Feasibility Study for the Q152

74.9 MW Summer / 74.9 MW Winter Solar Project

March, 2018

DUKE ENERGY® FLORIDA

Bulk Transmission Planning, Florida

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1. Executive Summary

The Q152 customer has submitted an Interconnection Request on Duke Energy Florida's (DEF's) system for a Solar PV station, capable of 74.9 MW Summer / 74.9 MW Winter net output. The proposed facility will be located in Columbia County, Florida with two (2) interconnect options considered. Option 1 connected to the Ft. White to Ginnie 230 kV line, and Option 2 to the Ft. White to Newberry 230 kV line. Option 3 would connect both of these lines into a common interconnection substation. A third option was considered in case one of these two were not sufficient, and due to a number of subsequent requests near this location.

The customer has requested this generation facility be evaluated for Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS) with a requested Commercial Operating Date (COD) of June 30, 2018. The three (3) potential interconnection configurations will be referenced in this report as Option 1, Option 2 and Option 3.

Cost estimates in this report are based on the facilities that are identified as directly impacted by the generator under study, and do not take into account results that may indicate unrelated existing issues. Additional detailed study may result in changes to scope and cost. The estimates from this Feasibility Study are only Planning estimates (level 5) and may change significantly due to additional information determined from a more detailed System Impact and Facilities Studies to follow.

The conclusion of this Feasibility Study is that Q152 could be connected to the Ft. White to Ginnie 230kV line (Option 1) without additional network facilities other than upgrades assumed to be present due to prior queue requests. However should one or more of the prior queue requests be modified or withdrawn, Q152 may become responsible for such upgrades in addition to those estimated here in this report. A new 230kV substation south of DEF's current Ft. White 230/115/69kV substation for interconnection is already required for Q151. If this substation is in place, Q152 would only be responsible for expansion of the new facility to include a new terminal for interconnection. No attributable Third Party thermal Impacts were identified however short circuit impacts greater than 3% were identified on third-party substations. The estimated DEF cost required for interconnection the Q152 Solar Project using Option 1 is $1,050,000, potential Third Party costs have not been estimated or included [see Cost section for more detail].

2. Point of Interconnection (POI)

Three POIs were considered in this study:

- **Option 1** – Add 4th Breaker to Q151's Ring Bus Substation connecting to DEF's Ft. White – Ginnie 230 kV line.

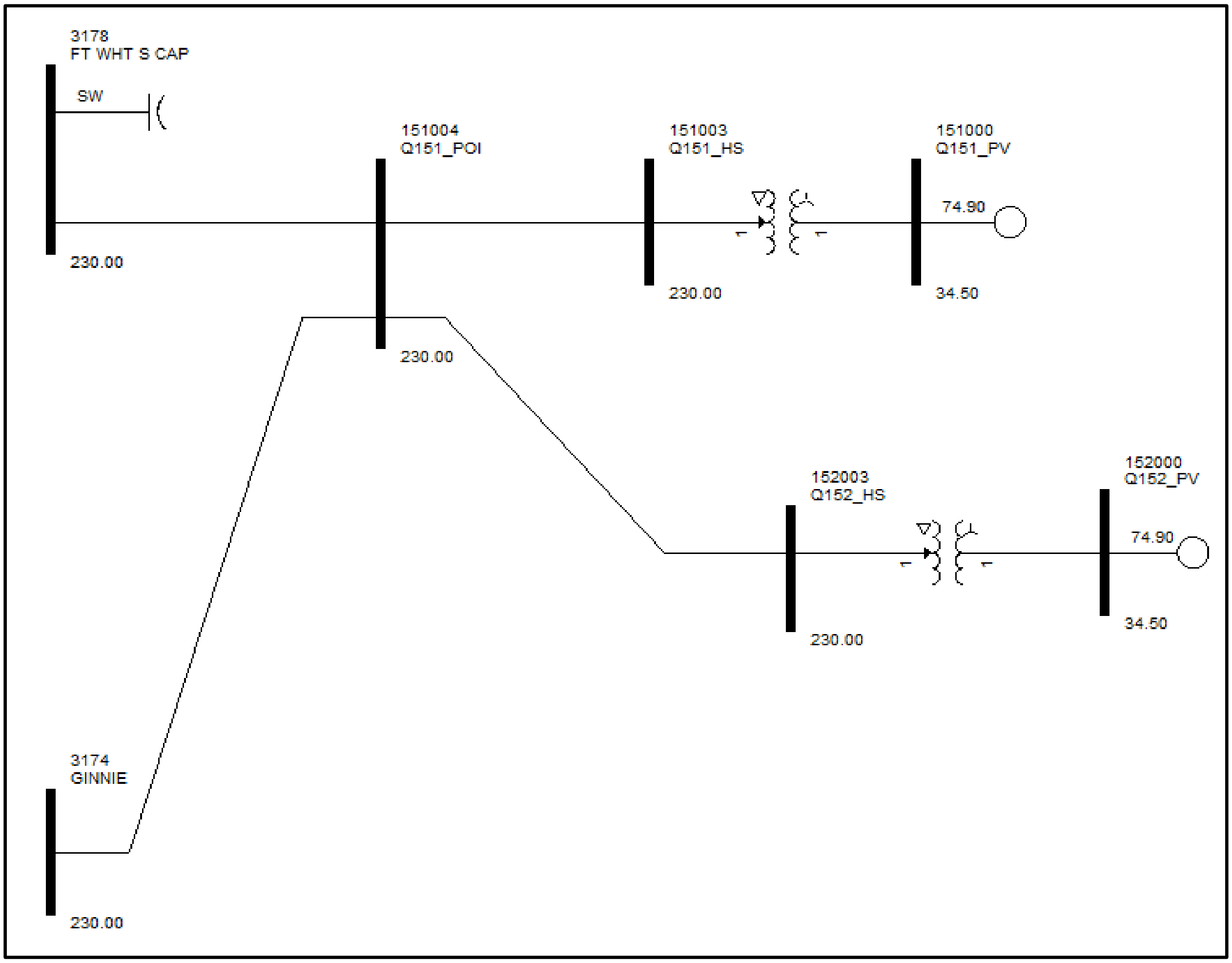

Figure 1: Diagram of Q152 Interconnection Option 1

- **Option 2** – Add 4th Breaker to Q151's Ring Bus Substation connecting to DEF's Ft. White – Newberry 230 kV line.

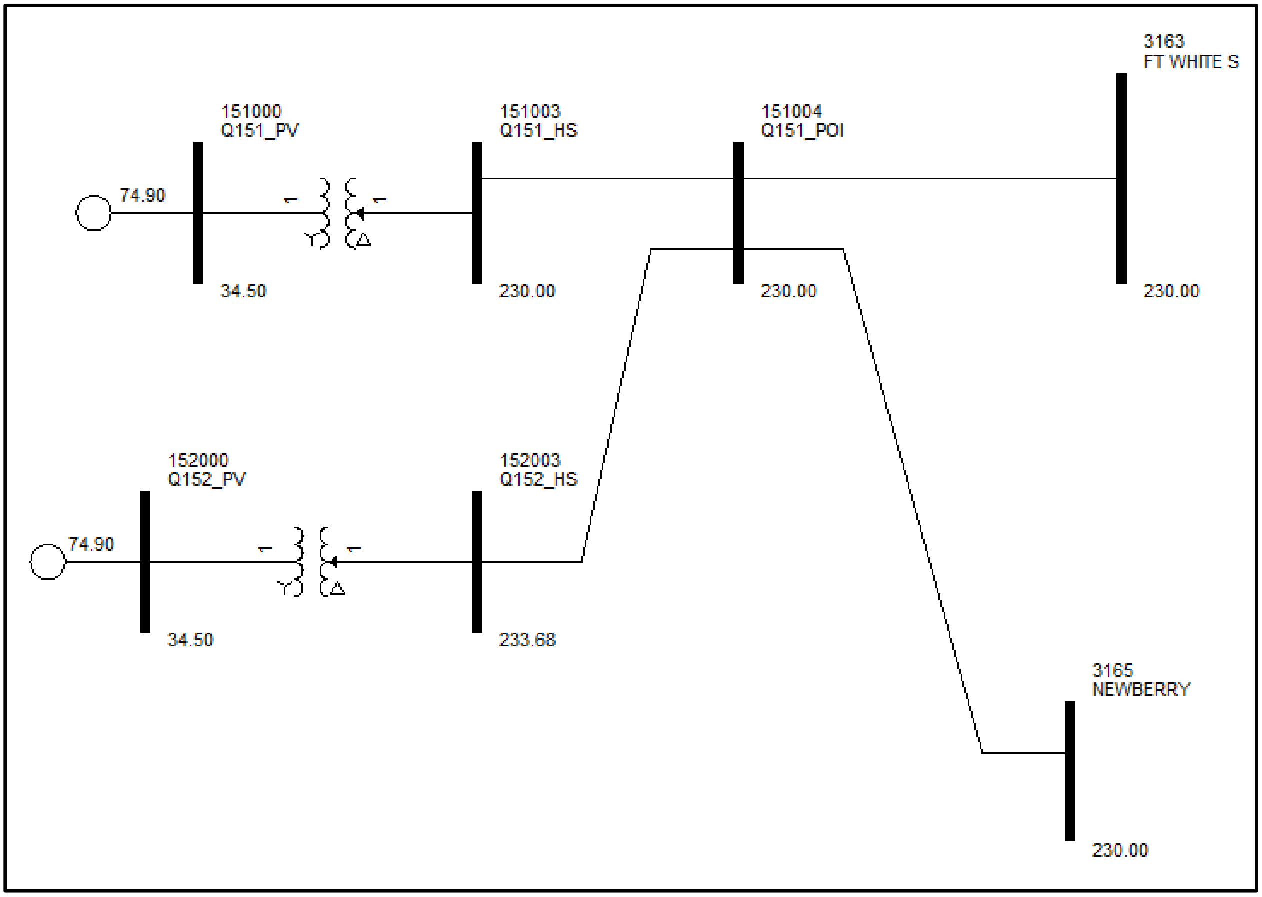

Figure 2: Diagram of Q152 Solar Interconnection Option 2

- **Option 3 (only if Option 1 or Option 2 are not sufficient)** –Add 6th Breaker to Q151's Ring Bus Substation connecting to DEF's Ft. White – Ginnie and Ft. White – Newberry 230 kV lines.

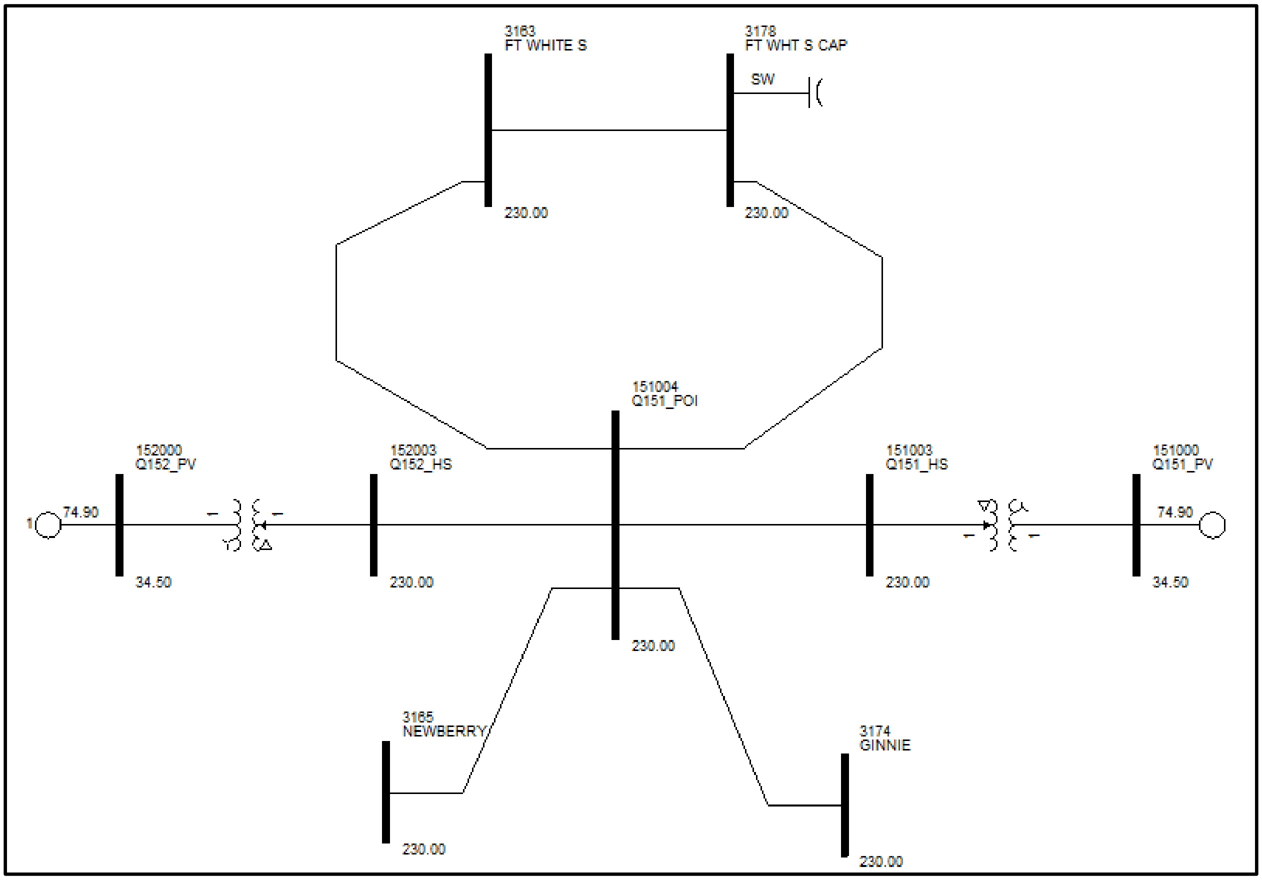

Figure 3: Diagram of Q152 Solar Interconnection Option 3

3. Model Development

3.1. Power Flow Models

Power flow models were built using the Siemens PSS/E power system simulation program and were based on the FRCC 2017 series cases, which were the most recent models available at the time of the study. The model years studied for power flow impacts were 2019/20 Winter and 2020 Summer. The study case models utilized the adjusted base models with the addition of the Q152 Solar Project generation and the required basic interconnection facilities for each option.

3.2. Interface Models

No interface analyses were performed as part of this evaluation.

3.3. Short Circuit Models

Short circuit analyses performed utilized the FRCC 2017 short circuit model (y17_20sRls-SC1b.sav). The model year studied for the short circuit analysis was 2020.

3.4.Generator Interconnection Queue Considerations

Prior queued generation in the FRCC coordinated queue was reviewed. One prior queued generator interconnection that is currently undergoing the study process, and directly impact DEF's System, was identified (Q152).

> Generator Interconnect Studies for prior queued generation interconnection requests in the form of Feasibility and System Impact Studies are currently conducted in accordance with FERC rules and are prioritized by their queue positions to determine the assignment of required interconnection facilities and transmission upgrades to accommodate their requested interconnections. In the instances where these studies are not complete, the facilities and upgrades required for these earlier queued requests were not included in the base cases used in this study. To the extent that one or more of these requests are modified or withdrawn, the results presented in this analysis may no longer be valid and/or may change materially. DEF will advise the customer of any changes associated with the preceding GIS requests that may require a re-study of this GIS request.

3.5. Transmission Service Request Priority List Considerations

A review of transmission service requests in the FRCC coordinated priority list was performed, and it was determined that there are no relevant transmission service requests in the study area that were not already built into the FRCC cases.

4. Analyses Performed

4.1. Power flow analyses

Power flow analyses of the cases were performed using the PowerGEM TARA software (TARA) to determine the impact of interconnecting the queued generation to the transmission system in the area. The base and interconnection study cases were compared to determine if the interconnection option created thermal overloads or voltage violations or exacerbated existing thermal overloads or voltage violations. All 69 kV and above branch flows and bus voltages in the FRCC region were monitored.

The following contingencies were observed in this study:

- Selected Category P1, P2, P4, P5, and P7 contingencies within the FRCC region as previously defined by FRCC transmission owners. Selection variations include:
  - All single element contingencies (69 kV and above) in the FRCC region

4.2. Short circuit analyses

Short circuit analyses were performed using PSS/E activity ASCC. All local generators were online for the analysis. Activity FLAT was used to set up the network conditions corresponding to classical fault analysis assumptions. Three phase and single line-to-ground faults were applied at all buses within FRCC and were analyzed using a 3% cutoff criterion. The final results represent all buses within FRCC with a difference between the base case and study case study greater than 3%.

5. Screening Criteria

The following criteria were used for screening **thermal results**.

- Unrelated GSU transformers were excluded from results.
- Transmission system elements operated at less than 69 kV nominal voltage were excluded.
- System-intact overloads must be greater than 100% of rate A.
- Post-contingency overloads must be greater than 100% of rate A.
- Post-contingency overloads that are improved by the interconnection were excluded.
- Post-contingency overloads must have been made worse than the base case by 3% of the affected element's rating or greater.

The following criteria were used for screening **voltage results**.

- Buses in DEF and SECI were monitored for values outside of the range 0.9-1.05 p.u.
- FPL 69, 115, 138, and 230 kV buses were monitored for values outside the range 0.95-1.07 p.u.
- FPL 500 kV buses were monitored for values outside the range 0.95-1.10 p.u.
- TECO 69 kV buses were monitored for values outside the range 0.925-1.05 p.u.
- TECO 138 and 230 kV buses were monitored for values outside the range 0.95-1.06 p.u.
- Turkey Point bus voltage was monitored for values outside the range of 1.01 p.u. and 1.06 p.u.
- St. Lucie bus voltage was monitored for values outside the range of 1.00 p.u. and 1.06 p.u.
- All other monitored areas were monitored for values outside of the range 0.95 and1.05 p.u.
- Generator buses and buses with nominal voltage below 69 kV were excluded from consideration.
- Absolute change in bus voltage between base case and the interconnection case must have been greater than 0.02 p.u.

The following screening criteria were used for screening the ASCC **short circuit results**.

- Three phase and single line-to-ground fault current on the DEF system had to exceed the interrupting rating of the breaker.
- Three phase and single line-to-ground fault current results are provided to third parties close to this area for their acceptance or rejection of the results based on their own breaker rating criteria.

6. Study Results Option 1

6.1. Thermal Results

The NRIS evaluation did not identify any network upgrades to DEF's transmission network to accommodate the full capacity (74.9 MW Summer/74.9 MW Winter) of the Q152 Solar Project. The results for the analysis are shown in Appendix A. Additional analyses will be performed in the future System Impact Study.

6.2.Voltage

There were no identified voltage violations that were attributable to the interconnection of the Q152 Solar Project interconnection.

6.3. Short Circuit

Short circuit analyses did not identify any potential impacts from the proposed interconnection exceeding known interrupting capability of breakers on DEF's System. The short circuit results are tabulated in Appendix B.

6.4. Third-party Impacts

The thermal analysis revealed no potential third-party impacted facilities in the relevant study area to third parties. Short circuit analysis revealed a number of third-party substations with short-circuit impacts greater than 3%.

Additional analysis for third-party impacts will be studied in future studies.

6.5. Costs

Required upgrades for basic physical interconnection:	Est. Costs
Add 4th Breaker to Q151's Ring Bus Substation	$1,050,000
Total Estimated Cost:	**$1,050,000**

These estimates are preliminary planning estimates, and details specific to this project discovered in the System Impact Study and Facilities (design engineering) Study phases may significantly affect these estimates and projected in-service dates.

From a planning perspective, a reasonable projected in-service date for a terminal at the previously identified substation would be 2 to 3 years after project commitment or mid-2020 to mid-2021, if commitment was mid-2018.

7. Study Results Option 2

7.1. Thermal Results

The NRIS evaluation did not identify any network upgrades to DEF's transmission network to accommodate the full capacity (74.9 MW Summer/74.9 MW Winter) of the Q152 Solar Project. The results for the analysis are shown in Appendix A. Additional analyses will be performed in the future System Impact Study.

7.2.Voltage

There were no identified voltage violations that were attributable to the interconnection of the Q152 Solar Project interconnection.

7.3. Short Circuit

Short circuit analyses did not identify any potential impacts from the proposed interconnection exceeding known interrupting capability of breakers on DEF's System. The short circuit results are tabulated in Appendix B.

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The thermal analysis revealed no potential third-party impacted facilities in the relevant study area to third parties. Short circuit analysis revealed a number of third-party substations with short-circuit impacts greater than 3%.

Additional analysis for third-party impacts will be studied in future studies.

7.5. Costs

Required upgrades for basic physical interconnection:	Est. Costs
Add 4th Breaker to Q151's Ring Bus Substation	$1,050,000
Total Estimated Cost:	**$1,050,000**

These estimates are preliminary planning estimates, and details specific to this project discovered in the System Impact Study and Facilities (design engineering) Study phases may significantly affect these estimates and projected in-service dates.

From a planning perspective, a reasonable projected in-service date for a terminal at the previously identified substation would be 2 to 3 years after project commitment or mid-2020 to mid-2021, if commitment was mid-2018.

8. Study Results Option 3

Evaluation of Option 3 was not required due to acceptable cost effective solution identified in Option 1.

Appendix A - Summary of Thermal Analysis Results

Option 1

Summer 2020 Results Meeting Impact Criteria – % Loading				
Monitored Facility	Contingency Name	Base	Study	Delta
N/A	N/A			

Results potentially impacting 3rd parties to be resolved under the FRCC process.

Summer 2020 Results Meeting Impact Criteria – % Loading				
Monitored Facility	Contingency Name	Base	Study	Delta
N/A	N/A			

Option 2

Summer 2020 Results Meeting Impact Criteria – % Loading				
Monitored Facility	Contingency Name	Base	Study	Delta
N/A	N/A			

Results potentially impacting 3rd parties to be resolved under the FRCC process.

Summer 2020 Results Meeting Impact Criteria – % Loading				
Monitored Facility	Contingency Name	Base	Study	Delta
N/A	N/A			

Appendix B - Short Circuit Analysis Results

Option 1

PSS®E ASCC SHORT CIRCUIT CURRENTS (V @ 1 .0 pu)				Base Case		Study Case			
Bus #	Bus Name	kV		3ϕ (I1) Amps	SLG (3I0) Amps	3ϕ (I1) Amps	SLG (3I0) Amps	%Δ 3ϕ	%Δ SLG
6736	HAILEMIL	230	SECI	7021.8	4015.7	7116.0	4613.7	1.34%	14.89%
4102	PARKER	230	GVL	9166.7	4556.0	9245.9	4841.1	0.86%	6.26%
6639	NEALS	69	SECI	5718.4	3736.3	5745.0	3919.8	0.47%	4.91%
7476	FMP-NEWB	69	SECI	7192.7	5926.8	7214.7	6126.9	0.31%	3.38%
6684	FT WHITE	69	SECI	5187.8	2976.9	5201.8	3067.4	0.27%	3.04%
Base Case: "y17_20sRls-SC1b.sav" with all FRCC generation in-service plus Q151 Option 1.									
Study Case: Base case plus152 Option1. 4 Position Ring Bus 6.1 Miles from Ft. White to Ginnie 230kV line.									

Option 2

PSS®E ASCC SHORT CIRCUIT CURRENTS (V @ 1 .0 pu)				Base Case		Study Case			
Bus #	Bus Name	kV		3ϕ (I1) Amps	SLG (3I0) Amps	3ϕ (I1) Amps	SLG (3I0) Amps	%Δ 3ϕ	%Δ SLG
6736	HAILEMIL	230	CEC	6990.2	4009.9	7046.6	4353.6	0.81%	8.57%
7476	FMP-NEWB	69	SECI	7208.7	5933.0	7250.7	6291.2	0.58%	6.04%
6640	OLDTOWN	69	SECI	6783.8	4194.1	6819.9	4366.3	0.53%	4.11%
4102	PARKER	230	SECI	9140.1	4552.4	9188.1	4721.7	0.53%	3.72%
6647	NEWBERRY	69	SECI	6960.7	3282.6	6999.8	3389.2	0.56%	3.25%
6642	TRENTON	69	CFEC	6117.5	3274.0	6147.3	3378.8	0.49%	3.20%
6632	BRONSON	69	SECI	7068.6	5246.8	7096.5	5414.0	0.39%	3.19%
6639	NEALS	69	SECI	5710.0	3734.4	5726.8	3845.8	0.29%	2.98%
Base Case: "y17_20sRls-SC1b.sav" with all FRCC generation in-service plus Q151 Option 2.									
Study Case: Base case plus 152 Option2. 4 Position Ring Bus 5.9 Miles from Ft. White to Newberry 230kV line.									