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Issues: Interconnection Issues and Congestion
Witness: Dr. Wayne Galli
Sponsoring Party: Grain Belt Express Clean Line LLC
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MISSOURI PUBLIC SERVICE COMMISSION

CASE NO. EA-2014-0207

SURREBUTTAL TESTIMONY OF

DR. ANTHONY WAYNE GALLI, P.E.

ON BEHALF OF

GRAIN BELT EXPRESS CLEAN LINE LLC

October 14, 2014

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I. INTRODUCTION

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"), the ultimate parent company of Grain Belt Express Clean Line LLC ("Grain Belt Express" or "Company"), the Applicant in this proceeding.

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

A. Yes, I have previously submitted direct testimony on March, 26, 2014, and additional direct testimony dated June 27, 2014.

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

A. I am responding to certain issues raised in the rebuttal testimonies of other parties in this proceeding, including witnesses representing Commission Staff, the Missouri Landowners Alliance ("MLA"), Eastern Missouri Landowners Alliance d/b/a Show Me Concerned Landowners ("Show Me"), Rockies Express Pipeline, and Christina Reichert. Additionally, I will provide an update on the Grain Belt Express Project's interconnection studies with PJM.

Q. Please summarize your testimony's organization.

A. Section II of my testimony addresses Commission Staff's recommendations for conditions on Grain Belt Express' certificate of convenience and necessity ("CCN"). Section III addresses the recommendations for CCN conditions proposed by Rockies Express Pipeline. Section IV addresses Staff's concern that the Project may create transmission congestion and other issues related to the Project's interconnection. Section V responds to issues related to the Project's technical specification, including its

power levels and design criteria. Section VI addresses operational issues raised in rebuttal testimony submitted by other parties in this proceeding.

II. RESPONSE TO STAFF CONDITIONS

Q. Commission Staff recommended a number of conditions to the Company's CCN. What your response to these conditions?

A. Schedule DAB-14 to David Berry's surrebuttal testimony summarizes the Company's response to Staff's proposed conditions. Below I explain in more detail the Company's position with respect to conditions relating to the subject matter of my testimony in this proceeding.

Q. What is the Company's response to the specific technical and engineering conditions recommended by Staff witness Robert Leonberger?

A. Below is the response to each of the recommendations raised in the rebuttal testimony of Mr. Leonberger:

i. Page 5, lines 5-7: Mr. Leonberger recommends that *"the Commission limit the authority it gives for building the HVDC transmission line in any CCN to construction of a HVDC transmission line built with DMR [dedicated metallic return] conductors."*

Response – Grain Belt Express finds this condition acceptable. The Project has been designed as such and will be built utilizing DMR conductors.

ii. Page 6, lines 2-7: Mr. Leonberger recommends that *"the Commission limit any CCN it issues in this case by explicitly requiring the installation of protection and control safety systems that will automatically de-energize the system when an abnormal or fault condition occurs. Staff also recommends that the Commission condition any such CCN by requiring proof to the Commission that these safety*

systems are operational prior to commercial operation of the Grain Belt Express HVDC electric transmission line."

Response – Grain Belt Express find these two conditions acceptable and to be good practice both from the aspect of public safety and the protection of equipment. In the absence of these conditions, the Company would have implemented appropriate control and protection measures, but there is no objection to formalizing this commitment.

iii. Page 6, line 22 to page 7, line 7: Mr. Leonberger recommends that Grain Belt Express conduct studies that include *"the effect of tower footing groundings, if used; analysis of metallic underground facilities, other AC lines, and telecommunications facilities within a half a mile of the HVDC transmission line; analysis of metallic underground facilities, other AC lines, and telecommunications facilities within two miles of the HVDC converter station, a determination whether there are locations where the HVDC line parallels a pipeline and an existing AC line and, if so, whether there are any combined effects on steel pipelines (and underground metallic facilities); a determination of how the interference study will be conducted (for example, continuous 24-hour recordings at a certain time of year); and the effects of the HVDC transmission line exiting the converter station."*

Response – Grain Belt Express finds this recommendation acceptable but has concerns on the Commission specifying distances. Regardless of the condition, the Company will perform all appropriate technical studies to assess the potential impacts to subsurface utility facilities. However, with regard to the distance from

the transmission line (1/2 mile) and from the converter station (two miles) to be studied, Grain Belt Express proposes that the appropriate distances be determined by an engineering firm well versed in such analysis. In order to ensure that the studies review all subsurface utility facilities that are potentially impacted, the Company will, with assistance from an appropriate expert and input from Staff, identify all potentially impacted subsurface utility facilities and incorporate them into the studies. Limiting the study ranges to any arbitrary distance may not capture all affected subsurface utilities, or it may include some which have no practical need of study.

iv. Page 8, lines 11-21: Mr. Leonberger recommends that *"if the Commission issues Grain Belt Express a CCN in this case it include as a condition that if any of the studies show that mitigation measures are identified/needed, those measures must be in place prior to commercial operation of the HVDC transmission line. The Commission should also require that these studies be made available to Staff and affected facility owners at least 45 days prior to commercial operation of the HVDC transmission line and that these engineering studies/analyses are conducted by persons knowledgeable in (1) HVDC power lines, (2) DC-to-AC converter stations, (3) pipeline cathodic protection systems, (4) corrosion of underground metallic facilities, (5) interference with AC utility lines, (6) interference with telecommunications facilities, and (7) the effects of DC and AC interference on the facilities identified in Exhibit 3 of Grain Belt Express' Application."*

Response – Grain Belt Express finds this condition acceptable and considers it to be a best practice and in the interest of all parties involved.

v. Page 9, lines 12-15: Finally, Mr. Leonberger recommends that *"the Commission order Grain Belt Express to file annual status updates on discussions with Staff regarding the need for additional studies, a summary of the results of any additional studies, and any mitigation measures that have been implemented to address underground metallic structures, telecommunications facilities, and AC lines."*

Response – Grain Belt Express accepts this condition as reasonable and will prepare an annual status update per Staff's recommendation.

Q. What is your response to the specific technical and engineering conditions recommended in the rebuttal testimony of Staff witness Shawn Lange?

A. Below is the response to each of the conditions recommended by Mr. Lange:

i. Page 2, lines 13-30: Mr. Lange recommends that*" the Commission order Grain Belt Express to provide for Commission acceptance, the following items:*

- *Completed Storm Restoration Plans for the proposed project,*
- *The Interconnection Agreement with SPP,*
- *The Interconnection Agreement with MISO, and*
- *The Interconnection Agreement with PJM,*
- *MISO Feasibility Study,*
- *MISO System Planning Phase Study,*
- *MISO Definitive Planning Phase Study,*

- *SPP Dynamic Stability Assessment of Grain Belt Express Clean Line HVDC Project,*
- *SPP Steady State Review,*
- *SPP System Impact Study,*
- *PJM Feasibility Study,*
- *PJM System Impact Study,*
- *PJM Facilities Study, and*
- *Any further study necessary for interconnection with any of SPP, MISO, or PJM"*

Response – Although Grain Belt Express does not understand the term "acceptance" in this context, it agrees to submit such reports to the Commission as they become available. Therefore, Grain Belt Express suggests replacing the phrase "to provide for Commission acceptance" with "to submit to the Commission when completed."

ii. Page 3, lines 1-4: Mr. Lange recommends that*" the Commission order Grain Belt Express to comply with the appropriate NERC standards for a project of this scope and size, National Electric Safety Code for a project of this scope and size, 4 CSR 240-18.010, and the Overhead Power Line Safety Act section 319.075 et al."*

Response – Grain Belt Express finds this condition acceptable.

iii. Page 3, lines 5-9: Shawn Lange recommends that*" the Commission order Grain Belt Express to provide to the Commission completed, documentation of the Grain Belt Express plan, equipment, and engineering drawings to achieve compliance*

with NERC standards for a project of this scope and size, National Electric Safety Code for a project of this scope and size, 4 CSR 240-18.010, and the Overhead Power Line Safety Act section 319.075 et al."

Response – Grain Belt Express finds this condition acceptable and will provide all as-built drawings and final design documentation.

iv. Page 3, lines 10-12: Mr. Lange recommends that "*the Commission order Grain Belt Express to meet a short-circuit ration of at least two, at the Kansas converter station, Missouri converter station, and the converter station near Sullivan, Indiana."*

Response – Grain Belt Express cannot accept this condition because: (1) it confuses a "rule of thumb" for an electric reliability standard; (2) it could be extremely burdensome and expensive; and (3) because it fails to recognize that the RTO interconnection processes will assure a reliable interconnection.

In the implementation of an HVDC project, a short-circuit ratio of 2.0 is a "rule of thumb" when initially analyzing whether additional measures may be needed to support robust voltage and system recovery following a fault. It is <u>not</u> an electric reliability or safety standard, such as a NERC standard, that must be met in all circumstances. The Commission should not impose a technical rule of thumb as an inflexible condition that could lead to a large and expensive increase in the transmission upgrades needed to accommodate the Project. Modern HVDC control systems and fast-acting dynamic reactive equipment such as static var compensators ("SVC") or static synchronous compensators ("STATCOM") allow many existing HVDC projects to operate reliably in systems with a short-circuit

ratio less than two. If these technologies are more appropriate than a large number of transmission upgrades, Grain Belt Express should be allowed to implement them. Examples of successful HVDC projects operating in a short-circuit ratio environment of around 2.0 or less include: Basslink (connecting the Australian mainland to Tasmania built by Siemens), Haenam-Cheju (connecting the South Korean mainland and island of Jeju, built by Alstom), the McNeill project in Canada, the High Gate project in Vermont, and the Garabi project between Brazil and Argentina.

Importantly, the RTOs and incumbent utilities, with which the Project will interconnect, study stability and voltage issues related to the Project and assure that its interconnection is robust and reliable. These studies take into account the totality of system conditions and the Project's control systems. The RTOs, interconnecting utilities, and the Company can be relied upon to ensure a reliable interconnection as mandated by NERC standards and enforce those standards under FERC oversight. The Commission should not prescribe to the RTOs that they must build more upgrades to reach an arbitrary short circuit ratio if there is a more appropriate solution.

v. Page 3, lines 13-16: Mr. Lange recommends that "*the Commission order Grain Belt Express to provide to the Commission as completed, documentation of the Grain Belt Express plan, equipment, and engineering drawings to achieve a short-circuit ratio of at least two, for each converter station.*"

Response – Grain Belt Express disagrees with this recommendation for the reasons stated above. However, the Company agrees to provide, when completed,

documentation that shows the Project meets all the requirements of the utilities and RTOs with which the Project will interconnect.

vi. Page 7, lines 12-14: Mr. Lange recommends that "*any Granting of a Certificate of Convenience and Necessity be conditioned on Grain Belt Express providing the Storm Response Plan to the Commission."*

Response – Grain Belt Express finds this condition acceptable as it fully intends to develop necessary storm/emergency restoration plans for the Project's transmission line and converter stations prior to commercial operation. Grain Belt Express will makes these plans available to Commission Staff once they have been developed and finalized.

III. RESPONSE TO ROCKIES EXPRESS PIPELINE CONDITIONS

Q. In his rebuttal testimony, Robert Allen, on behalf of Rockies Express Pipeline LLC ("REX"), indicates several possible concerns of HVDC lines and interactions with gas pipelines. Do you share those concerns?

A. Mr. Allen raises the general concerns of pipeline coating damage, pipeline corrosion, loss of cathodic protection, and damage to corrosion control and monitoring equipment. These are indeed appropriate issues to study whenever a new piece of infrastructure parallels a gas pipeline. In fact, if another gas pipeline paralleled the REX pipeline, it is my understanding that there would need to be coordination of the cathodic protection equipment, and of the monitoring and control equipment between the two pipelines. It is not uncommon for pipelines and transmission lines to parallel each other and these concerns are commonly dealt with through coordinated mitigation studies. The Company is committed to studying the potential impacts of the Project on the REX pipeline and all potentially affected subsurface utility facilities

Q. What is the Company's response to the technical recommendations suggested by Mr. Allen in his rebuttal testimony?

A. Below are the responses to eight of the recommendations suggested by Mr. Allen in his rebuttal testimony. Recommendation #1 is discussed in Company witness Timothy Gaul's surrebuttal testimony and in my response to Recommendation #7 because, as Mr. Allen noted on page 9 of his rebuttal, both relate to monitoring systems. Regarding Mr. Allen's comment in Recommendation #1 that "[i]deally, where the HVDC line parallels REX's pipeline, it should be located 1,000 feet or more away from the pipeline," Grain Belt Express expressly disagrees. Such a policy is not a common industry practice, not a good routing practice, and unnecessary from a safety perspective.

i. Recommendation #2 at Page 10, lines 7-11: Mr. Allen recommends that Grain Belt Express "*be required, after an exact route for the HVDC line is determined and prior to the commencement of construction, to conduct a DC interference analysis to determine the mitigation measures necessary to prevent the negative effects to the pipeline and related facilities that I outlined.*"

Response – Grain Belt Express finds this recommendation acceptable and will perform such analysis in coordination with all affected pipelines.

ii. Recommendation #3 at Page 10, lines 21-23 to page 11, lines 1-2: Mr. Allen recommends that Grain Belt Express *"be required to confirm all data or other assumptions about REX's pipeline system including routing, soil resistivity, cathodic protection systems and pipeline facilities, coating type and condition, wall thickness, and other technical parameters with appropriate REX personnel before engaging in the DC interference analysis."*

Response – Grain Belt Express finds this recommendation acceptable.

iii. Recommendation #4 at Page 11, line 22: Mr. Allen recommends "*that all crossings of the HVDC line over the REX pipeline be required to be at 90 degrees angles, plus or minus 10 degrees.*"

Response – Grain Belt Express does not agree to this recommendation as presented. In response to a data request regarding this recommendation, Mr. Allen conceded that there were no industry standards or best practices supporting this recommendation nor any technical studies substantiating this arbitrary requirement.[1] Some degree of flexibility is therefore appropriate. Grain Belt would agree to the recommendation if it were reworded to state: "When engineering, routing, and cost constraints allow, as reasonably determined by Grain Belt Express, all crossings of the HVDC line over the REX pipeline will be at 90 degree angles, plus or minus 10 degrees."

iv. Recommendation #5 at Page 12, line 6: Mr. Allen recommends that Grain Belt Express in regard to crossing structures "*not be permitted to construct towers closer than 300 feet from the pipeline.*"

Response – Grain Belt Express does not agree to this recommendation as presented. In response to a data request on this recommendation, Mr. Allen conceded that there were no industry standards or best practices supporting this recommendation nor any technical studies substantiating this requirement.[2] Mr.

[1] *See* Response 5 to Rockies Express Responses to Grain Belt Express' First Set of Data Requests, attached as Schedule AWG-11.
[2] *See* Response 6 to Rockies Express Responses to Grain Belt Express' First Set of Data Requests, attached as Schedule AWG-11.

Allen stated that he had assumed a 600' span between structures and that 300' was the mid-span. Grain Belt Express will agree to provide REX with preliminary and final pole locations and to meet with REX regarding crossing permits, the assessment of impacts, and the need for appropriate mitigations.

v. Recommendation #6 at Page 12, lines 18-22: Mr. Allen recommends *"that as to grounding the towers nearest [sic] pipeline crossings, GBX be required to locate (install) any ground rods or other local methods of grounding towers on the side of the tower farthest from the pipeline. If additional grounding methods at towers near crossing are required, only ground rods or ground wells are acceptable."* Mr. Allen further recommends that Grain Belt Express *"not be permitted to use counterpoise methods of grounding in tower spans where the pipeline will be crossing between towers."*

Response – Grain Belt Express finds this recommendation unacceptable as proposed. Studies will be completed in collaboration with the potentially impacted utilities, including Rockies Express Pipeline, that operate nearby underground facilities. The studies will determine what grounding techniques are appropriate. Rather than impose specific engineering restrictions before the issues are actually understood in detail, Grain Belt Express suggests that the best engineering decisions can be made after the conclusion of the applicable studies.

vi. Recommendation #7 at Page 13, lines 14-17: Mr. Allen recommends *Grain Belt Express "install a DC voltage monitoring system at each crossing of the HVDC line and REX's pipeline. GBX [the Company] should be required to provide the*

specifications and capabilities of any proposed system to REX for REX's prior review and approval."

Response – Grain Belt Express finds this recommendation unacceptable as proposed. Studies will be completed in collaboration with the potentially impacted utilities operating underground facilities, including Rockies Express Pipeline, and will determine what voltage monitoring systems are required. As with Recommendation #6, Grain Belt Express suggests that the best engineering decisions can be made after the conclusion of the applicable studies. Grain Belt Express can commit, however, to implement the voltage monitoring that is prescribed by the technical studies.

vii. Recommendation #8 at Page 14, lines 14-17: Mr. Allen recommends *Grain Belt Express "be required to immediately notify REX pipeline operations personnel if and when a fault occurs <u>anywhere</u> on the HVDC line, and to disclose the approximate location of the fault condition, the magnitude and duration of the fault current situation, and the time when the system returned to normal operation."*

Response – Grain Belt Express disagrees with this recommendation as premature. The applicable DC interference studies, to be conducted by an independent engineering firm, should determine the notice requirements and need for voltage monitoring devices to provide this notice. Grain Belt Express can commit, however, to provide the notice that is recommended by the technical studies to be conducted with Rockies Express Pipeline.

viii. Recommendation #9 at Page 14, lines 16-17: Mr. Allen recommends *Grain Belt Express "be required to conduct DC interference analysis with respect to the converter stations."*

Response – Grain Belt Express finds this recommendation acceptable since it already intends to follow best utility practices, to perform studies assessing the impact of faulted conditions on subsurface utility facilities near the converter station, and to implement any necessary mitigation measures.

IV. INTERCONNECTION ISSUES AND RESPONSE TO STAFF'S CONCERN ABOUT CONGESTION

Q. On page 11, line 18 of his rebuttal testimony Shawn Lange discusses Staff concerns with the "MISO Steady State review study". Do you share Mr. Lange's concern regarding the congestion in the area and the studies that he has referenced?

A. No, I do not. Mr. Lange actually points to the studies that were conducted by Siemens PTI at Clean Line's request and confirmed by Southwest Power Pool ("SPP") as part of the SPP Criteria 3.5 studies, not the MISO feasibility analysis. As I stated in my direct testimony at pages 11-13, the SPP Criteria 3.5 studied the impacts of the Grain Belt Express Project on the SPP system and did not focus on the MISO footprint, though the area was indeed monitored and MISO participated in the studies. The MISO feasibility study (attached as Schedule AWG-6 to my direct testimony) is MISO's view of the interconnection under the MISO and Ameren Missouri interconnection requirements, and it clearly indicates that there are no thermal overloads associated with the cases they have studied.

Q. Why is the MISO feasibility study a more reliable view of congestion at the point of the Project's injection?

A. The MISO feasibility study, unlike the SPP Criteria 3.5 Studies, focuses on the MISO system and the deliverability of the Project's injection to load in MISO during steady state conditions. Further, the base case of the SPP Criteria 3.5 studies was, in essence, an N-1 scenario where one pole of the HVDC converter had tripped and approximately 1,800 MW was being injected into the SPP grid in western Kansas. If such a contingency occurs, the generation in Kansas connected to the Project would be curtailed or tripped offline in a period of less than one second. Thus, any congestion in MISO that occurs during such a contingency would be extremely short-lived.

Q. Should the overloads that were seen in the SPP study, but that were mitigated by the MISO Multi-Value Portfolio ("MVP") projects be a cause for concern if there is a delay in the implementation of the MVPs?

A. No, I do not believe they raise a concern. As noted above, any such congestion would be extremely short lived and cured by the curtailment or tripping of the wind generation connected to the Project.

Q. In his rebuttal testimony at page 11, lines 17-19, Mr. Lange asserts that the existence of a Special Protection Scheme ("SPS") at the Ameren Missouri's Audrain CT plant indicates that the area is congested. Do you agree with this assertion?

A. No. I understand that if the Audrain combustion turbines are dispatched at 100% and the line(s) leaving Audrain heading south trip, the SPS reduces the generator dispatch unit to prevent an overload at Palmyra due to increased flows to the north. An SPS is designed to deal with certain contingency situations that require a generator to respond over a very short time interval; it is not designed to deal with transmission congestion under normal operating conditions.

In a nodal LMP market such as MISO, the security constrained economic dispatch manages congestion under normal conditions. The dispatch issues generation instructions to minimize cost subject to transmission constraints. In the event transmission congestion occurs, it will show up in the LMPs received by a generator at a specific location.

Q. Does the evidence regarding LMPs near the Project's point of injection indicate that congestion is a common issue?

A. No, as discussed in the surrebuttal testimonies of David Berry and Robert Cleveland, neither historical LMPs nor the Company's PROMOD analysis indicate that congestion is a common or significant issue.

Q. Is there any reason to believe, as suggested by Staff witness Sarah Kliethermes at page 10, lines 10-14 of her rebuttal testimony, that the Project will exacerbate existing congestion issues and could cause an RTO to recommend a new transmission upgrade to relieve that congestion?

A. No. In the MISO planning process, transmission projects to relieve congestion are implemented based on the total economic value of the transmission congestion. If the congestion occurs infrequently, and if historical and forecasted LMPs do not show a substantial cost from congestion, then it is unlikely that MISO would recommend new transmission projects to relieve it.

With respect to the issues raised regarding congestion in Mr. Lange's testimony, I have described above that both the SPP Criteria 3.5 Studies and the Audrain SPS deal with system contingency events, not recurring congestion issues. As is detailed in Mr. Berry's surrebuttal testimony, Ms. Kliethermes' discussion of the economic value of

congestion is inaccurate and misstates the impact of the Project. Neither Ms. Kliethermes nor Mr. Lange has presented evidence that the Project will actually cause economic congestion in MISO of any substantial magnitude. Therefore, there is no reason to believe new transmission lines will be needed to resolve economic congestion because of the Project.

Q. In his rebuttal testimony at page 13, lines 18-21, Commission Staff witness Shawn Lange asserts that the Project's "SPP System Impact Study" did not include additional planned wind within the SPP footprint area …." What is your response?

A. The apparent source of Mr. Lange's comment is a statement on page 39 of the SIS Report (Schedule AWG-4) which refers to "Additional considerations for **future** studies of the GBX project … [emphasis added]." When the SPP Transmission Working Group approved the Project's interconnection studies, it specified that the studies should be updated once the exact locations of the wind generation connected to the Project are known, and with the appropriate scenario models (i.e., models containing any updated SPP information since the last studies were performed) to confirm there are no adverse impacts on the system.

To be clear, however, the Project's interconnection studies with SPP explicitly consider 3756 MW of new wind generation directly connected to the Project, as indicated on page 2-12 of the Dynamic Stability Assessment report completed as part of the approved SPP Criteria 3.5 studies.[3] Additionally, the report, minus the appendices, is attached to this testimony as AWG-9. This Dynamic Stability Assessment report also

[3]http://www.grainbeltexpresscleanline.com/sites/grain_belt/media/docs/GBX_Stabiltiy_Study_Report_031413_with_Appendices_JA.pdf

considers wind that was already interconnected to the SPP grid and additional wind generation included in the scenario cases that were approved by the SPP Transmission Working Group for the analysis.

Q. What is the Company's response to the rebuttal testimony of Staff witness Daniel I. Beck at page 5, line 17, stating that the Company's view that the Project would not incur any interconnection upgrades is unreasonable?

A. Mr. Beck's comment relates to the Company's Application, which states on page 3 that the estimated Project cost of $2.2 billion "does not include the cost of upgrades required to interconnect the Project to electric transmission grid." The Application does not state the position that Mr. Beck attributes to it. Rather, the Application highlights that there is an additional cost not included in the $2.2 billion estimate.

The levelized cost of energy model presented in David Berry's direct testimony includes an estimate of network upgrade costs. In his surrebuttal testimony, Mr. Berry updates his model to include the estimated upgrade costs from the PJM System Impact study, which I discuss below.

Q. Has Grain Belt Express recently received the PJM System Impact Study ("SIS") report?

A. Yes, Grain Belt Express received the PJM SIS report on October 1, 2014. I have attached the study as Schedule AWG-10.

Q. Does the PJM SIS report identify any required system upgrades to accommodate the reliable interconnection of the Grain Belt Express Project to PJM?

A. Yes. The PJM SIS report identifies the system upgrades required to accommodate the reliable interconnection of the Project. The primary upgrade is the construction of a new

line, the Sullivan-Reynolds 765 kV line. PJM estimates that the cost to construct this line is $500 million. Grain Belt Express expected that this upgrade would be required and had included its cost in its business plan prior to the receipt of the report.

In addition to this system upgrade, PJM identified two additional required system upgrades that need to be finalized as they involve coordination with other RTOs and/or other interconnection customers. They are:

- Upgrade the wave-trap at Dumont station on X1-020 765 kV line: Estimated cost of $1 million; and
- Rework the breaker and line arrangement at the new Reynolds 345 kV station, which is to be owned by Northern Indiana Public Service Company, which is in MISO: No estimate has yet been provided, although I expect its cost to be in the $5-10 million range.

Q. Will the stability analysis in the PJM SIS be updated as more granular information about the HVDC converter design becomes available?

A. Yes. In preparing the SIS, PJM and AEP used the generic HVDC models that are available in the standard library of software modeling tools used to perform such studies. When PJM conducts the Facilities Study, Grain Belt Express will provide PJM and AEP with a more detailed model of the Project's HVDC system that will include the full control capabilities of the proposed system. I expect this model to fully address the outstanding stability issues that PJM and AEP observed during the SIS because it will include the comprehensive, responsive capabilities of the Project's HVDC system within the short timescales studied. The facilities study is expected to commence in November 2014.

Q. Does the PJM SIS report identify any other upgrades to accommodate the reliable interconnection of the Grain Belt Express project?

A. Yes. In addition to the Sullivan-Reynolds 765 kV line, the following attachment facilities for the Project are required to physically interconnect to the Breed 345 kV substation:

- Three 345 kV breakers, and
- Dual 345 kV revenue metering.

PJM estimated the cost of these attachment facilities to be $3,447,100.

V. PROJECT TECHNICAL SPECIFICATION

Q. Staff witness Michael Stahlman in his rebuttal at page 2 states that "staff cannot confidently describe the parameters for Grain Belt Express' transmission project." Has Grain Belt Express provided a sufficient description of the Project's parameters?

A. Yes. The record in this proceeding is clear as to the basic technical specifications of the Project. While these specifications have evolved during the four years the Project has been under development, there should be no confusion about the Project that Grain Belt Express is proposing to construct in this proceeding. Mr. Stahlman's uncertainty appears to stem from reading different documents provided to Staff during discovery without taking into account when the documents were prepared.

Q. What are the rating specifications of the converter stations?

A. As stated in paragraph 6 of the Application, the Project is being designed to simultaneously deliver 3,500 MW to AEP's system in western Indiana and 500 MW to Ameren's eastern Missouri system. These MW values are being specified on the AC side

of the respective converter stations, thus the converter stations have to be rated slightly higher to account for the losses associated with them.

Q. What is the design rating of the eastern converter station?

A. The Project's eastern converter station that will deliver 3,500 MW in western Indiana needs to be rated at approximately 3,525 MW to account for losses at the station. When the Company provides the HVDC vendors with our design specifications, we will specify a delivered amount of megawatts on a continuous basis and the vendor will rate the converter station accordingly.

Q. Regarding the rating of the converter station in Missouri, you have stated that it should be rated to deliver 500 MW to the Ameren system. However, you have also stated that the converter may have nameplate ratings as high as 1000 MW. Why is there a need to essentially double the rating of the Missouri converter relative to the delivered MW range?

A. Similar to the eastern converter station, the Missouri converter station needs to be rated slightly higher than the 500 MW it is delivering to Ameren's system to account for losses. However, when dealing with multi-terminal DC lines, there is a rule of thumb that states that the smallest converter station should be rated between 20-30% of the largest converter station so that during faulted conditions, the equipment in the smallest station is not over stressed. Much of this depends upon the vendor control capabilities and external system conditions as well. Thus, the converter transformers and valves at the Missouri converter station could be rated for 1,000 MW. In doing this, one effectively increases the inductance in the HVDC circuit, which improves the ability to manage fault conditions. However, this technical rating would not result in the converter

station actually delivering more power. The Project has an interconnection request to MISO for 500 MW and therefore will not be allowed by the RTO to inject more than 500 MW. The power injected can be strictly limited by the HVDC control system as this is a control set point and not a rating issue. Should Grain Belt Express seek to deliver more than 500 MW in eastern Missouri, it must submit an interconnection request for the incremental values above 500 MW to MISO, as well as obtain the permission of this Commission based on the condition proposed by Commission Staff and accepted by Grain Belt Express.

Q. What is the rating of the Kansas converter station?

A. To accommodate the simultaneous delivery of 3,500 MW to western Indiana and 500 MW to Missouri, the Kansas converter station needs to be rated high enough to account for its own losses, the losses of the other two converter stations, and the losses of the HVDC line. This equates to a rating of approximately 4,300 MW.

Q. What is the total power to be delivered into PJM?

A. The Project has an interconnection request to PJM for total delivered power of 3,500 MW. The Project will not be allowed to inject more than 3,500 MW without a subsequent interconnection queue process in PJM.

Q. Mr. Stahlman at page 9, line 19 of his rebuttal testimony notes that the Sullivan, Indiana injection was not studied at 3,500 MW. How do you respond?

A. To be clear, PJM has studied and will continue to study the Project based on a 3,500 MW injection. The upgrades identified by PJM in the System Impact Study, described above and attached as Schedule AWG-10, are to accommodate a 3,500 MW injection.

While it is true that the SPP studies assumed 3,000 MW injection at Sullivan (with the remaining 500 MW assumed to be injected in eastern Missouri), the SPP study was primarily intended to study the impact of the Project as an interconnection to the SPP system. This study was not intended to fully assess the impact of injecting the Project's power in to the AC systems in eastern Missouri and western Indiana, which PJM is doing. Rather, the SPP studies focus on system impacts in abnormal operating conditions with a focus on the SPP system. Prior to operation, the SPP studies will be refreshed once the proprietary HVDC vendor models become available in order to confirm current study results, at which point the analysis will include the full 3,500 MW injection in PJM.

Q. Do you agree with the statement by Jeffrey M. Gray on behalf of the Missouri Landowners Alliance ("MLA") in his rebuttal at page 7 that the Grain Belt Express Project would not be an integrated component of MISO or SPP?

A. No, his statement is quite misleading. Although PJM will have functional control over the Project, its real-time operations will be coordinated by PJM with SPP and MISO because the Project will be operating in three RTOs. Thus, from an operational perspective, the Project will be an integrated component of the PJM, SPP and MISO systems, like any other transmission or generation facility.

Q. What is your response to the rebuttal testimony at page 13 of Christina Reichert that the Project's transmission lines should be buried rather than constructed overhead?

A. This is not technically feasible for a variety of significant reasons. Underground cable systems for electric power transmission are very complex and very dependent upon a number of factors in order to operate efficiently and reliably. To date, there have been no

underground cable systems designed or installed at the proposed voltage (±600 kV) and power ratings (4,000 MW) of the Grain Belt Express Project or its proposed length (approximately 750 miles). The highest achieved cable ratings for underground or underwater HVDC, thus far, are ±500 kV at about 2000 MW. They are utilized in very specific applications and for relatively short distances compared to the Grain Belt Express Project.

A project entitled "Western Link" that has been proposed to connect Scotland to Wales via a ±600 kV, 2000 MW cable project is currently in development. However, to my knowledge, the cable vendor has yet to successfully install the cable. Assuming that the Western Link project is successful in developing a 600 kV cable, it still cannot be directly applicable to the Grain Belt Express Project for three main reasons: (1) the Western Link project has a significantly smaller power rating (2000 MW v. the Project's 4,000 MW); (2) the Western Link project is an undersea project, which provides for an atmosphere with significant cooling capabilities so that additional losses are not incurred, as compared with the heat dissipation issues of underground cable systems; and (3) the Western Link project is less than 250 miles in length (compared to the Project's 750 miles).

Additionally, there are no standard industry testing protocols for HVDC cables at this voltage. As a result, the Company cannot be reasonably assured that building the first experimental underground cable system in the world at such unprecedented voltage and power ratings could be done reliably and economically.

Other challenges of buried high voltage lines include the fact that these cables cannot be directly buried (i.e., be buried under the ground without any kind of extra

covering, sheathing, or piping to protect it). Rather, the lines must be mechanically protected by being buried in a duct bank, conduit, or tunnels with frequent access from the surface for splices. Open trench construction is typically utilized when cable is buried, and the trench remains open for a significant amount of time as sections are spliced together. Splicing the type of cable that would be required for the Grain Belt Express Project would take several days to a week to complete due to the complexity of the process, and would require specialized skills and equipment that to my knowledge is not directly available in this country.

The large size of the cable, due to insulation requirements, also means that underground cable is extremely heavy relative to overhead conductors and only relatively short sections can be spooled and shipped due to size and weight. I would expect that less than 1000 meters could be effectively spooled and transported which would mean that a splice would need to occur every 1000 meters. Another detriment to underground cable systems is repair time. In the event of a failure of a cable, the outages are significantly longer than with overhead lines. Moreover, due to the specialized labor required to splice the cables, the availability of personnel to make the repairs could delay restoration of service. Excavation of the site could also be required to locate the failure.

VI. OPERATIONAL ISSUES

Q. What is your response to concerns raised by Show Me witness Kurt C. Kielisch at page 15 of his rebuttal regarding stray voltage from high voltage transmission lines and the impact it has on dairy cows?

A. The term "stray voltage" typically refers to extraneous, unwanted voltage that appears on grounded surfaces in buildings, barns, or other structures. This may also be referred to as a neutral-earth ("neutral to earth") voltage. These voltages are generated as a result of

improper wiring techniques (e.g., the neutral conductor is grounded at multiple points, defective equipment, or incorrect wiring of transformers), or incorrect connections at the distribution utility transformer, where the distribution utility has connected the high side neutral and the low side neutral together. Because the Grain Belt Express Project will have no distribution lines and will not have direct interaction with distribution systems in the areas through which the line is passing, it will not create stray voltage issues. The same pertains to areas around the converter station.

Further, to the general question of health and productivity of cattle operations and agriculture, I am aware of several studies that have assessed the impacts on agricultural operations and did not find any adverse impact:

- According to an epidemiologic study of 500 herds of Holstein dairy cattle using multiple indicators, herd health did not differ between periods before and after a nearby +/- 400 kV direct current line was energized. These results did not vary based on the herd's distance from the high voltage direct current power line.[4]
- Another study conducted by Oregon State University titled "Joint HVDC Agricultural Study" determined that no differences were found between cattle and crops raised under +/-500 kV direct current lines and those raised away from the lines.[5]

[4] F.B. Martin, A. Bender, G., Steurnagel, R.A. Robinson, et al., "Epidemiologic Study of Holstein Dairy Cow Performance and Reproduction near a High Voltage Direct Current Powerline," 19 J. Toxicol. Environ. Health 303-324 (1986).

[5] R.J. Raleigh, Joint HVDC Agricultural Study: Final Report to Bonneville Power Administration (Ore. State. Univ., 1988).

- A report by the Western Interstate Commission for Higher Education also determined that a +/- 400 kV direct current transmission line did not affect crops, vegetation, or nearby wildlife, nor were the electric and magnetic fields from the line felt by persons walking in the right-of-way.[6]

Q. What is the Company's response to certain safety concerns identified in the public comments submitted to the Commission, as summarized in the rebuttal testimony at page 7, line 5 of Staff witness Natelle Dietrich?

A. The Project will use dedicated metallic return conductors, as opposed to ground electrodes, which will eliminate the possibility of the Project injecting ground current during normal operating conditions. To assess the impact of ground current from the Project during abnormal conditions, Grain Belt Express will conduct appropriate studies in coordination with utilities operating underground facilities such as pipelines near the Project's transmission line and converter stations.

Q. What is the Company's response to Christina Reichert's rebuttal testimony at page 10 regarding noise levels from HVDC lines?

A. The audible noise generated from the Project will be in the range of 25-45 dB-A. At the edge of the right-of-way, this will result in a noise level in the same volume range as a whisper.

Q. What is the Company's response to Ms. Reichert's comments at page 17 of her rebuttal testimony regarding the size and voltage of the Grain Belt Express Project?

[6] D.B. Griffith, "Selected Biological Parameters Associated with a ±400 kV DC Transmission Line in Oregon," Report by the Western Interstate Commission for Higher Education for the Bonneville Power Administration (1977).

A. Ms. Reichert's understanding of the Project and her assertion that it will deploy an uncommon technology are incorrect. HVDC technology has been tested and proven for over 60 years with the first commercial power link being energized in 1958. In North America, there are over 30 HVDC installations, dating as far back as 1968.[7] Worldwide, HVDC applications, similar to the Grain Belt Project, are commonplace. Since the early 1990s, there have been over 16 significant applications in China and India, including projects as high as ±800 kV delivering more than 6,000 MW. Australia, New Zealand, Brazil, Japan and Europe have all installed significant HVDC transmission projects since the late 1960s[8]

Q. What is the Company's response to Ms. Reichert's rebuttal testimony at page 17 regarding the Company's statements concerning magnetic fields from overhead HVDC lines and the Earth's static magnetic field?

A. The booklet Ms. Reichert referred to provides reference to the magnetic fields generated by a variety of sources that the general public is familiar with. This includes MRI machines (15,000,000 – 40,000,000 mG), battery-operated appliances (3,000 – 10,000 mG), and electrified railways (less than 10,000 mG). The booklet also describes magnetic fields generated by HVDC transmission lines both at 500 kV (300 – 600 mG) and 600 kV (less than 900 mG). As illustrated by the figures above, HVDC lines are

[7] DC and Flexible AC Transmission Subcommittee of the IEEE Transmission and Distribution Committee by the Working Group on HVDC and FACTS, HVDC Projects Listing (July 2009); available at: http://www.ece.uidaho.edu/hvdcfacts/Projects/HVDCProjectsListingJuly2009-existing.pdf (last visited Oct. 14, 2014).

[8] Chan-Ki Kim, et al., HVDC Transmission: Power Conversion Applications in Power Systems (John Wiley & Sons, 2009).

indeed less than or similar to the Earth's magnetic field when compared to other sources that the general public is exposed to on a regular and frequent basis.

Q. What is the Company's response to the rebuttal testimony at page 9 of Kurt Kielisch that because high voltage transmission lines are not insulated, irrigation systems should not spray water on the electric lines in order to avoid electrical damage to the irrigation system?

A. To the contrary, high voltage lines are insulated from the structures they are suspended on. However, because the electrical conductors do not have an outer plastic jacket like electric cables, care must be taken that any irrigation system operating under the line does not spray a continuous stream of water onto pole conductors. If such a situation were to occurr, the Project will have the necessary protection and control system in place to de-energize the line once such a condition is detected. More importantly, Grain Belt Express will work with any land owner who operates an irrigation system to mitigate this possibility.

Q. What is the Company's response to Mr. Kielisch's rebuttal testimony at page 10 that a power line has a minimum distance of 20-24 feet above ground at the low sag point?

A. The minimum clearance of an electric transmission line is predicated on the operating voltage of the line, as set forth in the National Electric Safety Code ("NESC"). For the Grain Belt Express Project, the minimum clearance outlined by NESC is 31 feet. In addition to this, the Company, per its design criteria (Schedule AWG-3 to my direct testimony, discussed at page 10) is adding a minimum 3-foot buffer. Thus, the lowest the pole conductors will be is 34 feet above ground. It is important to note that the Project

will be designed to maintain this minimum clearance during the most stressful conditions (e.g., hot summer days with high currents flowing). As a result, the electrical conductors will have more than a 34-foot clearance from ground for the majority of its operation.

Q. What is the Company's response to the rebuttal testimonies of Mr. Kielisch at page 12 and of Charles E. Kruse at page 12 that high voltage transmission lines may interfere with GPS units?

A. As discussed in my direct testimony, it is extremely unlikely that the Project will interfere with GPS signals because the frequencies that are used to communicate between orbiting satellites and GPS units, including those associated with farm equipment, are much higher than the frequency of radio noise from the Project's transmission line. On pages 25 and 26 of my direct testimony, I cite two studies that were conducted after the 2009 Wisconsin Department of Agriculture report that Mr. Kruse relies upon to make his assertion that further studies are required. These studies were published in 2011[9] and 2012,[10] and explicitly focused on the operation of GPS underneath HVDC lines. While it is theoretically possible that a signal from a single GPS satellite could be blocked or degraded due to the physical presence of a transmission structure in the line-of-sight between the GPS receiver and the satellite, this is extremely unlikely to result in the loss of functionality for a GPS receiver in an agriculture setting. GPS receivers require only three satellite signals to calculate horizontal positions on earth, but typically can access 12 or more satellites simultaneously. Thus, it is very unlikely that a transmission line,

[9] Pollock & Wright, "Effects of Transmission Lines on Global Positioning Systems," PLAN Group, Manitoba Hydro DC-Line GNSS Survey Report (2011).

[10] J.B. Bancroft, A. Morrison, G. Lachapelle, "Validation of GNSS under 500,000 V Direct Current (DC) Transmission Lines," 83 Computers and Electronics in Agriculture 58, 66 (2012).

which would only physically block satellite signals from one direction, could cause the loss of a GPS signal. In the very unlikely event that any interference occurred, Grain Belt Express would discuss mitigation and other potential remedies with the individual landowner.

Q. What is the Company's response to Mr. Kruse's rebuttal at page 15 that in the event of a storm, the Project will damage land?

A. Grain Belt Express recognizes this possibility and fully intends to compensate any landowners for damage that occurs as a result of the Project during a storm, as well as for damages incurred during restoration efforts associated with the Project. Further, Grain Belt Express has agreed to the Staff condition to file a Storm Restoration Plan with the Commission.

Q. Does this conclude your testimony?

A. Yes, it does.