II)				
Flowpaths	**Ratings**			
BC South	1000	0.000	0	
SZA-SZB	2000	0.250	750	
SZC-SZA	1000	0.250	750	
SZC-SZB	2000	0.750	2250	250
Flowgate Model III (Path Definiton Option III)				
Flowpaths	**Ratings**			
BC-NPS	1000	0.000	0	
SeaN-SeaS	1000	0.083	250	
Coulee-NPS	1000	0.250	750	
Coulee-SeaS	1000	0.500	1500	500



Schedule: Coulee - Seattle South
Amount: 2000 MW

True Network Model (assume this is the true model)

Links	**Ratings**	**FDF**	**Flow**	**Overload**
BC-NPS	1000	0.000	0	
NPS-SeaN	1000	0.083	167	
NPS-SeaS	1000	0.167	333	
SeaN-SeaS	1000	0.083	167	
SeaS-Oly	1000	-0.250	-500	
Coulee-NPS	1000	0.250	500	
Coulee-SeaS	1000	0.500	1000	
Coulee-Oly	1000	0.250	500	

Flowgate Model I (Path Definiton Option I)

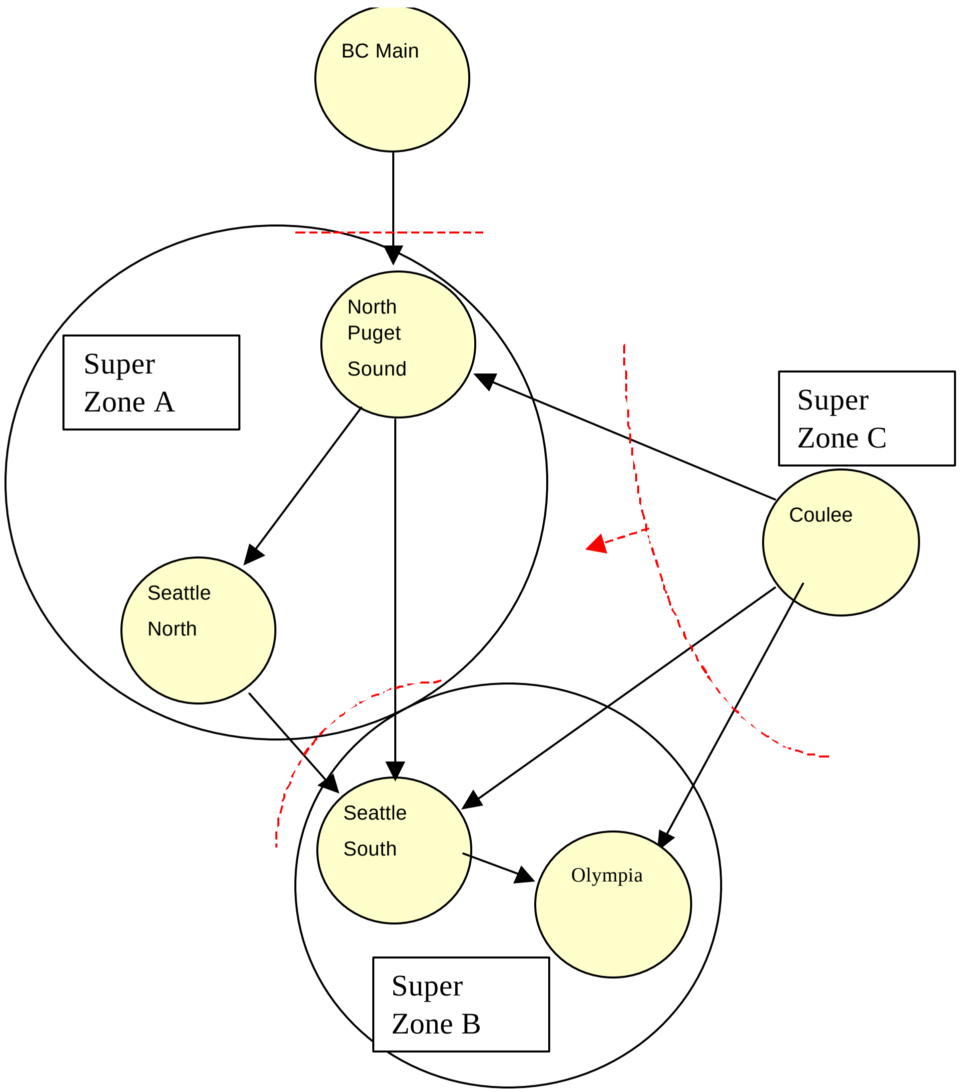
Flowpaths	**Ratings**			
BC South	1000	0.000	0	
W Casc. N	2000	1.000	2000	
S SnoKing	1333	-0.083	-167	

Flowgate Model II (Path Definiton Option II)

Flowpaths	**Ratings**			
BC South	1000	0.000	0	
SZA-SZB	2000	0.250	500	
SZC-SZA	667	0.250	500	
SZC-SZB	1333	0.750	1500	167

Flowgate Model III (Path Definiton Option III)

Flowpaths	**Ratings**			
BC-NPS	1000	0.000	0	
SeaN-SeaS	1000	0.083	167	
Coulee-NPS	1000	0.250	500	
Coulee-SeaS	1000	0.500	1000	



Schedule: Coulee - Seattle North
Amount: 3000 MW

True Network Model (assume this is the true model)

Links	Ratings	FDF	Flow	
BC-NPS	1000	0.000	0	
NPS-SeaN	1000	0.250	750	
NPS-SeaS	1000	-0.083	-250	
SeaN-SeaS	1000	-0.542	-1625	625
SeaS-Oly	1000	-0.250	-750	
Coulee-NPS	1000	0.375	1125	125
Coulee-SeaS	1000	0.375	1125	125
Coulee-Oly	1000	0.250	750	

Flowgate Model I (Path Definiton Option I)

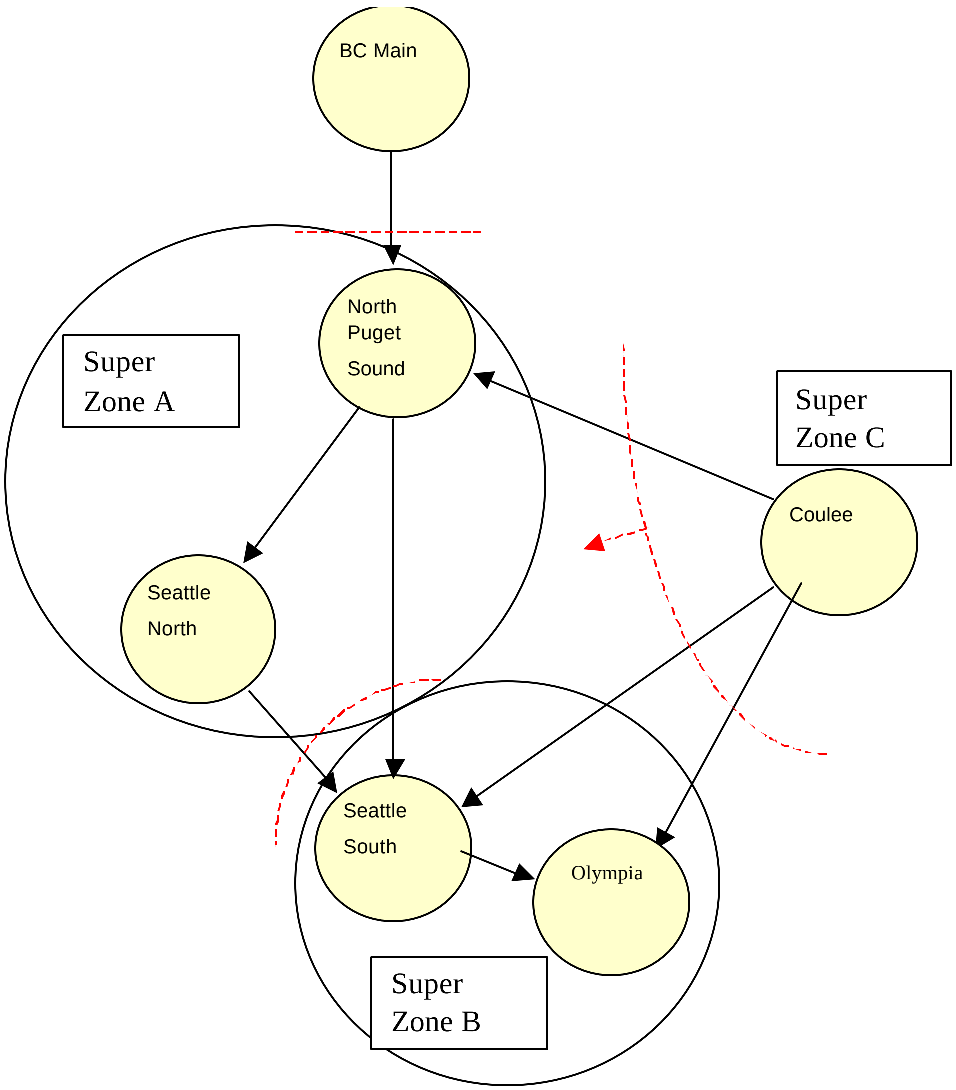
Flowpaths	Ratings			
BC South	1000	0.000	0	
W Casc. N	3000	1.000	3000	
S SnoKing	2000	-0.333	-1000	

Flowgate Model II (Path Definiton Option II)

Flowpaths	Ratings			
BC South	1000	0.000	0	
SZA-SZB	2000	-0.625	-1875	
SZC-SZA	1000	0.375	1125	125
SZC-SZB	2000	0.625	1875	

Flowgate Model III (Path Definiton Option III)

Flowpaths	Ratings			
BC-NPS	1000	0.000	0	
SeaN-SeaS	1000	-0.542	-1625	625
Coulee-NPS	1000	0.375	1125	125
Coulee-SeaS	1000	0.375	1125	125



Schedule: Coulee - Seattle North
Amount: 1847 MW

True Network Model (assume this is the true model)				
Links	**Ratings**	**FDF**	**Flow**	
BC-NPS	1000	0.000	0	
NPS-SeaN	1000	0.250	462	
NPS-SeaS	1000	-0.083	-154	
SeaN-SeaS	1000	-0.542	-1000	0
SeaS-Oly	1000	-0.250	-462	
Coulee-NPS	1000	0.375	693	
Coulee-SeaS	1000	0.375	693	
Coulee-Oly	1000	0.250	462	
Flowgate Model I (Path Definiton Option I)				
Flowpaths	**Ratings**			
BC South	1000	0.000	0	
W Casc. N	1847	1.000	1847	
S SnoKing	1231	-0.333	-616	
Flowgate Model II (Path Definiton Option II)				
Flowpaths	**Ratings**			
BC South	1000	0.000	0	
SZA-SZB	1231	-0.625	-1154	
SZC-SZA	1000	0.375	693	
SZC-SZB	2000	0.625	1154	
Flowgate Model III (Path Definiton Option III)				
Flowpaths	**Ratings**			
BC-NPS	1000	0.000	0	
SeaN-SeaS	1000	-0.542	-1000	0
Coulee-NPS	1000	0.375	693	
Coulee-SeaS	1000	0.375	693	