Transmission Service Request Study

TSR-09-0527

April 30, 2010

Background

Tri-State received a Transmission Service Request, designated TSR-09-0527, and subsequent application for long-term firm transmission service in a letter dated May 28, 2009. The Transmission Customer requested a total of 200 MW of Long-Term Firm Point-to-Point Transmission Service over Tri-State's system from a 230kV interconnection point located at the Wray Substation (Point of Receipt) to the Story 230kV Substation (Point of Delivery). The Transmission Customer executed a Transmission Service Request System Impact Study Agreement (TS-09-0137) received September 21, 2009.

The Transmission Customer submitted an Interconnection Request for a Large Generating Interconnection Project, designated TI-07-0713, in the Tri-State Interconnection Request queue. An Interconnection System Impact Study (SIS) for the Project was subsequently conducted and a draft report was issued on February 2, 2010.

The Interconnection SIS should be referenced for a discussion of the performance of the transmission system with the proposed generation. The Interconnection SIS identified transmission upgrades and facility additions required to interconnect the project to the Tri-State transmission system. Those facility additions are required to mitigate certain N-1 and fault conditions as identified in the power flow and transient stability analyses. The final Interconnection SIS report will provide a list of those facilities, and a good faith estimate of the cost and time required to interconnect the project.

In contrast to the Interconnection SIS, this Transmission Service Request Study evaluates the ability of the transmission system to provide the requested Long-Term Firm Point-to-Point Transmission Service taking into consideration Tri-State's native load requirements and existing committed uses (ETC) for the requested transmission path.

Scope

This study consists of the following:

- Evaluation of the Available Transfer Capability (ATC) of the requested path which begins at a the Wray 230 kV bus and continues to the Story 230kV bus.

- Identification of thermal overloads or violations of voltage criteria resulting from providing Transmission Service over the requested path.

- Identification of all committed uses on the requested path including Tri-State native load requirements through the ten year planning horizon as it will affect the ability of Tri-State to provide the requested Transmission Service.

Methodology

Determining ATC for the requested path requires an analysis of the Total Transfer Capability (TTC) of the transmission system owned or available to Tri-State to meet the transmission request. The Wray 230kV to North Yuma 230kV to Story 230kV path is a primary transmission source utilized by Tri-State to serve its native load obligation in eastern Colorado. The Story to Wray path is also a part of a larger contractual transmission path providing service over the Wray to Burlington to Big Sandy to Midway path to the Tri-State native loads of Y-W Electric Association, Mountain View Electric Association, Southeast Colorado Power Association, San Isabel Electric Association, San Luis Valley Rural Electric Cooperative and Gunnison County Electric Association.

Equation 1: ATC Equation

ATC = Total Transfer Capability (TTC) – Existing Transmission Commitments (ETC) – Transmission Reliability Margin (TRM)

- TTC was determined in accordance with Tri-State's *Engineering Standards Bulletin – Reliability Criteria for System Planning and Service Standards* which states the maximum loading criteria for transmission lines as a percent of the continuous rating. Based on that criteria, TTC in this study was defined as 100 percent of the thermal rating of the line sections in the requested path.

- ETC is defined as Tri-State native load-serving needs, existing commitments for transmission service and existing commitments for purchase/exchange/delivery.

- TRM is defined as loop flow across the requested path and transfer capability required to ensure reliable system operation as system conditions change. WECC operating practice requires transmission providers to accommodate some through-flow which may decrease ATC. TRM is also utilized to deliver and receive reserve obligations associated with a Reserve Sharing Group.

Since Tri-State owns and purchases network generation resources in eastern Colorado, network generation output beyond what can displace the local load must be exported over the transmission network and therefore will reduce ATC. During certain N-1 conditions, generation beyond what can displace the local load must be exported over the Transmission Customer's requested path.

The study identified the N-1 contingency that maximized the flows across the requested path prior to the Transmission Customer's generation interconnection. That N-1 contingency is a loss of the Midway to Lincoln 230kV transmission line. The resultant flow over the requested path during a loss of the Midway to Lincoln 230kV line identified the transmission capacity that the Transmission Provider must reserve to serve native loads plus the transmission required for generation export including transmission for generation reserve obligations.

For study purposes, the requested path was divided into two sections, 1) the Point of Receipt (Wray) to the North Yuma Substation, and 2) the North Yuma Substation to the Point of Delivery (Story).

Study Assumptions

Tri-State System Operations provided the firm committed uses for the requested path. Tri-State Energy Management confirmed Tri-State's reserve obligations for the study. The Interconnection SIS power flows were used for the power flow analysis. The Interconnection SIS power flows were performed utilizing four WECC base cases, analyzing both summer and winter seasons for the pre-project and post-project system configurations. The load and resource assumptions in these cases were reviewed and were considered appropriate for the flow-based analysis of this transmission service study. Specifically, the load and generation assumptions of the light winter case were identified as those which produce the most limiting ATC. The light winter case generation assumptions contribute to maximizing the loading on the requested path since available network resources in eastern Colorado are modeled as on-line in the cases. The light winter loads were selected since under light loading conditions not all of the generation in eastern Colorado can be absorbed locally, again resulting in maximizing the loading on the requested path. Each base case generation dispatch assumption is as noted in the Interconnection SIS study.

The 200 MW resource was injected at the Point of Receipt and the worst N-1 contingency was simulated to verify that there is adequate transmission capacity with the interconnection. The study selected the N-1 contingency that maximized the loading on the requested path but did not concern itself with all other N-1 conditions. Other critical N-1 conditions that may require system upgrades are identified in the Interconnection SIS.

The Interconnection SIS power flow analysis was performed using the National Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) planning standards. The analysis identified any line loading exceeding 100% of its continuous thermal rating and monitored the voltage performance of the transmission system. Normal voltage violations were limited to the conditions where per unit voltages were between 0.95 and 1.05. Emergency voltage violations were limited to the conditions where per unit voltages were not less than 0.90 or greater than 1.10. In addition, voltage deviations greater than 5% between the pre and post-contingency were monitored.

This Interconnection SIS study includes dynamic analysis to determine the ability of the transmission system to recover from short circuit conditions and meet voltage ride through requirements. No further dynamic stability analysis was deemed necessary for this transmission service study.

Results

A flow-based analysis was conducted to determine the maximum flow across the requested path. The flow-based analysis is based on the Interconnection SIS power flow cases. Reference the Interconnection SIS for a comprehensive analysis of all single element outages.

Table 1

Summary of Line Flows Across the Requested Path
From the Flow-Base Analysis

Case	Line Flows by Line Section (MVA)			
	Project Tap – Wray	Wray – North Yuma*	North Yuma – Story*	
2103lw LGIP Full Network Generation Pre-Project	50.3	41.3 (14%)	7.1 (7%)	System Normal
2013lw LGIP (Base Case) Full Network Generation Post-Project	206.0	159.4 (57%)	87.9 (31%)	System Normal
2103lw LGIP Full Network Generation Pre-Project Midway – Lincoln out	162.0	145.8 (51%)	88.9 (31%)	
2103lw LGIP Full Network Generation Post-Project Midway – Lincoln out	332.0	276.0 (98%)	181.8 (64%)	
2103lw LGIP Full Network Generation Post-Project Midway – Lincoln in Wray transformer out	190.0	189.8 (67%)	93.5 (33%)	
2103lw LGIP Full Network Generation Post-Project Midway – Lincoln out Wray transformer out	313.8	312.9 (111%)	189.4 (67%)	
* NOTE: Line rating is 284 MVA				

Power flow diagrams of the above are included in the Appendix to this report. A review of the Interconnection SIS cases led to the following conclusions.

1. Light winter loading on the system resulted in a higher power flow across the requested path (in the requested direction) than heavy summer loading under normal system conditions. This was due to a larger amount of local generation being absorbed by local load during the summer than during the winter.

2. The post-project loading across the requested path was higher than the pre-project loading. This was true for both the light winter and heavy summer cases.

3. The maximum pre-project system normal power flow across the Wray to North Yuma line was 41.3 MVA and across the North Yuma to Story line was 7.1 MVA (east to west direction).

4. The maximum post-project system normal power flow across the Wray to North Yuma line was 159.4 MVA and across the North Yuma to Story line was 87.9 MVA (east to west direction).

5. The maximum pre-project N-1 power flow across the Wray to North Yuma line was 145.8 MVA and across the North Yuma to Story line was 88.9 MVA (east to west direction with the Midway to Lincoln 230kV line out).

6. The maximum post-project N-1 power flow across the North Yuma to Story line was 276.0 MVA and across the North Yuma to Story line was 181.8 MVA (east to west direction with the Midway to Lincoln 230kV line out).

ATC Calculation

The determination of ATC for the requested path involved identifying TTC as defined below and subtracting native load obligations and other existing commitments.

Determination of TTC:

Transmission sources owned by or purchased by Tri-State comprise the TTC that Tri-State has available to serve it native load and meet other existing transmission commitments. TTC for the purposes of this study is defined as the thermal rating of the Wray to North Yuma to Story line. The line rating is 284 MVA and is based on 954 ACSR conductor constructed for 50 degrees C.

TTC = Transmission MW capacity of the Wray to North Yuma to Story 230kV line = 284 MW

Determination of ETC:

The worst local N-1 scenario was simulated in the power flow analysis to maximize the flow across the requested path. As stated in the Methodology section of this report, the maximum flow occurs during an outage of the Midway to Lincoln 230kV line. During an outage of the Midway to Lincoln 230kV line, the flow on the Wray to North Yuma portion of the requested path was determined to be 145.8 MVA and for the North Yuma to Story portion of the requested path was determined to be 88.9 MVA for the system prior to the 200 MW injection. These values (145.8 MVA and 88.9 MVA) represent what Tri-State needs to serve native load and includes TRM.

There are existing Firm Committed Uses by Others on the North Yuma to Story portion of the requested path:

PSCo 110 Firm (bi-directional) 110 MW

Determination of ATC:

1. Wray to North Yuma:
   Based on the above, the ATC prior to the 200 MW injection for the Wray to North Yuma portion of the requested path is as follows:

   ATC = TTC – ETC – TRM
   ATC = 284 MVA – 145.8 MVA = 138 MVA

2. North Yuma to Story:
   Based on the above, the ATC prior to the 200 MW injection for the North Yuma to Story portion of the requested path is as follows:

   ATC = TTC – ETC – TRM
   ATC = 284 MVA – 110 MW – 88.9 MVA = 85 MVA

Conclusions

The Transmission Customer requested 200 MW of Long-Term Firm Point-to-Point Transmission Service over Tri-State's system from a 230kV interconnection point located at the existing Wray 230kV bus (Point of Receipt) to the Story 230kV bus (Point of Delivery).

Based on the results of this study, 138 MVA is available for the Transmission Customer on the Wray to North Yuma portion of the requested path without the addition of network upgrades. The study identified committed uses which, together with Tri-State's native load requirements and TRM, limit the ATC on the North Yuma to Story portion of the requested path to 85 MVA without network upgrades. Therefore, transmission system upgrades are required in order to accommodate the full Transmission Service request. It is anticipated that local load growth may free up additional ATC since ATC is limited in this analysis due to the export of local

generation. Therefore, these values of ATC are considered reasonable for the 10 year scope of this study since some modest load growth is expected.

The flow-based analysis confirmed that steady state system performance was acceptable for the Midway to Lincoln 230 kV outage. However as noted, the flow-based analysis resulted in a maximum post-project N-1 power flow of 276.0 MVA on the Wray to North Yuma portion of the requested path, or 98 percent of the thermal rating of the line. The Interconnection SIS identified additional network upgrades required to interconnect the project to the Tri-State transmission system. Those upgrades are required to mitigate certain N-1 and fault conditions. The Interconnection SIS should be referenced for a discussion of the network upgrades required to interconnect the project to the Tri-State transmission system and for cost estimates of those network upgrades.

The capacity of the Wray to Story path used in this study is based on the conductor thermal rating of 50 degrees C. A possible alternative to accommodate the full amount of requested Transmission Service would be to uprate the existing line to a higher design operating temperature, 100 degrees C if possible. Assuming that the existing conductor could be operated at 100 degrees C, the thermal rating of the line could be increased to approximately 512 MVA, providing an additional 228 MVA of capacity. Such an alternative may require several short outages of the existing line during which it may be necessary to purchase transmission service from other providers. A Facilities Study would be required to determine if this alternative is feasible. The Transmission Customer would be responsible for all costs associated with such an alternative. Based on Tri-State's experience with this type of line uprate, the following planning cost estimate is provided.

<u>Estimated Cost</u>

1. Thermal Uprate of the existing North Yuma to Story 230 kV line (45.2 miles)
   45.2 miles @ $155,000 per mile = $7,006,000
   Cost of transmission service during outages $60,000

2. Thermal Uprate of the existing Wray to North Yuma 230 kV line (30.7 miles)
   30.7 miles @ $155,000 per mile = $4,758,500
   Cost of transmission service during outages $40,000

   Total Estimate = $11,864,500

Appendix 1

Steady State Power Flow Diagrams

2013lw LGIP - Pre Project

Network Generation "ON"

Bus - VOLTAGE (KV/PU)
Branch - MVA
Equipment - MW/MVAR
KV <=69.000 <=115.000 <=138.000 <=230.000 <=345.000 >345.000

2013 lw LGIP - Base Case

Network Generation "ON"

System Normal

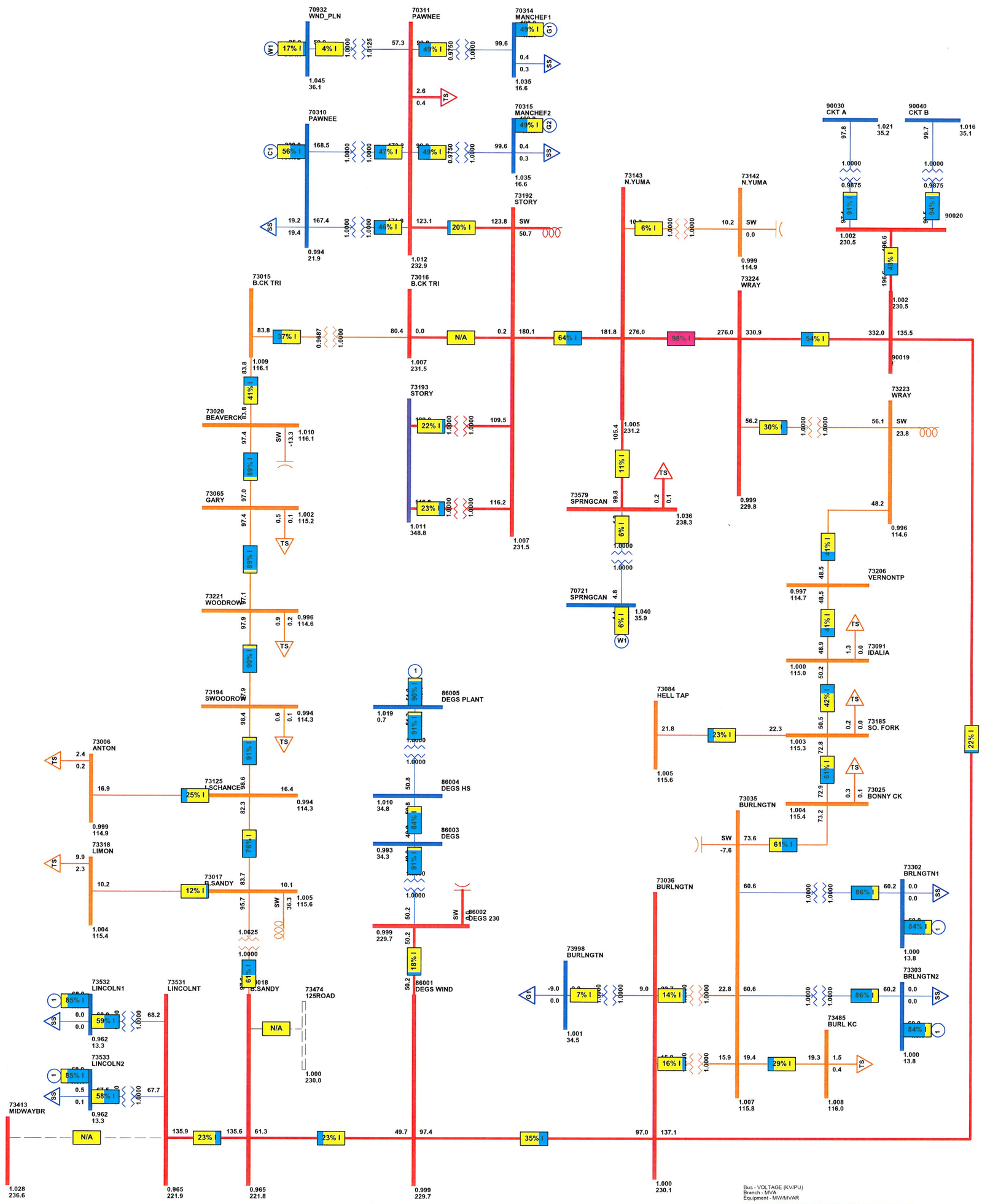
Bus VOLTAGE (KV/PU)
Branch - MVA
Equipment - MW/MVAR
KV: <=69.000 <=115.000 <=138.000 <=230.000 <=345.000 >345.000

2013lw LGIP - Pre Project

Network Generation - "ON"

Midway - Lincoln Circuit - "OUT"

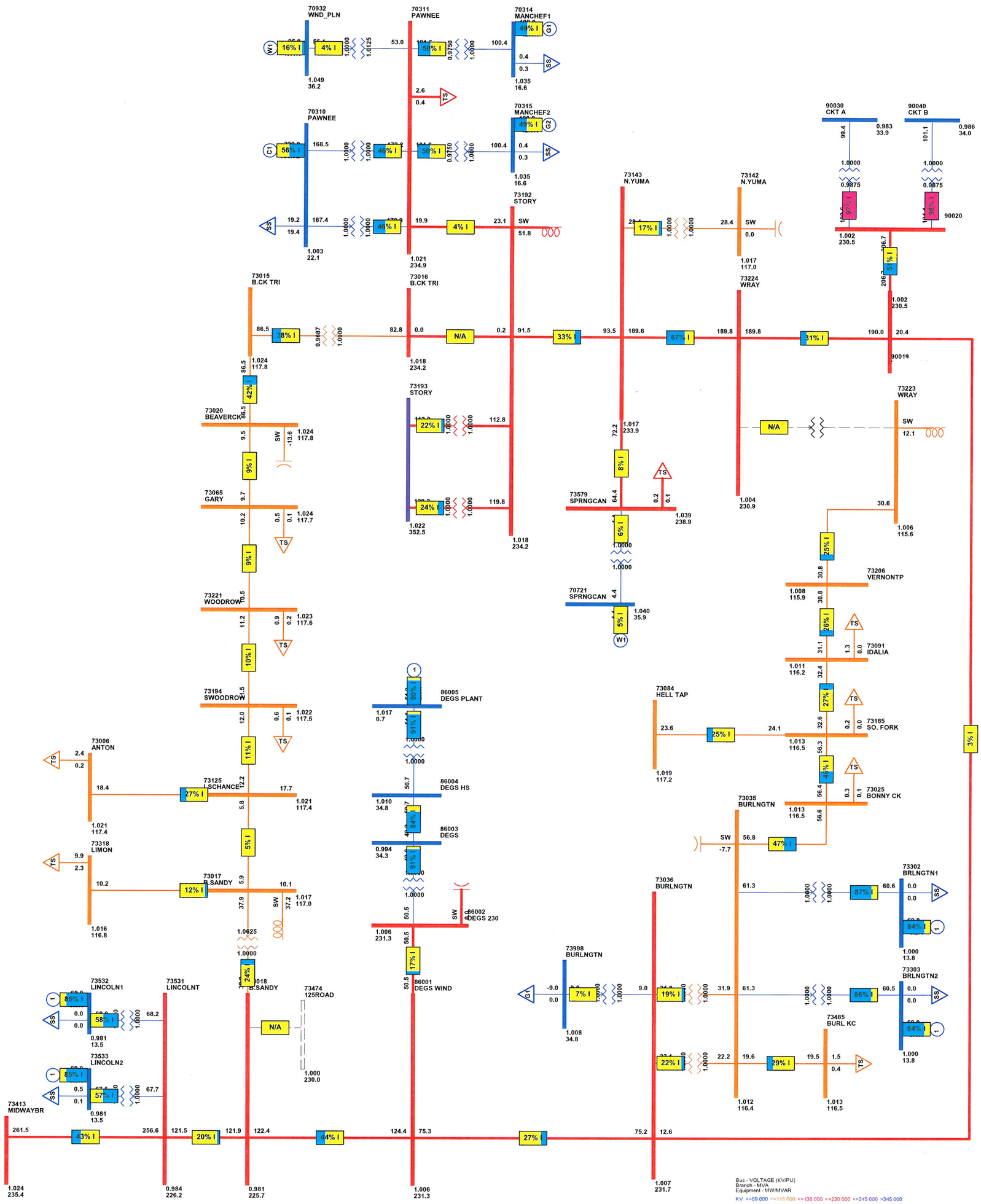
Bus - VOLTAGE (KV/PU)
Branch - MVA/MVAR
Equipment - MW/MVAR
KV <=69.000 <=115.000 <=138.000 <=230.000 <=345.000 >345.000



2013lw LGIP - Post Project

Network Generation - "ON"

Midway - Lincoln Circuit - "OUT"

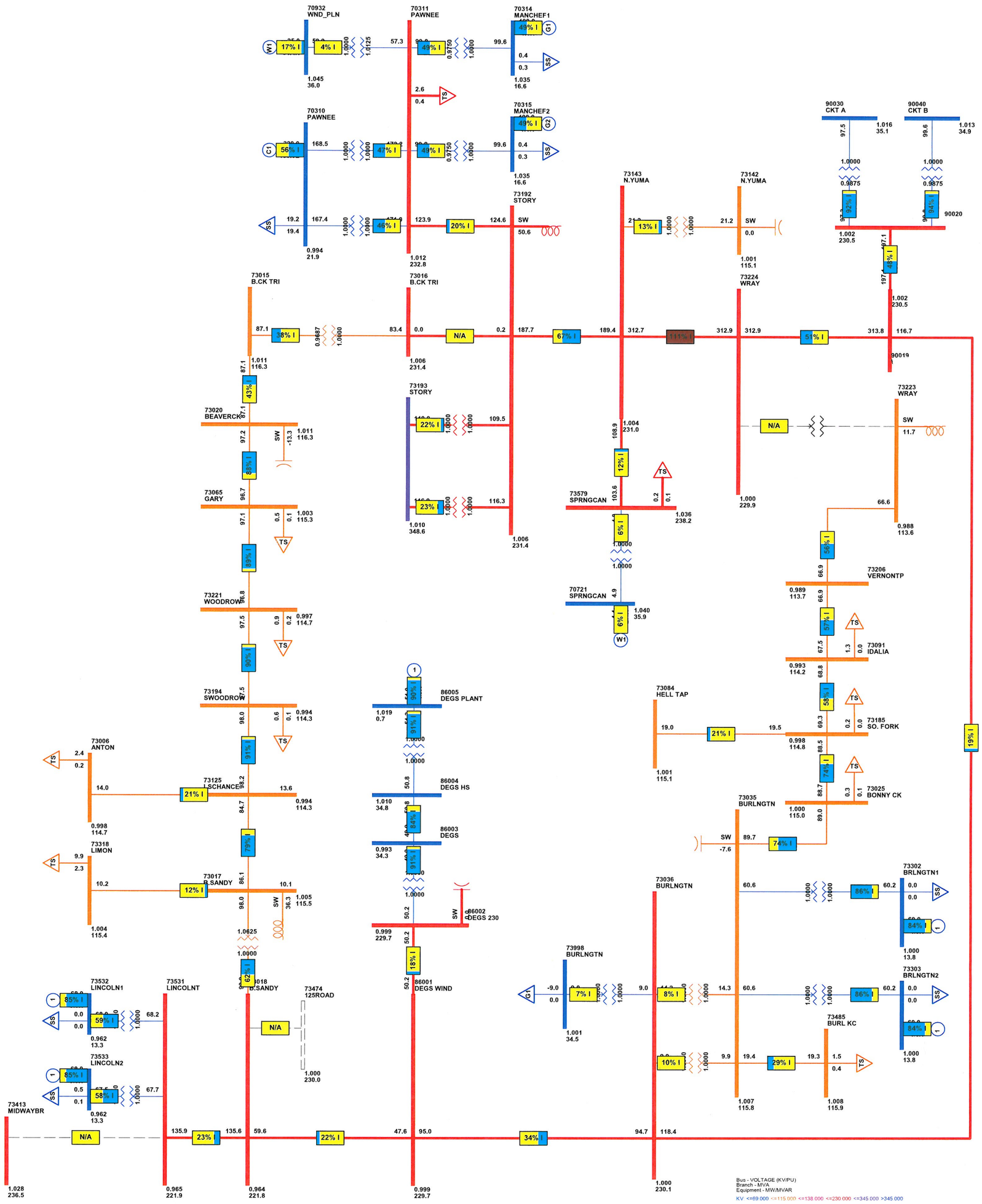


2013lw LGIP - Post Project

Network Generation - "ON"

Midway - Lincoln Circuit "IN"

Wray 230/115 kV xfmr "OUT"



2013lw LGIP - Post Project

Network Generation "ON"

Midway - Lincoln Circuit "OUT"

Wray 230/115 kV xfmr "OUT"