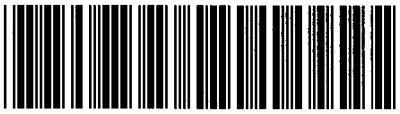

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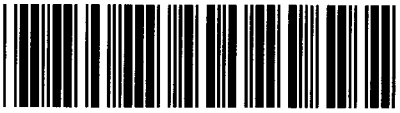

Item Number: 250

Addendum StartPage: 0

SOAH DOCKET NO. 473-16-2751
PUC DOCKET NO. 45624

APPLICATION OF THE CITY OF GARLAND TO AMEND A CERTIFICATE OF CONVENEINCE AND NECESSITY FOR THE RUSK TO PANOLA DOUBLE-CIRCUIT 345-KV TRANSMISSION LINE IN RUSK AND PANOLA COUNTIES	§	**STATE OFFICE OF ADMINISTRATIVE HEARINGS**

DIRECT TESTIMONY

OF

DAN WOODFIN

ON BEHALF OF

ELECTRIC RELIABILITY COUNCIL OF TEXAS, INC.

APRIL 27, 2016

250

TABLE OF CONTENTS

I. INTRODUCTION AND QUALIFICATIONS

Q. PLEASE STATE YOUR NAME AND CURRENT POSITION.

A. My name is Dan Woodfin. I am the Director of System Operations for the Electric Reliability Council of Texas (ERCOT), 2705 West Lake Drive, Taylor, Texas 76574. In this position, I am responsible for ERCOT activities related to the real-time operation of the power system in the ERCOT region, as well as numerous engineering and support activities.

Q. **PLEASE DESCRIBE YOUR EDUCATION AND PROFESSIONAL EXPERIENCE.**

A. I received a Bachelor of Science degree in Electrical Engineering from Texas A&M University in 1986 and a Master's Degree in Business Administration from Texas A&M University in 1988.

I began my career in 1988 in the System Planning area at West Texas Utilities (WTU). After a short time as the Manager of Telecommunications for WTU in 1993, I became the Manager of Resource Planning for Central and South West (CSW) Services as a result of a corporate restructuring of the CSW Companies in 1994. I remained in this position until the closing of the CSW merger with American Electric Power in 2000, when I became a Manager of Transmission Policy for Reliant Energy.

I became the Manager of Resource Planning for ERCOT in January 2003, where I developed a group to be responsible for reliability must run (RMR) evaluations and economic transmission planning. In a January 2006 reorganization of the ERCOT planning function, I became the Manager of Regional Planning for ERCOT, with

added responsibility for all steady-state planning studies and regional planning activities. In April 2007, I was named Director of System Planning, with responsibility for all ERCOT activities related to planning the power system for the ERCOT Region. I was named to my current position in March 2012.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE PUBLIC UTILITY COMMISSION OF TEXAS (COMMISSION)?

A. Yes, I testified on behalf of ERCOT in Docket No. 33672, *Commission Staff's Petition for the Designation of Competitive Renewable Energy Zones*, Docket No. 33687, *Entergy Gulf States Inc.'s Transition to Competition Plan*, and Docket No. 35665, *Commission Staff's Petition for the Selection of Entities Responsible for Transmission Improvements Necessary to Deliver Renewable Energy from Competitive Renewable Energy Zones*. I also provided written testimony on behalf of CSW's Texas operating companies in several dockets related to those companies' Integrated Resource Plans in the 1997-98 timeframe, and I have participated in several technical conferences before the Commission.

II. PURPOSE OF TESTIMONY AND SUMMARY OF CONCLUSIONS

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. The purpose of my testimony is to discuss several of the issues that will need to be addressed prior to completion of the Southern Cross DC Tie in order to preserve the reliable and efficient operations of the ERCOT System. These issues were included as issues to be addressed in this case, including whether the Southern Cross DC tie should be included in economic dispatch, whether ramp rate

limitations should be imposed on the tie, how outage coordination will be impacted by the tie, how ERCOT will coordinate with neighboring authorities to control imports and exports during emergencies, whether Southern Cross should be required to provide certain reliability services, and how the tie may impact ancillary service needs.

III. MANAGING CONGESTION DUE TO DC TIE IMPORTS

Q. HOW DOES ERCOT DISPATCH RESOURCES ON THE GRID SO THAT TRANSMISSION FACILITIES ARE NOT OVERLOADED?

A. ERCOT uses a security-constrained economic dispatch (SCED) system to set the output of participating resources in the manner that is the most economic way to use those resources to serve the system load, based on the resources' offer prices and operating limits, which does not result in the post-contingency overload of any transmission element.

Q. WHAT DO YOU MEAN BY THE TERM "POST CONTINGENCY?"

A. In this context, the term "post-contingency" means that the loading on transmission elements is not only maintained lower than the ratings of those elements, but also that none of the transmission elements would be overloaded if any transmission element or generating unit were to trip out of service (known as a "contingency").

Q. HOW DOES SCED ALLEVIATE A POTENTIAL POST-CONTINGENCY OVERLOAD?

A. Generally speaking, if the use of the most economic set of generator outputs would result in the post-contingency overload of a transmission element, SCED will lower the output of one or more generators that would contribute to that overload and

increase the output of one or more of the next-lowest-cost generators that do not contribute to that or any other overload.

Q. IS SCED ALWAYS ABLE TO RESOLVE THESE POTENTIAL OVERLOADS?

A No, in some cases it is not possible to redispatch generation to alleviate a potential post-contingency overload. For example, if the load in an area exceeds the capacity of the transmission system to import power into that area, and the generation in the area is insufficient to serve the load without imports, redispatch is not possible. In these cases, ERCOT will work with the Transmission Service Provider in the area to develop a Constraint Management Plan (CMP) that may be implemented.

Q WHAT IS A CONSTRAINT MANAGEMENT PLAN?

A. A CMP is a plan to implement certain actions, including shedding load in the area, in order to alleviate an overload and prevent a broader system problem. Typically, these actions are taken in the event that the contingency in question actually occurs. However, in some cases CMPs require actions to be taken prior to the contingency occurring because there would not be sufficient time after the contingency to prevent the broader system problem.

Q. HOW ARE THE EXISTING DC TIES SCHEDULED?

A. ERCOT currently has five DC Ties with other regions. ERCOT's ties with Mexico include a 35 MW DC tie at Eagle Pass, a 100MW variable frequency transformer at Laredo, and a 300MW DC tie at the Railroad substation in McAllen; ERCOT's ties with the Southwest Power Pool (SPP) include a 220MW tie in north Texas and a 600MW tie in east Texas. Scheduling on these ties is accomplished through the

OATI e-Tagging system, a transmission scheduling platform used across other Independent System Operators (ISOs) that adheres to federal North American Reliability Corporation (NERC) reliability guidelines. The appropriate entities on either side of the scheduled transfer have some opportunity to study the impact of the proposed transfer on their systems, before approving the proposed schedule. Once the e-Tag is approved by all of these entities, the DC Tie operator ramps the tie flow up to the now-approved schedule over the course of ten minutes, beginning five minutes before the hour. The flow on the tie remains at the scheduled level for the scheduled time period unless transmission loading relief procedures are implemented on the Eastern Interconnection or a system emergency is declared by the Reliability Coordinator for one or the other side of the transfer.

Q. ARE THE EXISTING DC TIES DISPATCHED BY SCED TO RELIEVE POTENTIAL POST-CONTINGENCY TRANSMISSION OVERLOADS?

A. No, the existing DC ties are not dispatched by SCED. DC ties are currently "price takers" in the ERCOT market. Qualified Scheduling Entities (QSEs) scheduling over the ties determine when and how much power to schedule over the DC Ties based on market predictions. The scheduled power receives, or pays, the locational marginal price calculated by SCED at the time the power is imported or exported. If a scheduled transfer with an approved e-Tag over a DC tie contributes to a potential overload, SCED will dispatch other generation to relieve the overload by lowering the output of one or more generators that may be contributing to the overload and increasing the output of other, more costly generators in a corresponding amount. While this result will minimize the cost to serve the net

system load (including the impact of the fixed quantity of DC Tie transfer) without having any overloads for that period, it does not take into account the economics of this re-dispatch relative to the value of the power that is being transferred over the tie.

Q. WHAT HAPPENS IF SCED CANNOT SUFFICIENTLY REDISPATCH OTHER GENERATION TO RESOLVE THE POTENTIAL OVERLOAD TO WHICH THE DC TIE TRANSFER IS CONTRIBUTING?

A. If this action does not relieve the violation, ERCOT operators must declare a transmission emergency and coordinate with the Reliability Coordinator for the other side of the tie to try to implement a mutually acceptable solution to the violation. If there are export flows on the DC tie for the RC with the emergency, that RC will seek to curtail the export flows by coordinating with the other RC to ensure that curtailing those exports will not create a reliability issue for the other RC. If the import capability is not being fully utilized, or after export flows have been curtailed, the RC with the emergency will then seek to maximize the import capability across the DC tie in coordination with the other RC.

Q. SHOULD THIS SAME APPROACH BE APPLIED TO THE SOUTHERN CROSS TIE?

A. While existing practices have been sufficient for the smaller, existing DC ties, the introduction of the much-larger Southern Cross DC tie may present substantially larger congestion management issues than the existing smaller ERCOT DC ties. The size of the Southern Cross DC tie may make it more difficult for SCED to manage thermal constraints impacted by transfers over the tie using only the

redispatch of generation without reducing the transfer over the tie. ERCOT operators will likely need to resort to manual action much more frequently, which could increase the likelihood of operator error and in turn raise the likelihood of an actual violation of thermal limits. It would be better to develop an alternative approach that does not require the declaration of an emergency to adjust the transfers across the tie.

Q. WHAT ALTERNATIVE APPROACHES MIGHT BE USED?

A. Two alternative approaches have been discussed: the inclusion of DC tie transfers in SCED and the use of Congestion Management Plans (CMPs). Both of these options have significant drawbacks, including changes to the e-Tag rules.

While it might be possible to add the functionality to dispatch the DC Ties using the SCED system, this would be difficult to coordinate with the control area on the other side of the Tie. In addition, it is unclear whether a five minute "schedule" over the tie would fit within the current e-Tagging framework. The current e-Tagging system is the process by which coordination on power transfers between control areas within other interconnections are accomplished. It is unlikely that a more flexible scheme could be developed between separate interconnections and using DC Ties for the transfers than what has been developed for coordinating transfers between AC connected control areas within a single interconnection.

Another solution that has been discussed is to implement a CMP. A CMP would utilize a set of predefined actions executed in response to system conditions to prevent or to resolve transmission constraints. The use of a CMP might be possible to resolve some issues, but its effectiveness would depend on the specific situation,

so it is unlikely to be a uniform solution for managing congestion in all cases. A broader discussion by ERCOT stakeholders may be helpful to investigate these and other options and determine the relative benefits and costs of each.

IV. MANAGING DC TIE RAMPING

Q. SHOULD ERCOT IMPOSE RESTRICTIONS ON HOW QUICKLY THE IMPORTS/EXPORTS OVER THE DC TIES CAN CHANGE?

A. Yes. It will likely be necessary to impose some type of ramp rate limit on the Southern Cross DC tie, perhaps beyond what is currently in place for the smaller existing ties, in order to preserve system reliability by limiting frequency deviations associated with sudden changes in the flow of exports or imports across the tie or the inability of the other resources on the system to match the ramp rate of the change in DC Tie transfer. A ramp rate limit will decrease the need to procure and deploy ancillary services to compensate for this variability in imports and exports of power.

Q. WHY WOULD THE OTHER RESOURCES ON THE SYSTEM NOT BE ABLE TO MATCH THE RAMP RATE OF THE DC TIE?

A. Generating units do not generally have the capability to change their output instantaneously, and different units change that output at different rates. In addition, the ramping capability of a particular generator may vary depending on its current operating conditions. Even the resources that are providing Ancillary Services take some period of time to respond to changes in system conditions. If the change in transfer over the DC Tie exceeds the aggregate ability of the

generating units on the system to match that change, there will be an impact on system frequency until the change can be matched.

Q. HOW ARE DC TIE RAMP RATES CURRENTLY DETERMINED?

A. The OATI system used to schedule flows on the DC ties automatically builds in a ten-minute ramp each hour (i.e., the last five and the first five minutes of each hour) to accommodate the scheduled flows from one hour to the next. The tie operator then implements this schedule by adjusting the flows on the ties. For example, if the scheduled import quantity increases by 200MW from one hour to the next, the tie operator will increase the quantity transferred over the tie at a rate of 20MW per minute for a ten-minute period beginning five minutes before the hour until five minutes after the hour begins.

Q. WHAT IS THE OPERATIONAL IMPACT OF RAMPING THE DC TIES OVER A TEN-MINUTE PERIOD?

A. Flows over the ties are not controlled by ERCOT's market management tools. Consequently, other generators must be dispatched to address the impacts created by DC tie flows, including higher or lower flows due to changes in DC tie schedules. In general, this means that the output of the generation on the system must ramp at the same rate as the ramp of the DC tie transfer in order to maintain balance between generation and load in the ERCOT Interconnection and maintain frequency around 60 Hz. While this ten-minute ramp approach has generally not led to problems with the existing smaller ties, a new 2000 (or 2100) MW DC tie could create operational issues.

Q. WHAT IS THE OPERATIONAL CONSEQUENCE OF ALLOWING A DC

TIE OF 2100 MW TO RAMP WITHIN TEN MINUTES?

A. If a DC Tie were to ramp from zero transfer in one hour to 2100 MW export in the next, then the other generation on ERCOT System must increase its output by 2100 MW within 10 minutes, which could exceed the ramping capability of the ERCOT System and would likely require immediate operator actions to restore frequency to acceptable levels. Ramping from full import to full export (or vice versa) over this same time span (a change of 4100 MW) would exceed this capability even more substantially.

It is important to note that ERCOT has the discretion to deny scheduled transactions via the OATI system, and ERCOT would certainly endeavor to deny any e-Tag that exceeded expected system ramp capability. However, NERC standards also allow Southern Cross to provide ERCOT as little as fifteen minutes' notice of its import and export scheduling plans, and this may not provide ERCOT sufficient time to evaluate whether the schedule can be accommodated. ERCOT would need to implement additional tools and processes to ensure sufficient review can occur within this timeframe.

Q. WHAT CHANGES WOULD YOU RECOMMEND TO ENSURE RELIABILITY IF A LARGER DC TIE IS INTERCONNECTED WITH ERCOT?

A. ERCOT suggests that the DC tie schedules be integrated with market tools so that the ramping behavior of DC ties can be reliably managed. Alternatively, extending the ramping period to some point well beyond 10 minutes could also effectively achieve a ramp-rate limit on DC ties, but this would need to be addressed through

a change to the OATI process. A broader discussion by ERCOT stakeholders may be helpful to investigate these and other options and determine the relative benefits and costs of each.

V. IMPACTS OF DC TIES ON OUTAGE COORDINATION

Q. HOW WOULD THE INTEGRATION OF LARGER DC TIES IMPACT OUTAGE COORDINATION IN ERCOT?

A. One of ERCOT's core functions is coordinating outages of transmission facilities and generation resources to ensure continuous, reliable operation of the transmission system. Outage coordination requires ERCOT to predict future system conditions—including DC Tie imports or exports—with some measure of accuracy so that it can determine whether requested outages of generators and transmission elements can occur contemporaneously while maintaining system reliability. The expected availability of imports over DC ties may lead ERCOT to allow transmission outages in one area within operational reliability criteria. If a tie ends up exporting instead, ERCOT may not have sufficient generation to meet system load or it could result in post-contingency transmission overloads that cannot be resolved by redispatch. The consequences may be that ERCOT has to curtail exports over the tie or withdraw approval of the outage. Conversely, if the DC tie is predicted to be exporting, then it will be modeled much like firm load and ERCOT will ensure that generation is available to meet the predicted demand. An incorrect prediction in this situation may also result in post-contingency transmission overloads that cannot be resolved by redispatch and require the tie

transfer to be cut. With substantially larger DC ties, these problems become much more difficult.

Q. CAN DC TIE IMPORTS AND EXPORTS BE PREDICTED WITH REASONABLE CERTAINTY?

A. No. While some general trends in import/export behavior may be identifiable, actual tie flows cannot be known with any reasonable certainty, especially as far in advance as when such knowledge would be required for outage scheduling. Thus, when a much larger DC tie is interconnected, ERCOT's margin of error in outage coordination increases substantially.

Q. HOW SHOULD ERCOT ADDRESS THE GREATER COMPLEXITY OF COORDINATING OUTAGES AND THE ADDITIONAL COST OF THAT COMPLEXITY, GIVEN THE UNPREDICTABLE NATURE OF DC TIE FLOWS?

A. At the very least, ERCOT will need to substantially expand its analytical capabilities to incorporate the Southern Cross DC tie into outage coordination because the new tie will exponentially increase the contingency scenarios that must be studied and/or to improve predictions of likely future DC Tie transfers. This will increase costs for ERCOT.

ERCOT will also need to consider how conservative to be when incorporating the Southern Cross DC tie into outage schedule modeling. Being more conservative limits the number of potential outages that can be accommodated because ERCOT would need to plan for a wide range swing from maximum export to maximum import capability of the Southern Cross DC tie at any given time. This is a

difference of approximately 4,100 MW, assuming a maximum export of 2,100 MW, and a maximum import of 2,000 MW. On the other hand, if ERCOT were to take a less conservative approach and rely more heavily on expectations for future transfers, situations are more likely to arise for which ERCOT would need to cut the tie transfer or cancel previously approved outages.

VI. INTER-REGIONAL COORDINATION

Q. HOW WILL ERCOT COORDINATE WITH OTHER INDEPENDENT SYSTEM OPERATORS (ISOs), REGIONAL TRANSMISSION OPERATORS (RTOs), AND/OR NERC BALANCING AUTHORITIES (BAs) ON IMPORTS OR CURTAILMENT OF EXPORTS DURING EMERGENCIES?

A. If the Southern Cross project proceeds, ERCOT will need to negotiate one or more agreements with the ISO/RTO and/or RC on the eastern end of the Southern Cross DC tie to ensure reliable operations during emergency conditions, among other issues. ERCOT currently has agreements in place with SPP and Comisión Federal de Electricidad (CFE) that coordinate operation of existing DC ties during emergency conditions. The amount of coordination that will be required to operate this new DC tie will likely be greater than any of the other ties due to the larger scale of the tie. Also, the more entities that ERCOT is required to coordinate with, the more complex the arrangements become. To ensure reliability of the grid, ERCOT should have all relevant coordination agreements in place before the Southern Cross DC tie is permitted to energize. However, to date, Southern Cross

has not identified the precise location of the eastern end of the project, so it is not possible for ERCOT to know with which entities ERCOT would need to coordinate or what the potential complexities of coordinating with those entities might be.

VII. PROVISION OF CERTAIN RELIABILITY SERVICES

Q. SHOULD EITHER THE DC TIE OWNER OR OPERATOR OR THE QUALIFIED SCHEDULING ENTITY SCHEDULING OVER THE TIE BE REQUIRED TO SUPPLY REACTIVE POWER OR PRIMARY FREQUENCY RESPONSE TO THE ERCOT SYSTEM, CONSISTENT WITH ERCOT'S TREATMENT OF GENERATORS?

A. It would be helpful for Southern Cross to be able to provide Primary Frequency Response ("PFR") and Voltage Support Service ("VSS"). PFR provides an automatic response to system frequency deviations and is used to stabilize frequency. VSS is used to maintain transmission voltages on the ERCOT system within acceptable limits and provide dynamic reactive capability to respond to changes in local reactive requirements. If the Southern Cross DC tie is importing at full capacity without providing PFR or VSS, there could be reliability implications because it is displacing generation on the ERCOT System that has such capabilities. VSS would be more of a localized concern, if dynamic reactive capability is needed in the area around the tie. If insufficient PFR is available on the ERCOT System due to this displacement by the DC Tie of other generation, ERCOT will have to secure adequate system levels of PFR by procuring more Responsive Reserve Service, which obligates generators to reserve capacity to

provide immediate frequency response.

VIII. IMPACT OF LARGE DC TIES ON ANCILLARY SERVICES PROCUREMENT

Q. WILL THE INTERCONNECTION OF THE PROPOSED SOUTHERN CROSS DC TIE INCREASE THE MOST SEVERE SINGLE CONTINGENCY IN THE ERCOT SYSTEM?

A. Yes. NERC Standard BAL-002-1 R3 requires ERCOT to maintain sufficient contingency reserve to cover the loss of the "most severe single contingency" (MSSC) in the ERCOT system. ERCOT's MSSC is 1375 MW, which corresponds to the loss of one of the nuclear generator at South Texas Project (STP). As described in the application in this proceeding, the proposed Southern Cross DC tie has an import capability of 2000 MW, which would establish a new supply-side MSSC for the ERCOT system.

Q. HOW WOULD ERCOT'S CONTINGENCY RESERVE CRITERIA CHANGE WITH THIS INCREASE IN MSSC?

A. ERCOT meets this contingency reserve requirement by maintaining sufficient Physical Responsive Capability (PRC) through Responsive Reserve Service (RRS). As described in the application in this proceeding, the proposed Southern Cross DC tie has an import capability of 2000 MW, which would establish a new supply-side MSSC for the ERCOT system. This would reduce the reliability margins that ERCOT is maintaining today above and beyond the minimum contingency reserve requirements. To ensure similar reliability margins are maintained, ERCOT will have to procure additional ancillary services.

Increasing the size of the MSSC is important because it increases operational risk by consolidating risk of loss in one location. If lightning or some other force were to take out one of the large DC ties or the 345 kV double-circuit transmission line interconnecting the ties to the Rusk substation, for example, ERCOT would lose all of that import or export, requiring ERCOT to call on its frequency-responsive reserves to maintain system frequency within acceptable tolerances. Also, in shoulder months when the ERCOT system load is less and generation from wind units (which are generally not dispatchable up) is higher and nuclear units (which are relatively non-dispatchable in either direction) are on-line, relying on price-taking DC tie imports means substantially increasing the amount of non-dispatchable generation, which increases the risk that the ERCOT system may lack the ramp capability to respond if it unexpectedly loses a large dispatchable unit.

Q. WHAT IF THE TIE IS EXPORTING?

A. The Southern Cross Project would also establish a new most-severe contingency on the demand side. The proposed DC tie's import and export limits are significantly higher than any of the existing DC ties. The export capability of 2100 MW in essence would have characteristics similar to that of a load of 2100 MW. Experiencing the loss of the DC tie while exporting 2100 MW would instantaneously send the grid frequency to a much higher value, although more detailed studies are needed to accurately estimate the peak post-contingency frequency under the expected range of system conditions. ERCOT currently does not have any ancillary services designed to address the high frequency events of such a large magnitude. If DC ties of such magnitude were to interconnect, ERCOT

will need to investigate whether primary frequency response by the online generators coupled with the procurement of a substantially higher amount of Regulation Down service would be sufficient to moderate the frequency spike or whether it is necessary to design a new Ancillary Service that activates more quickly to return the frequency to normal bounds in order to reliably operate the grid.

Q. WAS YOUR TESTIMONY AND ANALYSIS PREPARED BY YOU OR UNDER YOUR DIRECT SUPERVISION?

A. Yes.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does.

CERTIFICATE OF SERVICE

I hereby certify that a copy of this document was served on all parties of record on April 27, 2016, by posting on the PUC Interchange in accordance with the provisions regarding service in SOAH Order No. 3 in this proceeding.