Exhibit No ._____
Issues: HVDC Technology & Construction; RTOs & Interconnection;
Witness: Anthony Wayne Galli
Type: Surrebuttal Testimony
Sponsoring Party: Grain Belt Express
Clean Line LLC
Case No.: EA-2016-0358
Date Testimony Prepared: February 21, 2017

**MISSOURI PUBLIC SERVICE COMMISSION**

**CASE NO. EA-2016-0358**

# SURREBUTTAL TESTIMONY OF

# DR. ANTHONY WAYNE GALLI, P.E.

# ON BEHALF OF

# GRAIN BELT EXPRESS CLEAN LINE LLC

**February 21, 2017**

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## I. INTRODUCTION AND QUALIFICATIONS

**Q. Please state your name, present position, and business address.**

A. My name is Anthony Wayne Galli. I am Executive Vice President – Transmission and Technical Services of Clean Line Energy Partners LLC ("Clean Line"). Clean Line is the ultimate parent company of Grain Belt Express Clean Line LLC ("Grain Belt Express" or "Company"), the Applicant in this proceeding. My business address is 1001 McKinney Street, Suite 700, Houston, Texas 77002.

**Q. Have you previously submitted prepared testimony in this proceeding?**

A. Yes, I submitted direct testimony on August 29, 2016.

**Q. What is the subject matter of this surrebuttal testimony?**

A. I will address items raised by the Missouri Public Service Commission Staff ("Staff") in their Staff Rebuttal Report ("Staff Report") related to the Grain Belt Express Clean Line HVDC Project ("Grain Belt Express Project" or "Project") with respect to interconnection studies, design status, Project operational modes, and safety. I will also address various conditions that were recommended by Staff.

**Q. Please summarize your testimony's organization.**

A. First, in response to Staff's discussion of various technical studies in its Rebuttal Report, I will describe the difference between interconnection studies that deal with Bulk Electric System ("BES") impacts versus studies which are performed in the design of an HVDC transmission project. Second, I will provide updates, clarifications, and next steps related to the Project's Regional Transmission Organization ("RTO") interconnection studies, including why the scope and cost of network upgrades from these studies are not risks to the Project's economic feasibility. Third, I'll explain why the present level of design of the Grain Belt Express Project is completely appropriate at the current stage of its

development. Fourth, I'll explain why consideration of additional operating modes of the Project is reasonable because the RTOs can accommodate bi-directional power flow. Fifth, I will address Staff's testimony regarding the Project's crossings of existing underground utilities. Sixth, I'll address some of the conditions proposed by Staff.

## II. INTERCONNECTION STUDIES

a. General

**Q. Staff points to several ongoing and future interconnection studies for the Project beginning on page 22 of the Staff Report. Notwithstanding that some studies remain to be completed, will Grain Belt Express design, construct and operate the Grain Belt Express Project in a reliable manner?**

A. Yes. Grain Belt Express will design, construct and operate the Project to be compliant with industry standards, codes, and best practices such as those of the Institute of Electrical and Electronics Engineers, National Fire Protection Association, International Electrotechnical Commission, and the International Council on Large Electric Systems, to name a few. Additionally, Grain Belt Express will be required to meet national, regional, and local reliability standards, including Good Utility Practice.[1]

**Q. Will other regulatory bodies, procedures and laws ensure that the Grain Belt Express Project is designed and operated in a reliable manner?**

A. Yes. As I described in my direct testimony, Grain Belt Express must design, construct and operate the Project in a manner that complies with the mandatory reliability standards of the North American Electric Reliability Corporation ("NERC")[2] and of the regional

[1] Direct Testimony of Dr. Anthony Wayne Galli, P.E, p. 15, line 1.

[2] Direct Testimony of Dr. Anthony Wayne Galli, P.E, pp. 15-16.

entity, ReliabilityFirst Corporation ("RFC"). Grain Belt Express must sign Interconnection Agreements with the Southwest Power Pool ("SPP"), the Midcontinent Independent System Operator ('MISO") and PJM Interconnection L.L.C. ("PJM"). These Interconnection Agreements will require Grain Belt Express to fund and complete any transmission upgrades required to ensure the reliability of the grid prior to energizing the Project. Further, these Interconnection Agreements will require that the Project also operate in a manner that complies with mandatory reliability standards of the other relevant regional entities, Southwest Power Pool Regional Entity and the Midwest Reliability Organization.

b. Cost Impacts of Remaining Interconnection Studies

**Q. Does Grain Belt Express have a reasonable basis to estimate network upgrades for its SPP, MISO, and PJM interconnections?**

A. Yes. SPP, MISO, and PJM have conducted technical studies in sufficient detail to support cost estimates with a reasonable level of certainty. In addition, Grain Belt Express has hired reputable technical consultants to conduct studies that confirm the expected level of network upgrades. In the remainder of this section of my surrebuttal, I explain why there is limited risk of additional costs for network upgrades within the SPP, MISO, and PJM transmission systems due to the knowledge gained from (1) the January and March, 2013 SPP Criterion 3.5 study work performed by Siemens PTI, (2) the September 2013 SPP Criterion 3.5 verification studies performed by SPP, (3) the March 2015 Facilities Study performed by ITC Great Plains, (4) the October 2012 Feasibility study performed by MISO, (5) the November 2014 SPA Study and January 2017 Optional Study performed by Ameren Missouri, (6) the Project HVDC model

development and stability testing performed by TransGrid Solutions, (7) the January 2013 Feasibility Study performed by PJM and AEP, and (8) the October 2014 System Impact Study (and ongoing re-tooled System Impact Study) performed by PJM and AEP.

**Q. Please respond to Staff witness Sarah Kliethermes' concern at pages 30-31 that the costs of network upgrades identified by MISO in the interconnection studies for the Project could be partially recovered by Missouri ratepayers.**

A. Grain Belt Express and its transmission customers bear the risk of costs associated with network upgrades. Ms. Kliethermes describes a process of partial cost allocation of network upgrades[3] which currently exists only for generator interconnection projects. This process, as Ms. Kliethermes correctly points out, acknowledges the value of network upgrades to both the generator interconnection, as well as to the BES at-large. There is currently no way for an HVDC project developer to seek any amount of cost allocation of network upgrades identified by MISO through interconnection studies. If a process was implemented to allow partial cost recovery of network upgrades identified as a result of an HVDC interconnection, there is no reason to believe that it would deviate from the process that exists for generators. The current approach that MISO applies for generator interconnections provides for 10% cost recovery of any network upgrades across all MISO load where individual load zones within MISO are allocated their load-ratio share of the 10%. In order to apply this approach to new HVDC interconnections, MISO and its stakeholders would need to develop the appropriate tariff language and receive FERC approval.

[3] Staff Rebuttal Report, p. 31.

**Q. If MISO extends the cost allocation process from its generator interconnection procedures to apply to HVDC interconnections and specifically, for the Project, what would be the implications to Missouri load?**

A. If MISO utilized the generator interconnection cost allocation process for the Grain Belt Express Project network upgrades identified by Ameren to date, $2.02 million would be cost allocated across all of MISO. Of this $2.02 million, in accordance with the load-ratio share of Missouri load to the rest of MISO, 6.2% of this $2.02 million, or approximately $125,200, would be allocated to Missouri customers. This is a very low cost to Missouri load for enhancements that will make the transmission system in Missouri more reliable and would be available to all users of that transmission system.

**Q. In your professional opinion, does the possibility that network upgrades are higher than expected affect the economic feasibility of the Project?**

A. No. In my roles at SPP and NextEra Energy, I oversaw and participated in many interconnection studies. Compared to other projects on which I have worked, Grain Belt Express, at this stage of the Project's development, has performed a larger number of studies and done more due diligence about the level of network upgrades potentially associated with the Project. The completed studies and due diligence provide a solid basis for Grain Belt Express' financial estimates and business plan. Mr. Berry's surrebuttal testimony more specifically addresses the manageable financial impact to the Project of potentially higher upgrades. **Schedule AWG-7** is a table that summarizes the studies that have been performed at each point-of-interconnection including its status and references to where each study is discussed in both of my direct and surrebuttal testimony.

**Q. The Staff Report at pages 24-29 points to a number of ongoing and future technical studies related to the Project's interconnection. Please explain the distinction between studies that deal with a new project's <u>impacts on</u> the Bulk Electrical System ("BES") and studies that deal with a new project's <u>performance in relation to</u> the BES.**

A. It is helpful to visualize a new project and consider the fence line which separates the equipment <u>within</u> the boundaries of that new project substation ("inside the fence") and the rest of the BES on the other side of the fence line ("outside the fence"). The project developer, in this case Grain Belt Express, is responsible for designing the "inside the fence" facilities, while the interconnecting utility is responsible for designing the "outside the fence" facilities.

When a new project desires to interconnect to the BES, the regional grid operator conducts, or engages a third-party to conduct, a study to identify impacts "outside the fence" to the BES. This study is typically referred to as an Impact Study. Impact Studies identify potential violations of reliability standards that could occur due to operation of the new project. The results of the Impact Study may recommend network upgrades to the BES (i.e., "outside the fence") that would mitigate the identified reliability standard violations or otherwise an affirmation that the new project can be reliably interconnected without network upgrades.

Grain Belt Express, together with the manufacturer of the HVDC equipment, will perform Design-Level Studies in the normal course of designing the converter stations. The Design-Level Studies ensure that operation of the Project will meet interconnection requirements consistent with the Impact Study results including the RTO's and the

interconnecting utilities' operating and planning criteria. The Design-Level Studies assure that the final HVDC converter station equipment located "inside the fence" allows for the seamless integration of the new project into the BES at the chosen points-of-interconnection and complies with all interconnection requirements.

**Q. What is the purpose of differentiating between the Impact Studies or BES studies that are performed by the RTO, and the Design-Level Studies that are performed by Grain Belt Express and the equipment manufacturers?**

A. In the Staff Report, Staff suggests that various ongoing or future technical studies could potentially increase costs to Grain Belt Express due to unidentified network upgrades.[4] The majority of the studies that Staff discusses, however, are Design-Level Studies which only impact equipment "inside the fence" of the Grain Belt Express Project. They do not affect the number and/or scope of network upgrades identified "outside the fence" by SPP, MISO, or PJM.

**Q. What studies are required in order to properly <u>design</u> an HVDC project such as the Grain Belt Express Project?**

A. **Schedule AWG-8** is a table that shows Impact Studies (green-shaded) which, as I previously described, deal with BES impacts "outside the fence," as well as Design-Level Studies (un-shaded) which deal with the equipment requirements "inside the fence." Mr. Stahlman and Mr. Lange express concern in Staff's testimony about items that are studied and addressed through Design-Level Studies including harmonic performance,[5]

[4] Staff Rebuttal Report, p. 22.

[5] Staff Rebuttal Report, pp. 26, 60-61.

studies on control interaction with other DC links,[6] subsynchronous torsional interaction studies[7], as well as dynamic performance studies.[8] These studies and the others identified in **Schedule AWG-8** will be performed during the design process of the Grain Belt Express Project and will be complete prior to the start of construction since the results of these studies are required for final design and manufacture of equipment. The Design-Level Studies will prescribe an HVDC design which meets all interconnection requirements and complies with the HVDC model used in the completed RTO interconnection studies. As I previously described, these Design-Level Studies only impact Project equipment "inside the fence." Therefore, Staff's concerns are unfounded as to whether the RTOs have sufficient information about future Design-Level Studies to finalize the Impact Studies and identify any needed transmission upgrades.

**Q. Will SPP, MISO PJM and the interconnecting utilities coordinate and review the Design-Level Studies?**

A. Yes. Each utility which the Project interconnects with will advise on and review the Design-Level Studies. The utilities will advise on the scope of the study, provide applicable standards and data inputs, verify system parameters and assumptions, and review and confirm results. MISO's Merchant HVDC Task Team ("MHTT") is

[6] Staff Rebuttal Report, pp. 59-60.

[7] Staff Rebuttal Report, pp. 59-60.

[8] Staff Rebuttal Report, p. 58. Mr. Lange discusses short-circuit ratio issues which directly deals with dynamic performance.

discussing and developing a coordination process for MISO and interconnecting utilities to participate in HVDC Design-Level Studies.[9]

**c. MISO**

i. Study Updates and Developments

**Q. Were there any new MISO study results provided to Grain Belt Express since you filed your direct testimony?**

A. Yes. On January 25, 2017 MISO issued its Optional Study Report which was prepared by Ameren Service Company ("Ameren") at MISO's direction and is attached as **Schedule AWG-9.** This is the same report that I referred to as a "more advanced study".[10] The name of the study was changed from a System Planning & Analysis or "SPA Study" to an "Optional Study" because of FERC's January 3, 2017 Order[11] accepting MISO's proposed revisions[12] to MISO's generator interconnection procedures which included, among other changes, elimination of the SPA study phase. However, the scope and purpose of the study have not changed.[13]

**Q. How is the MISO Optional Study Report more advanced than the MISO SPA Study Report previously provided?**

[9] See p. 9-10 of the MHVDC Process Draft from the December 2016 MHTT meeting at: https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/MHTT/20161209/20161209%20MHTT%20Item%2004%20MHVDC%20Process%20Draft.pdf

[10] Direct Testimony of Dr. Anthony Wayne Galli, P.E, p. 12, lines 15-17.

[11] Midcontinent Indep. System Operator, Inc., Order Accepting Tariff Revisions Subject to Condition, No. ER17-156-000 (Jan. 3, 2017).

[12] Direct Testimony of Timothy Aliff, pp. 46-47, *available at*: https://www.misoenergy.org/Library/Repository/Tariff/FERC%20Filings/2016-10-21%20Docket%20No.%20ER17-156-000.pdf

[13] More information on Optional Studies is available on the MISO Generator Interconnection site available at: https://www.misoenergy.org/Planning/GeneratorInterconnection/Pages/ProceduresRequirements.aspx

A. Yes. This more advanced study addressed some concerns raised in Staff's Rebuttal Report. Compared to previous MISO studies, the Optional Study considered more contingency scenarios. In addition to NERC P0-P1 events (f/k/a category A and B events), the Optional Study also considered P2-P7 events (f/k/a category C1-C5 events) and other Ameren Local Planning Criteria.[14] Staff Witness Mr. Lange expressed concern that previous MISO studies did not include NERC category C events.[15] The Optional Study included these additional contingencies and provides more certainty regarding the impacts from interconnection of the Project's Missouri HVDC Converter Station.

**Q. Did the Optional Study Report consider stability analyses?**

A. No. Stability analyses are not typically performed until the Definitive Planning Phase ("DPP") of the MISO interconnection process since they involve even more detailed and expensive studies which require significant staffing resources from MISO and Ameren.

**Q. Does Grain Belt Express have a reasonable basis to believe MISO's stability analysis will not result in a large amount of additional upgrades?**

A. Yes. Outside of the MISO interconnection process, Grain Belt Express has commissioned technical studies that include stability analysis. In 2013, Siemens PTI performed a stability analysis for the SPP Criterion 3.5 Studies and did not identify any stability-related issues from interconnection of the Missouri HVDC Converter Station which would require new transmission upgrades. Siemens PTI is a highly reputable technical consultant, who is often hired by grid operators to perform stability analysis as part of interconnection studies. SPP, through their consultant Excel Engineering, Inc.,

[14] See Optional Study Report at p.7, Schedule AWG-9

[15] Staff Rebuttal Report, pp.55, 60.

verified Siemens PTI's work and concluded in their report, which I have included as **Schedule AWG-10**, that "[n]o stability problems were found for faults near the AMMO [Ameren Missouri] Palmyra station. The AMMO system is able to handle the additional 500 MW injection without a problem."[16]

Finally, Grain Belt Express' HVDC technical consultant, TransGrid Solutions Inc. ("TGS") [17] developed an HVDC model of the Project which has been and will continue to be utilized in the MISO and PJM interconnection studies. TGS performed detailed model testing which found that the HVDC performed as expected under fault conditions. TGS' testing considered the most severe faults that could impact operation of the Project; these are the same faults that will be included in the stability study that will be performed by MISO in the DPP. TGS did not identify any issues at the MISO interconnection in the HVDC model development. Therefore Grain Belt Express is confident that no additional network upgrades will be identified by MISO for the Project due to stability issues.

ii. Next Steps

**Q. The Staff Report at page 58 appears to suggest that transmission upgrades in MISO cannot be known until a short-circuit analysis is performed for the Project. Is this correct?**

A. No. Short circuit studies determine if, with the addition of a new power injection, fault current levels can still be safely managed in accordance with ratings of existing substation equipment. The contribution to fault current levels from HVDC converters are insignificant compared to fault currents produced from synchronous generators. This is

[16] Schedule AWG-9, p.8.

[17] I described the credentials of both Siemens PTI and TGS in my direct testimony. Direct Testimony of Dr. Anthony Wayne Galli, P.E, p.36, lines 7-19.

highlighted in the "Short Circuit Analysis" section of the MISO SPA Study Report which states "[n]o short-circuit analysis should be required for this connection because the customer's HVDC line should not contribute current to an ac short circuit (except for its rated load current)." Staff also acknowledged this in response to a Grain Belt Express data request where Staff was asked about its understanding of the contribution to short circuit currents by HVDC converter stations. Staff witness Mr. Stahlman responded: "HVDC transmission does not contribute to the short circuit current of the interconnected AC system."[18]

**Q. In response to Staff's concerns regarding MISO studies at pages 24-25, does the most recent Optional Study Report provide additional certainty regarding MISO interconnection studies?**

A. Yes. In the Optional Study Report, Ameren lists the network upgrades and interconnection facilities that were identified as a result of the interconnection of the Project's Missouri HVDC Converter Station.[19] The Optional Study included the same set of contingency events that will be included in the MISO DPP Impact Study which is the final stage of MISO's interconnection process. Thus, the Optional Study Report is a realistic view of the impacts from the Project and provides specific recommendations on the location and cost estimates of the network upgrades in MISO.[20] Ameren estimates that the cost to interconnect the Grain Belt Express Project to the MISO network is $21 million. While this is an increase from the Company's previous estimate of $10

[18] Question #11, *Staff Responses to Grain Belt Express Clean Line LLC's First Set of Data Requests Directed to Staff Witness Stahlman*, p.5.

[19] Schedule AWG-9, p.14.

[20] Staff Rebuttal Report, pp.22, 24, 26, 31, 33.

million,[21] it is less than 0.5% of the overall Project cost. All of these costs will be paid for by Grain Belt Express. The Optional Study Report confirms that while refinements of the Project's interconnection studies may result in additional upgrades or changes to identified upgrades, they will not affect the underlying economic feasibility of the Project.

**Q. How will the MISO interconnection process ultimately lead to the Project being interconnected to the Ameren transmission system?**

A. The final phase of study with MISO will be conducted in a new HVDC-specific interconnection process that MISO plans to roll-out by June 2017. This new process will include an Impact Study with the same scope as the Optional Study, to include MISO's up-to-date transmission topology, load, and generation assumptions, and will also include the stability analysis previously discussed.

Although MISO is still developing a process to study new HVDC interconnections, it has significant operational experience with HVDC links operating within its footprint, along with two (soon to be three) other HVDC lines in Manitoba Hydro's transmission system that actively participate in MISO's markets. MISO and its stakeholders recognize the value and need for HVDC transmission, and are dedicated to implementing a process for study and administration of new HVDC interconnections.

In MISO's generation interconnection FERC filings in Docket No. ER-17-156-000, MISO's Director of Reliability Planning Timothy Aliff testified: "MISO is currently developing, through a MISO stakeholder Task Team, a separate merchant HVDC process for the existing HVDC requests currently in the SPA. These HVDC projects [which

[21] Direct Testimony of Dr. Anthony Wayne Galli, P.E, p. 30, lines 15-21.

include the Grain Belt Express Project will be moved to this new process upon its completion."[22] The stakeholder process that Mr. Aliff is referring to is the MISO Merchant HVDC Task Team or MHTT.

**Q. Who participates in the MISO MHTT?**

A. The MHTT is open to all MISO stakeholders but is primarily attended by several MISO Transmission Owners, including Ameren, and merchant transmission developers, including Grain Belt Express staff.

**Q. What is the anticipated timeline for the MHTT to finalize development of merchant HVDC-specific interconnection procedures?**

A. MISO has targeted a roll-out of an HVDC interconnection process for June 2017. At that time, MISO would have a process to begin final studies for HVDC projects that are ready to advance to an Interconnection Agreement. The DPP is the final stage of the MISO interconnection process, which involves detailed studies and additional costs.[23] Grain Belt Express already has developed an advanced model of the Project sufficient for performing these final DPP studies with MISO.

**Q. Have other RTOs successfully implemented an interconnection process for HVDC lines?**

A. Yes. There are several relevant precedents of successfully implemented approaches to interconnect new HVDC projects in the United States. As Staff is aware,[24] PJM has interconnection procedures specific to HVDC projects. The New York Independent

[22] Direct Testimony of Timothy Aliff, p. 53, lines. 8-11 *available at: (see fn 12).*

[23] Direct Testimony of Dr. Anthony Wayne Galli, P.E, pp. 29-30.

[24] Staff Rebuttal Report, p.60.

System Operator, Inc ("NYISO"), utilizing their existing generation interconnection study processes, worked with the Consolidated Edison Company of New York, Inc. and Hudson Transmission Partners, LLC to revise the NYISO Large Generator Interconnection Agreement to accommodate the HVDC Hudson Transmission Project.

**Q. Is it possible to interconnect and operate the Project without the approval of the relevant RTOs that are charged with ensuring the reliability of the transmission system in Missouri?**

A. No. Staff witness Mr. Beck seems to suggest that the Company's CCN Application has placed the Commission in a position to determine whether Ameren and other Missouri utilities will be able to meet NERC reliability standards and Local Transmission Owner Planning Criteria. This concern is misplaced. The Project cannot interconnect with Ameren and the MISO-controlled transmission system without an executed Interconnection Agreement ("IA"). The execution of an IA cannot be achieved until all reliability studies – which "provide insight into the effect on reliability that a 500 MW interconnection on the Maywood-Montgomery 345kV Transmission Line would have" [25] – are completed. Furthermore, Grain Belt Express has agreed to a condition to receiving a CCN that all interconnections studies be completed and interconnection agreements be executed before energizing the Project.

**Q. Given Staff's comments at pages 56-58 the Staff Report, is it reasonable for MISO to continue to assume that the Mark Twain Transmission Project will be in-service prior to commercial operation of the Grain Belt Express Project?**

[25] Staff Rebuttal Report, p. 15.

A. Yes. Staff witness Mr. Lange points out on page 57 of the Staff Report that the Mark Twain Transmission Project ("Mark Twain") is part of the MISO Multi-Value Project ("MVP") portfolio. The MVP portfolio, among other benefits, allows MISO to "[m]aintain system reliability by resolving reliability violations on approximately 650 elements for more than 6,700 system conditions and mitigating 31 system instability conditions" [26] Nevertheless, Mr. Lange seems to suggest that even with the Commission's approval of this important transmission line, it may not get built.[27] Mark Twain has been modeled in every single transmission expansion plan and generation interconnection study performed by MISO, Associated Electric, SPP, and Southwestern Power Administration since Mark Twain was approved by the MISO Board of Directors in 2012. This is the case because approval by the MISO BOD eventually results in implementation of these approved facilities into the NERC Multi-Regional Modeling Working Group loadflow and stability cases which are used for reliability and expansion planning throughout the entire Eastern Interconnection. MISO justified the need for Mark Twain in 2012 as follows[28]:

*…the new lines provide reliability benefits by mitigating a number of contingent outage events during peak and shoulder periods, where the wind generation component is much higher. The addition of the 345 kV lines and step down transformer at West Adair is especially effective in resolving 161 kV line overloads on the lines out of West Adair and preventing the loss of the generation at West Adair during certain NERC Category C events. This project will mitigate two bulk electric system (BES) NERC Category B thermal constraints and five NERC Category C constraints. It will also relieve three non-BES NERC Category B and two NERC Category C constraints.*

[26] Staff Rebuttal Report, p. 57.

[27] Staff Rebuttal Report, pp. 57-58.

[28] *Multi Value Project Portfolio, Results and Analysis, MISO, January 10, 2012, p.31, available at: https://www.misoenergy.org/Library/Repository/Study/Candidate%20MVP%20Analysis/MVP%20Portfolio%20Analysis%20Full%20Report.pdf*

This highlights that MISO, should Mark Twain not proceed, must identify an alternative project(s) to Mark Twain with very similar characteristics in order to address these future reliability issues.

**Q. If the Mark Twain Project is not completed, what will MISO do?**

A. MISO will have to identify alternative solutions that provide the same or similar benefits offered by Mark Twain. In no way will MISO operate in a manner that jeopardizes reliability. The result of a delay in implementing Mark Twain (or an equivalent project) would likely involve redispatch of the MISO market generation fleet around any constraints that would have otherwise been addressed by Mark Twain.

**Q. Is potential congestion an indication of a risk to the reliable operation of the transmission system?**

A. No. Staff witness Mr. Lange uses the word "congestion" in a manner that seems to suggest that congestion is an indication that reliability criteria have been violated. Congestion – a condition that arises on the transmission system when one or more restrictions prevents the most economic dispatch of electric energy from serving load – results in electric prices that represent the inability to use the least expensive generation to meet the electricity demand due to transmission limitations. In other words, congestion is a market inefficiency. This is important because Staff witness Ms. Dietrich states that one of the reasons why a determination cannot be made at this time whether the Grain Belt Express Project is in the public interest is due to her perceived uncertainty surrounding Mark Twain and "its effects on the Missouri converter station and corresponding congestion"[29] Further, Ms. Dietrich suggests a condition where Grain Belt

[29] Staff Rebuttal Report, p.7.

Express would be required to submit "a modified plan to address congestion should [Mark Twain] not proceed.…" [30] Requiring a new transmission or generation interconnection project to address market inefficiencies has never been a requirement in any interconnection processes that I am aware of and such a condition here inappropriately requests that Grain Belt Express become the sponsor of new, unknown market efficiency transmission projects. If the Mark Twain line does not proceed, as I have discussed previously, the requirement to identify an alternative transmission solution properly belongs to the transmission planners at MISO, not to Grain Belt Express.

**Q. Based on the meaning of "congestion" as you describe above, is identification of transmission system congestion within an interconnection process, such as that identified in the PJM System Impact Study, a reliable source to predict expected congestion due to operation of the Grain Belt Express Project once the Project enters commercial operation?**

A. No. The interconnection planning studies performed to analyze the impacts of a new interconnection project utilize "snap shots" in time to identify conditions that would stress the transmission grid in order to identify network upgrades that need to be constructed to reliably integrate the new project. These interconnection processes do not rely on a market based security constrained economic dispatch of the generation fleet in determining which resources will be dispatched and at what levels in order to determine potential reliability violations. This is why the results of congestion-based studies, such

[30] Staff Rebuttal Report, p.7.

as that portion of the PJM System Impact Study ("SIS") dealing with energy deliveries[31], do not require mitigation. Interconnection Impact Studies point out where reliability violations may occur in various scenarios and the appropriate mitigations so that a project can operate reliably under a reasonable set of stressed scenarios. A production simulation tool would be a better approach to estimating congestion in a power system such as those studies performed by Grain Belt Express witness Mr. Copeland.

**Q. Regarding Staff's discussion of power factor criteria on page 25 of the Staff Report, what is power factor?**

A. Power factor is most simply defined as the ratio of real power to apparent power; where real power is the power transferred to do work and apparent power is simply the product of the root-mean-square values of voltage and current. Power factor is a dimensionless quantity that ranges from 0 to 1 and is indicative of how reactive a circuit is (i.e., how much reactive power it may draw). A low power factor means that a high reactive current is being drawn and thus more current is drawn to produce the same amount of work than an equivalent load with a high power factor (which means a low amount of reactive current is being drawn). At the transmission level, power factors are typically near unity depending on the loading of the transmission line, but can vary. There are typically no standards for power factor on a transmission line interconnection, as the concept is most often applied to loads and generators to ensure that they are unduly burdensome to the system from a reactive power perspective.

[31] *PJM Impact Study Report For PJM Merchant Transmission Request Queue Position X3-028 Breed 345 kV, October 2014,* p.12 (*Delivery of Energy Portion of Interconnection Request*), available at: http://www.grainbeltexpresscleanline.com/sites/grain_belt/media/x3028_imp.pdf

**Q. Are issues of power factor relevant to an HVDC project like the Grain Belt Express Project?**

A. No. HVDC projects are not designed to meet a specific power factor. Rather they are designed to ensure compliance with applicable reliability criteria including voltage criteria. An HVDC link that uses line commutated converter ("LCC") technology does not have the ability to control reactive power except by switching of reactive power devices, changing of transformer taps, or making slight changes to the control of the converter station. A generator, on the other hand, can independently and dynamically control reactive power output in a very straightforward manner.

In Staff's rebuttal testimony, Mr. Stahlman states that "if the Grain Belt converter station in Missouri is providing power to an AC transmission grid, it is effectively acting as a generator that would need to meet generation interconnection requirements."[32] Mr. Stahlman suggests that the Project would be, or should be, required to meet the generator-specific power factor requirements of the FERC pro-forma generation interconnection procedures. However, the Grain Belt Express Project is not a generator and, more importantly, adding additional equipment "inside the fence" of the Project's Missouri HVDC Converter Station is unnecessary for the Project to meet MISO's and Ameren's voltage criteria. In fact, in the Optional Study Report Ameren presents a more appropriate approach whereby appropriate equipment is installed in order to maintain system voltage and meet applicable criteria at the time the Project enters the DPP of the MISO interconnection process.[33]

[32] Staff Rebuttal Report, p. 25.

[33] Schedule AWG-9, p.5

The reactive power control design of an HVDC project like the Grain Belt Express Project ensures compliance with power quality standards (which is affected by both reactive power device switching and transformer tap changes); meets system voltage schedules "outside the fence" at each point-of-interconnection; maintains reactive power exchange within a pre-determined range; and otherwise operates in a reliable manner during system contingencies.

For any new transmission line interconnecting between transmission systems, if the AC system voltages at the points-of-interconnection can be shown to meet each utilities' existing voltage criteria in steady state and dynamic studies after the new transmission line is integrated into the studies, no additional equipment should be introduced into the network. The Grain Belt Express Project's reactive power control will be designed and operate to ensure compliance with MISO and Ameren's voltage criteria.

**Q. Regarding Staff's discussion on short circuit ratio on page 58 of the Staff Report, is the short circuit ratio between the Missouri HVDC Converter Station and the AC grid at the point-of-interconnection in Ameren Missouri a concern?**

A. Not at all. As Staff points out on page 58 of the Staff Report, the short circuit ratio ("SCR") is the ratio of the system short circuit level Mega Volt-Amperes ("MVA") to the DC power MW. Further, the denominator in the SCR is the DC power MW for the converter station interconnecting at that location; for the Missouri HVDC Converter Station this is 500 MW.[34] With a 345 kV system to interconnect to, the 500 MW interconnection of the Missouri HVDC Converter Station will have a relatively high

[34] In response to a data request from Grain Belt Express, Mr. Lange acknowledged this fact. Schedule AWG-11, Question 11c), p.5.

SCR. Using an SPP winter peak powerflow model, which had the nearby Audrain peaking power plant offline[35], the calculated short circuit power was 7.28 Giga Volt-Amperes ("GVA") which results in an SCR of 14.6 (or approximately seven times (7x) the SCR of 2.0). Removing the 345 kV transmission line between the Missouri HVDC Converter Station and the Maywood substation (and N-1 condition[36]) results in a short circuit power of 3.38 GVA which results in an SCR of 6.76 (or approximately three times (3x) the SCR of 2.0). Removing yet another line from service between Labadie and Montgomery (an N-2 condition), the calculated short circuit power dropped to 3.23 GVA which results in an SCR of 6.45. Therefore, as Mr. Lange concedes,[37] there are no concerns regarding whether the point-of-interconnection of the Missouri HVDC Converter Station would be too "weak".

**d. PJM**

i. Study Updates and Developments

**Q. The October 2014 PJM System Impact Study ("SIS") report states that a new model of the Project is required in order to address issues that were identified in the analysis. Is that model still necessary to resolve issues raised in the SIS?**

A. No. Grain Belt Express and its HVDC consultant TransGrid Solutions Inc. (TGS) analyzed the issues that were identified in the PJM SIS report and the need to ensure that

[35] When calculating the SCR during HVDC design studies, the HVDC manufacturer will perform calculations under multiple contingency conditions to identify the lowest short circuit ratio that would need to be accommodated to allow the Project's converters to maintain reliable operation at that specific point-of-interconnection.

[36] Note that this contingency also effectively eliminates any expected SCR benefit provided by the Mark Twain Transmission Project and therefore even without Mark Twain the grid in Missouri is considered strong from the perspective of a 500 MW HVDC converter.

[37] **Schedule AWG-11**, Question 10, pp. 4-5.

the HVDC model of the Project provided to PJM was properly tuned. TGS discovered that some of the issues identified by PJM resulted from numerical instabilities (software limitations) in other (that is, non-Grain Belt Express) generator models within the simulation cases that PJM was using. This can occur for various reasons when using the simulation software tool. When these numerical instabilities were addressed, PJM agreed that the model previously provided by Grain Belt Express was sufficient and that the Company was not required to provide a new model. Grain Belt Express did provide TGS's supporting technical notes to assist PJM in working with the existing model. These notes are provided in Highly Confidential **Schedule AWG-12.HC** and are considered Critical Energy Infrastructure Information ("CEII") under FERC rules.

.**Q. What issues did Staff identify in the PJM SIS?**

A. Staff witness Mr. Lange expressed concern over the PJM SIS, referencing language[38] from the SIS report which stated:

- The Grain Belt Project circuits disconnect from the system for several contingencies.
- The Grain Belt Project addition causes two wind farms to trip for several contingencies.

> "As X3-028 [the Grain Belt Express Project's PJM queue position nomenclature] is required to stay connected to the system for all faults, an updated model that exhibits this behavior is needed. The results suggest that further transmission reinforcement may also be required; the extent of this reinforcement cannot be confirmed prior to an updated X3-028 dynamic model being available."

**Q: Did the work of TGS resolve these issues?**

A; Yes. As a result of the TGS analysis, including the technical notes of Highly Confidential **Schedule AWG-12.HC**, all modeling issues have been resolved with PJM, which should also address Mr. Lange's concern.

[38] Staff Rebuttal Report, p.54.

**Q. What is the status of the PJM re-tooled SIS?**

A. PJM has indicated that the re-tooled SIS should be completed by the end of March 2017.

ii. Next Steps

**Q. Are there additional interconnection studies that are required before executing an Interconnection Agreement[39] with PJM and AEP?**

A. Yes. The final stage of study in the PJM process is the Facilities Study phase for which Grain Belt Express executed a study agreement in October 2014.[40] Additionally, as Staff is aware,[41] there are additional "detailed studies" that are required to be performed at some point before commercial operation of the Project. These will be performed before or after an Interconnection Agreement is executed and include some of the studies shown in **Schedule AWG-8** which are required as a matter of the Project design as well. To be clear, all of the studies that are included in **Schedule AWG-8** will be completed before construction of the Grain Belt Express Project since they are predecessors to the manufacturing of the Project's converter station equipment. All of the additional "detailed studies" which PJM requires to be completed before commercial operation are included in the list of studies in **Schedule AWG-8**.

**Q. What is the anticipated timeline for conclusion of the PJM interconnection process?**

A. A Facilities Study could take 12-18 months to perform. Thereafter, PJM, AEP, and Grain Belt Express will negotiate, execute, and file an IA with FERC.

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[39] MISO and SPP use the terms "Interconnection Agreement" while PJM uses the term "Interconnection Service Agreement." Since this refers to the same type of agreement, I use Interconnection Agreement in discussing PJM.

[40] Direct Testimony of Dr. Anthony Wayne Galli, P.E, pp. 26-27.

[41] Staff Rebuttal Report, p. 28.

**Q. Will the Grain Belt Express detailed design studies that are expected to be coordinated and reviewed by PJM and AEP create conditions that must be met under the Interconnection Agreement ("IA") between Grain Belt Express and PJM/AEP?**

A. Yes. Any of the "detailed studies" that are not performed and reviewed prior to execution of an IA will be listed within the IA as milestones that must be completed before commercial operation.

**Q. Is it possible that additional transmission upgrades will be identified as a result of the "re-tooled" System Impact Study ("SIS")?**

A. Yes, however, there have been positive developments for the Grain Belt Express Project since the first SIS was completed. Changes have occurred within the transmission system models that are being used to analyze the interconnection of the Project to the PJM system. This includes generator projects that have withdrawn from the PJM queue, as well as transmission topology changes that should help strengthen the grid near the interconnection of the Project's Illinois HVDC Converter Station. Two topology changes, in particular, will directly benefit this region of the PJM system: (1) approval by MISO and PJM of the interregional Rockport-Duff-Coleman 345 kV transmission line,[42] which will eliminate all of the stability limitations at AEP's Rockport Coal Plant, and (2) re-configuration of the Sullivan/Breed substation including the addition of a third

[42] *Selection Report, Duff-Coleman EHV 345 kV Competitive Transmission Project, MISO, December 20, 2016, available at: https://www.misoenergy.org/Library/Repository/Study/Transmission%20Developer/20161220_FINAL_Selection%20Report_SRPT_v1.pdf*

765/345 kV autotransformer.[43] Notably, this is the station to which the Project interconnects with PJM.

Staff witness Mr. Lange expressed concern surrounding "issues under certain conditions"[44] in this region, especially when the Rockport-Jefferson 765 kV line is out-of-service. However, beyond the inherent flexibility of HVDC transmission projects, the upgrades represented by the Rockport-Duff-Coleman 345 kV transmission line, and the re-configuration and addition of a third autotransformer at Sullivan/Breed will support overall grid stability in this region.

**Q. Will a "major transmission upgrade" be necessary within PJM to interconnect the Illinois HVDC Converter Station?**

A. Staff witness Mr. Lange references SPP's confirmation of the SPP Criterion 3.5 study work (**Schedule AWG-10**) where SPP's consultant Excel Engineering, Inc., stated that if a special protection system is not an acceptable solution to the stability issues near the point-of-interconnection of the Illinois HVDC Converter Station, "then a major transmission upgrade or reduction in the size of the [Grain Belt Express Project] will have to be considered."[45] As I discussed in my direct testimony, this fact has already been accounted for in the business plans of Grain Belt Express where I described the required network upgrades in PJM including "[a] new AEP 765kV transmission line from

[43] See PJM Baseline upgrade B1465.1 and Supplemental project S0764 which have projected in-service dates of June 2017, *PJM RTEP upgrades status website, available at: http://pjm.com/planning/rtep-upgrades-status/construct-status.aspx*

[44] Staff Rebuttal Report, pp.55-56.

[45] Staff Rebuttal Report, p.56

the Sullivan Substation to Northern Indiana Public Service Company's new Reynolds substation ("Sullivan to Reynolds") at an estimated cost of $500 million."[46]

Since the focus of the SPP Criterion 3.5 studies is the SPP system and not PJM, and the PJM SIS report was not available at the time of the SPP study, the system topology within the PJM system was not properly represented within the SPP Criterion 3.5 studies.[47] While this did not affect analysis of impacts on the SPP system, no conclusions can be drawn from that SPP report about the impacts of the Project on the PJM system. The SPP Criterion 3.5 studies did not include the Sullivan-Reynolds network upgrade within their models, nor did those models include the third autotransformer discussed above and in my direct testimony.[48] As such, "major transmission upgrades" will exist to address the issues raised by Mr. Lange.

**Q. Even though Grain Belt Express is going through PJM's interconnection process, will the generators that interconnect to the Kansas HVDC Converter Station have to go through the PJM interconnection process as well?**

A. No. As I discussed in my direct testimony, at pages 23-27, Grain Belt Express will enter into an Interconnection Agreement with PJM regarding the Project's PJM delivery point at the Sullivan/Breed Substation in Indiana[49]. Grain Belt Express' customers will avail themselves of the rights conveyed in Grain Belt Express' Interconnection Agreement

[46] Direct Testimony of Dr. Anthony Wayne Galli, P.E, p. 26-27

[47] Schedule AWG-10, Figure 3-1, p. 10.

[48] Direct Testimony of Dr. Anthony Wayne Galli, P.E, p. 23, ll.12-18.

[49] AEP has a Sullivan 765kV substation and a Breed 345kV substation next to one another. It is understood that these are effectively the same substation and therefore I refer to the stations interchangeably or simply as "Sullivan/Breed."

with PJM.

**Q. Staff witness Mr. Stahlman asserted in the Staff Report on page 35 that because transmission customers that utilize the Grain Belt Express Project are not themselves going through a PJM interconnection process, they would be subject to PJM Tariff schedules. Is this correct?**

A. No. Mr. Stahlman cites Grain Belt Express' response to Staff Data Request 0035 which requires clarification. Mr. Stahlman asked: "Will the wind farms that connect directly to Grain Belt's converter station in Kansas be required to perform a generator interconnection study with a RTO? If so, which RTO? If not, why not?"

Grain Belt Express responded: "The wind generators that interconnect directly to the converter station in Kansas will be required to undergo an interconnection study process to ensure compliance with the Grain Belt Express Open Access Transmission Tariff and applicable NERC and regional reliability requirements. Pursuant to Grain Belt's FERC negotiated rate authority, Grain Belt Express will turn over administration of the Grain Belt Express project facilities to an RTO or RTO-like entity prior to commercial operation (in the case of Grain Belt that will be PJM). PJM, in their role as Transmission Provider on behalf of their Transmission Owner members, administer the generator interconnection procedures in accordance with the open access requirements of FERC."

The interconnection process described in the above response occurs in western Kansas near the Project's Kansas HVDC Converter Station. It does not occur at the Project's Illinois HVDC Converter Station or at the Sullivan/Breed substation at the Project's point of interconnection with PJM. Moreover, prior to PJM assuming

functional control of the Project, Grain Belt Express -- not PJM -- will perform any necessary studies. The Company, not PJM, will enter into interconnection agreements with generators. PJM will administer any new generator interconnection requests that are proposed for interconnection to the Kansas HVDC Converter Station after PJM assumes functional control of the Project. These new interconnection studies and agreements will convey rights to interconnect with the Project in Kansas. Generators will still be able to use the rights that the Grain Belt Express Project will receive through PJM's transmission interconnection procedures at the Project's point-of-interconnection with PJM.

**Q. Will transmission customers using service on the Grain Belt Express Project from Kansas (SPP) to Missouri (MISO) have to pay PJM rate schedules 1 and/or 1A, as the Staff Report suggests at page 35?**

A. No. Schedule 1 and 1A to the PJM Tariff are the traditional "Scheduling, System Control, and Dispatch Service" fees which are billed to transmission system users in PJM. They do not apply to MISO customers.

**Q. Is it possible to interconnect and operate the Project without the approval of the authorities charged with ensuring reliability of the transmission system in Illinois and Indiana?**

A. No. The Grain Belt Express Project cannot interconnect to the PJM-controlled transmission system without an executed Interconnection Agreement ("IA") and execution of an IA cannot be achieved until all Impact Studies have been completed. The responsibility to ensure a reliable interconnection to the AEP system belongs to Grain Belt Express as the future Transmission Owner and Transmission Operator of the Project, as well as to PJM and ReliabilityFirst Corporation.

e. SPP

i. Study Updates and Developments

**Q. Have there been any updates with SPP and ITC Great Plains since your direct testimony?**

A. Yes. On October 17, 2016, Grain Belt Express, SPP, and ITC Great Plains ("ITC") executed an IA[50] to interconnect the Project's Kansas HVDC Converter Station to the ITC system.

ii. Next Steps

**Q. Are there any additional studies outlined in the IA with SPP/ITC?**

A. Yes. As Staff witness Mr. Stahlman points out, a few studies remain to be completed before the Project can enter commercial operation. These studies will be completed as part of the HVDC design process.

**Q. Is it possible that additional transmission upgrades will be identified as a result of the updated Criterion 3.5 studies?**

A. Based on the results of the existing Criterion 3.5 study work, it is unlikely that any additional transmission upgrades would be required in order to accommodate the interconnection of the Kansas HVDC Converter Station. Instead, one or more Remedial Action Schemes (a/k/a Special Protection Systems) will be developed to ensure grid reliability when fault conditions on the Project or near the AC terminals of the Project cause a temporary injection of power into SPP at the Kansas HVDC Converter Station. These Remedial Action Schemes are required because the AC system in SPP was not

[50] *Interconnection Agreement Between Grain Belt Express Clean Line LLC and ITC Great Plains, LLC and Southwest Power Pool, Inc,* available at: http://etariff.ferc.gov/TariffSectionDetails.aspx?tid=1225&sid=208517

constructed to accommodate the full amount of power that will be produced by the generator facilities expected to interconnect to the Kansas HVDC Converter Station. Therefore any faults that result in a temporary halt of power flow on one or both poles (i.e. circuits) of the HVDC link may require immediate cross-tripping of some amount of interconnected generators to maintain stability of the BES in SPP. The SPP Criterion 3.5 studies and SPP's confirmation of these studies did successfully simulate any necessary Remedial Action Schemes designed to maintain stability of the Grain Belt Express Project generation during multiple-contingency events within SPP while maintaining operation of the Grain Belt Express Project facilities.[51]

**Q. Does the IA between Grain Belt Express and SPP/ITC limit the amount of generators that can interconnect to the Kansas HVDC Converter Station?**

A. No. Staff witness Mr. Stahlman asserts that the additional studies discussed above are identified in the IA because the initial SPP studies were performed under an assumption that there would be 3,500 MW of simultaneous delivery between the MISO and PJM converter stations.[52] On the contrary, the IA with SPP/ITC specifically acknowledges the Grain Belt Express Project as a "high voltage direct current electric transmission system and associated facilities with the capacity to deliver approximately 4,000 MW…."[53] SPP and ITC included the additional studies in the IA in order to update their models to reflect near-final HVDC assumptions, and to ensure another opportunity to review before more advanced Design-Level Studies proceed.

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[51] Schedule AWG-10, pp.7-8

[52] Staff Rebuttal Report, p. 26.

[53] *Interconnection Agreement Between Grain Belt Express Clean Line LLC and ITC Great Plains, LLC and Southwest Power Pool, Inc,* p.1, available at: http://etariff.ferc.gov/TariffSectionDetails.aspx?tid=1225&sid=208517

**Q. Is it possible to interconnect and operate the Project without the approval of the authorities charged with ensuring the reliability of the transmission system in Kansas?**

A. No. The Grain Belt Express Project cannot interconnect to the SPP-controlled transmission system without meeting all of the obligations within the IA. The responsibility to ensure a reliable interconnection to the ITC system belongs to Grain Belt Express, as well as to SPP and the SPP Regional Entity.

## III. ADDITIONAL INFORMATION AND CLARIFICATIONS PERTAINING TO OPERATIONS AND MARKET INTERACTIONS

**Q. The Staff Report at pages 34-36 raises issues about the bi-directional capability of the Project. Is the Grain Belt Express Project being designed to allow for bi-directional operation of the converter stations?**

A. Yes. HVDC converter stations are inherently capable of bi-directional functionality. The Grain Belt Express Project is being designed as a bi-directional, interregional transmission asset.

**Q. Is the Grain Belt Express Project being studied within the interconnection processes of SPP, MISO, and PJM to operate in modes other than the baseline modes represented in testimony?**

A. No. Grain Belt Express has not requested specific approval to withdraw power from the SPP, MISO, or PJM markets, nor has Grain Belt Express specifically requested approval to inject power into the SPP market. However, this does not preclude Grain Belt Express transmission customers from making such requests in the future including in day-to-day operation of the Project without long-term access rights.

**Q. Do any of SPP, MISO and PJM have existing processes that could be used to withdraw power from those markets for transmission exports by the Project?**

A. Yes. PJM already has a process to request withdrawal of energy through their interconnection process and a means to administer requests of transmission service to export from the PJM market. SPP also has existing procedures to export from and sell into their market. Generators that are directly connected to the Kansas HVDC Converter Station but wish to inject power into the SPP market (due to short-term maintenance outages, for example) would be able to do so by pre-arranging interchange reservations using SPP's Market Import Service, which would not incur a transmission service fee from SPP. Options exist to withdraw energy from the SPP market as well through, for example, procurement of point-to-point transmission service to export power from SPP to adjacent transmission systems (which could include the Grain Belt Express Project). SPP and PJM's existing processes to move power to MISO support Grain Belt Express witness Mr. Pfeiffer's assumption that the Missouri HVDC Converter Station is able to deliver 500 MW from SPP and PJM in his Loss of Load Expectation ("LOLE") study.

Finally, while MISO does not have an existing interconnection process to accommodate energy withdrawal from their market, MISO does have existing processes for MISO Market Participants to procure point-to-point transmission service to export power from MISO to adjacent transmission systems (which could include the Grain Belt Express Project). Additionally, the MHTT, which I discussed previously, is developing a process for requesting, studying, and assigning energy withdrawal rights for HVDC interconnections.

**Q. To the extent that RTO processes for exports and bi-directionality have not been fully developed, is there any reason to expect that the processes will not be developed in the future?**

A. No. Based on my experience at SPP and other organizations, RTOs regularly develop new processes to manage their interactions with adjacent transmission systems. A transmission flow into or from the Project is not impossible just because a new RTO process may be needed. The benefits of operating the Project in other modes of operation should not be ignored.

**Q. In light of comments in the Staff Report on page 35, how will ancillary services within the AC collector system be handled?**

A. Staff witness Mr. Stahlman indicated that when he filed his testimony the response from Grain Belt Express to Staff Data Request No. 0046 regarding ancillary services on the Kansas AC collector system was still pending. The response is offered here in order to address Mr. Stahlman's inquiry.

Question: How does GBE expect ancillary services, such as voltage and frequency regulation, to be maintained on its AC collector system?

Response: Grain Belt Express is being designed to consider the needs of the AC collection system in order to ensure power delivery from the interconnected generator facilities to the Kansas [HVDC] Converter Station and beyond. This includes the reactive power requirements along these collector lines to ensure proper voltages for effective power delivery. In effect, the interconnected generator facilities, tie-lines to SPP, HVDC facilities, and tie-lines to MISO and PJM are to be looked at as a single, dispatchable aggregate whereby ancillary services, losses, and transmission service are all provided as a result of the design of the aggregate facilities.

As an example, frequency regulation is accommodated through the design of the controls between the HVDC facilities, SPP tie-line facilities, and the generator facilities. As generator outputs change, the measured electrical current outputs are communicated to the HVDC facility controls resulting in proper setting of the power order set-point of the HVDC facilities. This arrangement also accommodates scheduling or limiting exchange

with the SPP system with an integrated power flow controller for those SPP tie-line facilities.

**Q. Has SPP, the Staff of the Kansas Corporation Commission or ITC Great Plains (the transmission owner with which the Project will interconnect) raised any concerns regarding the maintenance of ancillary services at the Project's AC collector system?**

A. No, they have not.

**Q. Please address Staff witness Sarah Kliethermes' claim that the Project will cause reserve requirements to increase in MISO.**

A. Ms. Ms. Kliethermes stated in the Staff Report:[54]

"In fact, Staff is not aware of any reason that the converter station would not cause the need for contingency planning of a sudden failure of a 500MW generator in Northeast Missouri. To the extent that contingency planning for the region would need to account for the sudden failure of a 500MW generator, **this would increase reserve margin requirements to preserve existing reliability**."

In response to data requests from Grain Belt Express seeking clarity on Staff's concerns surrounding reserve margin requirements, Ms. Kliethermes seems to backtrack on her statement in the Staff Report. In response to the Company's data requests, she stated that her use of the terms "the region," "contingency planning," and "reserve margin requirements" was "intentionally vague" because Ms. Kliethermes was "uncertain" what Grain Belt Express witness and former FERC Commissioner Suedeen Kelly meant when she used these terms in her direct testimony. See **Schedule AWG-13**, Staff Response to Data Request 9(a)-(c) at pp. 8-9. Subsequently, Ms. Kliethermes conceded that:

[54] Staff Rebuttal Report, p.40.

"Staff has not stated or alleged that the 500MW injection from the Missouri converter station has any impact to **increase** or decrease the **reserve margin requirements** for "the region" as described by Ms. Kelly."

Id., Data Response 9(e) at p. 9 (emphasis added).

**Q. What is your response to Ms. Kliethermes' statement at page 40 of the Staff Report that the Project could increase "reserve margin requirements to preserve existing reliability?"**

A. In using the term "reserve margin requirements," it is unclear whether Ms. Kliethermes refers to "reserve margins" or "contingency reserves." In an attempt to seek clarity on Ms. Kliethermes' concern Grain Belt Express submitted data requests asking for Staff's understanding of how reserve margins are established in the region. Ms. Kliethermes responded with links to a NERC document and website for "reserve margins".[55] This suggests that Ms. Kliethermes is talking about "reserve margins" (otherwise referred to as "resource adequacy") on page 40 of the Staff Report. On the other hand, Grain Belt Express also asked for "relevant citations or documentations which support Staff's belief [of] the potential for additional reserve margins to be added because of the interconnection in Missouri." Ms. Kliethermes responded that "Staff does not agree that this question accurately states Staff's belief. Staff understands that every interconnection is studied in an N-1-1 contingency state."[56] This suggests that Ms. Klietheremes was talking about "contingency reserves" on page 40 of the Staff Report.

Either way, her claim is incorrect. "Reserve margin" refers to capacity reserves to ensure enough generation is available to meet load at all times—a requirement often

[55] Schedule AWG-13, Question #8(a), p.7.

[56] Schedule AWG-13, Question #8(d), pp.7-8.

termed "resource adequacy." Using this translation of the words "reserve margin requirement," Ms. Kliethermes' assertion implies that Grain Belt Express' injection causes the need for more generation to meet peak load. This cannot be right. A power injection into Missouri does not create the need for more generation to be available in case power from that power injection is no longer available. That assertion would imply that for every power plant that is built, one must build an additional backup plant; this is not the case.

Alternatively, Ms. Kliethermes may be referring to contingency reserves. Contingency reserves ensure the reliability of the electric grid if there is a sudden outage. However, the amount of contingency reserves required is typically determined by the size of the largest single generator in the region of interest. The portion of Missouri within MISO's purview (Columbia Water and Light and Ameren Missouri) is Load Resource Zone #5 (LRZ-5). Grain Belt Express' 500 MW power injection would not increase the contingency reserve margin requirements in LRZ-5 because it is not the largest injection in the region. A 500 MW injection is smaller in size by Ameren Missouri's units like the Labadie coal units (612 MW each) and Rush Island coal units (613 MW each), and Associated Electric Cooperative's Thomas Hill unit #3 (665 MW) and New Madrid units (575 MW each). It is dwarfed in size by Ameren Missouri's Callaway Nuclear Plant (1,224 MW). Thus, in no way does a 500 MW contingency from the loss of the Project's Missouri HVDC Converter Station create an increase to the contingency reserve requirements or the resource adequacy requirements to the State of Missouri.

## IV. RESPONSE TO STAFF'S CONCERNS RELATED TO THE LEVEL OF ENGINEERING DESIGN

**Q. Is it reasonable that specific transmission structure designs for the Grain Belt Express Project are not available since the siting process has not been completed and certain regulatory approvals still need to be issued?**

A. Yes. Staff witness Mr. Stahlman states that he is unclear why the Project design has not been further developed.[57] He refers to the Company's response to an intervenor's data request seeking structure height information regarding the Missouri and Mississippi River crossings. Grain Belt Express advised that this information will not be known until a final route is established, siting is complete, and a specific location is confirmed. The design of such structures is not only impacted by those location decisions, but also by the location of adjacent structures. Moreover, the cost to design large and robust river-crossing structures is significant. It would be imprudent to do so without accurate site and geotechnical information to determine the relevant soil conditions.

**Q. Please address Staff witness Stahlman's claim on page 22 of the Staff Report that there is insufficient information to conclude that the Project is economically feasible because the RTOs have insufficient information on the design of the Project to perform final and conclusive studies.**

A. As discussed above in Section II, the only studies that affect the need for network upgrades (and, therefore, the economics of the Grain Belt Express Project) are the Impact Studies which have been performed in one form or another and only require refreshing prior to construction. Design-Level Studies will need to be performed at each point-of-

[57] Staff Rebuttal Report, p.33-34.

interconnection, but these studies will not change the scope or number of network upgrades. Staff acknowledges this fact when, in response to data requests from Grain Belt Express requesting Staff's understanding of the mitigation measures for control interactions (with other HVDC facilities) [58] sub-synchronous torsional interactions ("SSTI" a/k/a sub-synchronous resonance studies), [59] and harmonic performance compliance,[60] Mr. Lange responded with lists of mitigation measures and what appear to be textbook excerpts, none of which include a single reference to network upgrades. See **Schedule AWG-11** Staff Response to Data Requests 12, 13, and 14 at pp. 6-13.

The combination of (1) the January and March, 2013 SPP Criterion 3.5 study work performed by Siemens PTI, (2) the September 2013 SPP Criterion 3.5 verification studies performed by SPP, (3) the March 2015 Facilities Study performed by ITC Great Plains, (4) the October 2012 Feasibility study performed by MISO, (5) the November 2014 SPA Study and January 2017 Optional Study performed by Ameren Missouri, (6) the Project HVDC model development and stability testing performed by TransGrid Solutions, (7) the January 2013 Feasibility Study performed by PJM and AEP, and (8) the October 2014 System Impact Study (and ongoing re-tooled System Impact Study) performed by PJM and AEP, clearly show that the network upgrades will not significantly change from what has been identified to date.

[58] Schedule AWG-11, Question 12, pp.6-7. Requested in reference to Staff Rebuttal Report, pp. 59-60.

[59] Schedule AWG-11, Question 13, pp.7-8. Requested in reference to Staff Rebuttal Report, pp. 26, 59.

[60] Schedule AWG-11, Question 14, pp.8-13. Requested in reference to Staff Rebuttal Report, pp. 60-61.

## V. RESPONSE TO STAFF'S CONCERNS RELATED TO SAFETY AND COORDINATION WITH NEARBY UTILITIES

**Q. Regarding the Staff's discussion in Section IV(b) at pages 47-51 of the Staff Report, is it safe to operate an HVDC transmission line that crosses a natural gas pipeline?**

A. Yes. To my knowledge, there is not a single overhead HVDC transmission line in the United States that does not cross or parallel one or more natural gas pipelines. This fact is presented in **Schedules AWG-14, AWG-15, and AWG-16** which are maps showing the HVDC transmission lines located in western North America, central North America, and eastern North America, respectively, along with all instances where those facilities cross major natural gas pipelines.

**Q. Has any Company witness identified measures that Grain Belt Express will implement to protect utilities with underground utility infrastructure?**

A. Yes. As Staff witness Ms. McNelis noted on page 48 of the Staff Report, I provided Schedule AWG-5 with my direct testimony which is the design criteria of the HVDC transmission line. These criteria include the design characteristics[61] of the Dedicated Metallic Return Conductors ("MRC") which is also referred to as a Dedicated Metallic Return ("DMR"). Ms. McNelis correctly acknowledges on page 48 of the Staff Report that use of a DMR prevents "stray current flow through the ground under normal conditions." In fact, use of a DMR prevents current from flowing into the ground in all defined operating modes.

**Q. What occurs when lightning strikes the line or a structure on the line that is paralleling or crossing a pipeline and a faulted condition occurs?**

[61] Schedule AWG-5, pp. 20, 22, and 29.

A. Fault currents that enter the ground as a result of a lightning strike are similar whether the transmission line is AC or DC. Although the waveforms of the transient currents in faulted conditions of AC and DC projects have similarities, DC projects limit the fault current to approximately two times (no more than three times) the full load current since the fault is only fed from the converter. AC faults, on the other hand, are fed from both ends the AC line resulting in a fault magnitude that will be larger in size and duration than a fault fed from a DC project of a similar voltage level.

Due to the similarity of the faulted waveforms, mitigation techniques that are used for an HVAC line can be applied to HVDC lines. The Canadian Association of Petroleum Producers developed guidelines on impact mitigation for HVDC line impacts on pipelines,[62] which the Grain Belt Express Project will follow to the extent applicable. To my knowledge, these guidelines are the only published recommendations in the energy industry outside of various academic and trade publications.

## VI. RESPONSE TO STAFF'S RECOMMENDED CONDITIONS

**Q. Which of the conditions proposed in the Staff Report do you accept?**

A. A list of conditions recommended by Staff is included in Schedule DAB-9, attached to the surrebuttal testimony of Grain Belt Express witness David Berry. On behalf of Grain Belt Express, I accept, without modification, the following conditions:

- All conditions in Section II, Interconnection Studies
- All conditions in Section III, Nearby Utility Facilities, with one minor addition to each Condition 1 and Condition 4.
- All conditions in Section IV, Emergency Restoration Plans

[62] Staff Rebuttal Report, p.48 (see fn 72).

- Conditions 12, 13, and 14 within Section V, Construction and Clearing

**Q. Which of the conditions proposed in the Staff Report do you not accept?**

A. Grain Belt Express does not accept Staff's recommendation on page 7 of the Staff Report that it submit "a modified plan to address congestion should the ATXI Mark Twain project not proceed as planned …"[63] Any plan to address congestion or other related issues is the responsibility of the relevant RTO, not the entity that proposes to build a project.

**Q. Is there a quick summary of the issues from the Staff Report that you address in this surrebuttal testimony?**

A. Yes. **Schedule AWG-17** includes both, a listing of the issues with references to where each is discussed in the Staff Report, as well as responses to each issue with references to where those responses can be found in my testimony.

**Q. Does this conclude your surrebuttal testimony?**

A. Yes.

[63] Staff Rebuttal Report, p. 7.

**BEFORE THE PUBLIC SERVICE COMMISSION**
**OF THE STATE OF MISSOURI**

| | | |
|---|---|---|
| In the Matter of the Application of Grain Belt Express Clean Line LLC for a Certificate of Convenience and Necessity Authorizing it to Construct, Own, Control, Manage, Operate and Maintain a High Voltage, Direct Current Transmission Line and an Associated Converter Station Providing an Interconnection on the Maywood-Montgomery 345 kV Transmission Line | ) ) ) ) ) ) ) | Case No. EA-2016-0358 |

**AFFIDAVIT OF ANTHONY WAYNE GALLI**

**STATE OF** Texas )
) **ss**
**COUNTY OF** Harris )

Anthony Wayne Galli, being first duly sworn on his oath, states:

1. My name is Anthony Wayne Galli. I am Executive Vice President – Transmission and Technical Services for Clean Line Energy Partners LLC.

2. Attached hereto and made a part hereof for all purposes is my Surreuttal Testimony on behalf of Grain Belt Express Clean Line LLC consisting of 44 pages, having been prepared in written form for introduction into evidence in the above-captioned docket.

3. I have knowledge of the matters set forth therein. I hereby swear and affirm that my answers contained in the attached testimony to the questions therein propounded, including any attachments thereto, are true and accurate to the best of my knowledge, information and belief.

Anthony Wayne Galli

Subscribed and sworn before me this 21st day of February, 2017.

Notary Public

My commission expires: 1/6/2018

DORCAS RUTH O'QUINN
Notary Public, State of Texas
Comm. Expires 01-06-2018
Notary ID 12966547-8