Frequently Constrained Areas – 2016 Study

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SPP Market Monitoring Unit

SPP Southwest Power Pool

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1. Executive Summary

1.1. Introduction

Frequently Constrained Areas are areas of the Integrated Marketplace footprint that experience high levels of congestion and are associated with a dominant or pivotal supplier. Attachment AF, Section 3.1.1 of the SPP Open Access Transmission Tariff defines Frequently Constrained Areas as electrical areas with one or more binding transmission constraints or Reserve Zone constraints that are expected to be binding for at least five-hundred (500) hours during a given twelve (12)-month period and within which one or more suppliers are pivotal. Prior to the start of the Integrated Marketplace, Potomac Economics Ltd., under contract with the SPP Market Monitor, recommended the designation of three Frequently Constrained Areas: (1) the Kansas City area, (2) the Northwest Kansas area, and (3) the Texas Panhandle area. A later study performed by the SPP Market Monitor found that transmission upgrades and expansion in 2013 and 2014 had significantly impacted congestion patterns and resolved some of the concerns with pivotal suppliers. In January 2015, the SPP Market Monitor reported that the Kansas City and Northwest Kansas areas no longer met the criteria to be designated as Frequently Constrained Areas. A recommendation to maintain the Texas Panhandle as a Frequently Constrained Area and to remove the designations for the Kansas City and Northwest Kansas areas was approved by the SPP Board of Directors in January 2015. The continued addition of wind resources in the western region of SPP prompted the addition of the Woodward, OK Frequently Constrained Area in January 2016 and, as seen in the Analysis and Results section, was the most binding constraint for this study. The historical FCAs along with results from this study are in Figure 1-1 below.

Figure 1-1 Historical FCAs

FCA	2013 Report	2014 Report	2015 Report	2016 Report
Kansas City	Yes	---	---	---
NW Kansas	Yes	---	---	---
Texas Panhandle	Yes	Yes	Yes	Yes
Woodward	---	---	Yes	Yes

The SPP Market Monitor, as required by Attachment AF, Section 3.1.1.3, has again reexamined the Frequently Constrained Area designations to determine if the current designations still meet the criteria and if the designation of any new areas is warranted. The contents of this report include an executive summary of the major findings and recommendations in Section 1, a description of the study process in Section 2, and a detailed description of the analysis in Section 3. Appendix A consists of the recommended changes to Addendum 1 of Attachment AF. Appendix B is a list of constraints with corresponding binding and pivotal supplier hours.

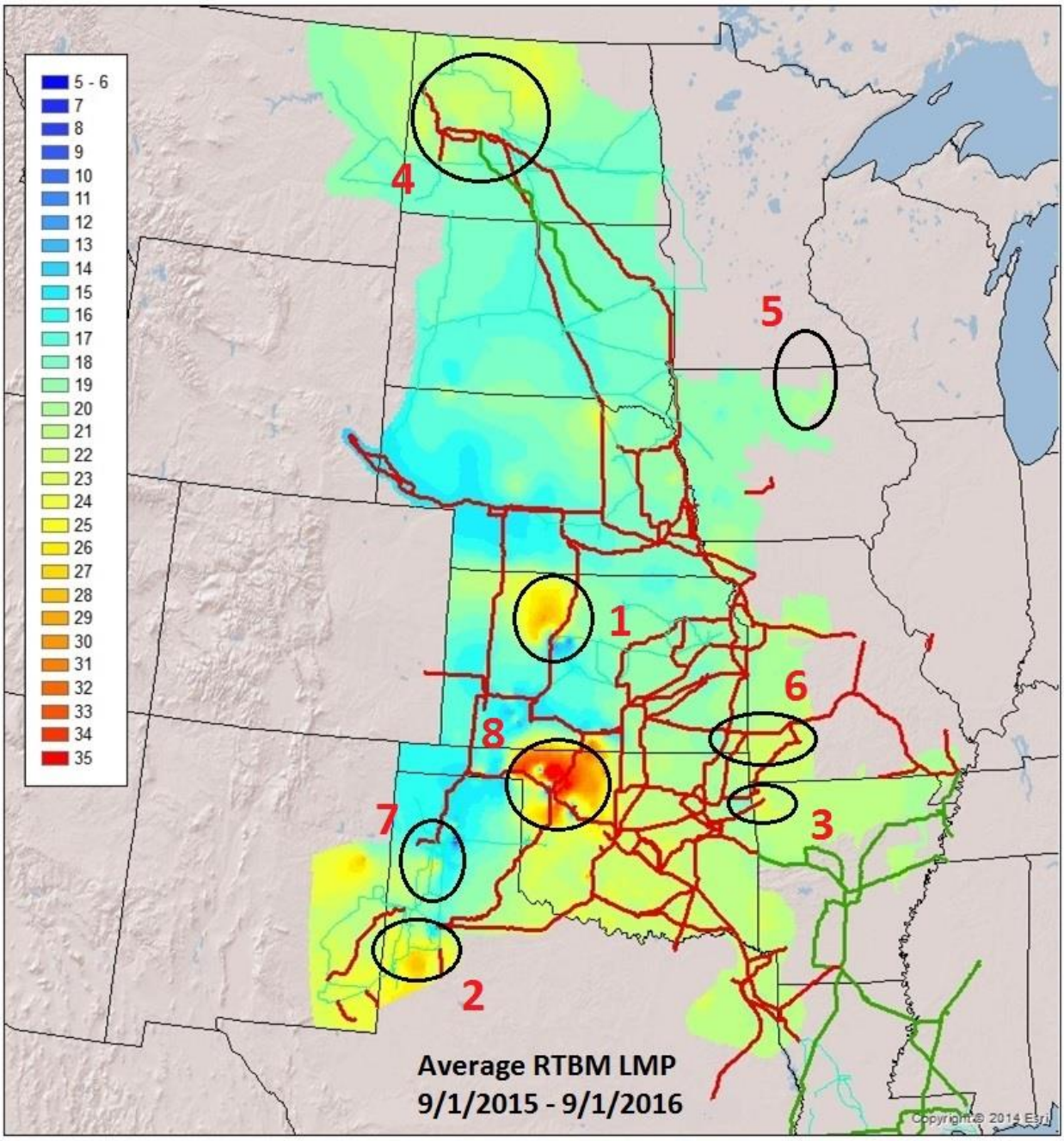
1.2. Results

Eight areas are identified as candidates for the Frequently Constrained Area (FCA) designation. Three of the eight areas, Texas Panhandle, Lubbock, and Woodward, are the same three areas studied in the previous FCA study.

Figure 1-2 Frequently Constrained Area Candidate Designations

Map Reference #	Geographical Area	FCA Candidate Name
1	Hays, KS	Hays, KS
2	Lubbock, TX	Lubbock
3	Northwest Arkansas	NW Arkansas
4	Northern North Dakota	Northern ND
5	Prairie Island, Minnesota (MISO Market-to-Market)	M2M – Prairie Island
6	Southeast Kansas – Southwest Missouri	SE KS – SW MO
7	Texas Panhandle	Texas Panhandle
8	Woodward, OK	Woodward

Figure 1-3 FCA Candidate Areas



The impact analysis (Section 2.2), where the number of hours for which the price impact in the FCA candidate exceeds the $25/MWh threshold are counted, indicates that the Texas Panhandle and Woodward areas continue to warrant designation as FCAs. The Hays, KS area also exceeded the $25/MWh threshold but upgrades to the monitored element during this study changed the congestion pattern compelling the SPP Market Monitor to forego adding this area at

this time. The other five FCA candidates are well below the 500 hour threshold and do not warrant designation.

The Woodward area has been a very highly congested area since November 2014, just 10 months after the start of the Integrated Marketplace. The limiting element for the WDWFPLTATNOW constraint (Woodward to FPL Switch 138kV for the loss of Tatonga – Northwest 345kV), is located near the intersection of several 345 kV transmission lines that were energized in 2014. This, and continued addition of wind generation, has propelled this to the most congested area in SPP.

Figure 1-4 Impact Analysis Results

FCA Candidate	Binding Constraint Hours	Pivotal Supplier Hours $25 Impact Threshold
Woodward	3,520	1405
Texas Panhandle	4,645	597
Hays, KS	1,225	547
Lubbock	1,577	148
NW Arkansas	292	147
SE KS – SW MO	324	116
North N. Dakota	1,423	96
M2M–Prairie Island	547	6

This marks the fourth year in a row that the Texas Panhandle area has had significant pivotal supplier hours. This year's total of 597 hours is slightly higher than the 536 hours in the 2015 study which was the lowest observed of all FCA studies for this area. The 2015 and 2016 studies captured the impacts of the 2012 through 2014 transmission expansion. The 2015 study observed low natural gas prices and this continued trend is also a cause for the lower number of pivotal supplier hours in the Texas Panhandle than in previous studies.

1.3. Recommendation

The results of the analysis indicate that the Woodward, OK and Texas Panhandle areas should remain designated as Frequently Constrained Areas. The binding hours and pivotal supplier results show that congestion and market power issues are still present. The expectation

of the Market Monitor is that both areas will be vulnerable to the exercise of market power during the next twelve month period. The Hays, KS area will not be added at this time due to upgrades to the monitored element of the primary constraint, however, the Market Monitor has the ability to reanalyze the impacts of this or any changes to congestion patterns at any time. Table 1 in Appendix A is a list of the defining constraints for each FCA and Table 2 in Appendix A contains a list of FCA resources. The lists in Tables 1 and 2 are used to update Addendum 1 to Attachment AF in the SPP Open Access Transmission Tariff.

2. Methodology

2.1. Data and Study Period

The study period runs from September 1, 2015 through August 31, 2016. Real-time Balancing Market (RTBM) congestion and dispatch data, and resource parameter offers for online resources are used in the analysis. The Integrated System became part of the SPP Integrated Marketplace on October 1, 2015 meaning this year's study included 11 months of data for this area. Much of the congestion in this area was realized during the first 5 months (October 2015 – February 2016) and has not appeared as consistently since that time.

2.2. Study Process

The study consists of the following six step process.

1. **Binding Hours Computation**: The number of binding hours is computed for each modeled transmission constraint. A constraint is counted as binding in a five minute interval if the loading on the constraint is within the greater of five megawatts (5 MW) or 2% of the effective constraint limit.
2. **Pivotal Supplier Analysis**: The number of pivotal supplier hours is computed for each modeled transmission constraint. A constraint is counted as having a pivotal supplier during a five minute interval if the supplier can cause a constraint to exceed the effective constraint limit by decreasing generation on resources that provide congestion relief and by increasing generation on resources that contribute to congestion. The re-dispatch of the potential pivotal supplier's resources is governed by the submitted ramp rates, and the economic minimum and maximum capabilities. A thirty minute re-dispatch period is considered. The ability of the market to react to the actions of the potential pivotal supplier is accounted for by allowing a similar re-dispatch of all resources not owned or controlled by the potential pivotal supplier.
3. **Selection of FCA candidates:** Candidates for designation as an FCA are chosen based on the binding hours and pivotal supplier analyses. Constraints that are in the same electrical proximity and have the same pivotal suppliers are grouped together; if the aggregate number of binding and pivotal supplier hours is significant, then the area is

selected as a FCA candidate. A primary constraint for the FCA candidate is generally selected as the constraint with the highest number of binding hours.

4. **Identify the FCA candidate resources:** A resource is a FCA candidate resource if its resource-to-load-distribution-factor (RLDF) relative to the FCA candidate primary constraint is less than or equal to the FCA candidate RLDF cut-off. To determine the RLDF cut-off the relief capability of the largest pivotal supplier relative to the primary constraint is computed. The RLDF cut-off is then set at the value corresponding to the ninetieth percentile of the relief capability. In other words, ninety percent (90%) of the largest pivotal supplier's relief capability has an RLDF less than or equal to the FCA candidate RLDF cut-off. In cases where the RLDF value corresponding to the ninetieth percentile is less than -3%, the RLDF cut-off is set to -3% to prevent the application of mitigation to resources with a very small impact on the primary constraint.
5. **Identify the FCA candidate secondary constraints:** A constraint is eligible to be defined as a secondary constraint for the FCA candidate if the FCA candidate resource group contributes at least seventy percent (70%) of the total relief capability on the constraint. Additional considerations for defining a constraint as a secondary constraint consist of (i) electrical proximity to the candidate resource group identified in step 4, (ii) an expectation that the constraint is not a short-term or temporary constraint, and (iii) an expectation that the constraint will experience congestion in the upcoming year.
6. **Impact Analysis:** An impact analysis is employed to determine the number of hours for which the FCA candidate resource group has significant impacts on prices in the FCA candidate. For each five minute interval in the study period, the resource price impacts on each defining constraint are calculated by multiplying the shadow price and the candidate resource's corresponding RLDF. The resource price impacts are then summed over the FCA candidate defining constraints to obtain a five minute price impact for each candidate resource. This calculation is similar to finding the contribution from the FCA candidate defining constraints to the candidate resource's marginal congestion component of the LMP.

   Any interval for which a candidate resource's price impact exceeds the impact test threshold is counted as an interval that is susceptible to the exercise of market power by a pivotal supplier. The market impact test threshold used in the Integrated Marketplace

mitigation system has been $25/MWh since March 1, 2015. The impact analysis in this study was computed using threshold levels ranging from $5/MWh to $25/MWh in order to test the sensitivity of the results to the various impact threshold levels.

As stated in Section 3.2 of SPP Tariff, Attachment AF, an area must expect to have 500 hours with pivotal supplier impacts to be designated as a Frequently Constrained Area. The importance of employing a threshold value such as $25/MWh is to account for the times when there is low cost relief capability in the FCA. This low cost relief prohibits the pivotal supplier from accruing significant benefits by pursuing a withholding strategy in the FCA.

3. Analysis and Results

3.1. FCA Candidates

The initial phase of the study identified eight candidates for the Frequently Constrained Area designation; the identified areas are;

(1) Hays, KS
(2) Lubbock
(3) NW Arkansas
(4) Northern ND
(5) M2M – Prairie Island
(6) SE KS – SW MO
(7) Texas Panhandle
(8) Woodward

These eight areas experienced significant congestion during the study period, and each area has one or more pivotal suppliers. The identification of candidate areas and associated primary constraints is based on the number of hours the constraints are binding and the number of hours for which the constraints have a pivotal supplier.

Figure 3-1 Top Binding Constraints

Constraint Name	Monitored Element	Binding Constraint Hours	Pivotal Supplier Hours	Geographical Area
WDWFPLTATNOW	Woodward to FPL Switch, 138 kV	2919	1434	Woodward, OK
TEMP56_21085	Tuco to Lubbock, 115kV	2748	2743	Texas
STAINDTUCCAR	Stanton to Indiana, 115kV	1460	1449	Texas
OSGCANBUSDEA	Osage Switch to Canyon East, 115 kV	1352	1351	Texas
TEMP50_20937	Wolfforth to Terry Co., 115 kV	1226	1223	Texas
SHAHAYPOSKNO	South Hays to Chetolah, 115 kV	1225	252	Hays, KS
WATXFRWATXFR	Watford 230/115 kV transformer	1067	873	Northern ND
TMP144_21263	Charlie Creek to Rough Rider, 115kV	750	630	Northern ND
WODFPLWODXFR	Woodward to FPL Switch, 138 kV	721	369	Woodward, OK
PR_ISLNROCH	Prairie Island to North Rochester, 345 kV	547	128	M2M – Minnesota
TMP133_21794	Harrington to Rolling Hills, 230kV	370	234	Texas
TEMP49_21150	Rugby (WAUE to OTP), 115kV	355	254	Northern ND
SILSPRTONFLI	West Siloam to Siloam City, 161kV	328	283	NW Arkansas
NEORIVNEOBLC	Neosho to Riverton, 161kV	324	287	SE Kansas – SW Missouri

Number one on the top binding constraints list is the Woodward – FPL Switch 138kV for the loss of Tatonga – Northwest 345kV (WDWFPLTATNOW) constraint. Another constraint in the Woodward, OK area is the Woodward – FPL Switch 138kV for the loss of Woodward 345/138kV transformer (WODFPLWODXFR) and is the ninth most binding on this list. The Osage Switch – Canyon East 115kV for the loss of Bushland – Deaf Smith 230kV (OSGCANBUSDEA) constraint is located in the Texas Panhandle and had been the most frequent binding constraint in previous studies. It was identified in the two prior FCA studies as the primary constraint for the Texas Panhandle FCA but is now fourth on this list and is a secondary constraint for the Texas Panhandle FCA. The Tuco – Lubbock 115kV for the loss of Jones – Tuco 230kV (TEMP56_21085) now appears as the most constrained element in the Texas Panhandle. Another constraint in the Texas Panhandle area is Stanton – Indiana 115kV for the loss of Tuco – Carlisle 230kV (STAINDTUCCAR). This and the TEMP56_21085 constraints appeared more often than OSGCANBUSDEA and are further south due to the Woodward – Border – Tuco 345kV transmission line addition providing a bypass for some of the flow around the typical Texas Panhandle area.

Congestion in the Kansas City and Western Kansas areas did not appear as in previous FCA studies. This study does not explore benefits or impacts due to factors such as transmission expansion or Market-to-Market (M2M), however congestion in the Kansas City area has decreased over the years and could be a result of these. The congestion in Western Kansas typically created north-south price splits along the Nebraska - Kansas border but the closest congestion to this area is now around Hays, KS and is more confined to this limited area.

The Texas Panhandle continues to be one of the most congested areas in the SPP footprint with the limited North-South transmission capability and abundant wind capacity in the western part of the footprint. The OSGCANBUSDEA constraint continues to experience congestion but some has shifted south around Tuco and Lubbock, TX due to transmission additions. The Lubbock area first appeared as a FCA candidate in the previous study and once again had enough congestion with pivotal supplier hours to warrant evaluating again for possible local market power concerns. Even though four of the top five constraints on this list are between the Texas Panhandle and Lubbock, TX areas, the Woodward, OK is now the most frequently congested area. This area was added in the previous year's study and is at an intersection of

several 345kV lines that provide a path for wind exports in the west to population centers to the east.

The Integrated System joined the SPP Integrated Marketplace on October 1, 2015 and experienced significant congestion in the northern half of North Dakota during the first five months but has not been as prevalent since. The three other new candidate areas are identified as Prairie Island, Minnesota; Northwest Arkansas; and Southeast Kansas – Southwest Missouri. These 3 areas were the least congested of all FCA candidates and were not expected to pass the impact analysis because of the magnitude of binding and pivotal supplier hours compared to other FCA candidates but were included to discover more details about the congestion in these areas.

Figure 3-2 shows the primary constraint and the resource-to-load distribution factor (RLDF) cut-off for each FCA candidate. The primary constraint for each candidate area is typically the constraint with the most binding hours and the RLDF cut-off is used to identify the candidate resources associated with the FCA candidate. A threshold cap of -3.0% is applied to prevent mitigation to a large number of low impact resources. This cap is consistent with prior studies and represents the lowest magnitude RLDF cut-off that has been applied since the inclusion of the FCA methodology in the SPP Tariff. The Raw RLDF value in Figure 3-2 represents the calculated cut-off using the established methodology for the areas where the -3.0% cap is applied. The WDWFPLTATNOW constraint remains the primary constraint for the Woodward FCA candidate. The Texas Panhandle had previously used OSGCANBUSDEA as the primary constraint but TEMP56_21085 experienced more binding hours during the study period. OSGCANBUSDEA still appears as a secondary constraint in this area. Sundown – Amoco 230kV for the loss of Tolk – Yoakum 230kV (SUNAMOTOLYOA) appeared in the previous year as the primary constraint for the Lubbock FCA candidate but TEMP50_20937 experienced more congestion in this area.

Figure 3-2 Primary Constraints and RLDF Cut-Offs

FCA Candidate	Primary Constraint	RLDF Cut-Off	Raw RLDF
Hays, KS	SHAHAYPOSKNO	-3.0%	-1.5%
Lubbock	TEMP50_20937	-4.2%	---
M2M–Prairie Island	PR_ISLNROCH	-3.0%	-1.7%
North N. Dakota	TMP144_21263	-13.6%	---
NW Arkansas	SILSPRTONFLI	-3.0%	-1.5%
SE KS – SW MO	NEORIVNEOBLC	-11.4%	---
Texas Panhandle	TEMP56_21085	-4.0%	---
Woodward	WDWFPLTATNOW	-3.0%	-1.8%

The RLDF cut-offs in Figure 3-2 are used to identify the candidate resources associated with the FCA candidates. Any resource with an RLDF that is less than the RLDF cut-off is a FCA candidate resource. For example, the candidate resource group for the Woodward FCA consists of all resources that have an RLDF corresponding to the WDWFPLTATNOW constraint that is less than or equal to -3.0%. Figure 3-3 shows the number of resources included in each FCA candidate and the corresponding capacity.

Figure 3-3 Candidate Resource Summary

FCA Candidate	Number of Resources	Total Capacity (MW)
Woodward	26	1,965
Texas Panhandle	42	5,259
Hays, KS	21	613
Lubbock	30	4,054
NW Arkansas	31	2,235
SE KS – SW MO	12	1,040
North N. Dakota	8	373
M2M–Prairie Island	12	176

The next step in the process is to identify the secondary constraints for each FCA candidate. The secondary constraints for each FCA candidate are shown in Figure 3-4. The identification of

secondary constraints is necessary because congestion in tightly constrained areas generally impacts a group of constraints. Operators may choose to activate a constraint in close proximity to the designated primary constraint instead of activating the primary constraint. Without the designation of the secondary constraints the market power mitigation logic will fail to recognize that the FCA is binding and may not adequately protect against market power abuse. For a constraint to be defined as a secondary constraint it must be determined that the FCA candidate resource group makes up more than seventy percent (70%) of the total relief capability on the constraint. For example, if the total relief capability on constraint XYZ is 1,000 megawatts and the resource candidate group corresponding to the Texas Panhandle area contributes 725 relief megawatts, then the 70% threshold is exceeded and constraint XYZ may be included as a secondary constraint for the Texas Panhandle Area.

Additional considerations for including a constraint as a secondary constraint include (i) electrical proximity to the candidate resource group, (ii) the expectation that the constraint is not a short-term or temporary constraint, and (iii) the potential for the constraint to experience significant congestion in the future. Four of the eight FCA candidates produced secondary constraints. The Woodward area yielded one secondary constraint as did the Northern North Dakota area. The Texas Panhandle yielded three secondary constraints as well as the Lubbock area.

Figure 3-4 FCA Candidate Defining Constraints

FCA CANDIDATE	Type	Constraint	Monitored Element
Lubbock	Primary	TEMP50_20937	Wolfforth to Terry Co., 115 kV
Lubbock	Secondary	CARLPDLUBWOL	Carlisle to Doud, 115 kV
Lubbock	Secondary	SUNAMOTOLYOA	Sundown to Amoco, 230 kV
Lubbock	Secondary	TEMP72_20647	Wolfforth to Terry Co., 115 kV
North N. Dakota	Primary	TMP144_21263	Charlie Creek to Rough Rider, 115 kV
North N. Dakota	Secondary	WATXFRWATXFR	Watford 230/115 kV transformer
Texas Panhandle	Primary	TEMP56_21085	Tuco to Lubbock, 115kV
Texas Panhandle	Secondary	OSGCANBUSDEA	Osage Switch to Canyon East, 115 kV
Texas Panhandle	Secondary	STAINDTUCCAR	Stanton to Indiana, 115 kV
Texas Panhandle	Secondary	TEMP86_21405	Kress to Hale Co., 115 kV
Woodward	Primary	WDWFPLTATNOW	Woodward to FPL Switch, 138 kV
Woodward	Secondary	WODFPLWODXFR	Woodward to FPL Switch, 138 kV

The Woodward area did not yield any secondary constraints in last year's FCA study but the Woodward – FPL Switch 138kV for the loss of Woodward 138/69 kV transformer (WODFPLWODXFR) was identified by the 70% test and was a top ten congested constraint for this year's analysis. This and the primary constraint for the Woodward area have the same monitored element but a different contingent element. The SUNAMOTOLYOA constraint was the primary constraint for the Lubbock FCA candidate but is a secondary constraint for the current study.

3.2. Impact Analysis

The final step is to determine the number of hours each FCA candidate was both binding and susceptible to the exercise of market power. This is done by applying a price impact test; the price impact is calculated by multiplying the constraint shadow price and the candidate resource's RLDF relative to the defining constraints for each FCA. The price impacts were

computed for each five minute interval in the study period. If the price impact on a single candidate resource exceeds the price impact threshold, then the FCA candidate is susceptible to the exercise of market power. The results of this final test are displayed in Figure 3-5. The results indicate that three of the FCA candidates--Woodward, Texas Panhandle, and Hays, KS--meet the 500 hour criteria for designation as a FCA. The remaining five candidates fall well short of the 500 hour threshold.

Figure 3-5 Impact Analysis Results

FCA Candidate	Binding Hours	Pivotal Supplier Hours $25 Impact Threshold
Woodward	3,520	1,405
Texas Panhandle	4,645	597
Hays, KS	1,225	547
Lubbock	1,577	148
NW Arkansas	292	147
SE KS – SW MO	324	116
North N. Dakota	1423	96
M2M–Prairie Island	547	6

The Woodward FCA candidate area exceeds the 500 hour threshold by a substantial margin, meeting the criteria for designation as an FCA. The limiting element for this FCA is the Woodward to FPL Switch (138 kV) transmission line. The line is located near the intersection of several 345 kV lines that were part of the transmission expansion completed in 2014. The primary constraint for this area, WDWFPLTATNOW[1], was created in November 2014 and has consistently appeared in monthly and quarterly reports as the most congested area since that time. The Texas Panhandle appeared in the first FCA study in 2013 and congestion in this area predates the EIS market. This area continues to exceed the 500 hour threshold, also meeting the designation as an FCA. This is the first year for the Hays, KS area to appear as an FCA candidate and also exceeds the 500 hour threshold. However, during the time of the study, the monitored element for the primary constraint was upgraded resulting in congestion appearing on other

[1] Woodward to FPL Switch (138 kV) for the loss of Tatonga to Northwest (345 kV); originally created as the temporary constraint TEMP95_20633 on 11/11/2014 and promoted to permanent status on 1/6/2015.

facilities. Until persistent congestion is realized as a result of this upgrade, the Market Monitor will not add this area as an FCA but has the ability to re-analyze at any time.

Figure 3-6 shows the binding constraint and pivotal hours for common FCA candidates between the 2015 and 2016 studies. Previous studies included data from transmission expansion from 2012 to 2014 which depicted a reduction in congestion in the Texas Panhandle area. The comparison with the 2015 study shows that the pivotal hours in the Texas Panhandle area are consistent over the past two studies and that local market power potential remains a concern. The Woodward area first appeared in the 2015 study and now is the most congested area in the SPP footprint as expected. Even with the -3.0% cut-off threshold applied for candidate resources in the Woodward area, the impact analysis exceeds the $25 threshold more than any area. The Lubbock area first appeared in the 2015 study and the impact analysis shows consistent results which are well below the 500 hour level.

Figure 3-6 Impact Analysis Comparison with 2015 FCA Study

FCA Candidate	2015 FCA Study		2016 FCA Study	
	Binding Hours	Pivotal Supplier Hours $25 Impact Threshold	Binding Hours	Pivotal Supplier Hours $25 Impact Threshold
Woodward	1,704	743	3,520	1,405
Texas Panhandle	4,182	536	4,645	597
Lubbock	1,036	133	1,577	148

The results of the sensitivity analysis using varying impact thresholds are presented in Figure 3-7. There is no change in the results at the $15/MWh threshold level; the five FCA candidates with less than 500 pivotal supplier hours at the $25 level are also well below the 500 hour level at the $15 threshold level. At the $5/MWh threshold there is a different result with the Lubbock candidate area now exceeding the 500 hour level.

Figure 3-7 Impact Threshold Sensitivity Analysis

FCA Candidate	Pivotal Supplier Hours $5 Impact Threshold	Pivotal Supplier Hours $15 Impact Threshold	Pivotal Supplier Hours $25 Impact Threshold
Woodward	2821	2201	1405
Texas Panhandle	2384	1065	597
Hays, KS	723	602	547
Lubbock	609	242	148
NW Arkansas	220	188	147
SE KS – SW MO	169	134	116
North N. Dakota	419	153	96
M2M–Prairie Island	68	12	6

Appendix A. FCA Constraints and Resources

Table 1 – Defining Constraints for the Frequently Constrained Areas	
Constraint Name	**Frequently Constrained Area**
OSGCANBUSDEA	TEXAS PANHANDLE
STAINDTUCCAR	TEXAS PANHANDLE
TEMP56_21085 (Tuco to Lubbock)	TEXAS PANHANDLE
TEMP86_21405 (Kress to Hale Co.)	TEXAS PANHANDLE
WDWFPLTATNOW	WOODWARD
WODFPLWODXFR	WOODWARD

Table 2 – Resources in Frequently Constrained Areas	
PNODE Name	**Frequently Constrained Area**
SPSCAPROCKUNWINDFARM	TEXAS PANHANDLE
SPSCARLSBADUN5	TEXAS PANHANDLE
SPSCHAVESUNCHAVES_SOLAR	TEXAS PANHANDLE
SPSCHAVESUNROSWELL_SOLAR	TEXAS PANHANDLE
SPSCIRRUSUNCIRRUS_WIND	TEXAS PANHANDLE
SPSCROSBY2UNPLSNTHILLWND	TEXAS PANHANDLE
SPSCROSSRDSUNMILO_WIND	TEXAS PANHANDLE
SPSCROSSRDSUNROSVELTWND	TEXAS PANHANDLE
SPSCUNNSUBUN1	TEXAS PANHANDLE
SPSCUNNSUBUN2	TEXAS PANHANDLE
SPSCUNNSUBUN3	TEXAS PANHANDLE
SPSCUNNSUBUN4	TEXAS PANHANDLE
SPSDOLLARHIUNSUNE_SPS1	TEXAS PANHANDLE
SPSHENDRIC2UNRALLS_WIND	TEXAS PANHANDLE
SPSHOBBSPLT1	TEXAS PANHANDLE
SPSHOBBSPLT2	TEXAS PANHANDLE
SPSHOPI_SUBUNSUNE_SPS5	TEXAS PANHANDLE
SPSJONESSUBUN1	TEXAS PANHANDLE
SPSJONESSUBUN2	TEXAS PANHANDLE
SPSJONESSUBUN3	TEXAS PANHANDLE
SPSJONESSUBUN4	TEXAS PANHANDLE
SPSLEA_ROADUNSUNE_SPS3	TEXAS PANHANDLE
SPSLOVINGTOPLT1	TEXAS PANHANDLE
SPSLOVINGTOUNWILDCATWIND	TEXAS PANHANDLE
SPSLP-BRND2UNBRANDON1	TEXAS PANHANDLE
SPSLP-COOP2UNLUBBOCK_WIND	TEXAS PANHANDLE
SPSLP-HOLL2UNCOOKE_GT2	TEXAS PANHANDLE

SPSLP-HOLL2UNCOOKE_GT3	TEXAS PANHANDLE
SPSLP-MACK2UNMASSENG1	TEXAS PANHANDLE
SPSMADDOXSUUN1	TEXAS PANHANDLE
SPSMADDOXSUUN2	TEXAS PANHANDLE
SPSMONUMENTUNSUNE_SPS4	TEXAS PANHANDLE
SPSMSTNGPLT1	TEXAS PANHANDLE
SPSMSTNGUN4	TEXAS PANHANDLE
SPSMSTNGUN5	TEXAS PANHANDLE
SPSMSTNGUN6_GSEC	TEXAS PANHANDLE
SPSPLXSUBUN4	TEXAS PANHANDLE
SPSQUAYCNTYUNQUAYCOUNTY1	TEXAS PANHANDLE
SPSS_JALUNSUNE_SPS2	TEXAS PANHANDLE
SPSSAN_JUANUNWINDFARM	TEXAS PANHANDLE
SPSTOLKSUBUN1	TEXAS PANHANDLE
SPSTOLKSUBUN2	TEXAS PANHANDLE
CSWSDEMPSRDGUNDEMPSEY_WIND	WOODWARD
CSWSELK_TAPUNELKCTY_WIND	WOODWARD
CSWSHOBART_JUNROCKYRDG_WIND	WOODWARD
CSWSROARKUNELKCTY2_WIND	WOODWARD
CSWSWFRDGUNUN1_WFRDG	WOODWARD
OKGEBRECKNR4UNBRECK_WIND	WOODWARD
OKGECHSHLMV7UNCHISHOLM2_WIND	WOODWARD
OKGEDEWEY1UNTALOGA_WIND	WOODWARD
OKGEFPL_WINDUNUN1_FPL_OMPA	WOODWARD
OKGEFPL_WINDUNUN1_FPL_WIND	WOODWARD
OKGENARDINUNCOWBOY_WIND	WOODWARD
OKGEOMKAWUN2	WOODWARD
OKGEOMKINGFUNOMPA_KNGFISHER	WOODWARD
OKGEOMPONCAUNOMPONCA1_3	WOODWARD
OKGEOMPONCAUNOMPONCA2	WOODWARD
OKGEOMPONCAUNOMPONCA4	WOODWARD
WFECANADARKOPLT1	WOODWARD
WFECBUFBEAR2UNWINDFARM	WOODWARD
WFECGOTEBOUNLITTL_ELK_WIND	WOODWARD
WFECMOORLN1UNMOORELAND_1	WOODWARD
WFECMOORLN1UNMOORELAND_2	WOODWARD
WFECMOORLN1UNMOORELAND_3	WOODWARD
WFECOMLVRNEUNOMPA_LAVERNE	WOODWARD
WFECOMMANGMUNOMPA_MANGUM	WOODWARD
WFECREDHILLSUNWINDFARM	WOODWARD
WFECSLP_BEARUNWINDFARM	WOODWARD

Appendix B. Binding Constraint and Pivotal Supplier Data

Constraint Name	Monitored Element	Binding Hours	Pivotal Supplier Hours
WDWFPLTATNOW	WDWRD1 - FPLSWTCH 138 kV	2919	1434
TEMP56_21085	TUCO - LUBBOCKE 115 kV	2748	2743
STAINDTUCCAR[2]	STANTON - INDIANA 115 kV	1460	1449
OSGCANBUSDEA	OSG_SWPS - CANYON_E 115 kV	1352	1351
TEMP50_20937	WOLFFORT - TERRY_CO 115 kV	1226	1223
SHAHAYPOSKNO	VINETAP3 - NHAYS 115 kV	1225	252
TEMP18_21404	MARTIN - HUTCH 115 kV	1011	0
WATXFRWATXFR[3]	WATFORD 230/1 kV	1067	873
TMP129_21713	LARAMIE 345/23.4 kV	920	0
TMP144_21263	CHAR_CK - RGHDRD 115 kV	750	630
WODFPLWODXFR	WDWRD1 - FPLSWTCH 138 kV	721	369
TMP169_21734	HAYBUTTE - LCGASPLT 115 kV	646	0
PR_ISLNROCH[4]	PR_ISLD - NROCH 345 kV	547	128
PMA_DOLET_PP	DOLET_PP	416	0
TMP133_21794	HARRSUB - RLNGHILS 230 kV	370	234
TEMP49_21150	RUGBY230 - RUGBY 115 kV	355	254
TMP120_21426	CARLISLE 230/115 kV	339	335
SILSPRTONFLI[5]	SILOAM - SILSPRNG 161 kV	328	283
NEORIVNEOBLC	NSES - RAM452 161 kV	324	287
SHAHAYKNOXFR	VINETAP3 - NHAYS 115 kV	318	113
TEMP48_20597	SETAB1 - SCOTCTY 115 kV	298	232
TMP179_21578	DOLET_PP - DOLET 24 kV	256	0
TMP203_21931	CIMARRON 345/138 kV	256	256
TEMP13_21818	PANTEX_S - HIGHL_TP 115 kV	252	0
TEMP23_21218	EAU_CLA - ARPIN 345 kV	228	161
TEMP14_20279	BUSHLAND - DEAFSMIT 230 kV	216	215
CARLPDLUBWOL	CARLISLE - DOUD 115 kV	203	203
TMP161_21545	GOTHNBG - COZAD 115 kV	197	0
HOBCARHOBALT	HOBART_J - CRNGIE_S 138 kV	188	23
TMP198_21927	ONETA 345/138 kV	186	169
TEMP99_21082	DENVER_C - SAN_AND1 115 kV	184	151
TMP204_21785	MARSHAL3 - SMIT 115 kV	183	0
TMP234_21795	ARENDS - FOSTRACB 69 kV	181	12

[2] STAINDTUCCAR; originally created as the temporary constraint TMP145_21718 on 3/22/2016 and promoted to permanent status on 7/1/2016.
[3] WATXFRWATXFR; originally created as the temporary constraint TMP169_21252 on 10/1/2015 and promoted to permanent status on 4/1/2016.
[4] PR_ISLNROCH; MISO Market-to-Market constraint.
[5] SILSPRTONFLI; originally created as the temporary constraint TEMP24_20438 on 7/22/2014 and promoted to permanent status on 4/1/2016.

TMP108_21422	NSES 161/138 kV	180	162
TEMP65_21162	ARCAD7 - OMLARCA 138 kV	179	169
SUNAMOTOLYOA	SUNDOWN2 - AMOCO_SW 230 kV	178	129
ARCKAMARCNOR	ARCAD7 - JONES_KA 138 kV	169	92
TMP187_20891	MCCLAI - 134PENTP 138 kV	162	0
TEMP82_20951	NASHUA 345/1 kV	162	76
TMP186_21583	WDRNG1 345/138 kV	151	59
TMP168_21247	KNOLL1 - REDLIN 115 kV	113	0
TMP215_21787	CIMARRON - DRAPR1 345 kV	111	67
FRASPECOLMEA	FTRANDL - SPENCE1 115 kV	105	97
TEMP38_21746	KNOLL1 - REDLIN 115kV	103	88
TMP193_21919	VERD_TAP - AMC_TAP 138 kV	102	43
ELKXFRSWEWHE	ELK-CITY 230/138 kV	94	75
TEMP86_21405	KRESS - HALE CO 115kV	91	88
TMP246_21945	BEULAH - HALIDYWP 115 kV	91	19
TMP226_21682	CIMARRON 345/138 kV	89	78
TEMP74_20773	MILANTP - CLEARWT4 138 kV	78	33
TMP247_21947	LUBBOCKS - LUBBOCKE 115 kV	77	73
TEMP46_21084	LAWH 230/115 kV	74	0
TEMP98_21113	SHEFFLD1 161/69 kV	73	0
TMP173_21361	ELK-CITY - CLINT_J 138 kV	72	71
TEMP63_21164	CIMARRON - DRAPR1 345 kV	70	29
TMP170_20876	KELL - TECH 161 kV	69	31
LUBXFMJONHOL	LP-SOUT2 230/69 kV	69	68
TEMP52_20619	MOORLN1 - GLMTN 138 kV	68	0
IATSTRSTJHAW	IATAN - STRA 345 kV	64	15
SARMINELDMOL	SAREPT - MINDE3 115 kV	63	0
SMOSUMMULCIR	WR_SMKHL - SUMM 230 kV	59	16
TEMP13_21262	MCHENRY 230/1 kV	59	0
TEMP13_21262	MCHENRY 230/1 kV	56	0
TMP101_20769	SNAKECK - ALIANCE 115 kV	54	54
TMP146_21459	CARLISLE - MURPHY 115 kV	52	29
TEMP58_21391	WR_SMKHL - SUMM 230 kV	52	38
TMP185_21334	SAILES - TXPSEX 115 kV	51	45
REDMINAXTPOS	REDWLO1 - MINGO1 345 kV	50	9
TEMP90_21398	B_SPRGS - BLUECK 115 kV	49	37
TMP192_21680	WR_SMKHL - SUMM 230 kV	49	22
FOXRUTNOBLAK	FOX_LK - RUTLAND 161 kV	48	29
HARPOTHARPOT	HARRSUB - POTTER_S 230 kV	48	37
TMP225_21946	CLBRTSNE - WILISTN 115 kV	48	47
ANOPLHANOMAB	ARK_NU - PLS_HL 500 kV	47	33
TEMP79_21771	NOWST1 345/1 kV	47	0
TEMP53_20942	134PENTP - WESTMOR4 138 kV	45	33
TEMP94_21410	SHAYS - MULGRE2 230 kV	45	34
TMP201_22011	MCHENRY 230/1 kV	44	30
NASXFRNASHAW	NASHUA 345/1 kV	44	12

TMP178_21910	PLXSUB - BAI_CO_R 115 kV	43	5
MINXFRMINSET	MINGO1 345/1 kV	43	3
TMP139_21456	PANTEX_S - HIGHL_TP 115 kV	41	6
GGS	6 ELEMENTS (G_GENT1)	56	13
RINXFRDOLSWS	RINGOL 138/115 kV	54	0
MABWRIWH_KEO	MABELV - WRIGHT_E 500 kV	53	36
IATSTRNASHAW	IATAN - STRA 345 kV	52	2
SUBTEKFTCRAU	SUB1226 - TEKAMHO 161 kV	52	47
REDWILLMINGO	REDWLO1 - MINGO1 345 kV	52	38
TMP137_21357	CARTHAGE - LAR3821 161 kV	51	46
JECAUBHOYJEC	JEFF - AUBU 230 kV	51	51
TEMP57_20945	ASB3491 - CJ366 161 kV	49	44
TMP183_22014	CRSW 138/69 kV	48	8
KNONHAPOSSHA	KNOLL1 - NHAYS 115 kV	47	8
TEMP88_21344	CARLISLE 230/115 kV	46	46
TEMP89_21853	ELSIETP - PAXTON 115 kV	46	38
TAHH59MUSFTS	TAHLQH5 - HWY59 161 kV	44	30
HAWXFRHAWXFR	HAWTHORN 345/161 kV	43	33
TEMP72_20647	WOLFFORT - TERRY_CO 115 kV	42	42
TMP158_21888	WICH 345/138 kV	41	28