Load and Resource Transmission Analysis
2011 through 2020

June 30, 2011

Prepared by: Joe Costello, Igor Kormaz and Mark Stout

Background

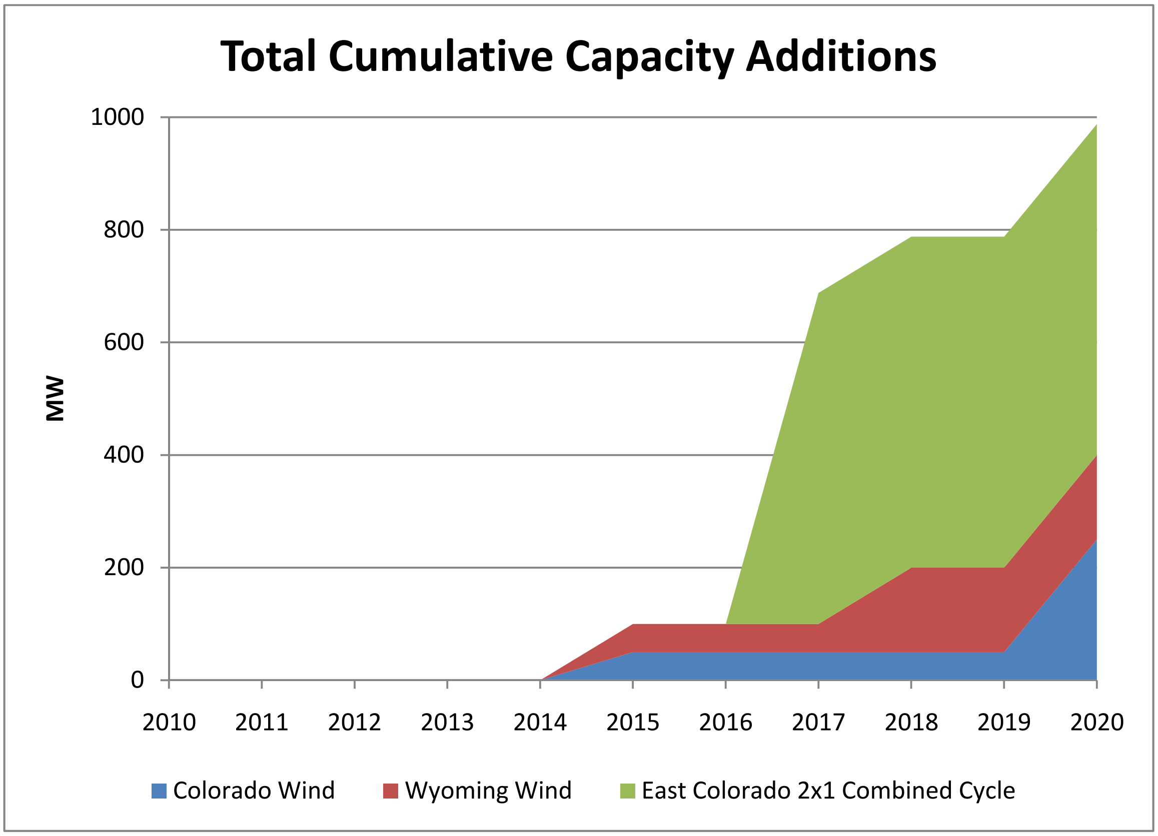
Pursuant to the provisions of Tri-State's Network Operating Agreements with its network customers, each customer is required to annually provide to Tri-State an update to its projected 10-year Network Integration Transmission Service Requirements. That update includes projected Network Loads and Network Resources as well as all other information necessary for Tri-State to plan the integrated transmission network to accommodate service to its network customers.

Tri-State's current network customers are Public Service Company of New Mexico (PNM), the Municipal Energy Agency of Nebraska (MEAN), the Arkansas River Power Authority (ARPA), and Tri-State Power Marketing. Tri-State Power Marketing performs the merchant or wholesale power function for Tri-State's member cooperatives and is responsible for all power sales to Tri-State's members (native load customers). Tri-State System Operations performs the transmission function for Tri-State and sells transmission services to Tri-State Power Marketing under the terms of Tri-State's tariff. Each of the network customers listed above have also submitted annual loads and resources as required by the Network Operating Agreements.

This study examines the need for new transmission for the next ten years based on the most up-to-date load and resource information submitted to Tri-State by its network customers. The evaluation of new transmission requirements is undertaken to satisfy the obligation of Tri-State to provide reliable and economic transmission service to its network customers.

The following proposed resource *additions* have been included in this study:

- 50 MW wind, Lamar, CO 2015
- 50 MW wind Archer, WY 2015
- 588 MW combined cycle, Lamar, CO 2017
- 100 MW wind Archer, WY 2018
- 200 MW wind Lamar, CO 2020



Each of the above resource additions was submitted by the network customers. Planned resource additions by other utilities (not network customers) were included as a part of this study as appropriate.

The Colorado Coordinated Planning Group (CCPG) studies performed in 2008 resulted in conceptual transmission plans that consist of new high-voltage transmission projects originating at or near Lamar, CO and extending to points along the Front Range of Colorado at potential substations such as Comanche, Burlington, and Calhan. Since a total of 838 MW of the above listed resource additions are planned for the Lamar area, this transmission analysis builds on the CCPG study effort and is consistent with its findings. The proposed transmission projects identified by this study to accommodate the resource additions at Lamar are consistent with those presented by Tri-State at its FERC 890 Stakeholder Meeting held June 28, 2010 and with the Lamar – Front Range Transmission Study performed in 2010[1].

[1]Tri-State Generation & Transmission ("Tri-State"), Public Service Company of Colorado ("PSCo"), and Black Hills Energy ("Black Hills") have jointly commissioned Utility System Efficiencies, Inc. ("USE") to perform this Lamar – Front Range Transmission Study, the purpose of which is to evaluate transmission alternatives for reliably alleviating existing transmission system constraints that inhibit generation from potential resource development in southeast and east central Colorado from reaching electrical customer loads along Colorado's Front Range.

Scope

This study consists of the following:

- Power flow analysis of the transmission system to determine the steady-state electrical performance of the transmission system during System Normal and N-1 conditions for the requested load and resource additions.
- Identification of thermal overloads or violations of voltage criteria resulting from providing transmission service to the requested loads and resources.
- Identification of transmission system improvements and network upgrades necessary to accommodate the load and resource additions.
- Improvement to the reliability of the interconnected transmission network in accordance with North American Electric Reliability Council (NERC) Standards and Western Electricity Coordinating Council (WECC) Criteria.
- Consideration of the needs and interests of neighboring utilities and coordination of transmission expansion to integrate with those needs.
- Design of the system so as not to burden neighboring electric systems by creating unacceptable system loading conditions.
- Development of transmission solutions that will integrate with proposed higher-voltage regional transmission system projects, with particular attention to integrating the recommendations in this report with those of the Lamar Front Range Study report.

Base Case

The study was initiated with a power flow model that represented 2015 summer peak loading conditions. The model was developed from the Western Electricity Coordinating Council (WECC) case 15hs2p. Neighboring utilities reviewed the input base case and confirmed regional transmission and generation projects expected to be operational by summer 2015. Resource and topology additions from the Tri-State Network Resource Expansion Plan and the anticipated first phase of the Lamar Front Range Project were added to the 2015HS case to create a 2017HS case. The following seven cases were used in the study:

- Benchmark: 2015HS without L&R additions
- Case 1: 2015HS with 50 MW wind added at Archer and 50 MW wind added at Lamar
- Case 2: Case 1 with 588 MW Lamar Energy Center generation added and Comanche to Lamar 345 kV circuit (single) in service
- Case 3: Case 1 with 588 MW Lamar Energy Center generation added and Comanche to Lamar to Burlington 345 kV circuits (single) in service

- Case 4: Case 2 with 100 MW wind added at Archer and Comanche to Lamar to Burlington 345 kV circuits (single) in service
- Case 5: Case 4 with 200 MW wind added at Lamar and Comanche to Lamar to Burlington 345 kV circuits (single) in service
- Case 6: Case 4 with 200 MW wind added at Lamar and Comanche to Lamar to Burlington to Big Sandy 345 kV circuits (single) in service

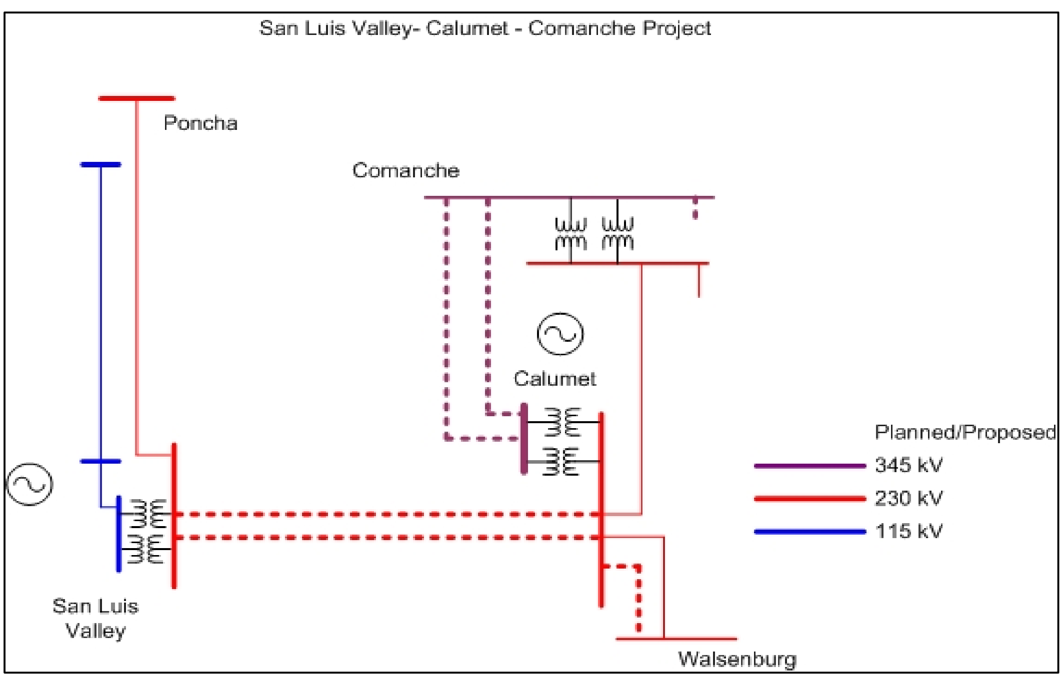
The 2020HS Lamar Front Range Case Study results were used to evaluate long term (2020 summer peak and 2020 off-peak) system performance.

Study Assumptions

The study was performed utilizing the 2015 and 2020 heavy summer base cases. The following modifications were made to the original WECC base cases:

- Cases were updated with new Tri-State's FAC009 ratings
- Cases were updated with new Tri-State load forecast developed in 2009
- Cases were updated with all known budgeted transmission and generation projects
- PSCo's existing wind generation in the Lamar area was maximized
- The following Figure 1 represents a major transmission project included in each case.

Figure 1



Facilities of **Figure 1** consist of the following:

- A new 230 kV transmission line from Calumet to Walsenburg Substation. Conductor modeled was single 1272 kcmil with a continuous thermal rating of 613 MVA.
- A new Calumet Substation, approximately six miles northwest of the existing Walsenburg Substation. Include two 560 MVA 345/230 kV autotransformers.
- A new double-circuit 230 kV transmission line from San Luis Valley Substation to the new Calumet Substation. Conductor modeled was single 1272 kcmil with a continuous thermal rating of 613 MVA per circuit.
- A new double-circuit 345 kV transmission line from Calumet Substation to Comanche Station. Conductor modeled was 1272 kcmil, two-conductor bundle with a continuous thermal rating of 1226 MVA.

Study Methodology

Power flow analysis was performed using PTI PSS/E version 32.1.0 and following NERC/WECC planning standards. Power flow analysis was used to evaluate thermal and voltage performance of the transmission system for NERC/WECC Category A normal (all elements in-service) conditions and NERC/WECC Category B emergency (single contingency) conditions. The criteria used in this evaluation are listed in the Study Criteria section of this report and located in the Appendix. Transient and voltage stability analysis was not performed as a part of this study. Refer to the Lamar Front Range Study for the transient analysis performed with all recommended transmission improvements in eastern Colorado.

In the steady state analysis the following system parameters were monitored and tabulated in the results section as needed:

- All busses, lines, and transformers with base voltages equal to or greater than 69 kV in the Colorado power flow areas 70 and 73, were monitored in all alternatives.

- Post contingency element loadings were only tabulated when an element rating was exceeded and the loading increased at least 1% from the normal system loading. Specifically, if an element was overloaded in the normal condition and increased no more than 1% in the outage condition, the overload was not reported.

- Post contingency voltage violations were tabulated only if the deviation was higher than 0.05 pu. from the normal system voltage or higher if allowed by local criteria. Base case and contingency low voltage violations were noted, but not emphasized since voltage issues will be managed by regular reliability planning studies and would not affect the development of the transmission identified here.

Benchmark Loads

Loads in the case remained constant for all power flow analyses, regardless of generation dispatch. The following table lists the regional load and resource values for the 2015 HS benchmark case.

Table 1   Base Case Loads and Generation Summary

Power flow Area	Load	Generation
70 (Public Service)	8170	7678
73 (Western Rocky Mountain)	5629	6840
10 (New Mexico)	2889	3116

Resources

Table 2 describes the new generation resources considered in the study. New generation was modeled using typical power flow models, assuming that sufficient reactive power would be available for voltage control.

A high stress scenario was created for all of the cases (including the Benchmark case) by maximizing some of the existing south area (Zone 3) generation resources, such as Colorado Green Wind and Twin Butte Wind, and by maximizing the Lamar DC Tie (East to West) and the Comanche generation. When new generation was added in area 70 and 73, the area load and resource levels remained constant. The balance was achieved by reducing existing generation north of the Denver area at various locations. Generation units were dispatched in this way to stress the system in order to evaluate the southeast Colorado transmission system. Table 3 describes the existing generation resources re-dispatched in the study in order to construct the desired scenarios.

It is possible that future generation interconnections will be constructed at other locations or other voltage levels which could change the results of this analysis. Only the locations noted above were evaluated for this study.

Table 2 New Generation Summary

Resource	Year	New Bus #	Area	Output (MW)
50 MW Lamar Wind (Lamar Wind)	2015	70254	70	50
50 MW Archer Wind (Archer Wind)	2015	73008	73	50
588 MW 2X1 Combined Cycle Holly Generation (LEC) – Phase 1	2017	73997	70	588
100 MW Archer Wind (Archer Wind)	2018	73008	73	100
200 MW Lamar Wind (Lamar Wind)	2020	70254	70	200

Table 3 - Re-dispatched Existing Generation Summary

Resource	Area	Output (MW)	Type of change
70702 CO_GRN_E Wind	70	81	Raised to max
70702 CO_GRN_W Wind	70	81	Raised to max
70703 TWNBUTTE Wind	70	65	Raised to max
73302 BRLNGTN1 Generation	73	0	Reduced
73303 BRLNGTN2 Generation	73	0	Reduced
70560 LAMAR_DC East to West	70	210	Raised to max
70310 PAWNEE Generation	70	300	Reduced
73532 LINCOLN1 Generation	73	37	Reduced
73533 LINCOLN1 Generation	73	37	Reduced
79015 CRAIG1 Generation	73	250	Reduced
79016 CRAIG2 Generation	73	351	Reduced
73130 MBPP-1 Generation	73	510	Reduced

Benchmark Analysis

A benchmarking analysis was performed to evaluate the existing system performance prior to the addition of new generation and transmission. System performance for various transmission alternatives could then be compared with the benchmark performance. Contingency loadings were monitored on all transmission elements (lines and transformers) in the region of study. Any contingency loadings greater than 100% on lines and 100% on transformers were flagged. The Benchmark transmission system is shown in **Figure 3**.

During the course of the benchmark analysis, some overloads appeared that were due to substation terminal equipment loadings, rather than line loadings. Certain substation equipment was assumed to be uprated based on the assumption that a minimal cost could alleviate the equipment constraints.

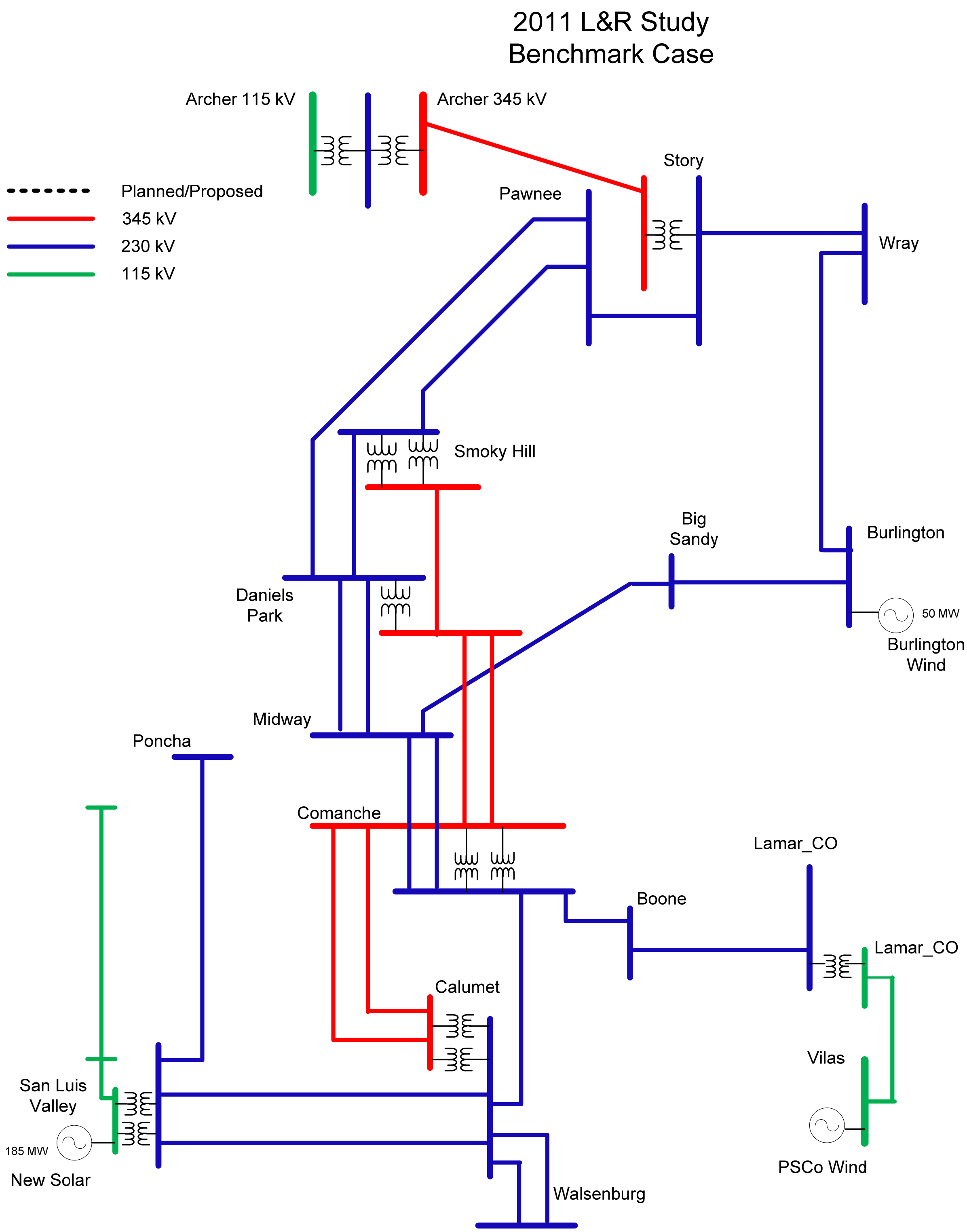

2011 L&R Study
Benchmark Case
Archer 115 kV
Archer 345 kV
Planned/Proposed
345 kV
230 kV
115 kV
Story
Pawnee
Wray
Smoky Hill
Big
Sandy
Burlington
50 MW
Burlington
Wind
Daniels
Park
Midway
Poncha
Comanche
Lamar_CO
Boone
Lamar_CO
Calumet
Vilas
San Luis
Valley
185 MW
New Solar
PSCo Wind
Walsenburg

Figure 3

Analysis

After benchmarking the performance of the transmission system, cases with the proposed generation additions were created. Initially, 638MW of requested resource was inserted in the Lamar area into the Benchmark case. The first run of power flow analyses confirmed that the existing radial 230 kV transmission system in southeastern Colorado is insufficient to export this resource out of the Lamar area. Therefore, additional transmission is required. Based on previous study work, it was assumed that at least two high voltage lines are required in order to accommodate the requested generation injection in the Lamar area and to plan for N-1 conditions. A number of transmission solutions were considered consistent with previous studies. Cases were prepared analyzing the system topology necessary to accommodate the anticipated resource and load additions.

One assumed transmission addition is a 345 kV circuit from the proposed Lamar Energy Center to Comanche. A second assumed addition is a single/double circuit line from the Lamar Energy Center to Burlington at 345 kV. An additional transmission line was studied out of Burlington to avoid an overload of the Burlington – Wray 115kV line during a loss of the existing Burlington – Big Sandy 230 kV line. A new 345 kV segment was studied for this section. These proposed line segments are consistent with the Xcel Energy Senate Bill 100 plan, the High Plains Express Study, and the Lamar Front Range Study. The proposed additions were analyzed in this study and are shown on Figures 4 through 9. The additions include all known transmission system improvements planned by transmission providers.

Case 1

Case 1 is shown in **Figure 4** and includes the following resource additions into the Benchmark Case:

1. 50 MW wind energy injected at Lamar 230 kV Bus
2. 50 MW wind energy injected at Archer 115 kV Bus

Case 1 consists of the following details:

- Same topology as Benchmark Case (2015 HS case).

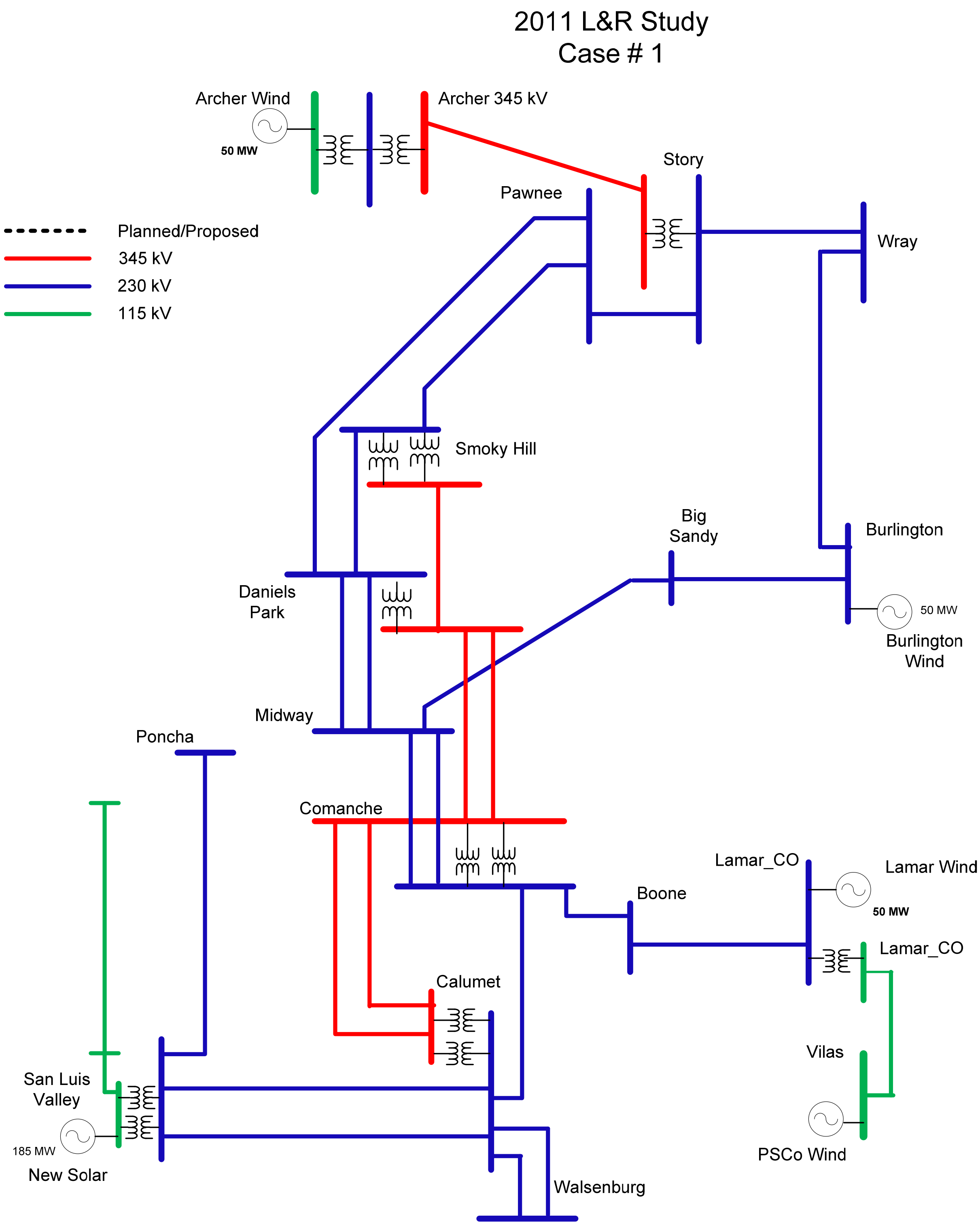

2011 L&R Study
Case # 1
Archer Wind
50 MW
Archer 345 kV
Story
Pawnee
Wray
Planned/Proposed
345 kV
230 kV
115 kV
Smoky Hill
Big
Sandy
Burlington
Daniels
Park
50 MW
Burlington
Wind
Midway
Poncha
Comanche
Lamar_CO
Lamar Wind
Boone
50 MW
Lamar_CO
Calumet
Vilas
San Luis
Valley
185 MW
New Solar
PSCo Wind
Walsenburg

Figure 4

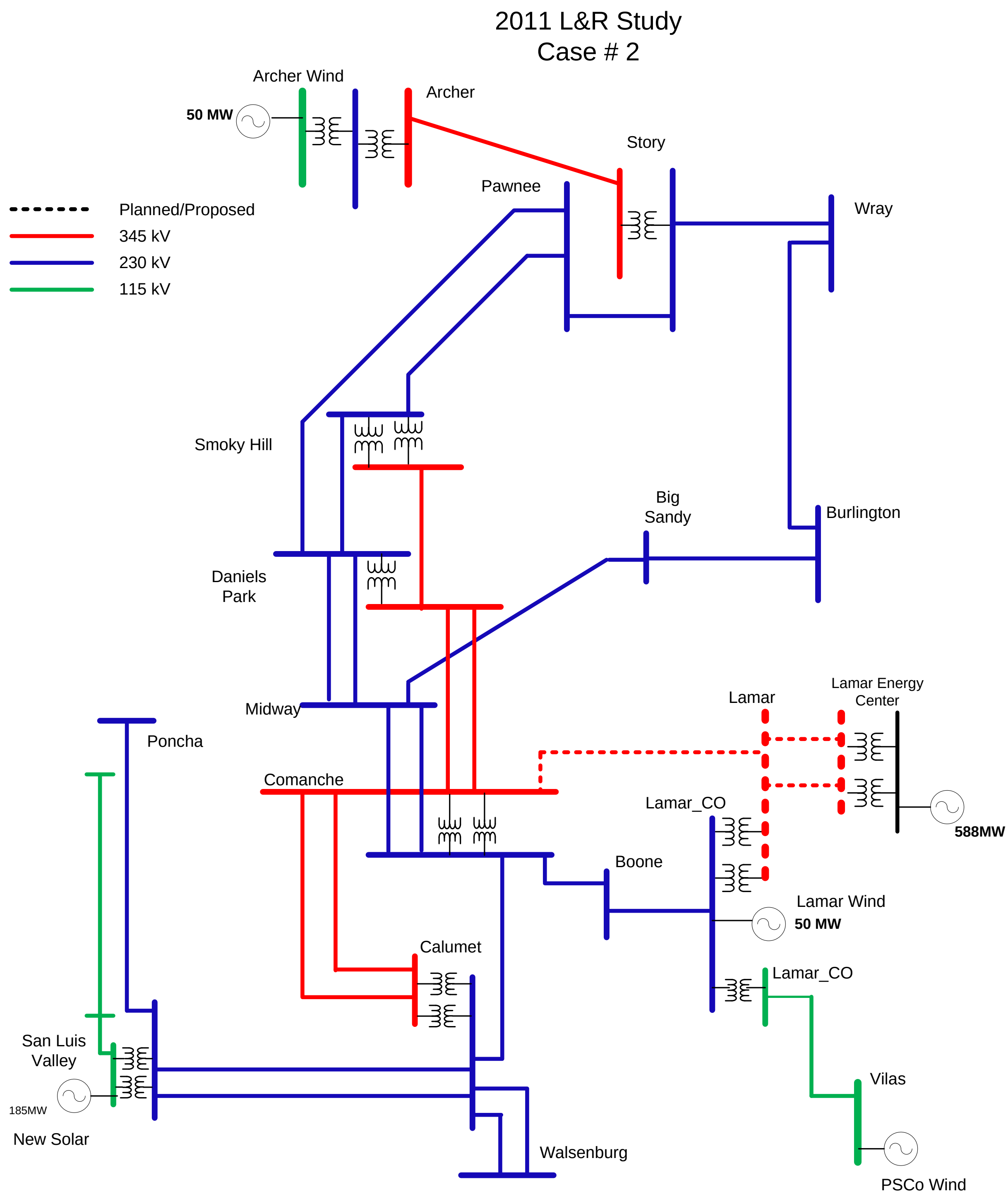
Case 2

Case 2 is shown in **Figure 5** and includes the following key bulk system additions:

1. Lamar – Comanche single circuit 345 kV
2. Energy Center – Lamar double circuit 345 kV
3. Lamar Energy Center 588 MW addition
4. 50 MW wind energy injected at Lamar 230 kV Bus
5. 50 MW wind energy injected at Archer 115 kV Bus

Case 2 consists of the following details:

- Build a new Energy Center substation, including two 600 MVA 345/22 kV autotransformers.
- Build a new Lamar substation, including two 600 MVA 345/230 kV autotransformers.
- Build a new 20 mile double circuit 345 kV line from Energy Center Substation to the Lamar Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA per circuit
- Build a new 140 mile single circuit 345 kV line from Lamar 345 kV Substation to the existing Comanche Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.



2011 L&R Study
Case # 2
Archer Wind
50 MW
Archer
Story
Pawnee
Wray
Planned/Proposed
345 kV
230 kV
115 kV
Smoky Hill
Big
Sandy
Burlington
Daniels
Park
Lamar Energy
Center
Lamar
Midway
Poncha
Comanche
Lamar_CO
588MW
Boone
Lamar Wind
50 MW
Calumet
Lamar_CO
San Luis
Valley
Vilas
185MW
New Solar
Walsenburg
PSCo Wind

Figure 5

Case 3

Case 3 is shown in **Figure 6** and includes the following key bulk system additions:

1. Lamar – Burlington single circuit 345 kV
2. Energy Center – Lamar double circuit 345 kV
3. Lamar – Comanche 345 kV
4. Lamar Energy Center 588 MW addition
5. 50 MW wind energy injected at Lamar 230 kV Bus
6. 50 MW wind energy injected at Archer 115 kV Bus

Case 3 consists of the following details:

- Build a new Energy Center substation, including two 600 MVA 345/22 kV autotransformers.
- Build a new Lamar substation, including two 600 MVA 345/230 kV autotransformers.
- Build a new Burlington substation, including one 600 MVA 345/230 kV autotransformers.
- Build a new 140 mile single circuit 345 kV line from Lamar 345 kV Substation to the existing Comanche Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 86 mile single circuit 345 kV line from Lamar 345kV Substation to the proposed Burlington Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 20 mile double circuit 345 kV line from Energy Center Substation to the proposed Lamar Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.

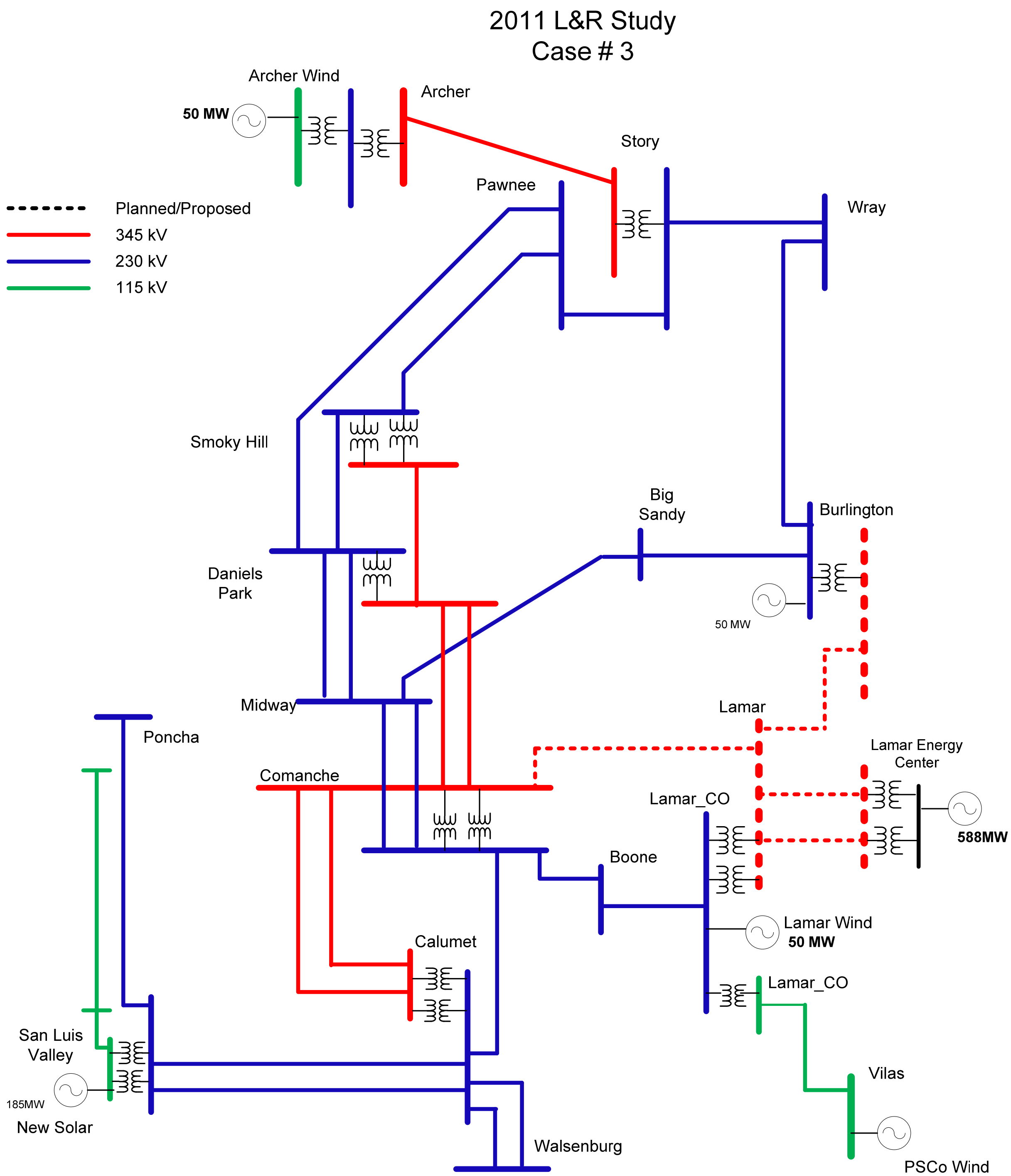

2011 L&R Study
Case # 3
Archer Wind
50 MW
Archer
Story
Pawnee
Wray
Planned/Proposed
345 kV
230 kV
115 kV
Smoky Hill
Big Sandy
Burlington
Daniels Park
50 MW
Midway
Lamar
Poncha
Lamar Energy Center
Comanche
Lamar_CO
588MW
Boone
Lamar Wind
50 MW
Calumet
Lamar_CO
San Luis Valley
Vilas
185MW
New Solar
Walsenburg
PSCo Wind

Figure 6

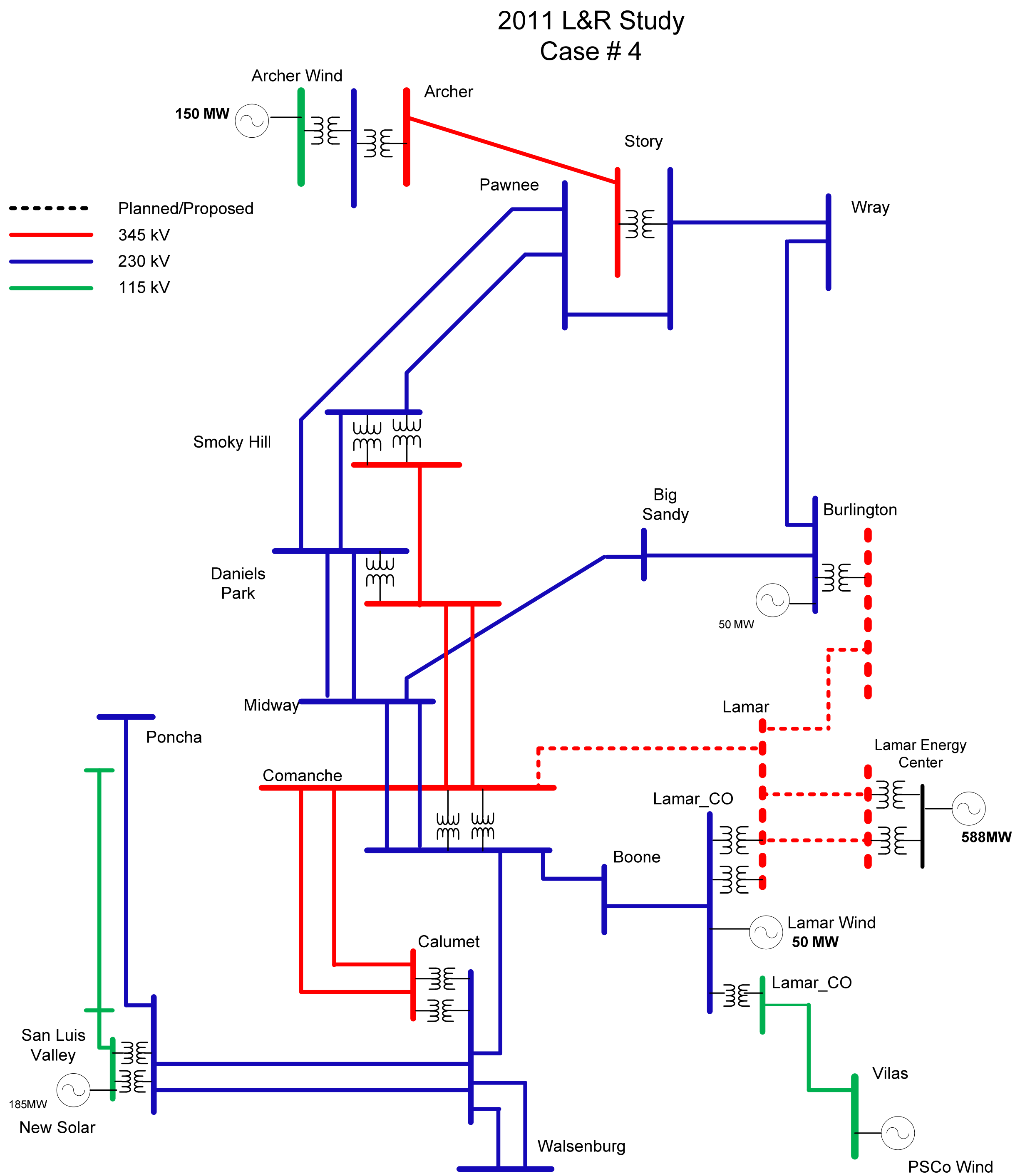
Case 4

Case 4 is shown in **Figure 7** and includes the following key bulk system additions:

1. Lamar – Burlington single circuit 345 kV
2. Energy Center – Lamar double circuit 345 kV
3. Lamar – Comanche 345 kV
4. Lamar Energy Center 588 MW addition
5. 50 MW wind energy injected at Lamar 230 kV Bus
6. 150 MW wind energy injected at Archer 115 kV Bus

Case 4 consists of the following details:

- Build a new Energy Center substation, including two 600 MVA 345/22 kV autotransformers.
- Build a new Lamar substation, including two 600 MVA 345/230 kV autotransformers.
- Build a new Burlington substation, including one 600 MVA 345/230 kV autotransformers.
- Build a new 140 mile single circuit 345 kV line from Lamar 345 kV Substation to the existing Comanche Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 86 mile single circuit 345 kV line from Lamar 345kV Substation to the proposed Burlington Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 20 mile double circuit 345 kV line from Energy Center Substation to the proposed Lamar Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.



2011 L&R Study
Case # 4
Archer Wind
150 MW
Archer
Story
Pawnee
Wray
Planned/Proposed
345 kV
230 kV
115 kV
Smoky Hill
Big
Sandy
Burlington
Daniels
Park
50 MW
Midway
Lamar
Poncha
Lamar Energy
Center
Comanche
Lamar_CO
588MW
Boone
Lamar Wind
50 MW
Calumet
Lamar_CO
San Luis
Valley
Vilas
185MW
New Solar
Walsenburg
PSCo Wind

Figure 7

Case 5

Case 5 is shown in **Figure 8** and includes the following key bulk system additions:

1. Lamar – Burlington single circuit 345 kV
2. Energy Center – Lamar double circuit 345 kV
3. Lamar – Comanche 345 kV
4. Lamar Energy Center 588 MW addition
5. 250 MW wind energy injected at Lamar 230 kV Bus
6. 150 MW wind energy injected at Archer 115 kV Bus

Case 5 consists of the following details:

- Build a new Energy Center substation, including two 600 MVA 345/22 kV autotransformers.
- Build a new Burlington substation, including one 600 MVA 345/230 kV autotransformer.
- Build a new Lamar substation, including two 600 MVA 345/230 kV autotransformers.
- Build a new 140 mile single circuit 345 kV line from Lamar 345 kV Substation to the existing Comanche Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 86 mile single circuit 345 kV line from Lamar 345kV Substation to the proposed Burlington Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 20 mile double circuit 345 kV line from Energy Center Substation to the proposed Lamar Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.

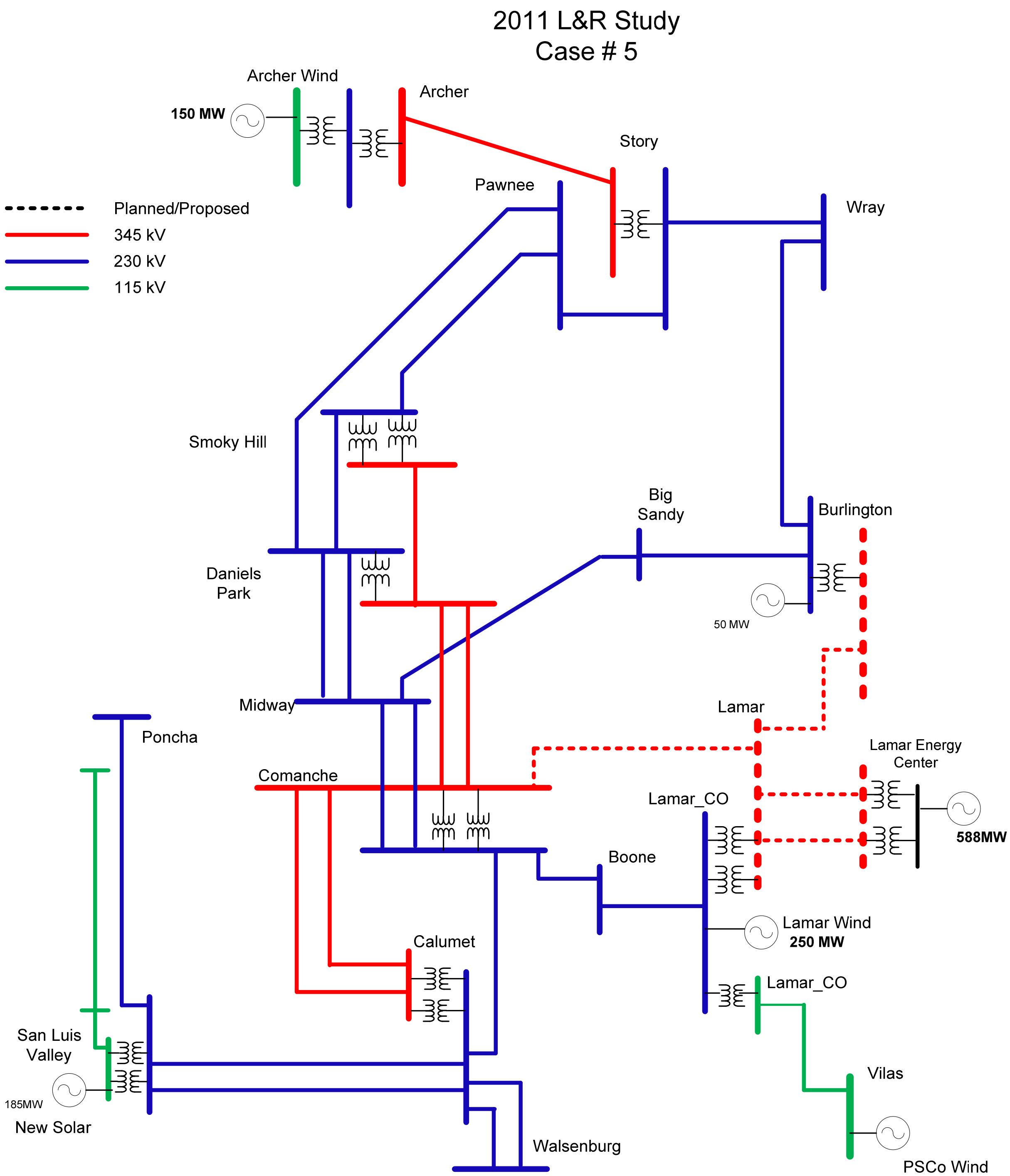

2011 L&R Study
Case # 5
Archer Wind
150 MW
Archer
Story
Pawnee
Wray
Planned/Proposed
345 kV
230 kV
115 kV
Smoky Hill
Big
Sandy
Burlington
Daniels
Park
50 MW
Midway
Lamar
Poncha
Lamar Energy
Center
Comanche
Lamar_CO
588MW
Boone
Lamar Wind
250 MW
Calumet
Lamar_CO
San Luis
Valley
Vilas
185MW
New Solar
Walsenburg
PSCo Wind

Figure 8

Case 6

Case 6 is shown in **Figure 9** and includes the following key bulk system additions:

1. Lamar – Burlington single circuit 345 kV
2. Energy Center – Lamar double circuit 345 kV
3. Lamar – Comanche 345 kV
4. Burlington – Big Sandy single circuit 345 kV
5. Lamar Energy Center 588 MW addition
6. 250 MW wind energy injected at Lamar 230 kV Bus
7. 150 MW wind energy injected at Archer 115 kV Bus

Case 6 consists of the following details:

- Build a new Energy Center substation, including two 600 MVA 345/22 kV autotransformers.
- Build a new Big Sandy substation, including one 600 MVA 345/230 kV autotransformer.
- Build a new Burlington substation, including one 600 MVA 345/230 kV autotransformer.
- Build a new Lamar substation, including two 600 MVA 345/230 kV autotransformers.
- Build a new 140 mile single circuit 345 kV line from Lamar 345 kV Substation to the existing Comanche Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 86 mile single circuit 345 kV line from Lamar 345kV Substation to the proposed Burlington Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 20 mile double circuit 345 kV line from Energy Center Substation to the proposed Lamar Substation. Conductor modeled was bundled 1590 kcmil with a continuous thermal rating of 1184 MVA.
- Build a new 81 mile single circuit 345 kV line from Burlington Substation to the existing Big Sandy Substation. Conductor modeled was single 1590 kcmil with a continuous thermal rating of 1184 MVA.

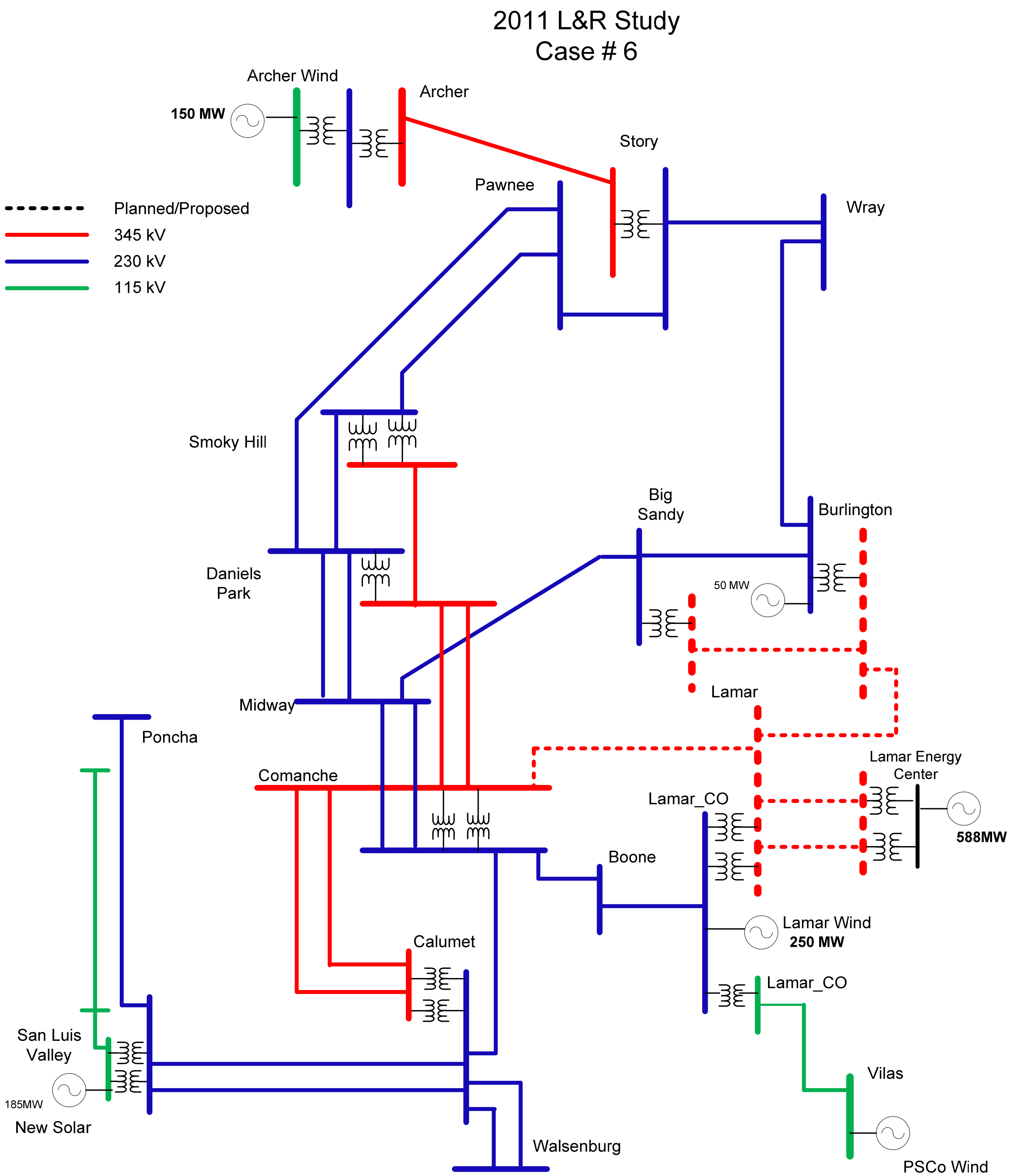

2011 L&R Study
Case # 6
Archer Wind
150 MW
Archer
Story
Pawnee
Wray
Planned/Proposed
345 kV
230 kV
115 kV
Smoky Hill
Big
Sandy
Burlington
Daniels
Park
50 MW
Lamar
Midway
Poncha
Comanche
Lamar Energy
Center
Lamar_CO
588MW
Boone
Lamar Wind
250 MW
Calumet
Lamar_CO
San Luis
Valley
Vilas
185MW
New Solar
Walsenburg
PSCo Wind

Figure 9

Study Results

Contingency analysis was performed for lines in two control areas (70 and 73) where potential resources were added. Only outages on the transmission system at a voltage 69 kV or greater are discussed in these results. **Table 4** summarizes the simultaneous results for the Benchmark case (case with no generation and no transmission additions) against all Cases (cases with planned resources and new transmission additions):

Table 4 Contingency Results for Cases

Element Loading/ Contingency	Rating (MVA)	Owner	Benchmark Loading (%)	Case1 Loading (%)	Case 2 Loading (%)	Case 3 Loading (%)	Case 4 Loading (%)	Case 5 Loading (%)	Case 6 Loading (%)
Boone – Lamar 230 kV Comanche – Lamar 345 kV	350	PSCo/ TSGT	NA		175.7			107.1	
LaJunta Tap – Willow Crk Boone – Lamar 230 kV	120	SECP		128.7					
LaJunta Tap – Willow Crk Comanche – Lamar 345	120	SECP			118.5				
Lamar_Co 230/115 kV T1 Boone – Lamar 230 kV	100	PSCo	129.3	182.9					
Lamar_Co 230/115 kV T1 Comanche – Lamar 345 kV	100	PSCo			163.9			115.8	107.5
Lamar_Co - Willow Crk Boone – Lamar 230 kV	120	SECP		128.6					
Waterton – Martin2 Tap 115 Soda Lake 230/115 kV T1	126	PSCo			101.8	100.0		102.0	105.6
Sunyside_TS – Hesperus 115 Mrtns Cnr – Iron H 115 kV	120	TSGT						100.6	101.3
Sunyside_TS –Flor Riv 115 Mrtns Cnr – Iron H 115 kV	120	TSGT		103.8	109.3	109.5	109.6	110.4	111.1

Element Loading/ Contingency	Rating (MVA)	Owner	Benchmark Loading (%)	Case1 Loading (%)	Case 2 Loading (%)	Case 3 Loading (%)	Case 4 Loading (%)	Case 5 Loading (%)	Case 6 Loading (%)
Reader 115/69 kV T1 or T2 Reader 115/69 kV T1 or T2	42	BHC	106.5	109.2	113.4	112.0	112.0	112.9	112.5
Rifle_CU 138/69 kV T2 Hopkins – Roaring Fork 69	25	NON	139.9	141.6	135.5	136.9	135.9	133.9	134.6
Rifle_CU 138/69 kV T2 Rifle_PS – Rifle_WA 230	25	NON	143.8						
Alvin – Sandhill 115 N Yuma – Red Willow 115	60	WALM						102.8	
Archer 230/115 kV T1 Archer 230/115 kV T2	167	WALM	110.0	103.2	103.0	102.7			
Archer 230/115 kV T2 Archer 230/115 kV T1	167	WALM	109.1	102.4	102.2	101.9			
Ault – Weld_LM 230 kV Com – Com_Unit3	540	WALM	114.3	111.7	100.7	101.5	101.3		107.0
Bonny Crk – Burl'n 115 kV Burlington – Wray 115 kV	120	WALM						107.0	
Briar_Gate – Cttnwd_S 115 Cttnwd_N – Kettle Crk 115	150	CSU			112.2	110.0	109.8	114.8	116.7
Cttnwd_N – Kettle Crk 115 Briar_Gate – Cttnwd_S 115	186	CSU			101.5			104.1	105.8
Curecanti – So Canal 115 Curecanti – Lost Can 230 kV	133	WALM						103.0	100.7

NOTES:

1. **Waterton – Martn2TP 115 kV line / Briargate- Cottnwood S 115 kV line / Cottnwood N - Kettleck 115 kV line / Kettleck – Flyhorse 115 kV line**

These lines experience overloads during certain outage conditions. The study indicated that the addition of generation in Lamar and the addition of a new Energy Center-Comanche 345 kV circuit will considerably increase south to north flows in the Colorado Springs area and will impact the parallel 115 kV system. The study assumptions contribute to an additional 200 MW-300 MW flow into the Comanche 345 kV bus and north to the Denver area loads. There are several options for mitigating these line overloads:

- Rebuilding or uprating the transmission lines
- Establishing operating limits on the south to north transmission path
- Adding a new parallel circuit
- Adding a new 345 kV or higher circuit in parallel to the existing Comanche-Daniels Park-Smoky Hill circuits
- Phase Shifter option at Monument

These overloads are consistent with the findings of the Lamar Front Range Study. That study investigated the addition of a phase shifting transformer at Monument to mitigate the overloads in the Colorado Springs area.

2. **Reader 115/69 kV Transformer / Rifle_CU 115/69 kV Transformer**

These transformer overloads are independent of the resource additions studied in this analysis. They are therefore considered pre-existing and are not owned by Tri-State. There are several options for mitigating the transformer overloads:

- Allow the contingency loading to reach 115% or higher.
- Replace with higher rated transformers
- Add a third transformer

3. **Lamar 230/115 kV Transformer**

The study indicated that with the addition of generation in the Lamar area east to west flows are significantly increased between Lamar and Boone, causing potential overloads in the parallel 230 kV to 115 kV system elements. This result is also consistent with the findings of the Lamar Front Range Study. There are several options for mitigating the transformer overloads:

- Allow the contingency loading to reach 115% or higher.
- Add a second 100 MVA transformer as recommended by the Lamar Front Range Study
- Operate the 230/115 kV system normally open under high generation scenarios

4. **Burlington 230/115 kV Transformer**

There are two 230/115 kV transformers at Burlington: one is rated 100MVA and the second is rated 167 MVA. The study indicated that an outage of the larger transformer could load the other parallel transformer to unacceptable levels as flows were increased on the Lamar-Burlington transmission path. There are several options for mitigating the transformer overloads:

- Allow the contingency loading to reach 115% or higher.
- Replace the existing 100 MVA transformer with one rated 167MVA to match the second existing transformer. (100 MVA transformer can be used in Lamar)

5. **Sunyside_TS – Florida River 115 kV / Sunyside_TS – Hesperus 115 kV**

These lines may overload during normal operating conditions. Especially under a Martins Corner to Iron Horse 115 kV outage. These overloads are due to terminal equipment ratings. The anticipated resource additions and topology changes will mitigate some of these contingencies, however CT and conductor re-rating evaluations will still be necessary.

6. **Alvin – Sandhill 115 kV**

This 115 kV line may overload for an outage to the North Yuma to Red Willow 115 kV line. The Alvin CT should be replaced with a 500 amp CT (to match the next limiting element) to raise the line rating to 95 MVA.

7. **Archer 230/115 kV Transformers**

There are two 230/115 kV transformers at Archer. The study indicated that an outage of the larger transformer could load the other parallel transformer to unacceptable levels. A solution would be the installation of a third transformer at Archer at such time as the wind resource is added or match the second transformer with the larger unit. These overloads will be mitigated upon connection of the network upgrades associated with the additional wind resources at or near Archer.

8. **Ault – Weld_LM 230 kV**

This 230 kV line overloads for a loss of the Comanche Unit # 3 and appears in the benchmark case. Therefore this issue is pre-existing and will be addressed as necessary with the network upgrades associated with the wind resource additions at Archer.

9. **Curecanti – South Canal 115 kV**

This 115 kV line may overload slightly (100.7%) for an outage to the Curecanti to Lost Canyon 230 kV line. The limiting element is the conductor rating (77F) of 133 MVA. The transmission line is owned by Western.

10. Regional 69kV overloads

There were a several contingency issues observed on the lower voltage 69 kV load-serving system. These issues will need to be addressed. Some may be mitigated by readjusting distribution load placement.

Conclusions

This report identifies the transmission infrastructure necessary to accommodate the loads and resources forecasted and submitted to Tri-State by its network customers. Those resources total 988 MW, of which 838 MW are to be located in the area of Lamar, Colorado. Therefore, this study focused on the eastern and southeastern Colorado transmission system to: 1) determine a preferred transmission configuration to accommodate the development of the forecasted generation resources, and 2) mitigate any transmission system deficiencies caused by the load and resource additions.

The recommended transmission infrastructure to accommodate 838 MW of generation at Lamar (Case 6 of this study) consists of the following bulk transmission system additions.

1. Lamar – Comanche single-circuit 345 kV line (140 miles)
2. Lamar – Burlington single-circuit 345 kV line (86 miles)
3. Burlington – Big Sandy single-circuit 345 kV line (81 miles)
4. Energy Center – Lamar double-circuit 345 kV line (20 miles)
5. New Energy Center Substation with two 600 MVA 345/22 kV transformers
6. 600 MVA 345/230 kV transformer at Big Sandy
7. 600 MVA 345/230 kV transformer at Burlington
8. Two 600 MVA 345/230 kV transformers at Lamar

This analysis found that 638 MW of generation (Case 3 of this study) could be accommodated at Lamar with the above transmission infrastructure less the Burlington – Big Sandy 345 kV line (81 miles) and the associated 345/230 kV transformer at Big Sandy. With the incremental addition of 200 MW of wind at Lamar (638 MW to 838 MW), the power flow analysis determined that additional transmission is needed out of Burlington to avoid an overload of the Burlington – Wray 115 kV path and the Burlington-Wray 230 kV system during a loss of the existing Burlington-Big Sandy 230 kV line. Therefore, an additional Big Sandy-Burlington circuit is necessary.

The addition of the 50 MW wind resource (2015) in the Archer area (115 kV bus) did not require transmission upgrades, except for monitoring the loading on the existing Archer 230/115 kV transformers. However, the addition of the next 100 MW wind resource (2018) at Archer may require an uprate of the Ault-Weld 230 kV line, depending on the generation dispatch at the time.

During the course of this analysis, some transmission overloads appeared that were determined to be preexisting and therefore unrelated to the proposed generation injections in eastern Colorado. Other overloads were identified that were considered mitigated by the owners based on the assumption that the overloads could be alleviated at minimal cost. A discussion of overloads is included in the Notes section of this report.

This 2011 Load and Resource Transmission Analysis demonstrated that system reliability is maintained or improved with the planned generation resources and with the proposed transmission system additions. Certain N-1 violations in the Colorado Springs area, some of which are pre-existing and have been identified by other studies, were noted, and will need to be addressed by the transmission providers in the region prior to the construction of a new Lamar to Comanche circuit.

This analysis documents the transmission infrastructure needs for the requested network load and resource additions. Tri-State Power System Planning performs this Load and Resource Transmission System Analysis on an annual basis and will update the findings of this report in 2012.

Appendix

Study Criteria

Power flow analysis was performed using NERC/WECC planning standards. Power flow analysis was used to evaluate thermal and voltage performance of the transmission system for NERC/WECC Category A System normal (all elements in-service) conditions and NERC/WECC Category B emergency (single contingency) conditions.

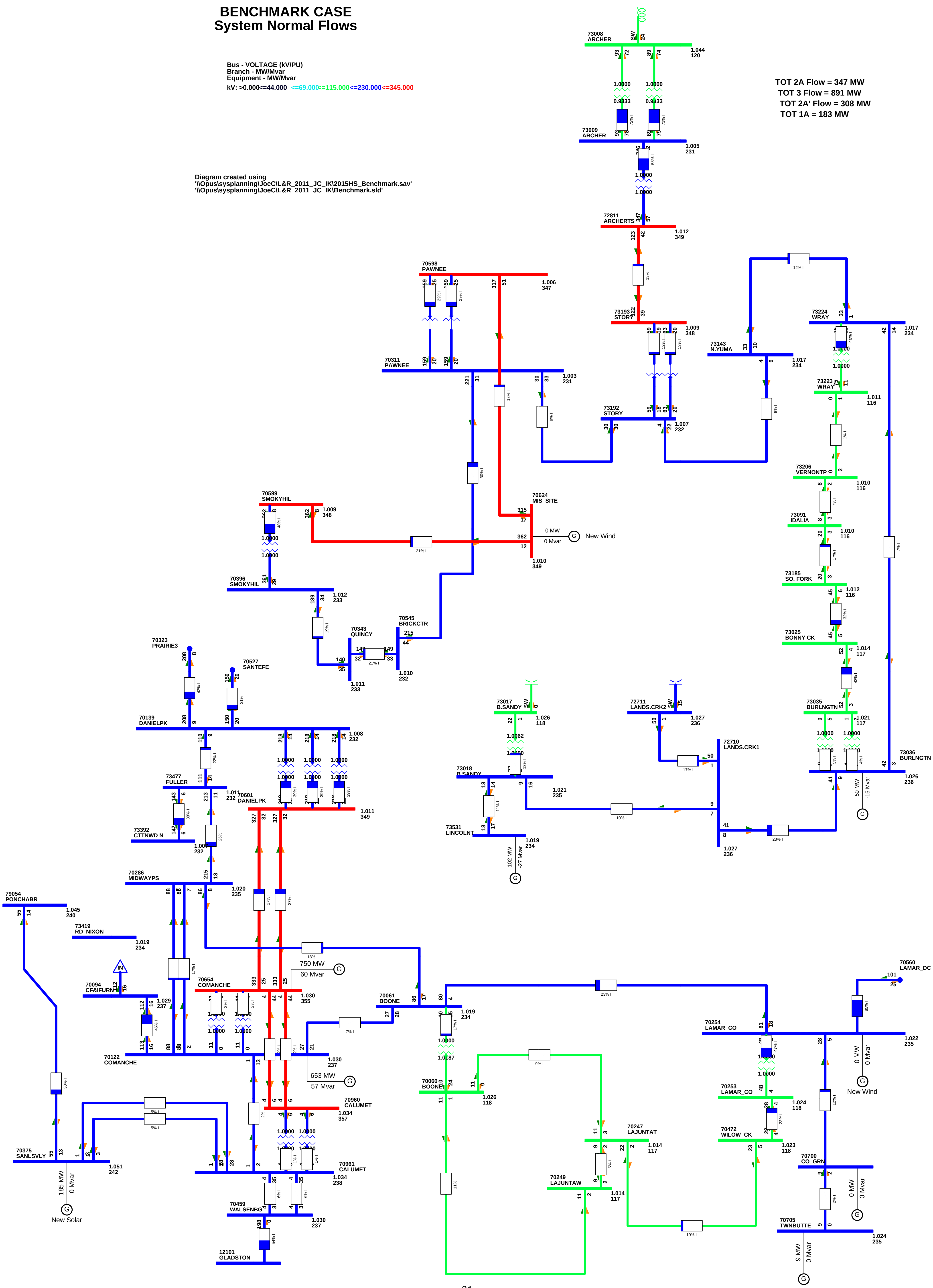
Category A System normal criteria

Bus voltage in the study was maintained between 0.95 and 1.05 p. u. (95% and 105% of the nominal voltage of the bus). Transmission line flows could not exceed 100 percent of the continuous rating. Transformer flows could not exceed 100 percent of nominal rating. Busses and branches were monitored. Manual or automatic system adjustments such as shunt capacitor or reactor switching, generator scheduling, or LTC tap adjustments were allowed.

Category B emergency criteria

Emergency bus voltages in the study were maintained between 0.9 and 1.1 p. u. (90% and 110%) of the nominal voltage of the bus. Transmission line flows could not exceed 100% of the continuous rating. Phase shifting transformer flows could not exceed 100% of stated ratings. Manual or automatic system adjustments such as shunt capacitor or reactor switching, generator scheduling, or LTC tap adjustment was allowed. Transmission line flows that exceeded 80% of rated capability were reported.

Power Flow Diagrams

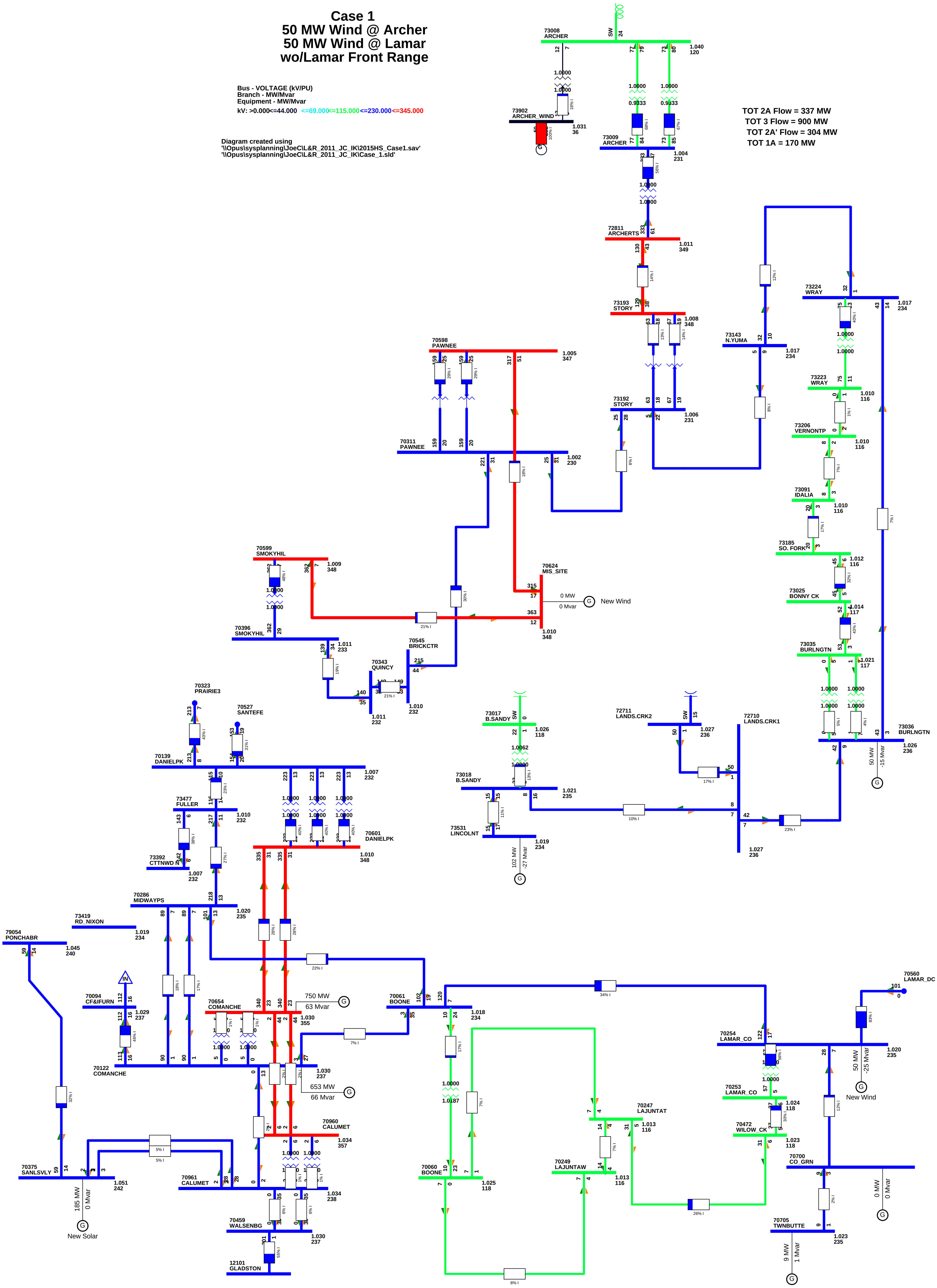

BENCHMARK CASE
System Normal Flows
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000<=44.000 <=69.000<=115.000<=230.000<=345.000
Diagram created using
'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\2015HS_Benchmark.sav'
'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\Benchmark.sld'
TOT 2A Flow = 347 MW
TOT 3 Flow = 891 MW
TOT 2A' Flow = 308 MW
TOT 1A = 183 MW
73008 ARCHER
73009 ARCHER
72811 ARCHERTS
73193 STORY
73192 STORY
70598 PAWNEE
70311 PAWNEE
73224 WRAY
73143 N.YUMA
73223 WRAY
73206 VERNONTP
73091 IDALIA
73185 SO. FORK
73025 BONNY CK
73035 BURLNGTN
73036 BURLNGTN
70624 MIS_SITE
0 MW
0 Mvar
New Wind
70599 SMOKYHIL
70396 SMOKYHIL
70545 BRICKCTR
70343 QUINCY
70323 PRAIRIE3
70527 SANTEFE
70139 DANIELPK
73477 FULLER
70601 DANIELPK
73392 CTTNWD N
70286 MIDWAYPS
79054 PONCHABR
73419 RD_NIXON
70094 CF&IFURN
IN
70654 COMANCHE
750 MW
60 Mvar
70122 COMANCHE
653 MW
57 Mvar
70960 CALUMET
70961 CALUMET
70459 WALSENBG
12101 GLADSTON
70375 SANLSVLY
185 MW
0 Mvar
New Solar
73017 B.SANDY
73018 B.SANDY
73531 LINCOLNT
102 MW
-27 Mvar
72711 LANDS.CRK2
72710 LANDS.CRK1
50 MW
-15 Mvar
70061 BOONE
70060 BOONE
70247 LAJUNTAT
70249 LAJUNTAW
70560 LAMAR_DC
70254 LAMAR_CO
70253 LAMAR_CO
0 MW
0 Mvar
New Wind
70472 WILOW_CK
70700 CO_GRN
0 MW
0 Mvar
70705 TWNBUTTE
9 MW
0 Mvar

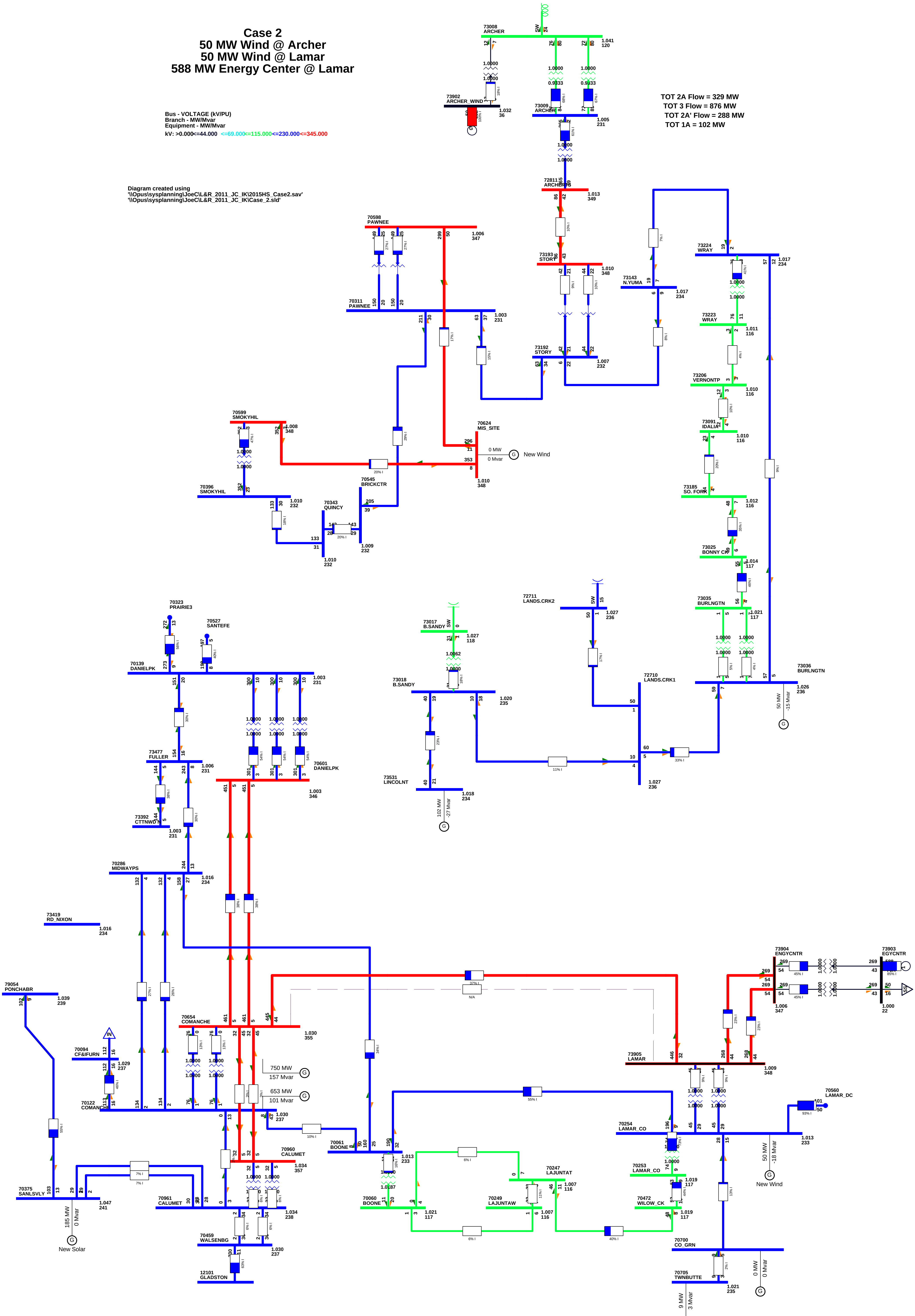
Case 1
50 MW Wind @ Archer
50 MW Wind @ Lamar
wo/Lamar Front Range

Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000<=44.000 <=69.000<=115.000<=230.000<=345.000

Diagram created using
'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\2015HS_Case1.sav'
'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\Case_1.sld'

TOT 2A Flow = 337 MW
TOT 3 Flow = 900 MW
TOT 2A' Flow = 304 MW
TOT 1A = 170 MW




Case 2
50 MW Wind @ Archer
50 MW Wind @ Lamar
588 MW Energy Center @ Lamar
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000<=44.000 <=69.000<=115.000<=230.000<=345.000
Diagram created using
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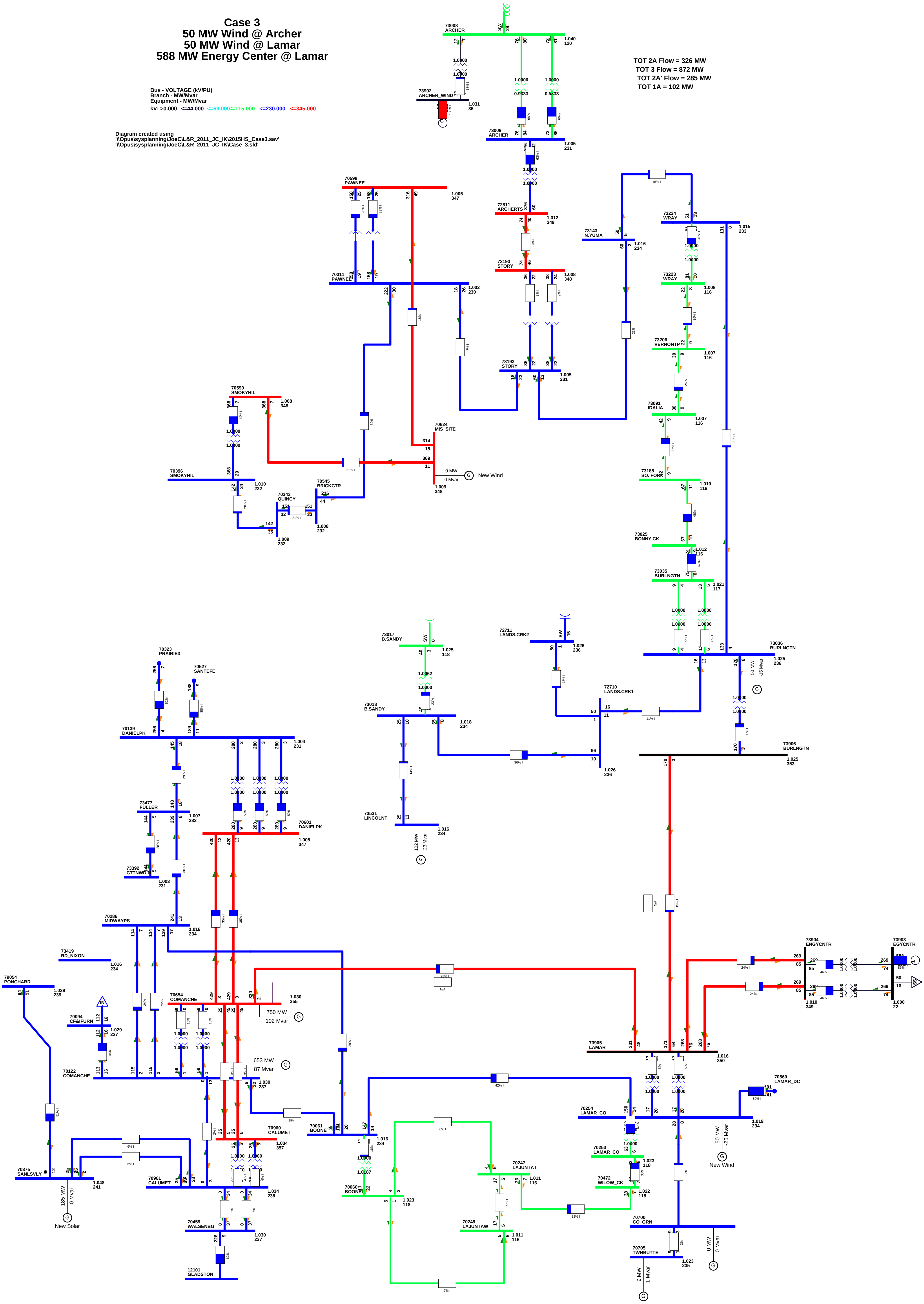
'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\Case_2.sld'
TOT 2A Flow = 329 MW
TOT 3 Flow = 876 MW
TOT 2A' Flow = 288 MW
TOT 1A = 102 MW
73008 ARCHER
73902 ARCHER_WIND
73009 ARCHER
72811 ARCHER
73224 WRAY
73193 STORY
73143 N.YUMA
73223 WRAY
70598 PAWNEE
70311 PAWNEE
73192 STORY
73206 VERNONTP
73091 IDALIA
70624 MIS_SITE
New Wind
70599 SMOKYHIL
70396 SMOKYHIL
70545 BRICKCTR
70343 QUINCY
73185 SO. FORK
73025 BONNY CR
73035 BURLNGTN
73036 BURLNGTN
72711 LANDS.CRK2
72710 LANDS.CRK1
73017 B.SANDY
73018 B.SANDY
73531 LINCOLNT
70323 PRAIRIE3
70527 SANTEFE
70139 DANIELPK
73477 FULLER
70601 DANIELPK
73392 CTTNWDTP
70286 MIDWAYPS
73419 RD_NIXON
79054 PONCHABR
70654 COMANCHE
70094 CF&IFURN
70122 COMANCHE
70375 SANLSVLY
New Solar
70961 CALUMET
70960 CALUMET
70459 WALSENBG
12101 GLADSTON
70061 BOONE
70060 BOONE
70249 LAJUNTAW
70247 LAJUNTAT
73904 ENGYCNTR
73903 EGYCNTR
73905 LAMAR
70560 LAMAR_DC
70254 LAMAR_CO
70253 LAMAR_CO
70472 WILOW_CK
70700 CO_GRN
70705 TWNBUTTE


Case 3
50 MW Wind @ Archer
50 MW Wind @ Lamar
588 MW Energy Center @ Lamar
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000 <=44.000 <=69.000 <=115.000 <=230.000 <=345.000
Diagram created using
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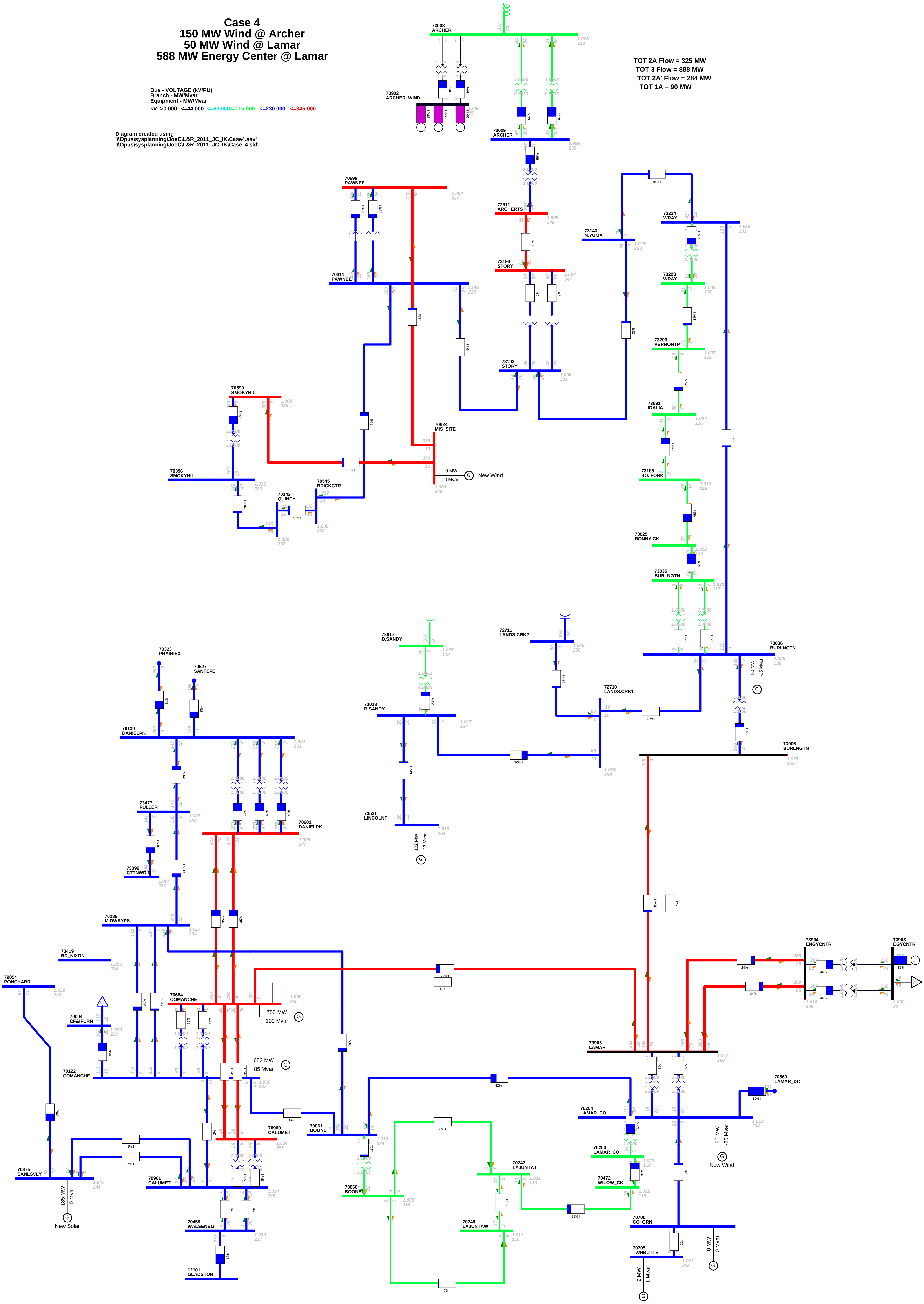
'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\Case_3.sld'
TOT 2A Flow = 326 MW
TOT 3 Flow = 872 MW
TOT 2A' Flow = 285 MW
TOT 1A = 102 MW
73008 ARCHER
73902 ARCHER_WIND
73009 ARCHER
72811 ARCHERTS
73193 STORY
73192 STORY
70598 PAWNEE
70311 PAWNEE
70624 MIS_SITE
New Wind
70599 SMOKYHIL
70396 SMOKYHIL
70343 QUINCY
70545 BRICKCTR
73143 N.YUMA
73224 WRAY
73223 WRAY
73206 VERNONTP
73091 IDALIA
73185 SO. FORK
73025 BONNY CK
73035 BURLNGTN
73036 BURLNGTN
73906 BURLNGTN
73017 B.SANDY
73018 B.SANDY
73531 LINCOLNT
72711 LANDS.CRK2
72710 LANDS.CRK1
70323 PRAIRIE3
70527 SANTEFE
70139 DANIELPK
73477 FULLER
73392 CTTNWD
70601 DANIELPK
70286 MIDWAYPS
73419 RD_NIXON
79054 PONCHABR
70654 COMANCHE
70094 CF&IFURN
70122 COMANCHE
70960 CALUMET
70961 CALUMET
70375 SANLSVLY
New Solar
70459 WALSENBG
12101 GLADSTON
70061 BOONE
70060 BOONE
70247 LAJUNTAT
70249 LAJUNTAW
70472 WILOW_CK
70253 LAMAR_CO
70254 LAMAR_CO
73905 LAMAR
73904 ENGYCNTR
73903 EGYCNTR
70560 LAMAR_DC
70700 CO_GRN
70705 TWNBUTTE
New Wind


Case 4
150 MW Wind @ Archer
50 MW Wind @ Lamar
588 MW Energy Center @ Lamar
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000 <=44.000 <=69.000 <=115.000 <=230.000 <=345.000
Diagram created using
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TOT 2A Flow = 325 MW
TOT 3 Flow = 888 MW
TOT 2A' Flow = 284 MW
TOT 1A = 90 MW
73008 ARCHER
73902 ARCHER_WIND
73009 ARCHER
72811 ARCHERTS
73193 STORY
73192 STORY
70598 PAWNEE
70311 PAWNEE
73224 WRAY
73143 N.YUMA
73223 WRAY
73206 VERNONTP
73091 IDALIA
73185 SO. FORK
73025 BONNY CK
73035 BURLNGTN
73036 BURLNGTN
73906 BURLNGTN
70599 SMOKYHIL
70396 SMOKYHIL
70624 MIS_SITE
0 MW
0 Mvar
New Wind
70545 BRICKCTR
70343 QUINCY
73017 B.SANDY
73018 B.SANDY
72711 LANDS.CRK2
72710 LANDS.CRK1
73531 LINCOLNT
102 MW
-23 Mvar
50 MW
-15 Mvar
70323 PRAIRIE3
70527 SANTEFE
70139 DANIELPK
73477 FULLER
73392 CTTNWD N
70601 DANIELPK
70286 MIDWAYPS
73419 RD_NIXON
79054 PONCHABR
70094 CF&IFURN
70654 COMANCHE
750 MW
100 Mvar
653 MW
85 Mvar
70122 COMANCHE
70960 CALUMET
70961 CALUMET
70375 SANLSVLY
185 MW
0 Mvar
New Solar
70459 WALSENBG
12101 GLADSTON
70061 BOONE
70060 BOONET
70247 LAJUNTAT
70249 LAJUNTAW
73905 LAMAR
73904 ENGYCNTR
73903 EGYCNTR
70560 LAMAR_DC
70254 LAMAR_CO
70253 LAMAR_CO
70472 WILOW_CK
50 MW
-25 Mvar
New Wind
70700 CO_GRN
70705 TWNBUTTE
9 MW
1 Mvar
0 MW
0 Mvar

Case 5
150 MW Wind @ Archer
250 MW Wind @ Lamar
588 MW Energy Center @ Lamar

Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000 <=44.000 <=69.000 <=115.000 <=230.000 <=345.000

Diagram created using
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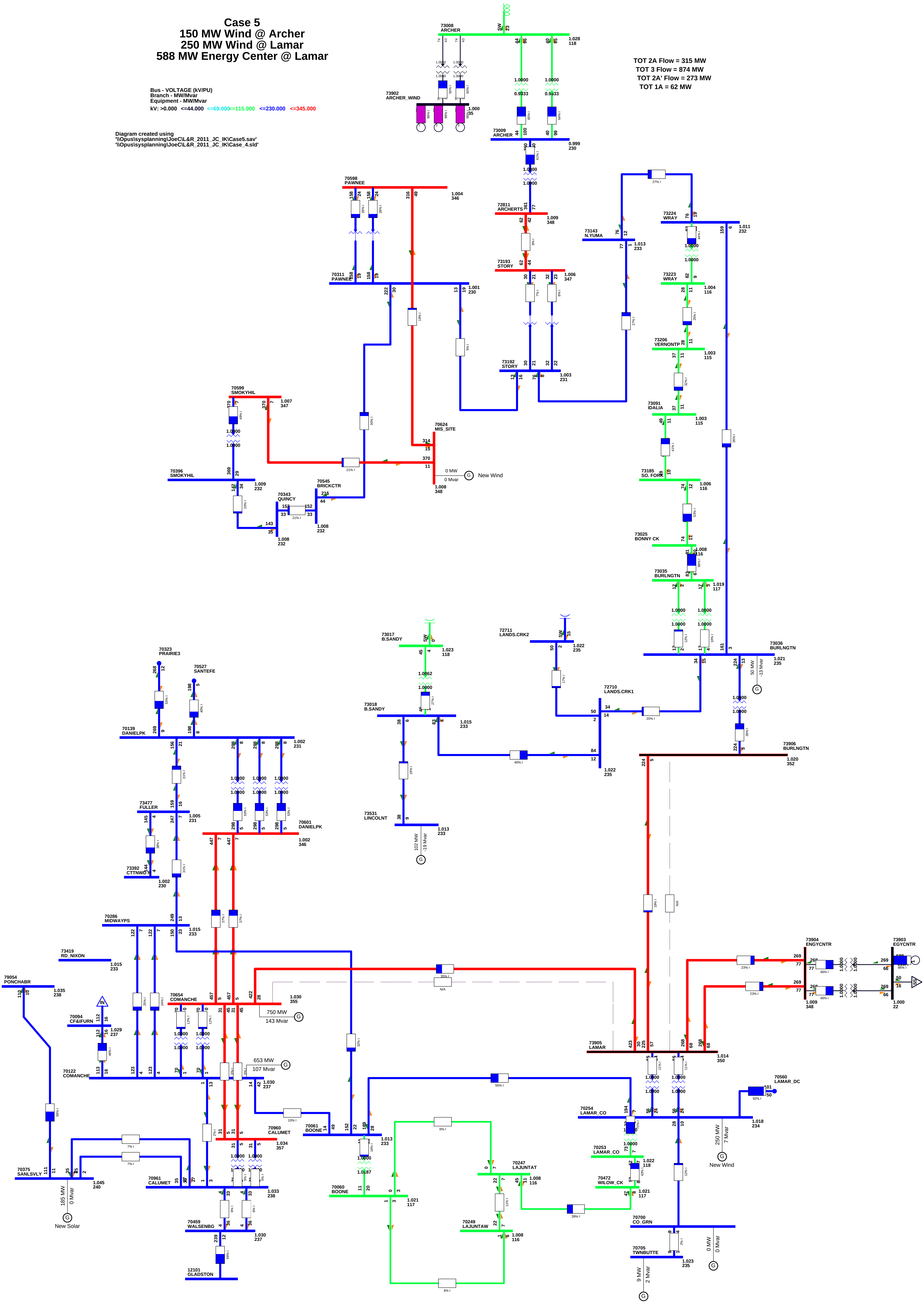
TOT 2A Flow = 315 MW
TOT 3 Flow = 874 MW
TOT 2A' Flow = 273 MW
TOT 1A = 62 MW



Case 6
150 MW Wind @ Archer
250 MW Wind @ Lamar
588 MW Energy Center @ Lamar

Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000 <=44.000 <=69.000 <=115.000 <=230.000 <=345.000

Diagram created using
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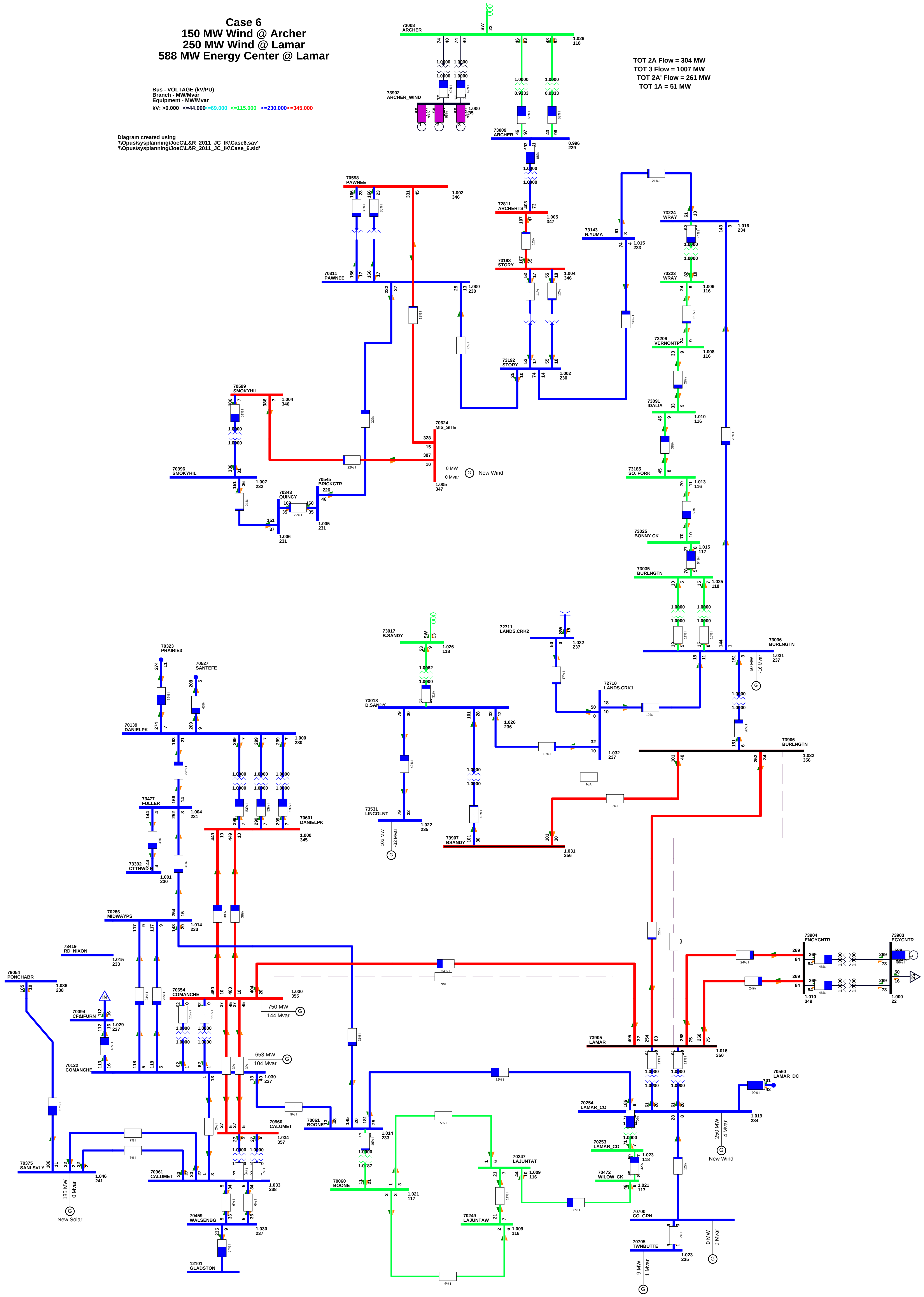
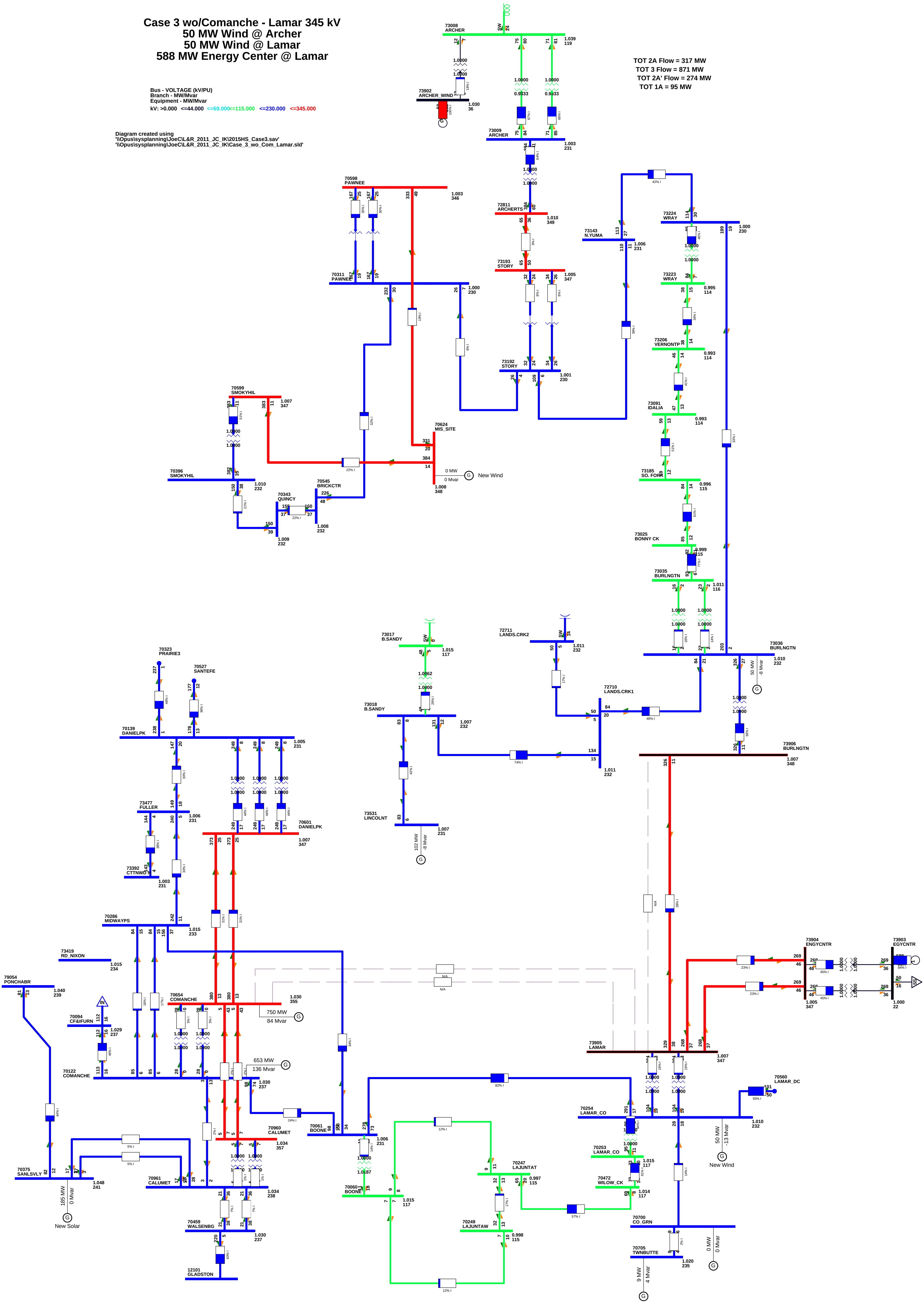
TOT 2A Flow = 304 MW
TOT 3 Flow = 1007 MW
TOT 2A' Flow = 261 MW
TOT 1A = 51 MW




Case 3 wo/Comanche - Lamar 345 kV
50 MW Wind @ Archer
50 MW Wind @ Lamar
588 MW Energy Center @ Lamar
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000 <=44.000 <=69.000 <=115.000 <=230.000 <=345.000
Diagram created using
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'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\Case_3_wo_Com_Lamar.sld'
TOT 2A Flow = 317 MW
TOT 3 Flow = 871 MW
TOT 2A' Flow = 274 MW
TOT 1A = 95 MW
73008 ARCHER
73902 ARCHER_WIND
73009 ARCHER
70598 PAWNEE
72811 ARCHERTS
73193 STORY
73192 STORY
73143 N.YUMA
73224 WRAY
73223 WRAY
73206 VERNONTP
73091 IDALIA
73185 SO. FORK
73025 BONNY CK
73035 BURLNGTN
73036 BURLNGTN
73906 BURLNGTN
70311 PAWNEE
70599 SMOKYHIL
70396 SMOKYHIL
70343 QUINCY
70545 BRICKTCR
70624 MIS_SITE
New Wind
73017 B.SANDY
73018 B.SANDY
72711 LANDS.CRK2
72710 LANDS.CRK1
73531 LINCOLNT
70323 PRAIRIE3
70527 SANTEFE
70139 DANIELPK
73477 FULLER
73392 CTTNWD
70601 DANIELPK
70286 MIDWAYPS
73419 RD_NIXON
79054 PONCHABR
70094 CF&IFURN
70654 COMANCHE
70122 COMANCHE
70375 SANLSVLY
New Solar
70961 CALUMET
70960 CALUMET
70459 WALSENBG
12101 GLADSTON
70061 BOONE
70060 BOONE
70247 LAJUNTAT
70249 LAJUNTAW
73905 LAMAR
73904 ENGYCNTR
73903 EGYCNTR
70560 LAMAR_DC
70254 LAMAR_CO
70253 LAMAR_CO
70472 WILOW_CK
70700 CO_GRN
70705 TWNBUTTE
750 MW
84 Mvar
653 MW
136 Mvar
185 MW
0 Mvar
102 MW
-8 Mvar
50 MW
-13 Mvar
9 MW
4 Mvar

Case 5 wo/ Comanche - Lamar 345 kV
150 MW Wind @ Archer
250 MW Wind @ Lamar
588 MW Energy Center @ Lamar

Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000 <=44.000 <=69.000 <=115.000 <=230.000 <=345.000

Diagram created using
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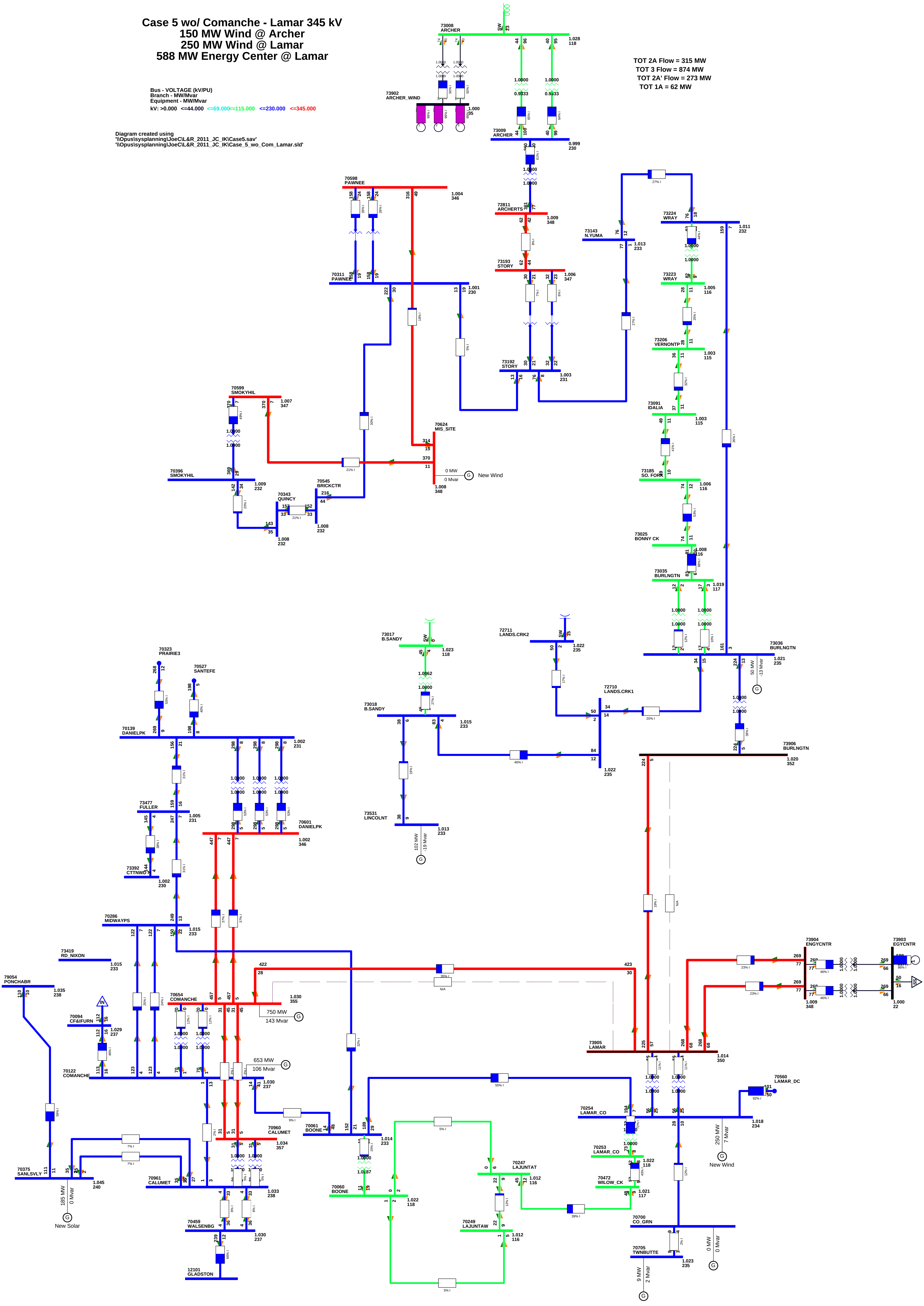

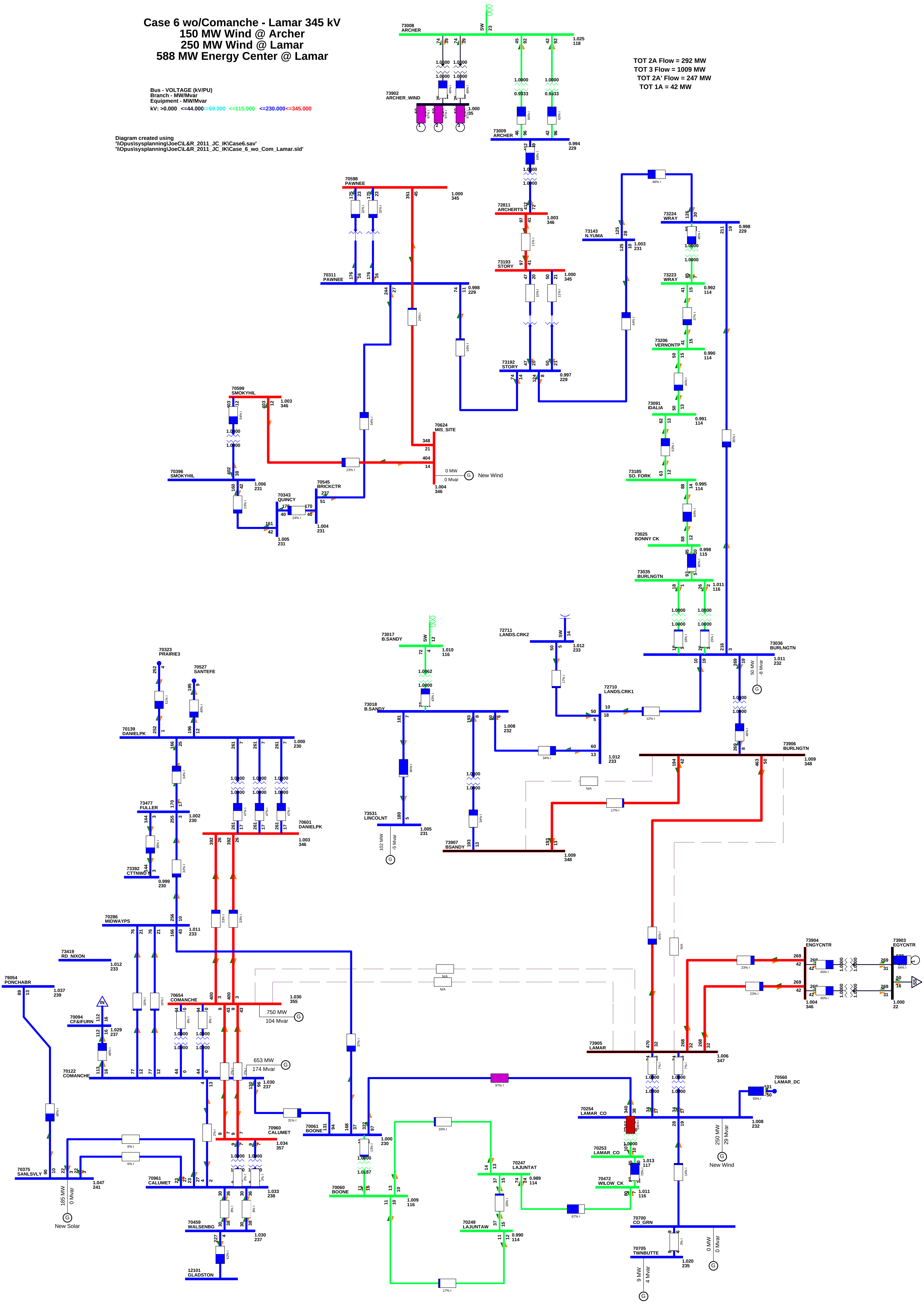
Case 6 wo/Comanche - Lamar 345 kV
150 MW Wind @ Archer
250 MW Wind @ Lamar
588 MW Energy Center @ Lamar
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000 <=44.000 <=69.000 <=115.000 <=230.000 <=345.000
Diagram created using
'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\Case6.sav'
'\\Opus\sysplanning\JoeC\L&R_2011_JC_IK\Case_6_wo_Com_Lamar.sld'
TOT 2A Flow = 292 MW
TOT 3 Flow = 1009 MW
TOT 2A' Flow = 247 MW
TOT 1A = 42 MW
73008 ARCHER
73902 ARCHER_WIND
73009 ARCHER
70598 PAWNEE
72811 ARCHERTS
73193 STORY
73224 WRAY
73143 N.YUMA
73223 WRAY
70311 PAWNEE
73206 VERNONTP
73192 STORY
73091 IDALIA
70599 SMOKYHIL
70624 MIS_SITE
New Wind
73185 SO. FORK
70396 SMOKYHIL
70545 BRICKCTR
70343 QUINCY
73025 BONNY CK
73035 BURLNGTN
73017 B.SANDY
72711 LANDS.CRK2
73036 BURLNGTN
70323 PRAIRIE3
70527 SANTEFE
72710 LANDS.CRK1
73018 B.SANDY
70139 DANIELPK
73906 BURLNGTN
73477 FULLER
73531 LINCOLNT
70601 DANIELPK
73907 BSANDY
73392 CTTNWD N
70286 MIDWAYPS
73419 RD_NIXON
73904 ENGYCNTR
73903 EGYCNTR
79054 PONCHABR
70654 COMANCHE
750 MW
104 Mvar
70094 CF&IFURN
653 MW
174 Mvar
70122 COMANCHE
73905 LAMAR
70560 LAMAR_DC
70254 LAMAR_CO
70960 CALUMET
70061 BOONE
70247 LAJUNTAW
250 MW
29 Mvar
New Wind
70253 LAMAR_CO
70375 SANLSVLY
70961 CALUMET
70060 BOONE
70472 WILOW_CK
185 MW
0 Mvar
New Solar
70459 WALSENBG
70249 LAJUNTAW
70700 CO_GRN
70705 TWNBUTTE
12101 GLADSTON