APPENDIX B

Southwest Twin Cities Load Serving Study Review

Southwest Twin Cities Load Serving Study Review
(Glencoe, Waconia and Chaska)

Prepared by:

Srinivas Vemuri
9/25/09

Appendix B
Certificate of Need Application
E-002/CN-09-1390

Executive Summary

This study was performed to re-evaluate the need for the planned 115 kV transmission projects between Eden Prairie and Glencoe, Southwest west of Twin Cities. The study was performed using the updated load forecast.

Table of Contents

1. Introduction 4
2. Models 5
   2.1 Historic And Projected Load Forecast 5
3. Analysis and Results 7
   3.1 Need for the project 7
   3.2 Transmission Options 9
   3.3 Incremental Load Serving Capabilities: 11
   3.4 Distributed generation option 13
   3.5 Loss analysis 15
4. Conclusion 16

Appendix A 17

Appendix B 19

1. Introduction

This study is to confirm the need for the planned 115 kV lines between Glencoe and West Waconia as part of the Southwest Twin Cities 115 kV development study using updated models and load forecast. The study area is shown in the Figure 1.1. This study also does not involve the 25 to 45 MW bio-technology park load that is proposed at the City of Chaska.

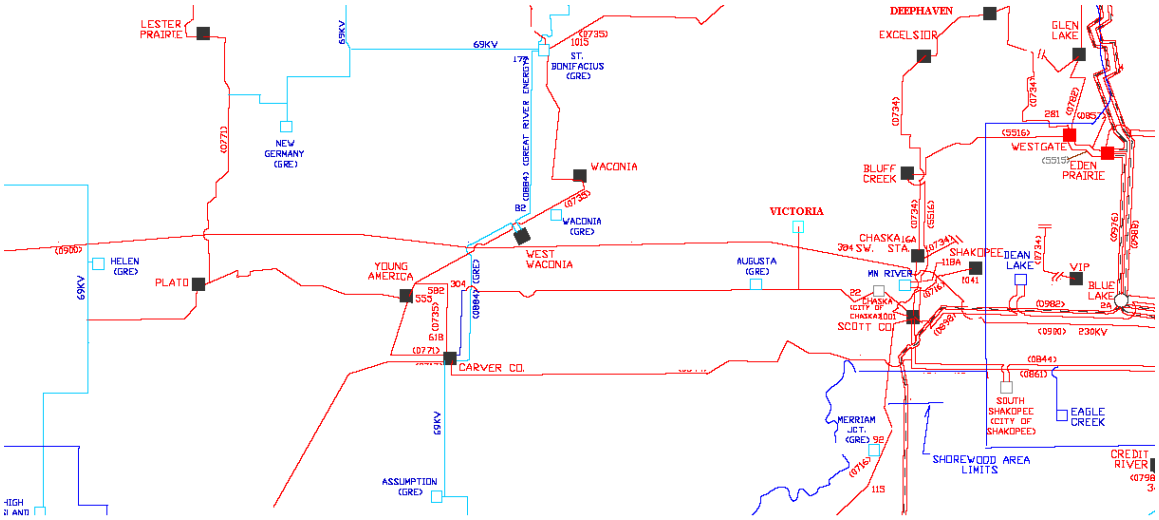


Figure 1.1

2. Models

The MRO 2009 series 2015 summer peak model was used to perform this analysis. The loads in the study region were updated using the non-coincident peak loads for each substation. The generation at Minnesota River, Shakopee, St. Bonifacius and Glencoe were turned off to evaluate the worst-case scenario.

2.1 Historic And Projected Load Forecast

Table 2.1 provides the historic loads seen by each substation in the study region. It should be noted that some of the 2009 loads are forecasted loads, as the actual peaks were not available during the time this study was performed. Victoria substation was built recently, therefore do not have 5 year historic loads available. Due to the addition of Victoria substation, part of the load was moved from Augusta to Victoria, this resulted in Augusta load dropping steeply from 2008 to 2009.

Table 2.1

Substation/Year	2004	2005	2006	2007	2008	2009
Chaska City	9.45	9.9	10.4	10.3	9.2	10.5
Xcel Chaska	3.98	2.98	5.41	6.84	5.22	6.97
Victoria	0.0	0.0	0.0	7.5	8.3	7.0
Augusta	11.1	11.4	13.3	14.4	8.0	5.1
West Waconia	29.7	24.2	24.5	25	21.6	26.3
GRE-Waconia	2.1	2.1	2.1	2.2	2.1	2.1
Xcel – Waconia	22	19.9	19.29	15.89	19.89	19.92
Plato	2.58	2.8	2.81	2.13	2.8	2.86
Lester Prairie	6.7	8.8	9.45	7.77	6.07	8.35
Young America	10.19	9.95	10.35	12.8	8.98	13.05
High Island	3.2	4.2	3.1	2.8	3.1	2.6
Glencoe Muni	20.4	20.6	23.3	22	24.8	20.5

Table 2.2 provides the forecasted peak loads for the study region from 2010 through 2015.

Table 2.2

Substation/Year	2010	2011	2012	2013	2014	2015
Chaska City	12	12.4	13	13.5	14.1	14.7
Xcel Chaska	7.0	7.2	7.3	7.5	7.6	7.8
Victoria	9.0	9.4	9.8	10.2	10.7	11.2
Augusta	5.3	5.5	5.7	6.0	7.6	7.9
West Waconia	26.6	27.2	27.7	28.2	28.75	29.3
GRE-Waconia	2.1	2.1	2.2	2.2	2.3	2.3
Xcel – Waconia	20.1	20.5	20.9	21.4	21.8	22.2
Plato	2.9	2.95	3.01	3.07	3.13	3.19
Lester Prairie	8.4	8.6	8.78	8.95	9.14	9.3
Young America	13.2	13.5	13.7	14	14.3	14.5
High Island	3.3	3.5	3.6	3.7	3.9	4.1
Glencoe Muni	25.1	25.3	25.6	25.9	26.1	26.4

3. Analysis and Results

The criteria used for analysis is listed below, although in some cases the violations are not seen, the line loads and bus voltages indicate that the violations will follow very soon, therefore voltages and thermal loading that are close to becoming violations are also documented.

- The minimum voltage should be at least 0.92 PU
- Maximum loading on the transmission line should be 100% under system intact and 110% under contingency.
- Maximum loading on the transformers should be 100% under system intact conditions and 115% under contingency.

3.1 Need for the project

The study area consists of two regions (1) Scott Co – Carver Co and (2) Carver Co – Glencoe shown in Figure 1.1. The deficiencies in the two regions are mostly independent of each other. Tables 3.1, 3.2 list the transmission deficiencies in the three regions for 2015 summer peak conditions.

Table 3.1

Facility	Contingency	Rating	MVA	% loading (or) PU voltage
Scott Co TR 1 or 2	Scott Co TR 2 or 1	70	89.6	128
Carver Co – Augusta 69 kV line	Loss of Scott Co – Chaska 69 kV line	47	44.65	95%
City of Chaska	Loss of Scott Co – Chaska 69 kV line			0.934

Table 3.2

Facility	Contingency	Rating	MVA	% loading (or) PU voltage
St. Bonifacius	Loss of St. Bonifacius – Dickinson 115 kV line			0.922
West Waconia	Loss of St. Bonifacius – Dickinson 115 kV line			0.934
Carver Co	Loss of St. Bonifacius – Dickinson 115 kV line			0.936
Glencoe load	Loss of Glencoe – McLeod tap 115 kV line			0.89
High Island Load	Loss of Glencoe – McLeod tap 115 kV line			0.89
Plato load	Loss of Glencoe – McLeod tap 115 kV line			0.92
Lester Prairie load	Loss of Glencoe – McLeod tap 115 kV line			0.90
Plato – Glencoe tap 69 kV	Loss of Glencoe – McLeod tap 115 kV line	37	37.74	102%
Glencoe tap – Young America 69 kV	Loss of Glencoe – McLeod tap 115 kV line	37	48.1	130%
Carver Co – Young America tap 69 kV	Loss of Glencoe – McLeod tap 115 kV line	47	55.46	118%

Condition of 69 kV line

The 69 kV line between Carver Co, Lester Prairie and Helen has been a source of poor reliability due to the age of conductor and structures. The line was built in 1949 and has failed 13 times in the past 5 years resulting in momentary (less than 5 min) and sustained (more than 5 min) power outages in the region. In some cases, the line was out of service for a few days before it could be re-energized. The list of sustained outages since 2003 is provided in Table 3.3.

Table 3.3

Out Date	Restored date	Duration
30th Jul 2003 (09:43)	30th Jul 2003 (09:03)	10Hrs:20min
19th Jun 2005 (03:36)	22 Jun 2005 (18:57)	3days:15Hrs:21min
28th Nov 2005 (10:19)	28th Nov 2005 (15:34)	5Hrs:15min
23rd Feb 2007 (12:06)	24th Feb 2007 (21:24)	22Hrs:18min
19th May 2007 (18:35)	22nd May 2007 (16:15)	2days:21Hrs:40min

Although the proposed project does not rebuild the entire line between Carver County, Lester prairie and Helen, a significant part of this line will be rebuilt resulting in improved reliability to Plato and Young America loads.

Possible switching procedure for Glencoe

During the loss of Glencoe – McLeod 115 kV line, it may be possible to close the line between New Germany tap and Lester Prairie tap to eliminate the overload on the Carver Co – Young America – Glencoe tap line. This operating procedure was not studied in detail, as it could be difficult to operate the system in this configuration from protective relaying standpoint. Also, this operating procedure may only delay the overload by a few years, the Plato – Glencoe tap line is found to load up to 97% in 2015 and the voltages at Glencoe were found to be close to 93.9%. The only other way to mitigate the overload is by running the generation at City of Glencoe. However, there are no switching procedures available for the low voltages at St. Bonifacius and West Waconia for the loss of loss of Dickinson – St. Bonifacius 115 kV line.

Impact of load coincidence factor

To analyze the impact of load coincidence, the 2015 summer peak load was scaled down by 7% to identify violations during coincident peak conditions. Table 3.4 below lists the violations seen in the 2015 summer peak model.

Table 3.4

Facility	Contingency	Rating	MVA	% loading (or) PU voltage
Scott Co TR 1 or 2	Scott Co TR 2 or 1	70	87.5	125
Chaska (voltage)	Loss of Scott Co – Chaska 69 kV line			0.943
Carver Co – Young America tap	Loss of McLeod – Glenco 115 kV line	47	50.29	107
Young America tap – Glencoe tap	Loss of McLeod – Glenco 115 kV line	37	43.66	118
Glencoe (voltage)	Loss of McLeod – Glenco 115 kV line			0.907
High Island (voltage)	Loss of McLeod – Glenco 115 kV line			0.909
St. Bonifacius	Loss of Dickinson – St. Bonifacius 115 kV line			0.93
West Waconia	Loss of Dickinson – St. Bonifacius 115 kV line			0.941
Carver Co	Loss of Dickinson – St. Bonifacius 115 kV line			0.942

From Table 3.4, it can be seen that even with the coincidence factor applied to the mode, several deficiencies are noticed through out the study area.

3.2 Transmission Options

The preferred plan for the load serving need of the study region is to

- Build 2 miles of 69 kV line capable of carrying 2nd 115 kV circuit from West Waconia to existing Carver Co – Augusta 69 kV line.
- Rebuild 7 miles of 69 kV line from Waconia tap to Augusta to 115 kV specifications.
- Rebuild 69 kV line from Glencoe East substation to Plato to 115/69 kV double circuit.
- Rebuild 69 kV line between Plato – Young America – West Waconia to 115 kV.
- Install 10 MVAR capacitors at Plato and move Plato load to Glencoe East.

The Map for preferred transmission plan is provided in figure 3.1.

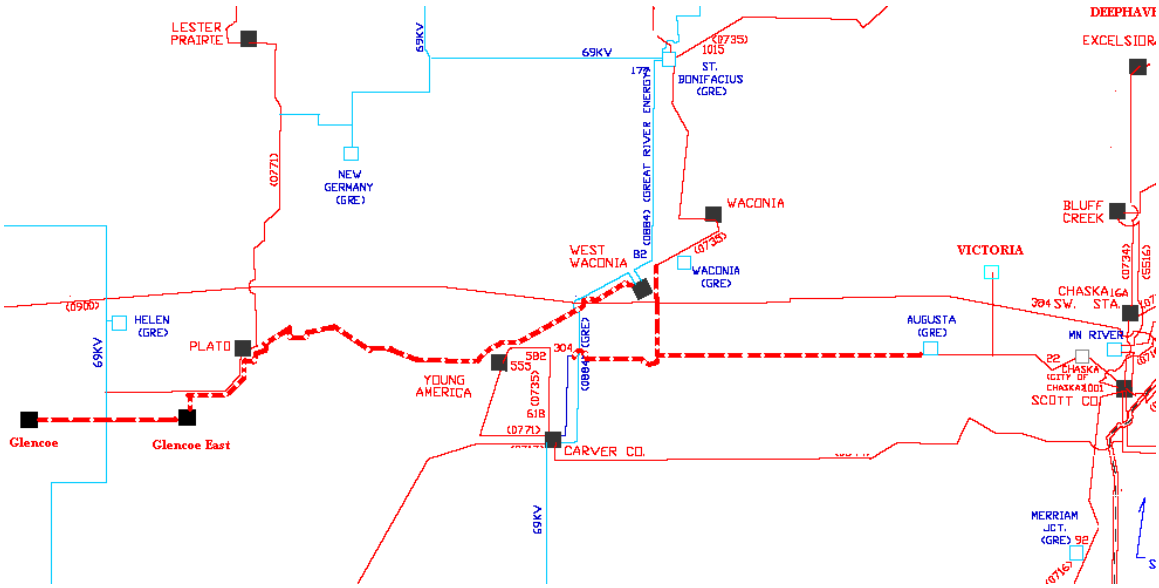


Figure 3.1

The alternative to the preferred plan is to

- Upgrade the line between Glencoe East substation and Plato to 115/69 kV double circuit.
- Upgrade the 69 kV line from Plato to Young America to Carver Co to 115 kV.
- Rebuild 7 miles of 69 kV line between Carver Co and Augusta to 115 kV specifications.

Full AC contingency analysis was performed on the model to ensure no additional violations were created due to the proposed plan.

The map of alternative transmission plan is provided in Figure 3.2

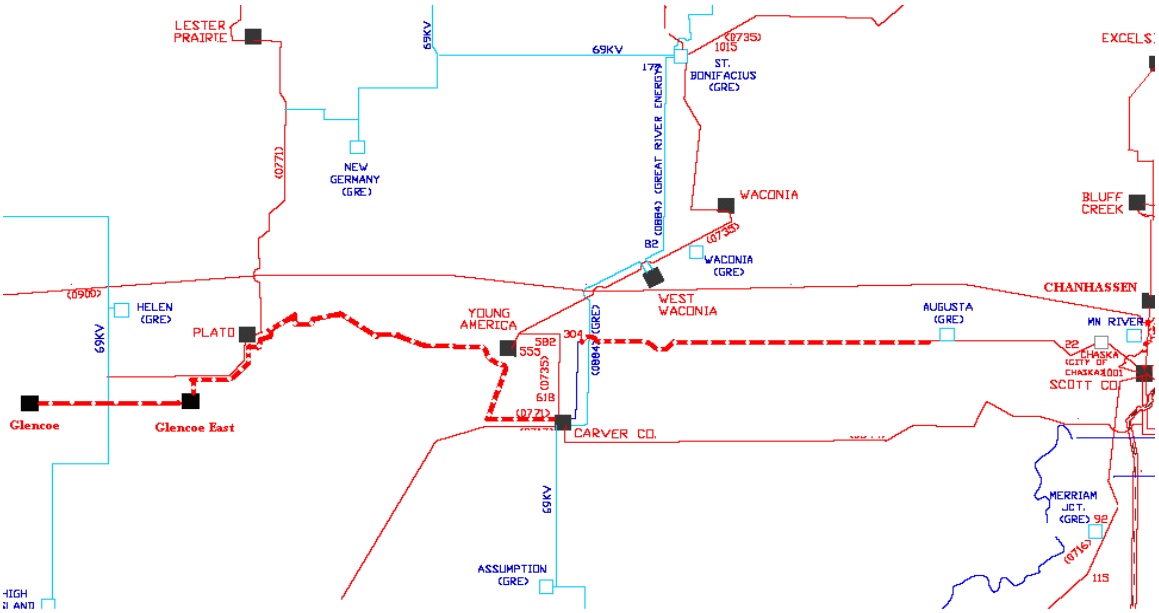


Figure 3.2

3.3 Incremental Load Serving Capabilities

The incremental load serving capability of the plan is evaluated by scaling the loads listed in Table 2.1 till a new violation is identified. If the violation could be mitigated without major upgrades, the mitigation plans were included in the study.

Scott Co Transformer Loading

For the preferred and alternative plans, the line between Scott Co and Chaska is assumed to be “normally open”. Closing this line will put additional load on Scott Co transformers leading to an overload during the outage of one of the transformers. Rebuilding the 69 kV line between Augusta and Carver Co tap will reduce the impedance sufficiently to avoid low voltages at Chaska when the line between Scott Co and Chaska is operated “normally open”. After opening the Scott Co – Chaska 69 kV line, the overload on Scott Co transformers drops to 108% under contingency, which is below the emergency rating of 115%.

It should also be noted that the conversion of Scott Co – Excelsior – Deephaven – Westgate 69 kV line to 115 kV will result in eliminating the overload completely.

Table 3.5

Preferred Plan	Incremental load growth	Limit	Mitigation
	25%	(1) Low voltages at Chaska, with the Scott Co – Chaska line open. (2) Low voltages at St. Bonifacius for the loss of Dickinson source.	Convert the line from Augusta to Scott Co to 115 kV along with Augusta and Chaska, and operate at 115 kV.
	15%	Low voltages at Lester Prairie.	Convert Glencoe - High Island to 115 kV along with High Island substation.
	15%	Low voltages at Lester Prairie	Yet to be planned.
	40%	**Low voltages at City of Glencoe**	**New 345/115 kV sub at West Waconia on McLeod – Blue Lake 345 kV double ckt (proposed).**
Alternative plan	**Incremental load**	**Limit**	**Mitigations**
	25%	Chaska Voltage	(1) Convert the line from Augusta to Scott Co to 115 kV along with Augusta and Chaska, and operate at 115 kV. (2) Convert Young America substation to 115 kV
	15%	Low voltages at Lester Prairie.	Convert Glencoe - High Island to 115 kV along with High Island substation.
	15%	Low voltages at Lester Prairie.	Yet to be planned.
	40%	**Low voltages at City of Glencoe**	**New 345/115 kV sub at West Waconia on McLeod – Blue Lake 345 kV double ckt (proposed).**

Although in both the plans, the load-serving limit would be caused by the growth in the Lester Prairie area, on 69 kV system, the 115 kV system between McLeod – Glencoe - West Waconia does not indicate any violations with 55% incremental load growth.

Reason for choice of preferred plan:

The preferred plan is based on the assumption that the 230 kV line from Minnesota Valley to Blue Lake substation could be converted to 345 kV in the future, due to the proximity of West Waconia substation to this line, any future need for bulk electric source in the area could be easily met with minimal addition of transmission facilities.

Although West Waconia substation could be used as a future 345 kV substation in the alternative plan, due to the absence of 115 kV lines at the substation, it could lead to overloading the Carver Co – West Waconia 115 kV line. Also the loss of West Waconia – Carver Co 115 kV line could pose voltage problems as all the loads at Glencoe, Victoria and Chaska are connected to Carver Co.

Due to this reason, terminating the lines from Glencoe and Chaska into West Waconia is beneficial from future bulk transmission utilization perspective. Even if the 230 kV line is not converted to 345 kV, it is still possible to tap the existing 230 kV line to serve the 115 kV load.

3.4 Distributed generation option

The distributed generation option is evaluated by identifying the amount of generation required to serve the same amount of load (25%) that the preferred transmission option could serve based on the incremental load serving capabilities listed in Table 3.5.

Generators were placed strategically to mitigate specific overloads and low voltages identified in Table 3.1 and 3.2. The City of Glencoe has 35 MW of diesel generators in-service, it is determined that the existing generators are sufficient to serve the entire load of the City, therefore no additional generation is added at this location. Also, St. Bonifacius substation has 75 MW of existing generation, therefore no additional generation is required at this location. However, since this is a NERC category B contingency, the generation at St. Bonifacius has to be run in anticipation of outage of St. Bonifacius – Dickinson 115 kV line during peak load conditions to meet NERC TPL-002 standard.

To mitigate the overloads and low voltages on the Carver Co – Scott Co 69 kV line, generation has to be installed at Chaska or Victoria. Table 3.6 shows the generation requirements assuming 2% load growth in the region. The initial requirement of generation is approximately 4 MW in 2015, the generation is increased in same amount as load there after.

Table 3.6

Year	Load on Carver Co – Augusta line (MVA)	MW of generation required
2015	44.3	4
2016	45.2	4.9
2017	46.1	5.8
2018	47.0	6.7
2019	48.0	7.7
2020	48.9	8.6
2021	49.9	9.6
2022	50.9	10.6
2023	51.9	11.6
2024	52.9	12.6
2025	54.0	13.7
2026	55.1	14.8
2027	56.2	15.9

In addition to the generation listed in Table 3.6, any facilities required for interconnection of the generators have to be identified and built through the MISO interconnection and transmission service processes.

It should be noted that the generation listed in Table 3.6 is based on the assumption that the line between Chaska and Scott Co is 'normally open' to avoid overloading the Scott County transformers. Even if the line is closed through, this generation would be needed for the loss of Chaska – Scott Co 69 kV line. However, closing the line would not require the generation to be run for less number of hours, but would require upgrading both the Scott Co transformers to 112 MVA.

Various distributed generation options are discussed below.

Wind turbines

Wind turbines come in sizes ranging from several KW to 2 or 3 MW. This form of generation is generally not suitable for load serving purposes due to its intermittent nature. Also, many wind turbines lack the capability to provide reactive support to the transmission system, which is essential to maintain healthy voltage. Based on the analysis, at least 16 MW of new generation in required at Chaska, this implies that about 8 (2 MW) turbines have to be running at full output in order to meet the load serving needs for the study region. The installation cost for the 16 MW, required to meet the load-serving needs, is estimated to be around $12.8 million (assuming $800/kW). It should be noted that the wind farms seldom run at 100% of their rated capacity therefore, more than 16 MW of wind generation will be required to meet the demand. Since the study region is part of the Twin Cities Metro, it may not be possible to build wind farms due to existing land development.

Gas turbines

These are generators driven by natural gas turbines that are available in sizes varying from 0.5 to 25 MW as distributed generation resources and few hundred MW for central power generation stations. The installed cost of CT is about 985$/kW, this does not include the right of way for gas pipeline, interconnection and transmission service facilities, operation and maintenance costs. The installation cost for the 16 MW, required to meet the load-serving needs, is estimated to be around $ 15.76 million.

Reciprocating Engines

These are generators driven by natural gas or diesel engines that are available in sizes varying from 5 kW to 7 MW for distributed generation purposes. The installed cost of diesel generators is about 1000 $/kW, this does not include the interconnection and transmission facilities and operation and maintenance costs. The installation cost for the 16 MW, required to meet the load-serving needs, is estimated to be around $ 16 million.

3.5 Loss analysis

Table 3.7 lists the total losses for GRE and Xcel Energy control areas for Base case, preferred plan and alternative plan.

Table 3.7

Model	Losses
Base Case[1]	350.7
Preferred plane	348
Alternative plan	347.9

Although the losses are less in the preferred plan and alternative plan models compared to the Base case, since the difference in losses between preferred plan and alternative is only 2 MW, no further analysis is performed to evaluate the savings due to losses.

The losses for distributed generation option are not evaluated, as the generation dispatch for this model is different from the transmission options. The addition of generation at Chaska, turning on generation at City of Glencoe and St. Bonifacius, and reduction of generation at Sherburne Co could result in significantly different results that can't be compared with the transmission options.

[1] Assuming line between Chaska and Scott Co is open, this is to make the system consistent with the transmission plans.

4. Conclusion

The line between Scott Co and Carver Co could be rebuilt in two phases starting with upgrade of Carver Co – Augusta to 795 ACSS (except the 2 mile 336 ACSR conductor near Carver Co).

There were no violations seen for the 115 kV transmission system between Glencoe and West Waconia for the preferred plan, the 69 kV violations could be mitigated by converting High island load to 115 kV.

Need Summery and Solutions

Table 4.1

Facilities	Benefits and problems addressed
Rebuild 69 kV line from Glencoe East – Plato – Young America – West Waconia 115 kV conversion.	1) Provide 2nd source to City of Glencoe for the loss of McLeod – Glencoe. 2) Remove failing line between Young America and Biscay Junction to improve reliability. 3) Provide voltage support to St. Bonifacius and West Waconia for the loss of Dickinson source.
10 MVAR cap bank at Plato, and 69 kV circuit from Biscay Jct to Plato (double circuited with the new 115 kV line)	This is required to maintain service to Lester Prairie and maintain 69 kV voltages at Lester Prairie under normal conditions, as the 69 kV line from Young America will not be serving this area after conversion to 115 kV.
Build 2 miles of 69 kV line from West Waconia towards Carver Co – Augusta 69 kV line.	This is needed to maintain the existing 2nd source to Waconia 69 kV substation.
Rebuild existing 69 kV line between Carver Co and Augusta to 115 kV specifications (approximately 7 miles)	1) This will improve the voltages at Chaska, Victoria and Augusta for the loss of Chaska – Scott Co 69 kV line. 2) This will also allow the system to be operated with Chaska – Scott Co 69 kV line normally open, this will in turn reduce the overload on Scott Co transformers.

The summery of the three alternatives is listed in Table 4.2

Table 4.2

	Preferred	Alternative
Cost	$ 17.8 million	$16.4 million
Load serving capabilities	25% growth initially, additional upgrades could get this up to 55%	25% growth initially, additional upgrades could get this up to 55%
Loss Savings	2 MW	2 MW
Future Upgrades	Possible	Possible

Appendix A
Cost Estimates

Preferred Plan

Year	Facility	Cost
2012	Carver Co tap – Augusta line upgrade	$ 5,100,000
2012	1.6 mile line from West Waconia to carver Co – Augusta line	$ 1,640,000
2012	Glencoe tap – Young America – West Waconia line upgrade to 115 kV	$ 4,579,000
2012	Glencoe tap – Glencoe East to 115/69 kV double circuit	$ 2,550,000
2012	West Waconia substation line termination work	$ 3,240,000
2012	Plato 10 MVAR capacitor bank	$ 700,000
	Total	**$ 17,809,000**

Alternative Plan

Year	Facility	Cost
2012	Rebuild 7 miles of 69 kV line between Carver Co and Augusta to 795 ACSS	$ 5,100,000
2012	Glencoe tap – Glencoe East to 115/69 kV double circuit	$ 2,550,000
2012	Glencoe tap – Young America – Carver Co line upgrade to 115 kV	$ 4,579,000
2012	Carver Co substation 115 kV line termination	$ 3,500,000
2012	Plato 10 MVAR capacitor bank	$ 700,000
	Total	**$ 16,429,000**

Distributed Generation Plan for Carver Co – Scott Co 69 kV line problems

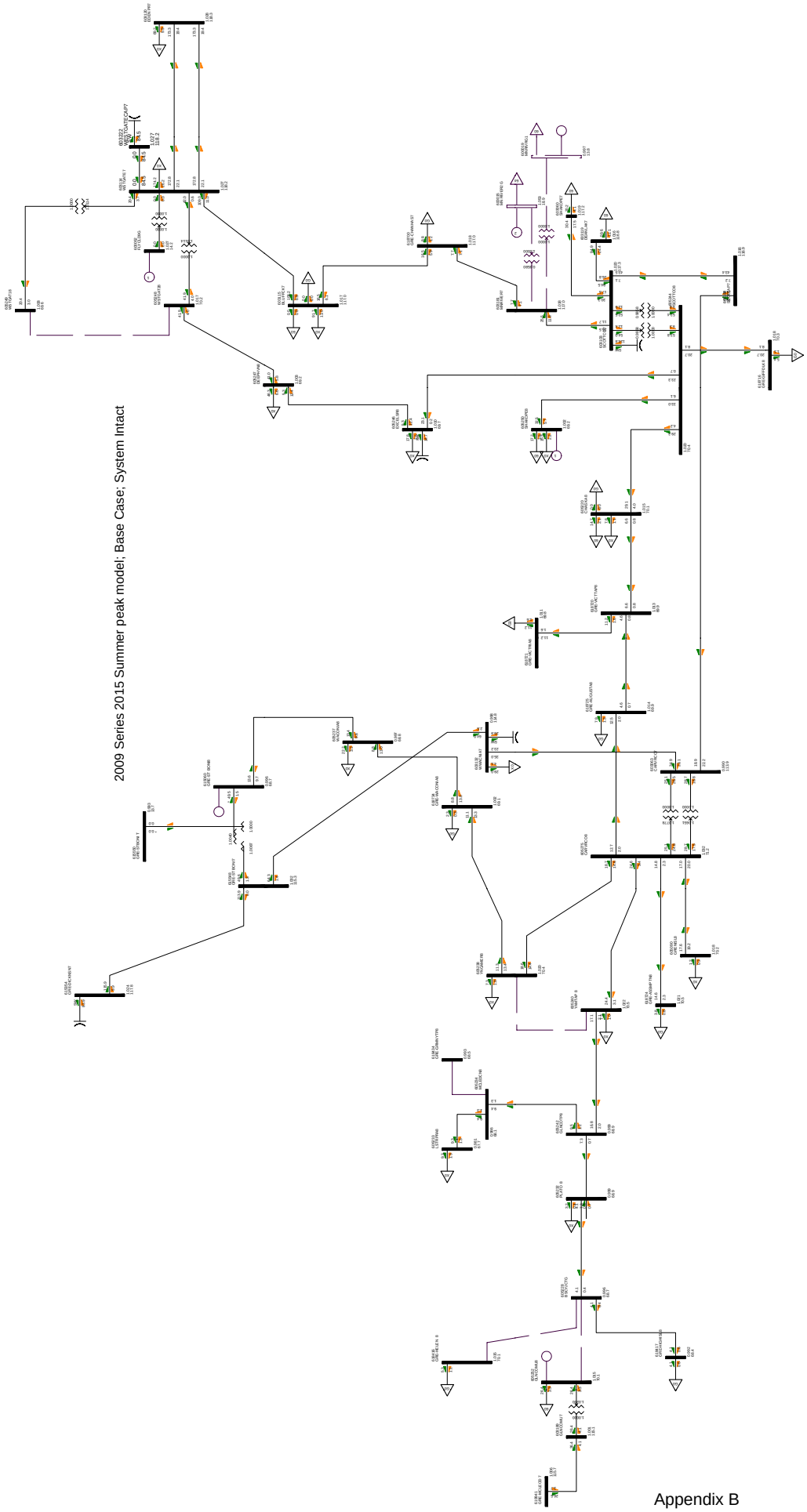
Location	Cost
Victoria – 16 MW	$ 16 million
Total	**$ 16 million**

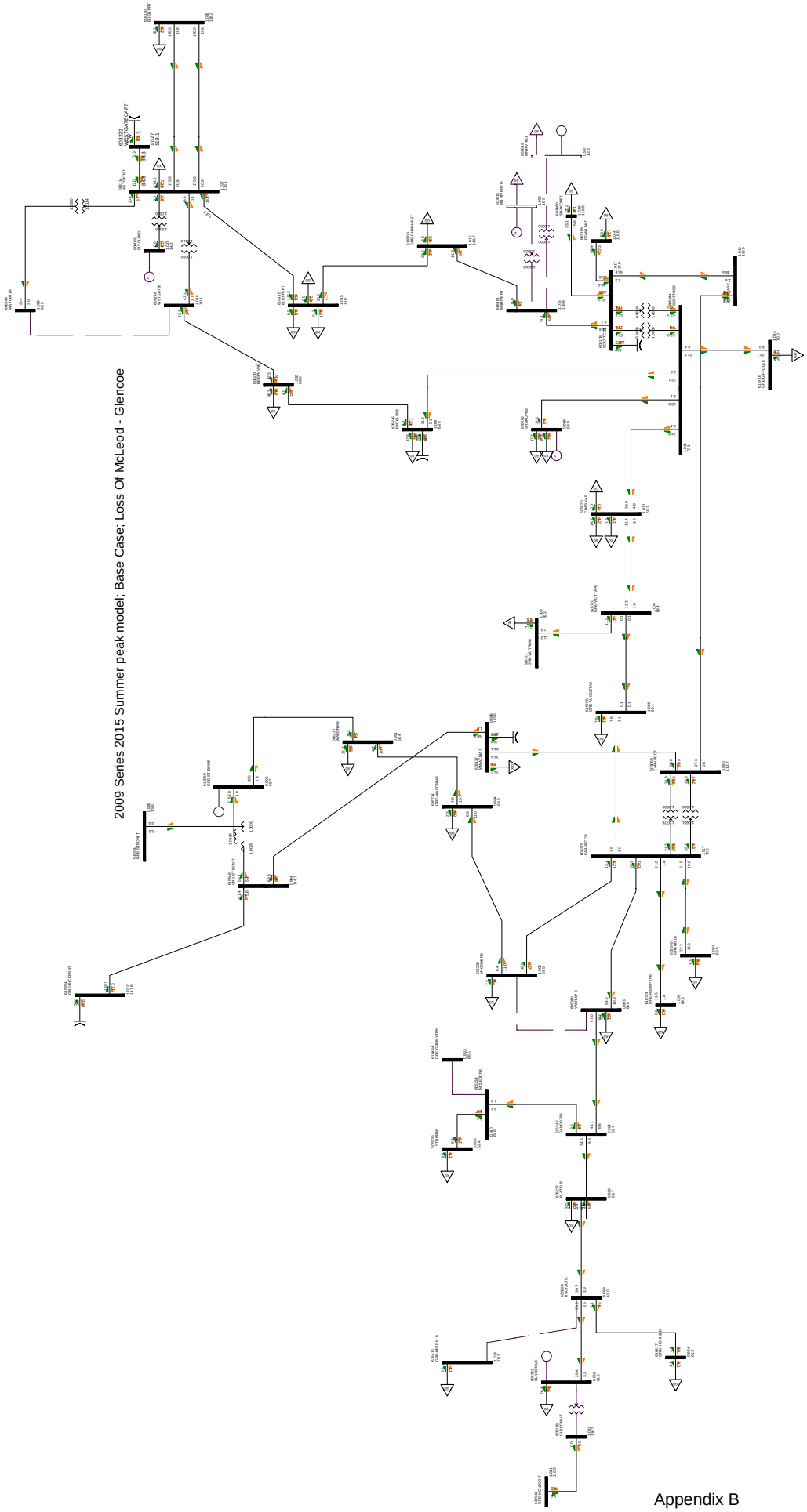
The cost estimates for generators do not include interconnection and transmission service related facilities for the generators. The estimates for distributed generation are based on 1000$/kW. Also, the estimate does not include operation, maintenance and fuel costs.

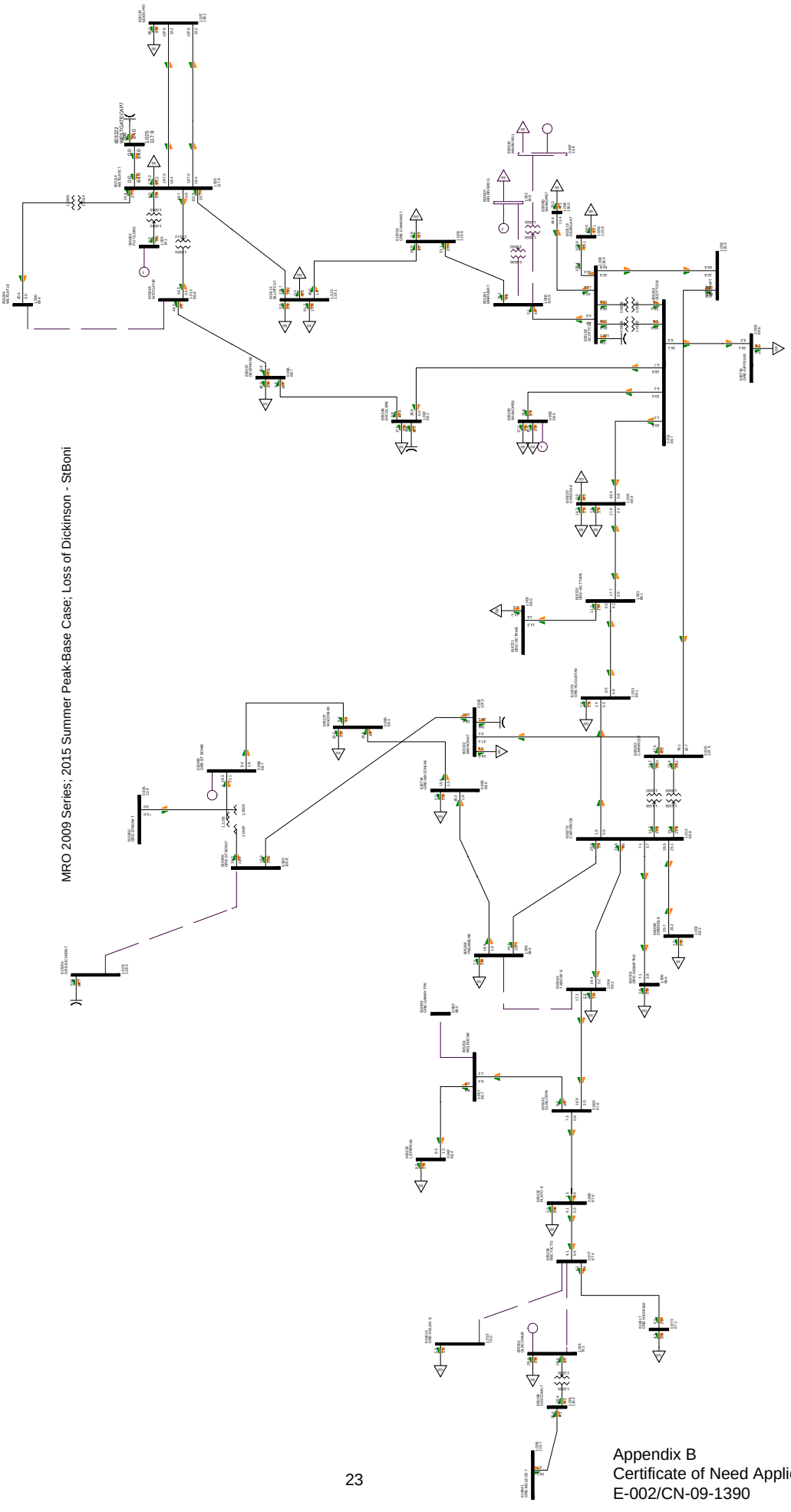
The $16 million for generation is required to offset rebuilding the 7 mile 69 kV line from Carver Co tap to Augusta to 115 kV specification, therefore the transmission option cost is only $5.1 million.

Appendix B
Powerflow maps

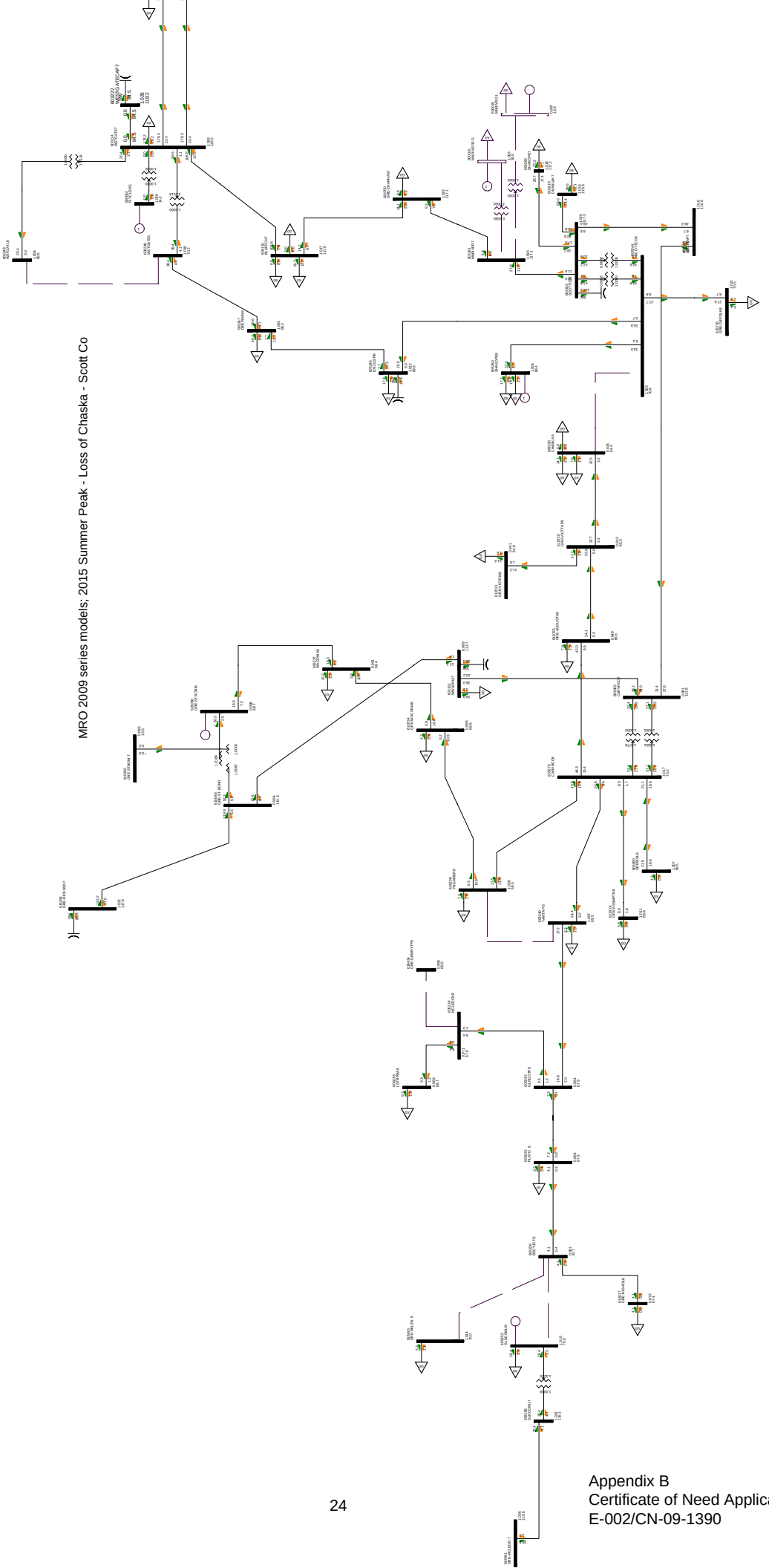
Base Case

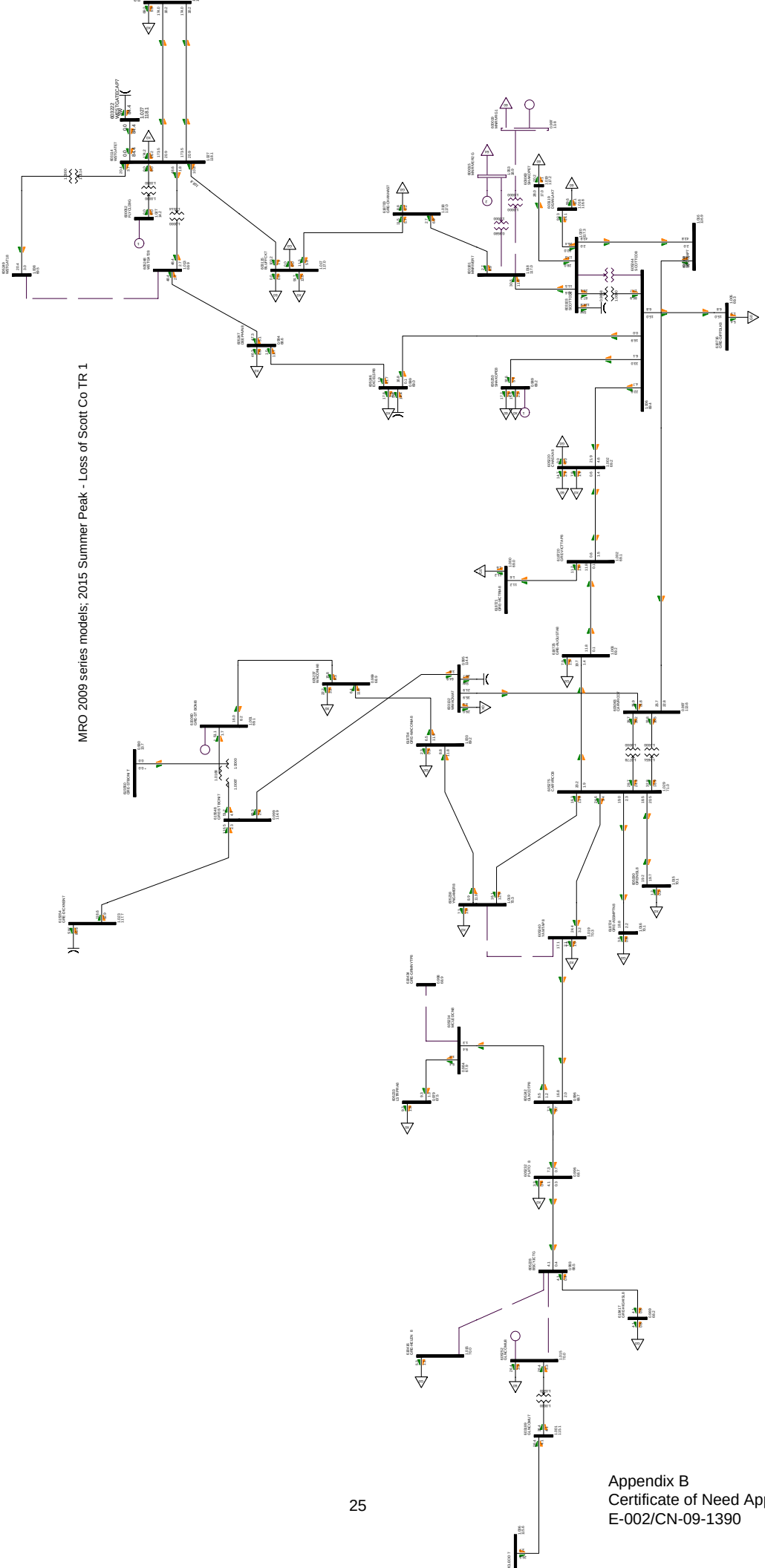

2009 Series 2015 Summer peak model; Base Case; System Intact


2009 Series 2015 Summer peak model; Base Case; Loss Of McLeod - Glencoe

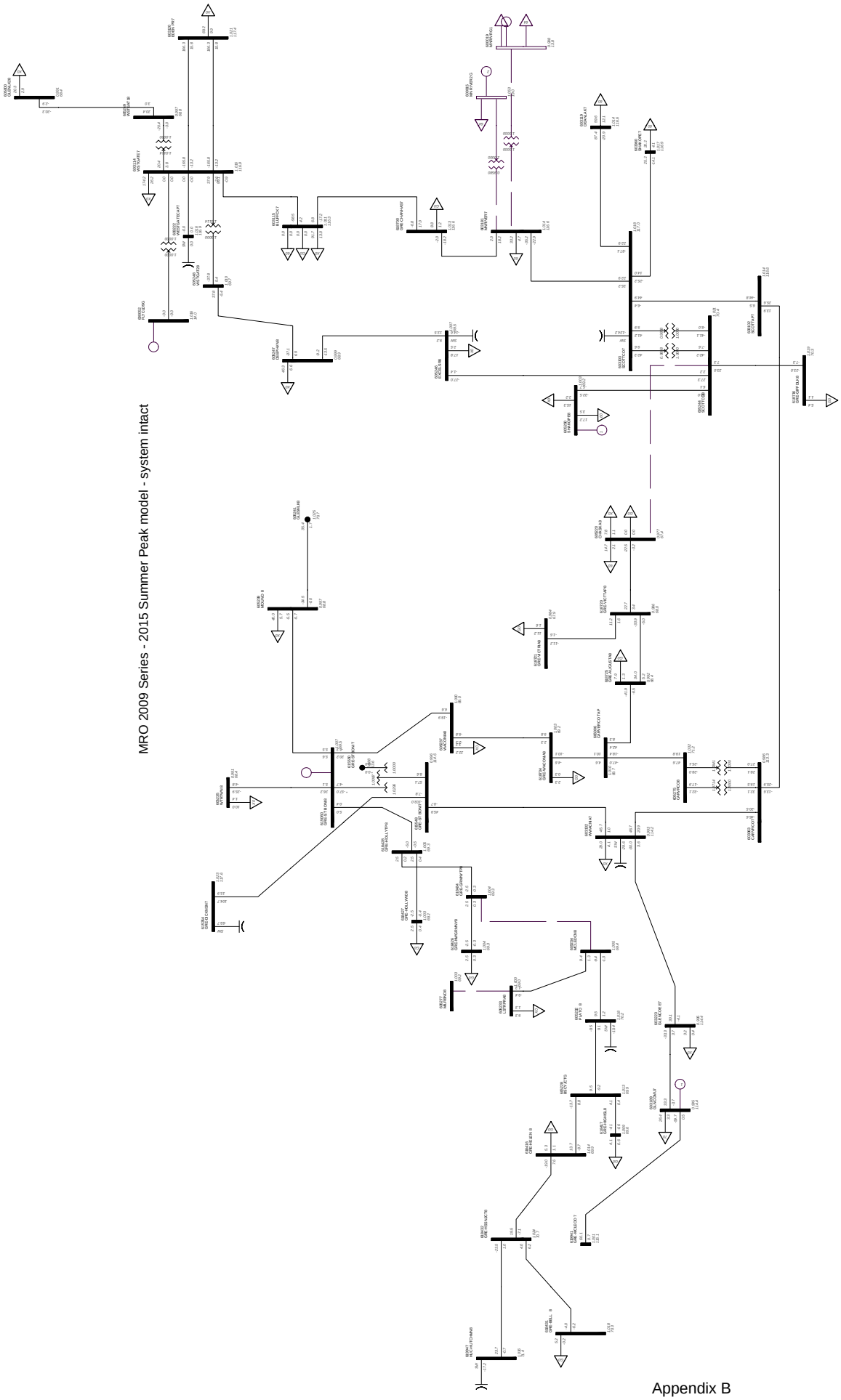


MRO 2009 Series; 2015 Summer Peak-Base Case; Loss of Dickinson - StBoni

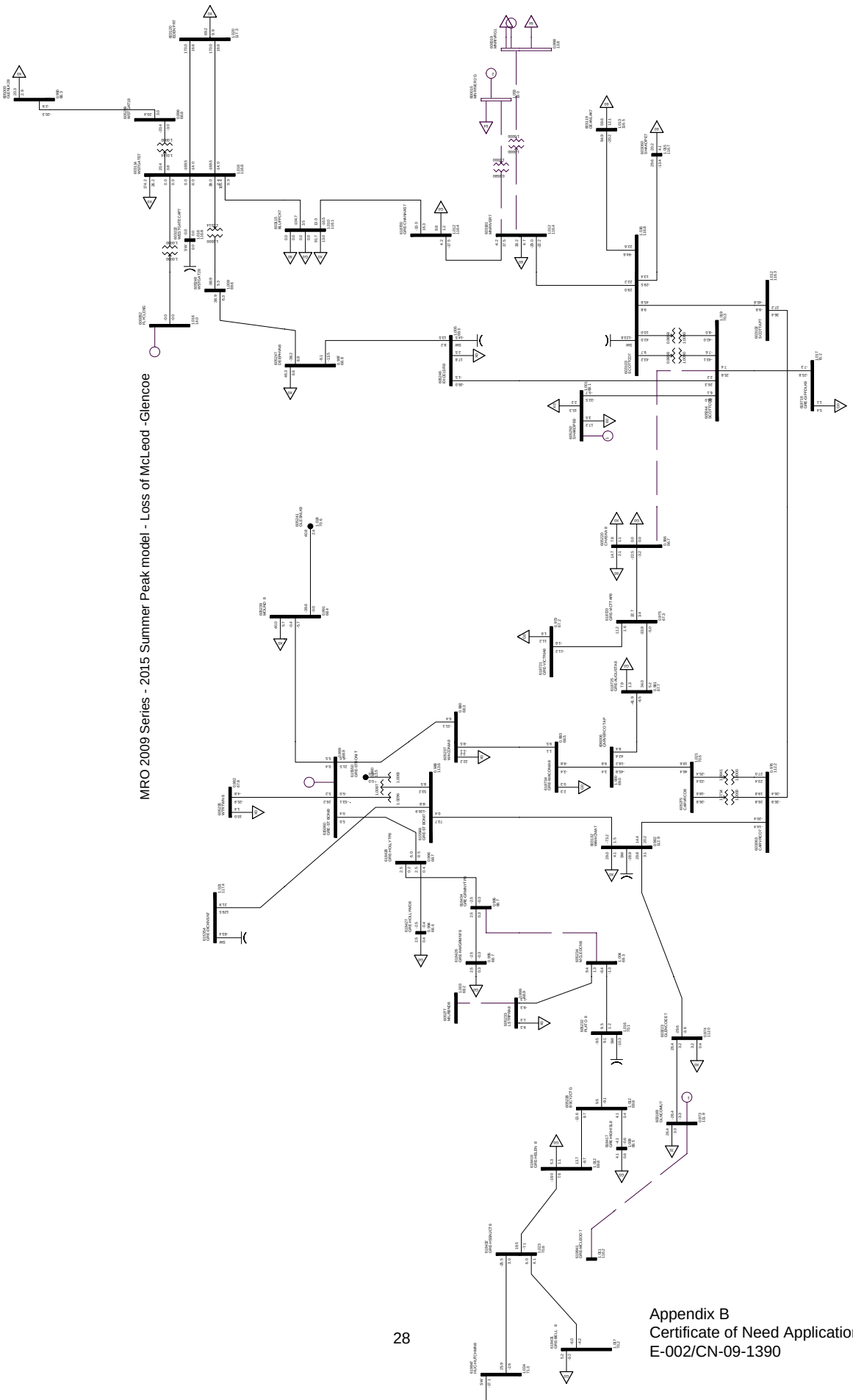

MRO 2009 series models; 2015 Summer Peak - Loss of Chaska - Scott Co

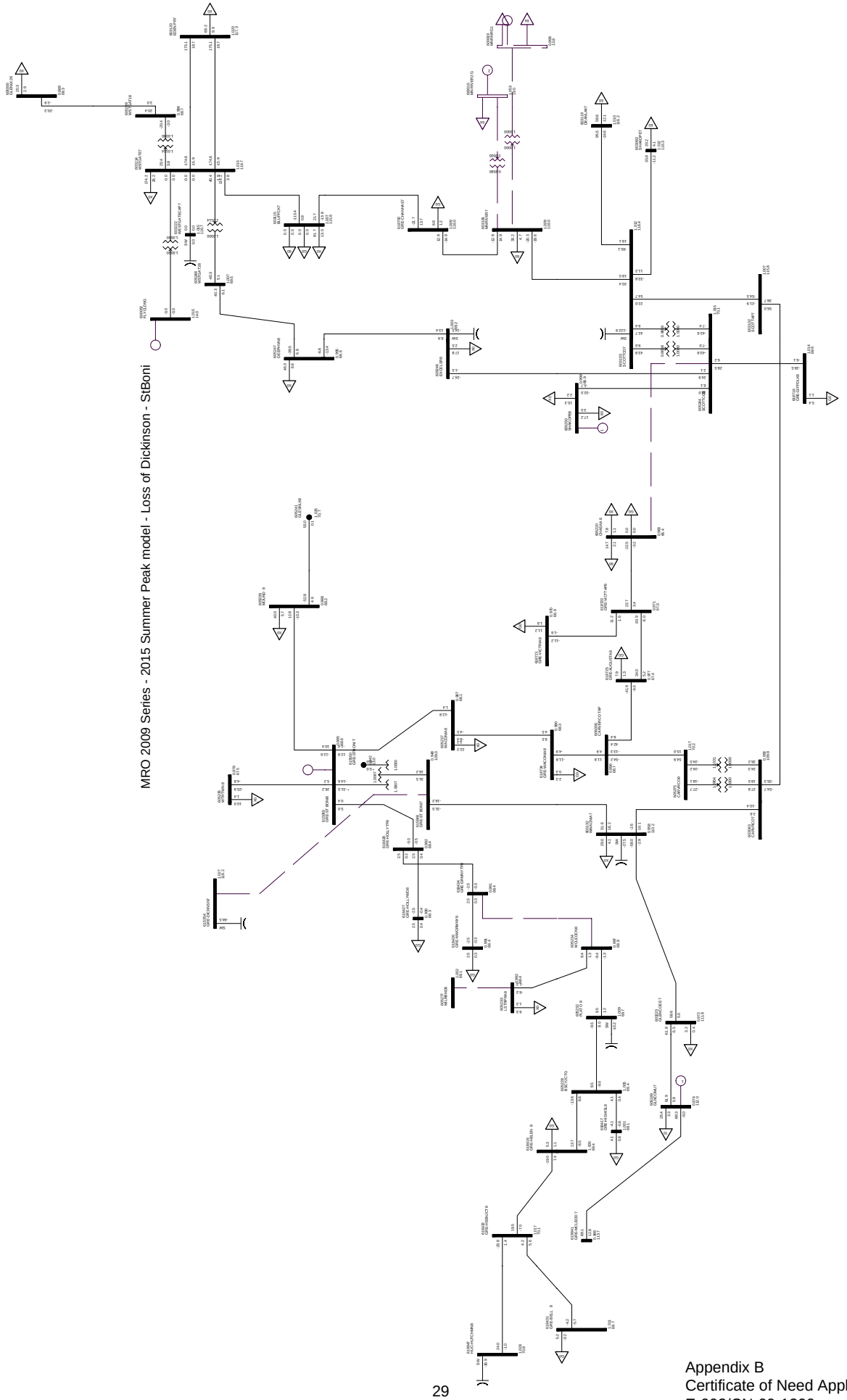

MRO 2009 series models; 2015 Summer Peak - Loss of Scott Co TR 1

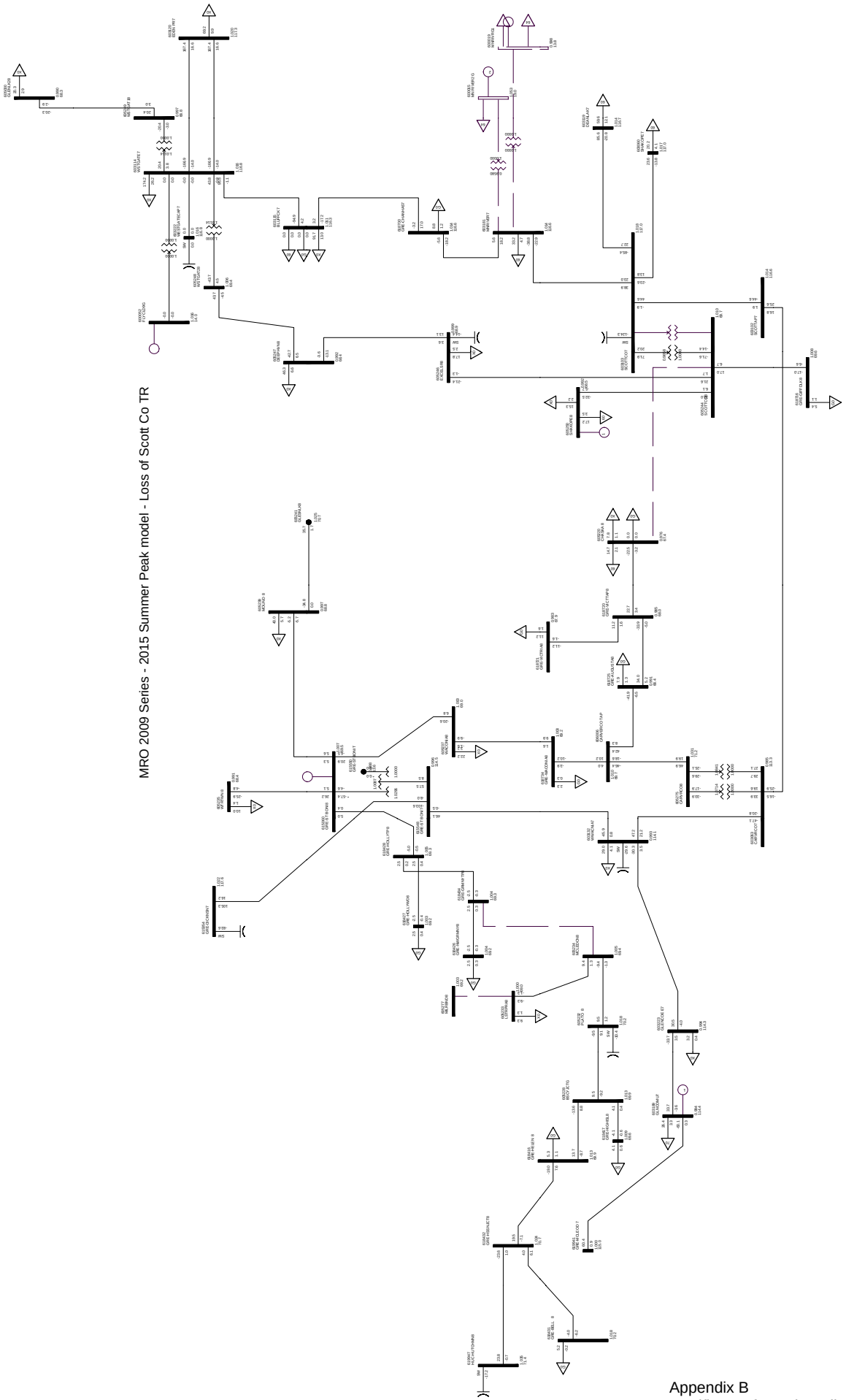
Preferred Plan



MRO 2009 Series - 2015 Summer Peak model - system intact

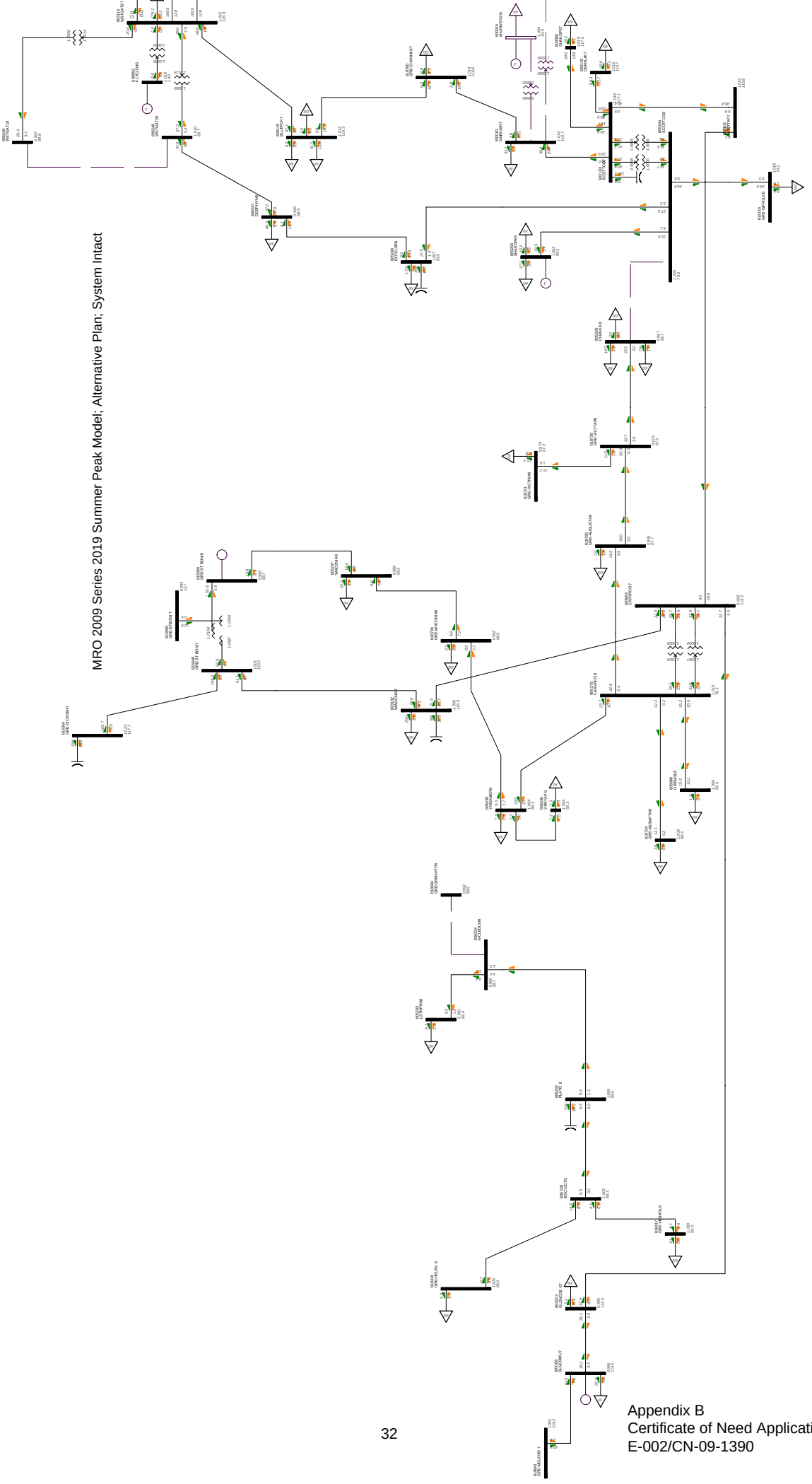

MRO 2009 Series - 2015 Summer Peak model - Loss of McLeod -Glencoe


MRO 2009 Series - 2015 Summer Peak model - Loss of Dickinson - StBoni

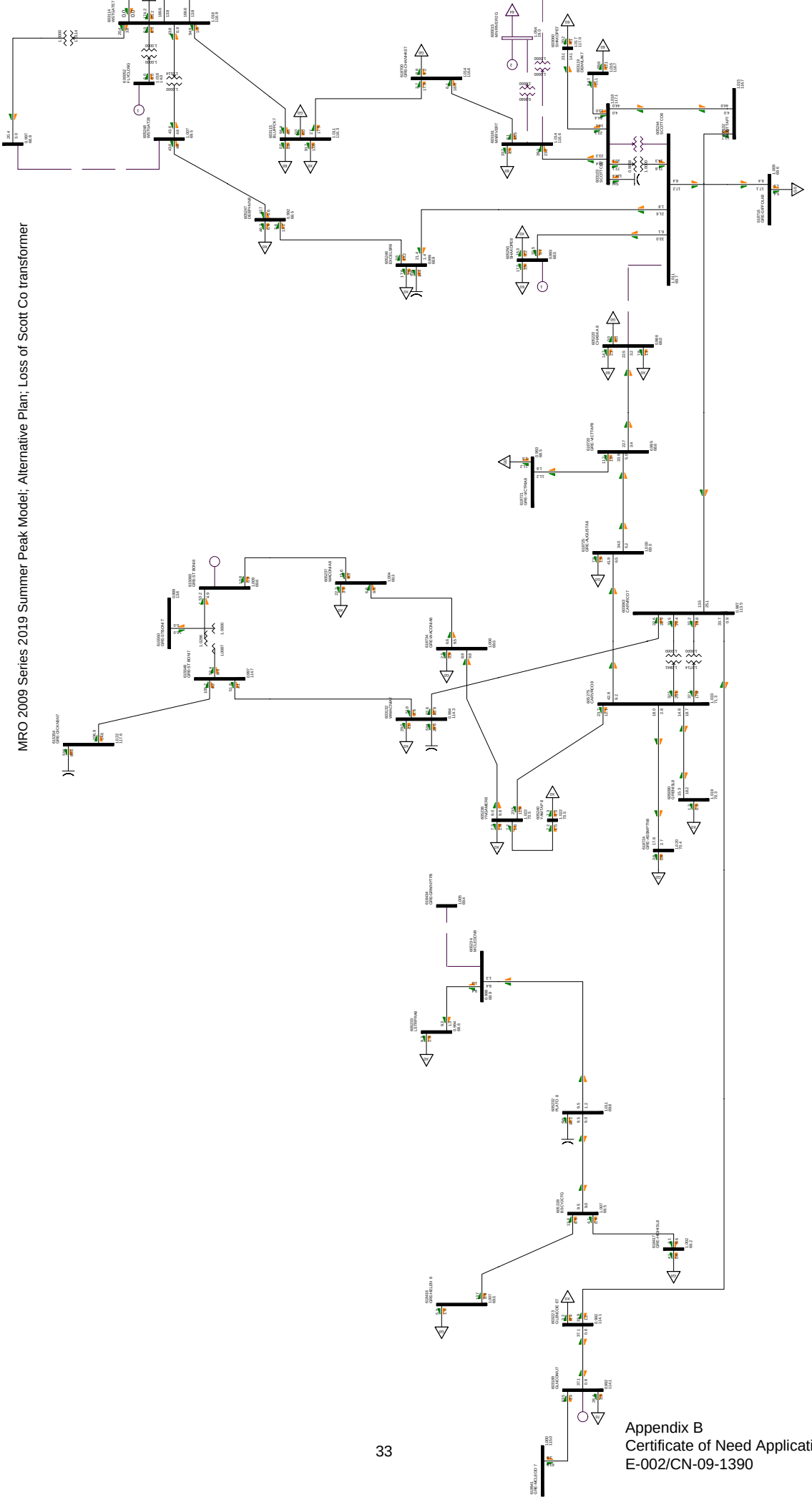


MRO 2009 Series - 2015 Summer Peak model - Loss of Scott Co TR

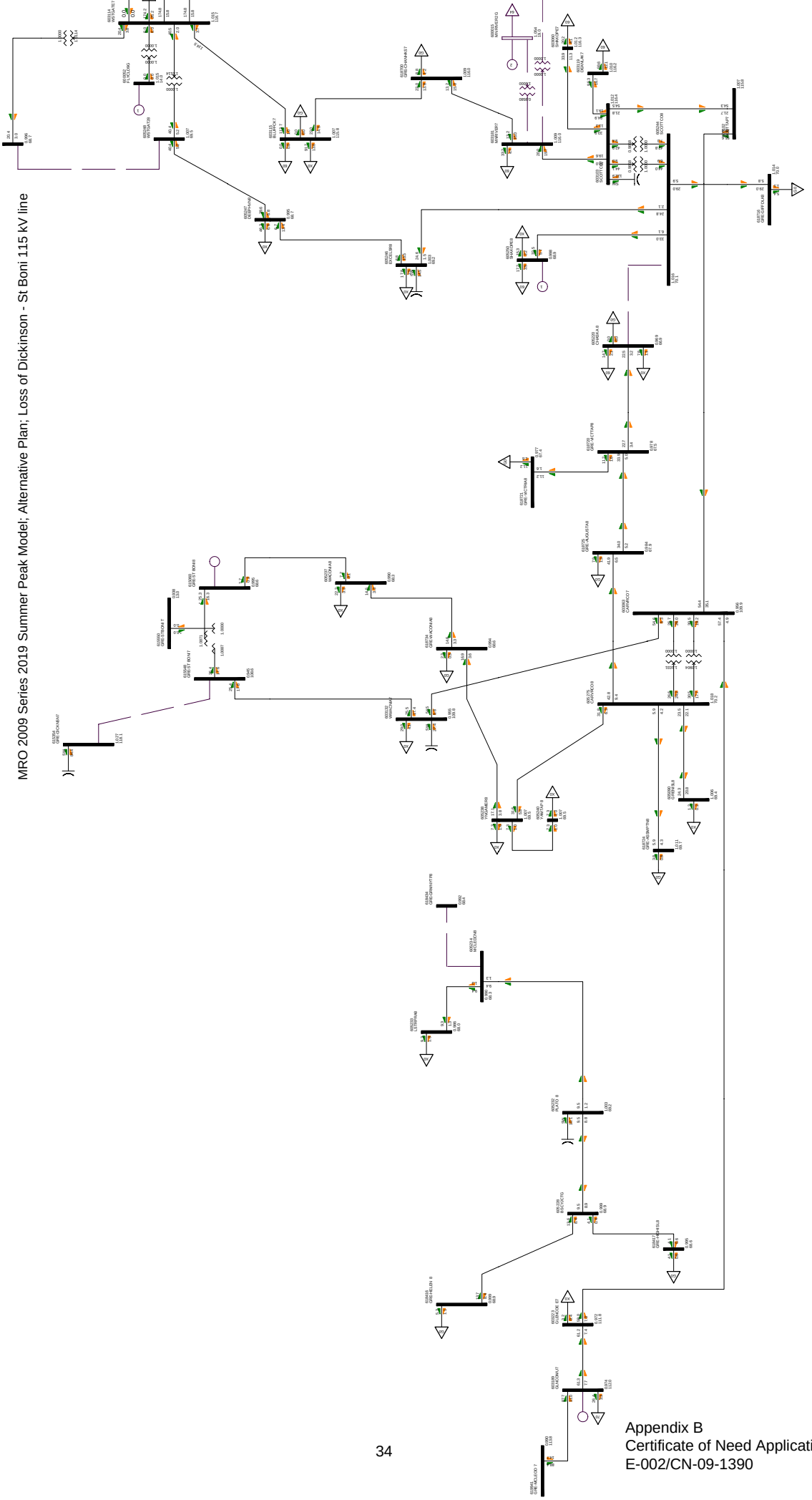
Alternative



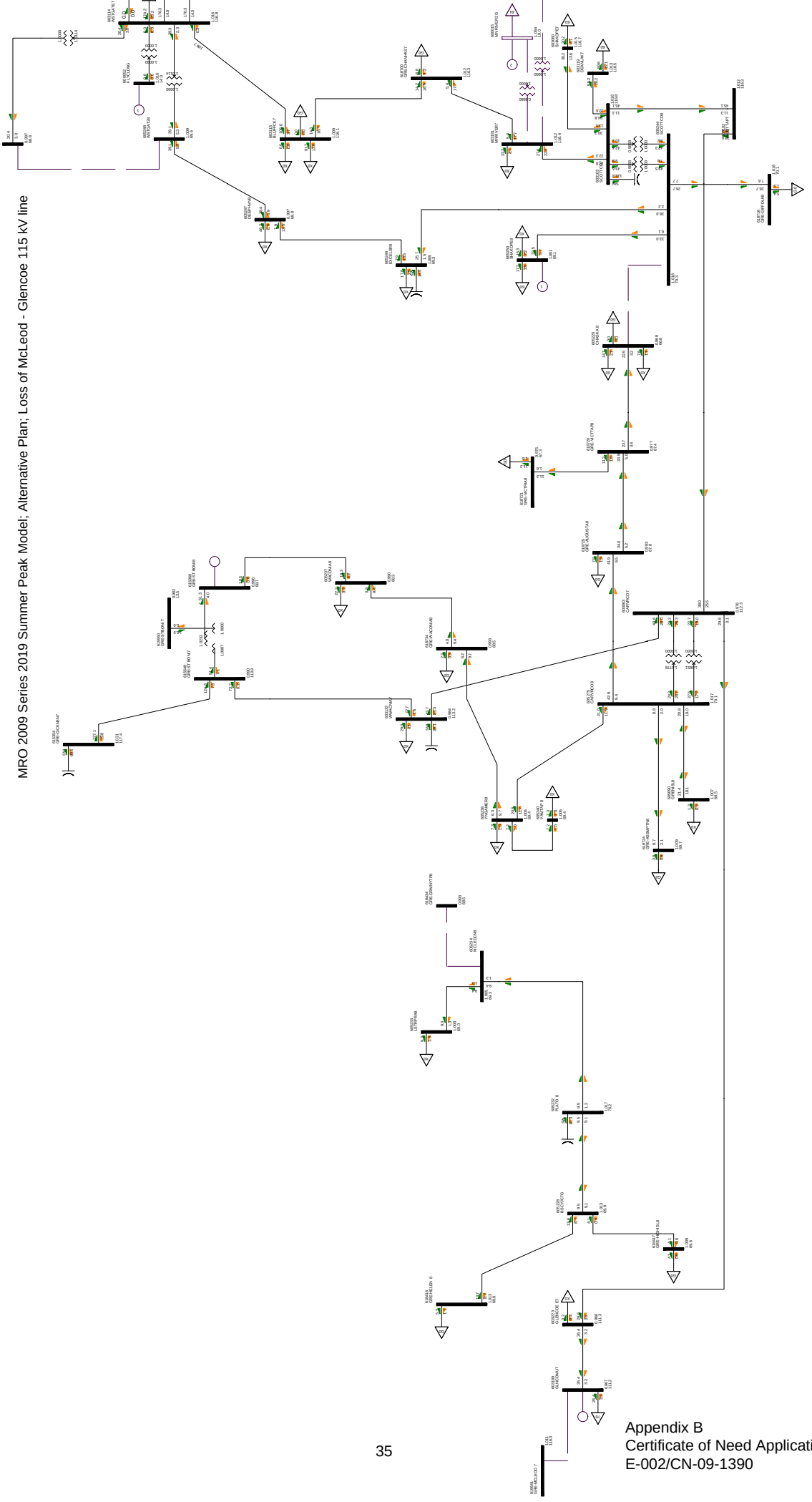
MRO 2009 Series 2019 Summer Peak Model; Alternative Plan; System Intact



MRO 2009 Series 2019 Summer Peak Model; Alternative Plan; Loss of Scott Co transformer



MRO 2009 Series 2019 Summer Peak Model; Alternative Plan; Loss of Dickinson - St Boni 115 kV line



MRO 2009 Series 2019 Summer Peak Model; Alternative Plan; Loss of McLeod - Glencoe 115 kV line